Honors Anatomy & Physiology

11th & 12th Grades

Prepared by
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Reviewed by
Supervisor of Science

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

(Revised July 2016)

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I. OVERVIEW

To provide students the opportunity to participate in an Anatomy and Physiology course that will study the microscopic and macroscopic structures and functions of the human body to the extent of a college level introductory course. The students will be able to demonstrate a cursory understanding of minor first aid practices. Additionally, this course will proffer periodic projects relating to a definitive understanding of the indicated anatomical system of study.

II. RATIONALE

Honors Anatomy and Physiology is an excellent option for any interested students who would like a more in-depth study of biology. The student must have successfully completed biology and will be required to have a recommendation from their biology teacher. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will learn to identify systems of interacting components and understand how their interactions combine to produce the overall behavior of the system.

5.2 All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.3 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.4 All students will develop an understanding of technology as an application of scientific principles.

5.5 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.6 All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

5.7 All students will investigate the diversity of life.

5.8 All students will gain an understanding of the structure and behavior of matter.

5.9 All students will gain an understanding of natural laws as they apply t motion, forces, and energy transformations.

5.10 All students will gain an understanding of the structure, dynamics, and

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geophysical systems of the earth.

5.11 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.12 All students will develop an understanding of the environmental as a system of interdependent components affected by Human activity and natural phenomena.

IV. STUDENT OUTCOMES

i. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. dissect various vertebrates
2. understand the interrelationship between these vertebrates
3. make comparisons to human through cat dissection
4. develop skills in dissection and other laboratory techniques while they compare body systems
5. clinically apply content material in the form of case studies and computer simulation
6. demonstrate mastery of laboratory techniques
7. demonstrate mastery of critical thinking skills as applied to the analysis of physiological processes and problem solving.
8. demonstrate particular care and attention to detail
9. demonstrate a willingness to collaborate and cooperate with classmates
10. complete all laboratory exercises including all written observations
11. pass all laboratory "practical" evaluations of lab technique
12. participate regularly in classroom discussion
13. demonstrate a willingness to collaborate and cooperate with classmates.

ii. ATTITUDES
The student will:

1. develop an appreciation for the study of anatomy and physiology and how it relates to his/her everyday life. [8.1,8.2, 5.1, 5.2, 5.4.A, 5.10.B]
2. research and investigate possible careers involving anatomy and physiology. [8.1,8.2,8.6, 5.2, 5.4, 5.10]
3. recognize the impact of anatomy and physiology on every aspect of daily life. [8.1, 8.2, 5.1, 5.2, 5.4.A, 5.10.B]

iii. SKILLS AND BEHAVIOR
The student will:

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1. demonstrate good problem-solving techniques.
   [8.1,8.2, 5.1, 5.4, 5.5]
2. write essays on specific topics in anatomy and physiology demonstrating comprehension of a given topic, i.e. the historical development of the subject.
   [8.1, 5.1, 5.2, 5.6]
3. demonstrate effective listening and note taking skills in lecture and discussion situations.
   [8.1, 5.1]
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments.
   [8.1, 5.1.C, 5.1.A]
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions.
   [8.1, 5.1.A]
6. demonstrate in class discussion and in writing a comprehensive knowledge of anatomy and physiology.
   [8.1, 5.5.A, 5.5.B, 5.4]
7. work cooperatively in small groups to solve problems or perform experiments.
   [8.1, 5.1.A, 5.1.B]
8. use spreadsheet and graphing software to report results of laboratory investigations.
   [8.1,8.2, 5.4, 5.1]
9. design and produce presentations using Power Point presentation software.
   [8.1, 5.4]
10. utilize Internet search engines to locate anatomy and physiology related websites for research and review.
    [8.1,8.2]
11. be aware of the connection between educational activities and the world of work.
    [9.1, 9.2]

V. STRATEGIES

The following strategies/activities will be used:

1. Interactive lectures
2. Problem solving activities
3. Group work
4. Independent projects
5. Peer review
6. Make the appropriate accommodations for special needs and ELL students:

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Additional time and other IEP stated accommodations
Audio text resources
Varied assessment

VI. EVALUATION

Assessment may include:

Exams
Quizzes
Lab reports
Laboratory practicum
Notebook
Performance Assessment
Benchmark Assessments
Homework
Class Participation
Student projects
Computer driven spreadsheets and graphs
Oral and/or Power Point presentations

Students will also be expected to design and execute projects and/or original research.

VII. REQUIRED RESOURCES

Text book Martini/Bartholomew, Essentials of Anatomy & Physiology, 2010. Pearson

Reference materials-audio-visual materials

Common science department web links (updated July 2016)
https://www.khanacademy.org/
www.bozemanscience.com
www.biologycorner.com

ACHS Media Center/Library:
www.Youtube.com
www.turninitin.com
NBC Learn Media - http://archives.nbclearn.com/portal/site/k-12
Purdue Writing Lab – MLA/APA Formats - https://owl.english.purdue.edu/owl/resource/747/13/
Gale Database (On-line and phone app)
Press of Atlantic City Newspaper Program
New York Times Newspaper Program

Specialized computer software
internet resources
dissection lab (specimens, dissecting tools, microscopes)
alternative assessment activities

Technology: Chromebook cart and Google Classroom

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EdConnect for Lesson Plans and Benchmark Assessments

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SCOPE AND SEQUENCE

September

Demonstrate an etymological understanding of rudimentary medical terminology and the historical association with science.

Explain the phylogeny and anthropology of *Homo sapiens.* Delineate a basic understanding of embryology.

Demonstrate an extensive understanding of the basic anatomical terminology, organismal organization, necessary life functions, and homeostasis.

October

Differentiate between organic and inorganic chemistry, with explanation of associated bonding mechanisms, and explain the structural composition of living matter.

List and discuss the function and structure of the integumentary system, along with the significance of homeostatic imbalance of the system.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Understand the anatomy of a generalized cell, and explain the physiology associated with membrane transport, cell division and protein synthesis.

Discuss and explain the generalized characters of epithelial tissue, connective tissue, muscle tissue, and nervous tissue.

Compare and contrast the classification of body membranes.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Explain the function, classification and generalized structure of various osteological structures.

List the various bones associated with, and differentiate between, the appendicular and axial skeletons.

Assessments – Chapter Test, journal review, lab reports (informal)

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Unit Exam

January

Discuss and explain the various muscle types, generalized activities of muscles, and the body movements associated with muscle nomenclature.
List and discuss the gross anatomy and location of skeletal muscles.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February

Discuss and explain the tissue specialization associated with the special senses, list their various anatomical structures, and illustrate all associated neuronal pathways.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March

Explain the classification, generalized structure and physiology of nervous tissue.
List, discuss, and differentiate between the structural functions of the central and peripheral nervous system.
Explain and illustrate the structure, physiology and location of the endocrine system and all of its components.
.List and explain the composition, physiology and associated functions of the blood.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April

Describe and illustrate the components, functions and associated locations of the circulatory system.
Explain specific and nonspecific bodily defenses, with all associated structures and mechanisms.
List and describe the functional anatomy, physiology and disorders

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associated with the respiratory system.
Discuss and define the structure, functions, physiology and location of the various components of the digestive system.
Discuss the minimal nutritional requirements of human metabolism.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May/June

List and define the structure, location and physiology of the urinary system and its components.
Differentiate between male and female reproductive organs, their respective locations, cycles and physiology.
List and describe the physiology and physical mechanisms associated with fertilization and embryological development.
Demonstrate and adhere to all established safety guidelines while performing all laboratory dissection exercises.

Assessments – Chapter Test, Benchmark Test, journal review, lab reports (informal)
Unit Exam
Final Exam

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
September	• What are Anatomy and Physiology? • What are the systems of the body? • What are the body's cavities and what do they contain? • Explain the significance of biochemistry to the study of A&P.	• Vocabulary • Directional Terms • Sectional Planes of Reference • Anatomical Systems • Homeostasis • Periodic Law	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests – Multiple Choice, Fill-In, OEQ	• Open discussion • Oral conjugation drills • Graphics Labeling • Personal demonstrations of bodily orientation

Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
October	• What is Organic Chemistry? • What is biochemistry? • How do the cells of the human body function? • What are tissues?	• Vocabulary • Periodic Table • Chemical Notation • Chemical Homeostasis • Equilibrium Reactions • Diffusion & Osmosis	• Etymology • Molecular Modeling • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests • Laboratory Practical Examinations	• Open discussion • Molecular Modeling • Microscopy

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
November	• What is functional cytology. • How does structure and function relate? • How do cells produce and store energy? • What are the differences and similarities between mitosis and meiosis?	• Discuss the basic concepts of the "cell theory". • List functions of cell membrane, and structural features • Describe various mechanisms that cells use to transport substances • Describe organelles of typical cell, and indicate specific functions of each. • Explain the functions of the cell nucleus. • Summarize the process of protein synthesis. • Describe the process of mitosis and explain its significance. • Define the differentiation and explain its importance.	• Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests • Laboratory Practical Examinations	• Open discussion • Microscopy • Tissue Classification • Note taking

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
December	Identify the body's four major tissue types & their roles. Describe the types and functions of epithelial cells. Describe the relationship between form and function for each epithelial type. Compare the structures and functions of the various types of connective tissues. Explain how epithelial and connective tissues combine to form four different types of membranes and specify the functions of each. Describe the general functions of the integumentary system. Describe the main structural features of the epidermis, and explain their functional significance. Explain what accounts for individual and racial differences in skin, such as skin color. Discuss the effects of ultraviolet radiation on the skin and the role played by melanocytes. Discuss the functions of the skin's accessory organs. Explain the mechanisms that produce hair and that determine hair texture and color. Explain how the skin responds to injury & repairs itself. Summarize the effects of aging on the skin. Describe the functions of the skeletal system. Compare the structures and functions of compact and spongy bone. Discuss bone growth and development, and account for variations in the internal structure of specific bones. Describe the remodeling and homeostatic mechanisms of the skeletal system.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests •	• Open discussion • Microscopy • Tissue Classification • Note taking

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Name the components and functions of the axial and appendicular skeletons. Identify the bones of the skull. Discuss the differences in structure and function of the various vertebrae. Relate the structural differences between the pectoral and pelvic girdles to their various functional roles.				

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
January	Distinguish among different types of joints, and link structural features to joint functions. Describe the dynamic movements of the skeleton and the structure of representative articulations. Explain the relationship between joint structure and mobility, using specific examples. Discuss the functional relationships between the skeletal system and other body systems. Describe the functions of skeletal muscle tissue Describe the organization of muscle at the tissue level. Identify the structural components of a sarcomere. Explain the key steps involved in the contraction of a skeletal muscle fiber. Compare the different types of muscle contractions. Describe the mechanisms by which muscles obtain and use energy to power contractions. Relate muscle fibers types to muscular performance. Distinguish between aerobic & anaerobic endurance, & explain their implications for muscular performance. Contrast skeletal, cardiac, and smooth muscles in terms of structure and function. Identify the principal axial muscles of the body, together with their origins and insertions.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES

Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
February	Identify the principal appendicular muscles of the body, together with their origins and insertions. Describe the effects of exercise and aging on muscle tissue. Discuss the functional relationships between the muscular system and other body systems. Describe the anatomical organization and general functions of the nervous system. Distinguish between neurons and neuroglia and compare their structures and functions. Discuss the events that generate action potentials in the membranes of nerve cells. Distinguish between continuous and saltatory nerve impulse conduction. Explain the mechanism of nerve impulse transmission at the synapse. Describe the process of a neural reflex. Describe the three meningeal layers that surround the central nervous system. Discuss the structure and functions of the spinal cord. Name the major regions of the brain and describe their functions. Locate the motor, sensory and association areas of the cerebral cortex and discuss their functions.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Distinguish between the general and special senses. Identify the receptors for the general senses and describe how they function. Describe the receptors and process involved in the sense of smell. Describe the receptors and proceses involved in the sense of taste. Identify the parts of the eye and their functions. Explain how we are able to see objects and distinguish colors. Discuss how the central nervous system processes information related to vision. Discuss the receptors and processes involved in the sense of equilibrium. Describe the parts of the ear and their roles in the process of hearing.				

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
March	Compare sim. between the endocrine & nervous systems. Compare the major chemical classes of hormones. Explain the general mechanisms of hormonal action. Describe how endocrine organs are controlled. Describe the location, hormones, and functions of the endocrine glands and tissues. Explain how hormones interact to produce coordinated physiological responses. Identify the hormones that are especially important to normal growth, and discuss their roles. Explain how the endocrine system responds to stress. Discuss the results of abnormal hormone production. Discuss the functional relationships between the endocrine system and other body systems. Describe important components & major functions of blood. Discuss the composition and functions of plasma. Describe the origin and production of the formed elements in the blood. Discuss the characteristics and functions of red blood cells. Categorize the various white blood cells on the basis of their structures and functions. Discuss mechanisms that control blood loss after an injury.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
April	Describe the location and general features of the heart. Trace the flow of blood through the heart, identifying the major blood vessels, chambers, and heart valves. Identify the layers of the heart wall. Describe the differences in the action potential and twitch contractions of skeletal muscle fibers and cardiac muscle cells. Describe the components and functions of the conducting system of the heart. Explain the events of the cardiac cycle and relate the heart sound to specific events in this cycle. Define stroke volume and cardiac output and describe the factors that influence these values. Distinguish among the types of blood vessels on the basis of their structure and function. Explain the mechanisms that regulate blood flow through arteries, capillaries, and veins. Discuss the mechanisms and various pressures involved in the movement of fluids between capillaries and interstitial spaces. Describe the factors that influence blood pressure and how blood pressure is regulated. Describe how central and local control mechanisms interact to regulate blood flow and pressure in tissues. Explain how the activities of the cardiac, vasomotor, and respiratory centers are coordinated to control blood flow through the tissues. Explain how the circulatory system responds to the demands of exercise and hemorrhaging.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Identify the major arteries and veins and the areas they serve. Describe the age-related changes that occur in the cardiovascular system. Discuss the structural and functional interactions between the cardiovascular system and other body systems. Identify the major components of the lymphatic system and explain their functions. Discuss the importance of lymphocytes and describe where they are found in the body. List the body's nonspecific defenses and explain how each functions. Define specific resistance and identify the forms and properties of immunity. Distinguish between cell-mediated immunity and antibody-mediated immunity (humoral) immunity. Discuss the different types of T cells and the role played by each in the immune response. Describe the structure of a antibody molecules and explain how they function. Describe the primary and secondary responses to antigen exposure. Relate allergic reactions and autoimmune disorders to immune mechanisms. Describe the changes in the immune system that occur with aging. Describe the primary functions of the respiratory system. Explain how the delicate respiratory exchange surfaces are protected from pathogens, debris and other hazards				

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Relate respiratory functions to the structural specializations of the tissues and organs of the systems. Describe the physical principles governing the movement of air into the lungs and the diffusion of gases into and out of the blood. Describe the actions of muscles on respiratory movements. Describe how oxygen and carbon dioxide are transported in the blood. Describe the major factors that influence the rate of respiration. Identify the reflexes that regulate respiration. Describe the changes that occur in the respiratory system at birth and with aging.				

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
May	Identify the organs of the digestive tract and the accessory organs of digestion. List the primary functions of the digestive system. Describe the histological characteristics of each segment of the digestive tract in relation of its function. Describe the characteristics of smooth muscle and explain how ingested materials are propelled through the digestive tract. Describe the anatomy and functions of the oral cavity, pharynx, and esophagus. Describe the anatomy of the stomach, its histological features, and its roles in digestion and absorption. Explain the functions of the intestinal secretions and discuss the relative significance of digestion in the small intestine. Describe the structure and functions of the pancreas, liver, and gall bladder and explain how their activities are regulated. Describe the structure of the large intestine, its movements, and its absorptive processes. Describe the digestion and absorption of carbohydrates, lipids, and proteins. Describe the changes in the digestive system that occur with aging. Define metabolism and explain why cells need to synthesize new organic components. Describe the basic steps in glycolysis, the TCA cycle, and the electron transport system. Describe the pathways involved in lipid metabolism. Discuss protein metabolisms and the use of proteins as an energy source.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Describe nucleic acid metabolism. Explain what constitutes a balanced diet, and why it is important. Discuss the functions of vitamins, minerals and other important nutrients. Describe the significance of the caloric value of foods. Define metabolic rate and discuss the factors involved in determining an individual's metabolic rate. Discuss the homeostatic mechanisms that maintain a constant body temperature. Identify the components of the urinary system and describe their functions. Describe the structural features of the kidneys. Describe the structure of the nephron and the processes involved in urine formation. Trace the path of blood flow through the kidney. List and describe the factors that influence filtration pressure and the rate of filtrate formation. Describe the changes that occur in the filtrate as it moves through the nephrons and exits as urine. Describe the structures and functions of the ureters, urinary bladder and urethra. Discuss the process of urination and how it is controlled. Explain how the urinary system interacts with other body systems to maintain homeostasis in body fluids. Compare the composition of the intracellular and extracellular fluids.				

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MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
	Explain the basic concepts involvd in the control of fluid and electrolyte regulation. Explain the buffering systems that balance the pH of the intracellular and extracellular fluids. Describe the effects of aging on the urinary system. Summarize the functions of the human reproductive system and its principal components. Describe the components of the male reproductive system. Describe the process of spermatogenesis. Describe the roles the male reproductive tract and the accessory glands play in the maturation and transport of spermatozoa. Describe the hormonal mechanisms that regulate male reproductive functions. Describe the components of the female reproductive system. Describe the process of oogenesis in the ovary. Detail the physiological processes involved in the ovarian and menstrual cycles. Discuss the physiology of sexual intercourse as it affects the reproductive systems of male and females.				

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Course: **Anatomy & Physiology Honors**

MONTH	ESSENTIAL QUESTION	CONTENT	SKILLS	ASSESSMENT	ACTIVITIES
June	Describe the events of fertilization. List the three prenatal periods and describe the major events associated with each period. Describe the origin of the three germ layers and their participation in the formation of extraembryonic membranes. Describe the contributions of the maternal organ systems to the developing fetus. List and describe the events that occur during labor and delivery. Discuss the major stages of life after delivery. Relate basic principles of genetics to the inheritance of human traits. Identify any and all structures of the thin man, as directed by the instructor. Complete all of the assigned graphical representations of the various components of the indicated systems.	• Vocabulary • Directional Terms • Relationship of Anatomical Systems • Maintenance of Homeostasis	• Word Construction • Etymology • Memorization • Concept Integration	• Quizzes • OEQs • Workbook • Tests	• Open discussion • Dissection • Structure Classification • Note taking

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Academic Biology

9th & 10th Grades

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Prepared by
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(Revised July 2016)

I. OVERVIEW

Academic Biology is a one-year lab science course meeting six periods per week with at least one double lab period per week. It is an overview of the biological sciences with an emphasis on the process and application of biology. The student is introduced to the science of biology, the diversity of life, biochemistry, cellular structure and function, the basic needs of organisms, natural selection, ecology and interdependence, genetics, taxonomy, and application in biotechnology.

II. RATIONALE

Biology has become an important and essential part of student learning in the 21st century. As topics such as public health, environmental stability, and biotechnology are on the forefront of our daily lives, it is ever more important that students are prepared to understand and use the information available, as it changes constantly. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as

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they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

IV. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of facts, terminology, concepts, generalizations, principles and scientific procedures that will help students confront and interpret occurrences in the everyday world. [5.1.A.1.2.3.4,B.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]**
2. summarize the characteristics that are common to all organisms [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
3. describe how technology has influenced the field of biology. [5.1.A.1.2.3.4,B.1.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]
4. describe the levels of organization in living systems from the simplest or atomic level to the most complex or organism level. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
5. describe the properties of water that are essential to life. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
6. explain the properties of carbon bonds and explain the structure of organic compounds. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
7. explain the relationship among the classes of organic compounds and describe their properties. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
8. describe the structure and function of the cell organelles. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
9. compare the various ways in which substances enter and exit cells and describe the properties of the cell membrane and the fluid mosaic model. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1]

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10. describe the process of mitosis and the cell cycle.
    [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
11. define the role of energy and ATP in living things.
    [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
12. define photosynthesis, glycolysis and aerobic respiration.
    [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
13. describe the relationship between ecology and biology.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.2.A.1]
14. define population, community, ecosystem and biosphere.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.1.A.1]
15. evaluate the population dynamics of a predator/prey cycle.
    [5.3.A; 5.3.B.1; 5.3.C.1; 5.3.D.1]
16. explain the work of Darwin, relating various types of evidence to support his hypothesis and summarize the process of natural selection.
    [5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.3.A.1; 8.1.C.1]
17. list various mechanisms for evolution including, genetic drift and sexual selection.
    [5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.1.A.1; 8.2.C.1]
18. demonstrate knowledge of various classifications systems such as the 5-kingdom system and the three-domain system of classification and describe the identifying characteristics for each.
    [5.2.B.1.2.3; 5.5.B.1; 8.1.A.1; 8.2.D.1]
19. describe the adaptations involved in the transition from an aquatic to terrestrial environment.
    [5.5.B.1.2; C.1.2; 8.1.A.1; 8.2.D.1]
20. define taxonomy and describe how Linnaeus created modern taxonomy and how it changes as new evidence is found.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 8.1.A.1]
21. understand the use of a dichotomous key in taxonomy.
    [5.5.B.1.2;8.1.A.4; C.1]
22. identify the people who contributed to biogenesis and describe the various origin of life hypotheses including the evolution of metabolic pathways.
    [5.1.A.1.3.4; B.2; 5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.2.A.1;]

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23. define meiosis and explain its role in genetics and evolution.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
24. explain the work of Gregor Mendel and define his contribution to genetic theory.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1; 8.6.A.5.8.9.10]
25. apply the laws of segregation and independent assortment to explain the behavior of chromosomes during meiosis.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1;]
26. apply probability to genetic crosses using Punnett squares
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
27. describe how genes are related to chromosomes
    [5.1.A.1.2;5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
28. compare different types of gene mutations and their effects.
    [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
29. explain the role of DNA as the carrier of genetic information.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
30. define the work of Watson, Crick and Franklin in determining the structure of DNA.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
31. trace the steps involved in DNA replication and protein synthesis.
    [5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
32. define bio-ethics and list the pros and cons of various current topics such as genetic engineering, stem cell research and cloning.
    [5.2.B.1.2; 5.5.C.1.2.3; 5.10.A.1; B.1.2]

B. ATTITUDES

The student will:

1. suggest reasons for a nonscientist to be educated in science. [5.2.A.1]
2. exhibit objectivity and sound decision-making in analyzing the bio-ethical issues confronting society in areas such as human genetics, medicine, reproduction, law.
   [5.2.A.1; 8.1.B.1.2; 8.2.A.]
3. develop curiosity about the many unanswered questions in biology. [5.4.A.1; 8.1.B.1]

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4. exhibit a fundamental respect for living things and the dependence of humans on other organisms.
   [5.4.A.1; 5.4.B.1]
5. appreciate the significance and variety of possible careers in biology and applications of biology.
   [5.2.A.1; 5.2.B.1.2.3; 8.2.A.1,2; 8.2.B.1,9.1, 9.2]
6. develop an appreciation of the role of technology in investigating, cataloging, comparing and altering living things.
   [5.4.A.4; 5.4.B.1; 5.4.C.1.2]
7. develop a sense of wonder at the amazing complexity, unity and balance of life.
   [5.2.A.1; 5.2.B.1.2.3; 8.2.A.1.2; 8.2.B.1]

C. SKILLS AND BEHAVIOR
The student will:

1. design an experiment with an experimental set-up and a control, and perform data analysis using varying techniques.
   [5.1.A.1.3.4; 5.1.B.1.2; 5.1.C.1; 8.2.A.1]
2. demonstrate effective use of the compound light microscope and stereoscopic dissecting microscope.
   [5.1.C.1; 5.1.B.1]
3. diagram accurate representation of size and shape of living things. [5.3.C.1; 5.3.D.1;]
4. predict the outcome of an experiment.
   [5.1.A.3.4; 5.1.B.2; 8.2.A.1]
5. classify organisms on the basis of similar morphology.
   [5.3.B.1; 5.3.D.1]
6. compare biochemical sequences of several diverse species to infer evolutionary relationships.
   [5.5.C.1.2]
7. use a dichotomous key to identify an unknown species.
   [5.1.A.1; 5.3.B.1; 5.3.C.1]
8. follow safety rules and practices in all laboratory and field activities.
   [5.1.C.1]
9. use computer interfaced probes to collect and analyze data. [5.1.B.1; 8.2.C.1.2]
10. use technological tools for problem-solving, writing and research.
    [8.1.A.1.2.3.4]
11. locate, organize, summarize and evaluate information.
    [8.2.C.1.2]

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12. be aware of the connection between educational activities and the world of work [9.1,9.2]

V. STRATEGIES

Interactive lectures, including where appropriate:

- Use of flex cam
- Computer-TV interface
- Digital projector
- PowerPoint presentations
- Overhead transparencies
- Handouts
- Demonstrations

Problem-solving activities, such as:

- Model building
- Cooperative group work
- Bio-ethics debates

Computer programs to:

- Run simulations
- Generate and evaluate data
- Run review-CD applications

Laboratory investigations, including:

- Observation
- Experimental design
- Hypothesis testing
- Dissections

Internet resources, used to:

- Supplement textbook on Exploring Life web-site
- Search medical and other science related databases
- Perform literature searches
- Obtain current information
- Run on-line lab activities

Videos:

- PBS Scientific American Explorers
- Discovery channel
- NOVA
- National Geographic

Independent projects

Make the appropriate accommodations for special needs and ELL students:

- Additional time and other IEP stated accommodations
- Audio text resources
- Varied assessment

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VI. EVALUATION

Assessment may include:

- Exams
- Quizzes
- Lab reports
- Lab notebook
- Lab practicum
- Homework
- Classwork
- Classroom Journal
- Open Ended Questions'
- Individual project
- Group projects
- Presentations
- End of Course Biology Benchmark Assessment
- STA test

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: Holt, Rinehart, and Winston. Modern Biology. Harcourt. 2002
2. Technology
   - Laptop cart
   - Word Processing and Data Base programs: Microsoft Office, etc.
   - CD-ROM: Biology: Modern Biology
   - Internet Resources: various
   - Virtual Dissections
3. Supplemental material via Inclusion/LRC: Bernstein, Schachter, Winkler, Wolfe. Life Science: Concepts and Challenges. Globe.
4. Lab manual: open (several labs within the textbook)
5. Videos: various

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VIII. SCOPE AND SEQUENCE

September

Life (Ch. 1)

Introduction
Scientific method, scientific process, logical thinking skills
Tools, techniques and skills for lab work
Microscope
Definition/characteristics of life
Themes in Biology
Biology and Society

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Chemistry of Life (Ch. 2 & 3)

Atoms and molecules
Bonding
Ionic, covalent, hydrogen
Properties of water
Polarity, pH, Specific heat
Organic chemistry
Carbon bonds
Carbohydrates, Lipids, Nucleic Acids, Protein structure & function
Enzyme

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Cells and Transport (Ch. 4 & 5)

History and Cell theory
Structure and function of organelles
Prokaryotes vs Eukaryotes
Fluid mosaic model of the cell membrane
Diffusion, passive and active transport

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

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December

Photosynthesis and Respiration (Ch. 6 & 7)

- Energy and ATP
- Photosynthesis
  - Light reactions and Calvin cycle
- Respiration
  - Anaerobic vs. aerobic
  - Glycolysis, Kreb's cycle, Electron transport
  - Energy flow through ecosystem
  - Material cycles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Cell Reproduction and Classic Genetics (Ch. 8 & 9)

- Chromosomes
- Mitosis
- Meiosis
- Probability
- Mendel
  - History
  - Independent assortment and recombination, dominance co-dominance, incomplete dominance
- Genetic Crosses, Punnett square

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/ March

Molecular Genetics (Ch. 10, 11, 12, & 13)

- DNA, RNA and Protein synthesis
  - History, Discovery
  - DNA structure and function
  - Replication, information storage, mutations, genes
  - RNA structure and function
  - Transcription, Translation, Protein synthesis
- Gene expression
- Human genetics
  - Pedigrees, patterns of inheritance, genetic diseases

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Biotechnology

Genetic engineering, Cloning, Biotechnology techniques, Bioethics

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March/April

History of Life on Earth (Ch. 14, 15, & 17)

Origins of Life

Geological and Ecological History of Life

Evolution and natural selection

History, Darwin

Evidence

Fossils, geology

Principals of natural selection, speciation

Human Evolution

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April/May

Ecology (Ch 19, 20, 21, 22, & 23)

Ecosystems, environment

Climate change, mass extinctions

Populations

Communities, species interactions

Succession

Energy flow, biochemical cycles

Biomes

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May/June

Taxonomy (Ch. 18)

Classification systems (Historical and current)

6 Kingdoms

Animal Phyla

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam, Benchmark Assessment, Final Exam

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
SEPT	• What is Biology? • What are the major themes in Biology? • What is a multicellular/ unicellular organism? • What is Ecology? • What is Homeostasis? • What is Heredity? • What is Evolution? • What are the characteristics of all living things? • What is the Scientific Method? • What is a Theory? • How is the microscope used in biology? • What are the SI units of measurement?	The Science of Biology • Introduction o Science of Biology o Themes of Biology • World of Biology o Characteristics of Life • Scientific Method o Steps of the Scientific Method o Tools used in Biology o Lab Safety • Microscope and Measurement o Light Microscope o Units of Measurement	• List the 6 themes in Biology • Discuss relationships between adaptation and evolution • Explain the relationship between hypothesizing, predicting, and experimenting • Describe the methods the scientists used in their work • List 6 characteristics of life • Become familiar with the usage and parts of the microscope	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 1) • Student portfolio, journal • Review sheets • Teacher/student discussion	• Labs: o Measurement o Data/Graphing o Tools of Science o Intro to Microscope • Videos: o *Invisible World* o *Life* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
OCT	• How are Chemistry and Biology related? • What is Matter? • What are atoms composed of? • What is an Element? • What determines an element's properties? • What is an Ion? • What is a Molecule? • Why do atoms form bonds? • How are states of matter determined? • What are Acids and Bases? • How are chemical reactions and energy important to living things? • What is ATP? • Why is H2O so important? • Why make Carbon the "element of life"? • What are the four major organic molecules?	• Composition of Matter: o Elements o Atoms o Compounds o Molecules o Bonding • Energy o States of Matter o Free Energy o Reactions ▪ Energy transfer ▪ Activation Energy ▪ Enzymes • Solutions o Describing Solutions o Acids and Bases o Aqueous Solutions • Organic Macromolecules o Structure & Function o Carbohydrates o Lipids o Proteins o Nucleic Acids	• Define and differentiate between elements, atoms, molecules and compounds • Explain the structure of an atom and what determines an atom's stability • Predict the number of bonds an atom can form • Explain the behavior of particles in liquids, solids and gases • Explain how energy is related to living things • Explain how enzymes affect chemical reactions in organisms • Contrast properties of acids and bases • Summarize the polarity of H2O • Describe the structure and function of the four class of organic macromolecules and their significance to organisms	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 2 & 3) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs o Atom models o Enzymes (liver or detergent) o Determining pH o Models of Organic Molecules • Videos: o *Body Story: Fat* • Organization of student portfolio • Jeopardy game • Articles • Notes/ class discussion

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	• What is an enzyme?				

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
NOV	• What are the discoveries that led to the development of the cell theory? • What is the cell theory? • How is cell shape related to cell function? • What are the structures and functions of the organelles? • What are the differences between prokaryotes and eukaryotes? • What are the differences between plant and animals cells? • How does diffusion and osmosis play an important role in cell function?	• Discovery of the cell: o Cell Theory o Cell Diversity • Eukaryotes o Cell Membrane o Lipids o Proteins o Fluid mosaic model • Organelles o Structure o Function • Passive Transport o Diffusion o Osmosis o Facilitated Diffusion • Active Transport o Channels and Pumps o Energy Demand	• Outline the discoveries that led to the development of the cell theory • State the cell theory • Distinguish between prokaryotes and eukaryotes • Describe the structure and function of all organelles • Distinguish between osmosis and diffusion. • Distinguish between passive transport and active transport	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch. 4 & 5) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Cell Model o Microscope: Animal vs. Plant o Microscope: Check cell o Micro-viewers o Osmosis and Diffusion Lab Kit • Videos: o *Magic of Cells* o *Body Story:* various • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
DEC	• What is Light? • What are Pigments? • What is Photosynthesis? • What is Carbon Fixation? • What materials are consumed/produced from photosynthesis? • What is Cellular Respiration? • What is Glycolysis? • What is Fermentation? • How is aerobic respiration related to the structure of the mitochondrion? • What materials are consumed/produced from respiration?	• Capturing Light o Light o Pigments o Photosystems • Calvin Cycle • Glycolysis and Fermentation o Chemical energy o Anaerobic pathways o Fermentation o Lactic acid/Alcohol formation • Aerobic respiration o Krebs cycle o Electron transport	• Describe the structure of the Chloroplast as it relates to photosynthesis • Describe the processes of light capture, electron transport and chemiosmosis • Describe how Carbon if fixed via the Calvin Cycle • Compare and contrast lactic acid fermentation and alcoholic fermentation • Calculate the efficiency of glycolysis. • Summarize the events of the Krebs cycle • Relate aerobic respiration to the structure of a mitochondrion.	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (6 & 7) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Viewing the Stoma of a Leaf o Planting Pea Plants • Videos: o *Photosynthesis (Standard Deviants)* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
JAN	• How are Chromosomes, Proteins, and DNA related? • How many chromosomes does a body cell/ sex cell have? • What is Mitosis/Meiosis? • Who was Gregor Mendel and how did his work effect the study of genetics? • What is the different between dominant and recessive traits? • How are genes and alleles similar and alike? • How do we calculate the probability of a genetic outcome? • What is the difference between a monohybrid and dihybrid cross?	• Chromosomes o Structure o Number • Cell Divison o Mitosis o Meiosis o Crossing over • Mendelian Genetics o Gregor Mendel and his experiments o Dominant traits o Recessive traits o Law of Segregation o Law of Independent Assortment o Barbara McKlintock • Probability and genetic crosses o Genotype o Phenotype o Monohybrid crosses o Dihybrid Crosses	• Relate Chromosomes, Genes, DNA • Explain the structure of a chromosome • Distinguish homologous and sex chromosomes • Distinguish haploid and diploid cells • Describe the cell cycle • Describe the process of Mitosis, Meiosis • Understand Gregor Mendel's contribution to genetics • Model Mendel's experiments with pea plants • Differentiate between dominant and recessive traits • Differentiate between genes and alleles • Use Punnett Squares to calculate the probability of obtaining a certain genetic outcome	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (8 & 9) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Chromosome beads o Microscope: Mitosis: Onion root tip o Mitosis/ Meiosis Models o Determining Genotypes: Tongue Rolling • Videos: o *Bill Nye: Genes* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

FEB/ MAR	• What is the principal function of DNA?
	• How does the structure of DNA relate to its function?
	• What is the role of complimentary base pairing?
	• How does DNA replicate?
	• How does RNA compare with DNA?
	• How does the shape of RNA compare to its function?
	• What is transcription and how does it relate to protein synthesis?
	• What factors affect gene expression?
	• What causes Cancer?
	• What are some human genetic diseases?
	• What are some common Biotechnology techniques?
		• Discovery of DNA
		• DNA shape and function
		  o DNA components
		  o Complementary base pairing
		• DNA replication
		• RNA shape and function
		  o RNA components
		  o The 3 types of RNA
		• Transcription and Translation
		• Gene Expression
		  o Cancer
		• Human Genetics
		  o Patterns of Inheritance
		  o Pedigrees
		  o Genetic Diseases
		• DNA Technology
		  o recombinant DNA
		  o DNA fingerprint
		  o Pharmaceuticals, Agriculture
		  o Bioethics
			• Identify DNA and it's components
			• Describe the shape of DNA
			• Explain how base pairs match each other
			• Identify the process of DNA replication
			• Transcribe sequences of DNA to RNA
			• Translate sequences of RNA into amino acids
			• Describe protein folding
			• Describe factors that affect gene expression
			• Describe chromosome and gene mutations
			• Describe common genetic disorders and their cause
			• Create and use pedigrees
			• Describe the process of creating a transgenic organism
			• Discuss the ethical questions that arise in biotechnology
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (Ch. 10)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  o DNA Model
					  o DNA Extraction
					  o Taste- Pedigree
					• Videos:
					  o *Gattaca*
					  o *Twins (Discovery Channel)*
					  o *Rosaline Franklin*
					  o *The Island*
					  o *Jurassic Park*
					• Project:
					  o Bioethics essay
					  o Biotechnology Power Point
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAR/ APRIL	• How old is the Earth? • What is radioactive dating? • How did organic compound arise? • What are the oldest know organisms? • What is evolution? • How do fossils give us evidence of evolution? • How did Darwin contribute to the theory of evolution? • What is the evidence for evolution? • How does natural selection drive evolution? • How do paleoanthropologists gather evidence of human ancestry? • What are Primates? • What are Hominids? • What is the current map of human evolution?	• Earth's History o Formation o Radioactive Dating o Life from nonliving chemicals o Urey and Miller o First organisms o Endosymbiosis • Geological time periods • Fossils and the fossil record o Law of superposition • Descent with modification • Evolution and its evidence, definition, and social impact. • Charles Darwin • Natural selection • Evidence o Homologous, analogous, and vestigial structures o Coevolution, divergent evolution, and convergent evolution • Primate Characteristis • Hominid Evolution o Fossil Evidence o Phylogenic Trees	• Describe how the age of the Earth is determined • Describe Urey and Miller's experiment • Describe the theory of how replicating chemicals could have evolved into the first cells • Describe the theory of endosymbiosis • Describe fossil formation • Give several pieces of evidence supporting evolution • Tell how biogeography suggests descent with modification • Explain Darwin's two major theories • Explain the process of Natural Selection • Describe primate characteristics • Describe australopithecies • Describe species of the genus *Homo* • Describe the current map of human	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 14, 15 &17) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Natural Selection • Videos: o *Walking with…*series o *Bill Nye: Greatest Discoveries: Evolution* o *Nova: Evolution on Trial* o *Inherit the Wind* o *Neanderthal* o *Land of Monsters* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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			evolution?		

Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
APRIL/ MAY	• Why is Ecology important? • What are some human caused environmental problems? • How are Communites, Populations and Organisms connected? • What is a niche? • What is symbiosis? • How do predators differ from parasites? • What is Succession? • How does energy flow through an ecosystem? • How does water cycle through an ecosystem? • How does carbon cycle through an ecosystem? • What are the 7 major Biomes?	• Ecology o Environmental changes o Levels of organization • Ecology of Organisms o Habitat o Biotic and abiotic factors o Niche • Community Ecology o Predation o Parasitism o Competition o Mutualism and Commensalism • Properties of Communities • Succession • Energy Transfer o Producers/ Consumers o Food webs • Ecosystem Recycling o Water cycle o Carbon cycle o Nitrogen cycle • Terrestrial Ecosystems o Biomes • Aquatic Ecosystems	• Define ecology and explain why it is important • Identify the five different levels of organization in ecology • Explain the theme of interconnectedness • Contrast abiotic factors with biotic factors • Explain the concept of a Niche • Distinguish predation from parasitism • Describe how plants can defend themselves against herbivores • Explain the difference between species richness and species diversity • Distinguish between primary and secondary succession • Describe how energy flows through an ecosystem • Trace the steps of the water, carbon, and nitrogen cycles • Describe the major	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Microscope: Pond Water o Observing Ecology • Video: • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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			terrestrial and aquatic biomes		

Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAY/ JUNE	• How has the classification of organisms changed over the past? • What are the modern criteria for classifying organisms? • How did Aristotle's classification system work? • In what ways was his system different than Linneaus's? • What are the primary criterion that modern taxonomists use to classify organisms?	• Taxonomy • Carolus Linneaus • Morphology • 7 class system of classification • Binomial nomenclature • Phylogeny • Cladistic	• Describe Aristotle's classification system and explain why it was replaced • Explain Linnaeus's system of classification and identify the main criterion he used to classify organisms • Name the primary criterion that modern taxonomists consider • List four types of evidence used to organize organisms in systematic taxonomy • Explain cladistic taxonomy	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 18) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs • Videos • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Honors Biology

9th & 10th Grades

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Prepared by
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Reviewed by
Supervisor of Science

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

(Revised July 2016)

I. OVERVIEW

Honors Biology is a one-year lab science course meeting six periods per week with at least one double lab period per week. It is an overview of the biological sciences with an emphasis on the process and application of biology. The student is introduced to the science of biology, the diversity of life, biochemistry, cellular structure and function, the basic needs of organisms, ecology, natural selection, genetics, taxonomy, and applications in biotechnology. The honors level course will be more rigorous than Academic Biology in terms of content, depth of coverage and laboratory study. Entry into the Honors level course is dependent upon performance in previous science courses.

II. RATIONALE

Biology has become an important and essential part of student learning in the 21st century. As topics such as public health, environmental stability and biotechnology are on the forefront of our daily lives, it is ever more important that students are prepared to understand and use the information available, as it changes constantly. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and behavior of matter.

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5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

IV. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of facts, terminology, concepts, generalizations, principles and scientific procedures that will help students confront and interpret occurrences in the everyday world.
[5.1.A.1.2.3.4,B.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]**
2. summarize the characteristics that are common to all organisms
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
3. describe how technology has influenced the field of biology.
[5.1.A.1.2.3.4,B.1.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]
4. describe the levels of organization in living systems from the simplest or atomic level to the most complex or organism level.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
5. describe the properties of water that are essential to life.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
6. explain the properties of carbon bonds and explain the structure of organic compounds.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
7. explain the relationship among the classes of organic compounds and describe their properties.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
8. describe the four levels of protein structure, and explain the significance of each structure. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.C.1]
9. explain how environmental factors such as temperature and pH effect the rates of enzymatic activity. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.4.C.1]
10. describe the structure and function of the cell organelles.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
11. compare the various ways in which substances enter and exit cells and describe the properties of the cell membrane and the fluid mosaic model.

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[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1]

12. describe the process of mitosis and the cell cycle.
    [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
13. define the role of energy and ATP in living things.
    [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
14. define photosynthesis, glycolysis and aerobic respiration.
    [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
15. explain the process of ATP formation in both mitochondria and chloroplasts. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.1.C.1]
16. trace the steps, and explain what happens in the following metabolic pathways: Light reactions of photosynthesis, Calvin-Benson cycle, Citric Acid cycle, Glycolsis, and Fermentation.
    [5.5.A.1.2.3; 5.6.A.1.7.8; 8.1.C.1]
17. describe the relationship between ecology and biology, including the C, N, S, P, and H_2O biogeochemical cycles, and energy transfers.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.2.A.1]
18. define population, community, ecosystem and biosphere.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.1.A.1]
19. evaluate the population dynamics of a predator/prey cycle.
    [5.3.A; 5.3.B.1; 5.3.C.1; 5.3.D.1]
20. explain the work of Darwin, relating various types of evidence to support his hypothesis and summarize the process of natural selection.
    [5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.3.A.1; 8.1.C.1]
21. list various mechanisms for evolution including, genetic drift, bottleneck-founders effect, stabilizing selection, directional selection, disruptive selection, and sexual selection.
    [5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.1.A.1; 8.2.C.1]
22. demonstrate knowledge of various classifications systems such as the 5-kingdom system and the three-domain system of classification and describe the identifying characteristics for each.
    [5.2.B.1.2.3; 5.5.B.1; 8.1.A.1; 8.2.D.1]
23. describe the adaptations involved in the transition from an aquatic to terrestrial environment.
    [5.5.B.1.2; C.1.2; 8.1.A.1; 8.2.D.1]
24. define taxonomy and describe how Linnaeus created modern taxonomy and how it changes as new evidence is found.
    [5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 8.1.A.1]
25. understand the use of a dichotomous key in taxonomy.
    [5.5.B.1.2;8.1.A.4; C.1]
26. identify the people who contributed to biogenesis and describe the various origin of life hypotheses including RNA as the first self

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replicating molecule, the evolution of metabolic pathways, and the endosymbionic hypothesis.
[5.1.A.1.3.4; B.2; 5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.2.A.1;]

27. define meiosis and explain its role in genetics and evolution.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
28. explain the work of Gregor Mendel and define his contribution to genetic theory.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1; 8.6.A.5.8.9.10]
29. apply the laws of segregation and independent assortment to explain the behavior of chromosomes during meiosis.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1;]
30. apply probability to genetic crosses using Punnett squares
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
31. describe how genes are related to chromosomes
[5.1.A.1.2;5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
32. compare different types of gene mutations and their effects.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
33. explain the role of DNA as the carrier of genetic information.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
34. define the work of Watson, Crick and Franklin in determining the structure of DNA.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
35. trace the steps involved in DNA replication and protein synthesis.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
36. define bio-ethics and list the pros and cons of various current topics such as genetic engineering, stem cell research and cloning.
[5.2.B.1.2; 5.5.C.1.2.3; 5.10.A.1; B.1.2]

B. ATTITUDES
The student will:

1. suggest reasons for a nonscientist to be educated in science. [5.2.A.1]
2. exhibit objectivity and sound decision-making in analyzing the bio-ethical issues confronting society in areas such as human genetics, medicine, reproduction, law.
[5.2.A.1; 8.1.B.1.2; 8.2.A.]
3. develop curiosity about the many unanswered questions in biology. [5.4.A.1; 8.1.B.1]
4. exhibit a fundamental respect for living things and the dependence of humans on other organisms.
[5.4.A.1; 5.4.B.1]
5. appreciate the significance and variety of possible careers

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in biology and applications of biology.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1,2; 8.2.B.1;9.1,9.2]

6. develop an appreciation of the role of technology in investigating, cataloging, comparing and altering living things.
[5.4.A.4; 5.4.B.1; 5.4.C.1.2]
7. develop a sense of wonder at the amazing complexity, unity and balance of life.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1.2; 8.2.B.1]

C. SKILLS AND BEHAVIOR

The student will:

1. design an experiment with an experimental set-up and a control, and perform data analysis using varying techniques.
[5.1.A.1.3.4; 5.1.B.1.2; 5.1.C.1; 8.2.A.1]
2. demonstrate effective use of the compound light microscope and stereoscopic dissecting microscope.
[5.1.C.1; 5.1.B.1]
3. diagram accurate representation of size and shape of living things. [5.3.C.1; 5.3.D.1;]
4. predict the outcome of an experiment.
[5.1.A.3.4; 5.1.B.2; 8.2.A.1]
5. classify organisms on the basis of similar morphology.
[5.3.B.1; 5.3.D.1]
6. compare biochemical sequences of several diverse species to infer evolutionary relationships.
[5.5.C.1.2]
7. use a dichotomous key to identify an unknown species.
[5.1.A.1; 5.3.B.1; 5.3.C.1]
8. follow safety rules and practices in all laboratory and field activities.
[5.1.C.1]
9. use computer interfaced probes to collect and analyze data. [5.1.B.1; 8.2.C.1.2]
10. use technological tools for problem-solving, writing and research.
[8.1.A.1.2.3.4]
11. locate, organize, summarize and evaluate information.
[8.2.C.1.2]
12. be aware of the connection between educational activities and the world of work [9.1,9.2]

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V. STRATEGIES

1. Interactive lectures, including where appropriate:

   Use of flex cam
   Computer-TV interface
   Digital projector
   PowerPoint presentations
   Overhead transparencies
   Handouts
   Demonstrations
   Textbook CD-Rom

2. Problem-solving activities, such as:

   Model building
   Cooperative group work
   Bio-ethics debates

3. Computer programs to:

   Run simulations
   Generate and evaluate data
   Run review-CD applications

4. Laboratory investigations, including:

   Observation
   Experimental design
   Hypothesis testing
   Dissections

5. Internet resources, used to:

   Supplement textbook on Exploring Life web-site
   Search medical and other science related databases
   Perform literature searches
   Obtain current information
   Run on-line lab activities

6. Videos

   PBS Scientific American Explorers
   Discovery channel
   NOVA
   National Geographic

7. Independent projects

8. Make the appropriate accommodations for special needs and ELL students:

   Additional time and other IEP stated accommodations

   Audio text resources

   Varied assessment

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VI. EVALUATION

Assessment may include:

- Exams
- Quizzes
- Lab reports
- Lab notebook
- Lab work
- Homework
- Classwork
- Classroom Journal
- Individual project
- Group projects
- Presentations
- End of Course Biology Benchmark Assessment
- STA test

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: Holt, Rinehart, and Winston. Modern Biology. Harcourt. 2002
2. Technology
   - Laptop cart
   - Word Processing and Data Base programs: Microsoft Office, etc.
   - CD-ROM: Biology: Modern Biology
   - Internet Resources: various
   - Virtual Dissections
3. Lab manual: open (several labs within the textbook)
4. Videos: various

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VIII. SCOPE AND SEQUENCE

September

Life (Ch. 1)

Introduction
Scientific method, scientific process, logical thinking skills
Tools, techniques and skills for lab work

Microscope

Definition/characteristics of life
Themes in Biology
Biology and Society

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Chemistry of Life (Ch. 2 & 3)

Atoms and molecules
Bonding
Ionic, covalent, hydrogen
Properties of water
Polarity, pH, Specific heat
Organic chemistry
Carbon bonds
Carbohydrates, Lipids, Nucleic acids Protein structure and function
Enzyme

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Cells and Transport (Ch. 4 & 5)

History and Cell theory
Structure and function of organelles
Prokaryotes vs Eukaryotes
Fluid mosaic model of the cell membrane
Diffusion, passive and active transport

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

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December

Photosynthesis and Respiration (Ch. 6 & 7)

- Energy and ATP
- Photosynthesis
  - Light reactions and Calvin cycle
- Respiration
  - Anaerobic vs. aerobic
  - Glycolysis, Kreb's cycle, Electron transport
- Energy flow through ecosystem
- Material cycles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Cell Reproduction and Classic Genetics (Ch. 8 & 9)

- Chromosomes
- Mitosis
- Meiosis
- Probability
- Mendel
  - History
  - Independent assortment and recombination, dominance co-dominance, incomplete dominance
- Genetic Crosses, Punnett square

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/ March

Molecular Genetics (Ch. 10, 11, 12, & 13)

- DNA, RNA and Protein synthesis
  - History, Discovery
  - DNA structure and function
  - Replication, information storage, mutations, genes
  - RNA structure and function
  - Transcription, Translation, Protein synthesis
- Gene expression
- Human genetics
  - Pedigrees, patterns of inheritance, genetic diseases

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Biotechnology

Genetic engineering, cloning, Biotechnology techniques, Bioethics

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March/April

History of Life on Earth (Ch. 14, 15, & 17)

Origins of Life

Geological and Ecological History of Life

Evolution and natural selection

History, Darwin

Evidence

Fossils, geology

Principals of natural selection, speciation

Human Evolution

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April/May

Ecology (Ch 19, 20, 21, 22, & 23)

Ecosystems, environment

Climate change, mass extinctions

Populations

Communities, species interactions

Succession

Energy flow, biochemical cycles

Biomes

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May/June

Taxonomy (Ch. 18)

Classification systems (Historical and current)

6 Kingdoms

Animal Phyla

Plants (Ch. 29)

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam, Benchmark Assessment, Final Exam

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
SEPT	• What is Biology? • What are the major themes in Biology? • What is a multicellular/ unicellular organism? • What is Ecology? • What is Homeostasis? • What is Heredity? • What is Evolution? • What are the characteristics of all living things? • What is the Scientific Method? • What is a Theory? • How is the microscope used in biology? • What are the SI units of measurement?	The Science of Biology • Introduction o Science of Biology o Themes of Biology • World of Biology o Characteristics of Life • Scientific Method o Steps of the Scientific Method o Tools used in Biology o Lab Safety • Microscope and Measurement o Light Microscope o Units of Measurement	• List the 6 themes in Biology • Discuss relationships between adaptation and evolution • Explain the relationship between hypothesizing, predicting, and experimenting • Describe the methods the scientists used in their work • List 6 characteristics of life • Become familiar with the usage and parts of the microscope	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 1) • Student portfolio, journal • Review sheets • Teacher/student discussion	• Labs: o Measurement o Data/Graphing o Tools of Science o Intro to Microscope • Videos: o *Invisible World* o *Life* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
OCT	• How are Chemistry and Biology related? • What is Matter? • What are atoms composed of? • What is an Element? • What determines an element's properties? • What is an Ion? • What is a Molecule? • Why do atoms form bonds? • How are states of matter determined? • What are Acids and Bases? • How are chemical reactions and energy important to living things? • What is ATP? • Why is H2O so important? • Why make Carbon the "element of life"? • What are the four major organic molecules?	• Composition of Matter: o Elements o Atoms o Compounds o Molecules o Bonding • Energy o States of Matter o Free Energy o Reactions ▪ Energy transfer ▪ Activation Energy ▪ Enzymes • Solutions o Describing Solutions o Acids and Bases o Aqueous Solutions • Organic Macromolecules o Structure & Function o Carbohydrates o Lipids o Proteins o Nucleic Acids	• Define and differentiate between elements, atoms, molecules and compounds • Explain the structure of an atom and what determines an atom's stability • Predict the number of bonds an atom can form • Explain the behavior of particles in liquids, solids and gases • Explain how energy is related to living things • Explain how enzymes affect chemical reactions in organisms • Contrast properties of acids and bases • Summarize the polarity of H2O • Describe the structure and function of the four class of organic macromolecules and their significance to organisms	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 2 & 3) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs o Atom models o Enzymes (liver or detergent) o Determining pH o Models of Organic Molecules • Videos: o *Body Story: Fat* • Organization of student portfolio • Jeopardy game • Articles • Notes/ class discussion

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	• What is an enzyme?				

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
NOV	• What are the discoveries that led to the development of the cell theory? • What is the cell theory? • How is cell shape related to cell function? • What are the structures and functions of the organelles? • What are the differences between prokaryotes and eukaryotes? • What are the differences between plant and animals cells? • How does diffusion and osmosis play an important role in cell function?	• Discovery of the cell: o Cell Theory o Cell Diversity • Eukaryotes o Cell Membrane o Lipids o Proteins o Fluid mosaic model • Organelles o Structure o Function • Passive Transport o Diffusion o Osmosis o Facilitated Diffusion • Active Transport o Channels and Pumps o Energy Demand	• Outline the discoveries that led to the development of the cell theory • State the cell theory • Distinguish between prokaryotes and eukaryotes • Describe the structure and function of all organelles • Distinguish between osmosis and diffusion. • Distinguish between passive transport and active transport	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch. 4 & 5) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Cell Model o Microscope: Animal vs. Plant o Microscope: Check cell o Micro-viewers o Osmosis and Diffusion Lab Kit • Videos: o *Magic of Cells* o *Body Story:* various • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

DEC	• What is Light?
	• What are Pigments?
	• What is Photosynthesis?
	• What is Carbon Fixation?
	• What materials are consumed/produced from photosynthesis?
	• What is Cellular Respiration?
	• What is Glycolysis?
	• What is Fermentation?
	• How is aerobic respiration related to the structure of the mitochondrion?
	• What materials are consumed/produced from respiration?
		• Capturing Light
		  o Light
		  o Pigments
		  o Photosystems
		• Calvin Cycle
		• Glycolysis and Fermentation
		  o Chemical energy
		  o Anaerobic pathways
		  o Fermentation
		  o Lactic acid/Alcohol formation
		• Aerobic respiration
		  o Krebs cycle
		  o Electron transport
			• Describe the structure of the Chloroplast as it relates to photosynthesis
			• Describe the processes of light capture, electron transport and chemiosmosis
			• Describe how Carbon if fixed via the Calvin Cycle
			• Compare and contrast lactic acid fermentation and alcoholic fermentation
			• Calculate the efficiency of glycolysis.
			• Summarize the events of the Krebs cycle
			• Relate aerobic respiration to the structure of a mitochondrion.
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (6 & 7)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  o Viewing the Stoma of a Leaf
					  o Planting Pea Plants
					• Videos:
					  o *Photosynthesis (Standard Deviants)*
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
JAN	• How are Chromosomes, Proteins, and DNA related? • How many chromosomes does a body cell/ sex cell have? • What is Mitosis/Meiosis? • Who was Gregor Mendel and how did his work effect the study of genetics? • What is the different between dominant and recessive traits? • How are genes and alleles similar and alike? • How do we calculate the probability of a genetic outcome? • What is the difference between a monohybrid and dihybrid cross?	• Chromosomes o Structure o Number • Cell Divison o Mitosis o Meiosis o Crossing over • Mendelian Genetics o Gregor Mendel and his experiments o Dominant traits o Recessive traits o Law of Segregation o Law of Independent Assortment o Barbara McKlintock • Probability and genetic crosses o Genotype o Phenotype o Monohybrid crosses o Dihybrid Crosses	• Relate Chromosomes, Genes, DNA • Explain the structure of a chromosome • Distinguish homologous and sex chromosomes • Distinguish haploid and diploid cells • Describe the cell cycle • Describe the process of Mitosis, Meiosis • Understand Gregor Mendel's contribution to genetics • Model Mendel's experiments with pea plants • Differentiate between dominant and recessive traits • Differentiate between genes and alleles • Use Punnett Squares to calculate the probability of obtaining a certain genetic outcome	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (8 & 9) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Chromosome beads o Microscope: Mitosis: Onion root tip o Mitosis/ Meiosis Models o Determining Genotypes: Tongue Rolling • Videos: o *Bill Nye: Genes* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
FEB/ MAR	• What is the principal function of DNA? • How does the structure of DNA relate to its function? • What is the role of complimentary base pairing? • How does DNA replicate? • How does RNA compare with DNA? • How does the shape of RNA compare to its function? • What is transcription and how does it relate to protein synthesis? • What factors affect gene expression? • What causes Cancer? • What are some human genetic diseases? • What are some common Biotechnology techniques?	• Discovery of DNA • DNA shape and function o DNA components o Complementary base pairing • DNA replication • RNA shape and function o RNA components o The 3 types of RNA • Transcription and Translation • Gene Expression o Cancer • Human Genetics o Patterns of Inheritance o Pedigrees o Genetic Diseases • DNA Technology o recombinant DNA o DNA fingerprint o Pharmaceuticals, Agriculture o Bioethics	• Identify DNA and it's components • Describe the shape of DNA • Explain how base pairs match each other • Identify the process of DNA replication • Transcribe sequences of DNA to RNA • Translate sequences of RNA into amino acids • Describe protein folding • Describe factors that affect gene expression • Describe chromosome and gene mutations • Describe common genetic disorders and their cause • Create and use pedigrees • Describe the process of creating a transgenic organism • Discuss the ethical questions that arise in biotechnology	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch. 10) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o DNA Model o DNA Extraction o Taste- Pedigree • Videos: o *Gattaca* o *Twins (Discovery Channel)* o *Rosaline Franklin* o *The Island* o *Jurassic Park* • Project: o Bioethics essay o Biotechnology Power Point • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAR/ APRIL	• How old is the Earth? • What is radioactive dating? • How did organic compound arise? • What are the oldest know organisms? • What is evolution? • How do fossils give us evidence of evolution? • How did Darwin contribute to the theory of evolution? • What is the evidence for evolution? • How does natural selection drive evolution? • How do paleoanthropologists gather evidence of human ancestry? • What are Primates? • What are Hominids? • What is the current map of human evolution?	• Earth's History o Formation o Radioactive Dating o Life from nonliving chemicals o Urey and Miller o First organisms o Endosymbiosis • Geological time periods • Fossils and the fossil record o Law of superposition • Descent with modification • Evolution and its evidence, definition, and social impact. • Charles Darwin • Natural selection • Evidence o Homologous, analogous, and vestigial structures o Coevolution, divergent evolution, and convergent evolution • Primate Characteristis • Hominid Evolution o Fossil Evidence o Phylogenic Trees	• Describe how the age of the Earth is determined • Describe Urey and Miller's experiment • Describe the theory of how replicating chemicals could have evolved into the first cells • Describe the theory of endosymbiosis • Describe fossil formation • Give several pieces of evidence supporting evolution • Tell how biogeography suggests descent with modification • Explain Darwin's two major theories • Explain the process of Natural Selection • Describe primate characteristics • Describe australopithecies • Describe species of the genus *Homo* • Describe the current map of human	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 14, 15 &17) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Natural Selection • Videos: o *Walking with…*series o *Bill Nye: Greatest Discoveries: Evolution* o *Nova: Evolution on Trial* o *Inherit the Wind* o *Neanderthal* o *Land of Monsters* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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			evolution?		

Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
APRIL/ MAY	• Why is Ecology important? • What are some human caused environmental problems? • How are Communites, Populations and Organisms connected? • What is a niche? • What is symbiosis? • How do predators differ from parasites? • What is Succession? • How does energy flow through an ecosystem? • How does water cycle through an ecosystem? • How does carbon cycle through an ecosystem? • What are the 7 major Biomes?	• Ecology o Environmental changes o Levels of organization • Ecology of Organisms o Habitat o Biotic and abiotic factors o Niche • Community Ecology o Predation o Parasitism o Competition o Mutualism and Commensalism • Properties of Communities • Succession • Energy Transfer o Producers/ Consumers o Food webs • Ecosystem Recycling o Water cycle o Carbon cycle o Nitrogen cycle • Terrestrial Ecosystems o Biomes • Aquatic Ecosystems	• Define ecology and explain why it is important • Identify the five different levels of organization in ecology • Explain the theme of interconnectedness • Contrast abiotic factors with biotic factors • Explain the concept of a Niche • Distinguish predation from parasitism • Describe how plants can defend themselves against herbivores • Explain the difference between species richness and species diversity • Distinguish between primary and secondary succession • Describe how energy flows through an ecosystem • Trace the steps of the water, carbon, and nitrogen cycles • Describe the major	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Microscope: Pond Water o Observing Ecology • Video: • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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			terrestrial and aquatic biomes		

Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAY/ JUNE	• How has the classification of organisms changed over the past? • What are the modern criteria for classifying organisms? • How did Aristotle's classification system work? • In what ways was his system different than Linneaus's? • What are the primary criterion that modern taxonomists use to classify organisms?	• Taxonomy • Carolus Linneaus • Morphology • 7 class system of classification • Binomial nomenclature • Phylogeny • Cladistic	• Describe Aristotle's classification system and explain why it was replaced • Explain Linnaeus's system of classification and identify the main criterion he used to classify organisms • Name the primary criterion that modern taxonomists consider • List four types of evidence used to organize organisms in systematic taxonomy • Explain cladistic taxonomy	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 18) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs • Videos • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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AP Biology

11th & 12th Grades

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Prepared by
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(Revised July 2016)

I. OVERVIEW

Advanced Placement Biology includes those topics regularly covered in a college biology course. This course differs significantly from the usual high school biology course with respect to the kind of textbook used, the range and depth of topics covered, the kind of laboratory work done by students, and the time and effort required of students. The textbook used for AP Biology is also used by college biology majors. The kinds of labs done by AP students equate to the kinds of labs experienced by college students.

The Advanced Placement Biology course is designed to be taken by students after successful completion of high school biology and chemistry. It aims to provide students with the conceptual framework, factual knowledge, and analytical skills necessary to deal critically with the rapidly changing science of biology.

This class meets six periods a week and includes one double period block of time for lab investigations.

II. RATIONALE

The Advanced Placement Biology course is designed to be the equivalent of a college introductory biology course usually taken by biology majors during their first year. After showing themselves to be qualified on the Advanced Placement Examination, some students, as college freshmen, are permitted to undertake upper-level courses in biology or register for courses for which biology is a prerequisite. Other students may have fulfilled a basic requirement for a laboratory science course and will be able to pursue their major.

III. STUDENT OUTCOMES

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will learn to identify systems of interacting components and understand how their interactions combine to produce the overall behavior of the system.

5.2 All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.3 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.4 All students will develop an understanding of technology as an application of scientific principles.

5.5 All students will integrate mathematics as a tool for problem-solving in

science, and as a means of expressing and/or modeling scientific theories.

5.6 All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

5.7 All students will investigate the diversity of life.

5.8 All students will gain an understanding of the structure and behavior of matter.

5.9 All students will gain an understanding of natural laws as they apply t motion, forces, and energy transformations.

5.10 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.11 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.12 All students will develop an understanding of the environmental as a system of interdependent components affected by Human activity and natural phenomena.

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. develop in writing/discussion an understanding of key concepts of chemistry and their relationships to the study of living things as determined by the correct usage of formulas and equations as they relate to biological principles and processes that occur daily.
2. demonstrate in writing/discussion an understanding of the interaction of living and non-living components of the environment. [3.1,3.8,3.13; 5.4.5 5.4.8,5.9.11 - 5.9.1 5,5.9.1 9,5.9.22,5.9.23,5.1 0.6-5.10.8,5.10.11,5.10.12]
3. describe in writing/discussion an understanding of the biological system of classification. [3.2,3.9,3.12, 4.10; 5.3.3-5.3.7,5.7.7]
4. describe in writing/discussion an understanding of the structure and function of cells, including the cell theory and cell organelles common to prokaryotic, eukaryotic, plant and animal cells. [3.2,3.12; 5.1.4,5.1.5, 5.1.8,5.2.9,5.22.12, 5.2.1 3,5.2.15,5.3.3-5.3.7,5.4.5-5.4.11,5.6.8,5.6.10-5.6.16]
5. summarize in writing/discussion an understanding of the structural organization and functioning of the vertebrate body. [3.2.3.8,3.12; 5.1.4-5.1.8,5.3.3 5.3.7,5.4.5-5.4.8,5.4.10, 5.6.9-5.6.11,5.6.14]
6. summarize in writing/discussion an understanding of the structural organization and functioning of higher seed plants. [3.2,3.8,3.12,5.1.4-5.1.8,5.2.6, 5.2.10,5.2.12-5.2.13,5.3.3-5.3.7,5.4.5-5.4.8,5.4.1 0,5.5.5-5.5.15]
7. explain in writing/discussion an understanding of heredity as

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determined by the correct application of genetic and statistical methods used for determining established hereditary patterns. [3.5.3.7,3.10,3.14,4.8,4.9,5.2.6, 5.2.1 0,5.3.3-5.3.7,5.4.5-5.4.11,5.5.5-5.5.8,5.5.10-5.5.15, 5.6.8-5.6.14,5.7.5-5.7.11]

8. describe in writing/discussion an understanding of Biological Theory of Evolution as determined by correctly interpreting fossil evidence, biochemical evidence, embryology evidence and other forms of indirect supportive evidence. [3.2,3.3,3.8,3.11,4.6; 5.1.4,5.1.5,5.1.7,5.1.9,5.2.6-5.2.1 4,5.3.3, 5.3.7,5.4.5-5.4.11,5.5.5-5.5.15,5.6.8-5.6.17,5.7.5-5.7.13,5.11.8]
9. explain in writing/discussion an understanding of the processes of photosynthesis and respiration by successfully describing the chemical mechanisms involved with each. [3.2,3.3,3.7,3.12; 5.1.4,5.1.5,5.1.8,5.2.6-5.2.9,5.2.12-5.2.15,5.3.3,5.3.6,5.4.5-5.4.11,5.5.5-5.5.15,5.6.9-5.6.11,5.6.14, 5.6.17,5.7.8,5.7.9,5.7.12]
10. recognize and relate in discussion/writing past and current leaders of biology and their contributions. [3.2,3.5,5.3.3-5.3.7]

B. ATTITUDES

The student will:

1. demonstrate interest and involvement in biology by contributing extra projects to the classroom and through observations made of class discussions. [3,2.2,2.3, 2.5,3.1,3.6,3.15,4.1-4.5,4.7,5.1; 5.2.6-5.2.15]
2. develop an appreciation for science and scientist that have affected our daily lives with precourse and postcourse surveys. [5.2.6,5.2.9- 5.2.11,5.2.13,5.2.15,5.4.5,5.4.6,5.4.8-5.4.10,5.5.7,5.5.8,5.5.10,5.5.12,5.5.15]
3. describe in writing/discussion the ethical implications of using biological concepts and principles to alter human genetic inheritance. [5.1.2,5.11.4-5.1.7,5.1.9, 5.1.10,5.3.3-5.3.7,5.12.6,5.12.9]
4. recognize in writing/discussion many of the various science and non-science professions that are related to the field of biology. [5.3.3-5.3.7]

C. SKILLS AND BEHAVIOR

The student will:

1. demonstrate proper use of biological tools and instruments such as the microscope, spectrophotometer, pH meter, dissecting implements, balance scales and other metric instruments of measurements during group and independent lab investigations. [5.2-5.7,5.9; 5.4.5-5.4.8,5.4.10,5.5.5- 5.5.1]
2. . demonstrate in clearly stated and organized lab reports the correct

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process of solving problems using the scientific method. [5,1.11,2.2,2.4,2.6,2.10,3.6,3.8; 5.2.6-5.2.15, 5.4.9,5.4.10,5.5.5-5.5.15]

3. demonstrate by observation proper aseptic technique when working with microorganism in laboratory investigations. [5.4,5.7,5.8,5.9,5.2.6 5.2.15,5.6.17]
4. relate scientific method to local and global ranging biological problems. [5.2,5.8,5.1.4,5.3.6,5.3.7,5.4.8-5.4.10,5.10.6, 5.10.8,5.10.11,5.10.13,5.10.14,5.12.4-5.12.7,5.12.9,5.12.10]
5. locate, organize, summarize and evaluate information. [8.2.C.1.2]
6. be aware of the connection between educational activities and the world of work [9.1,9.2]

V. STRATEGIES

This course will not be just a place where facts are disseminated and tested. Students will not only learn the facts associated with biology but will also learn and use higher level thinking skills that are a requirement for successful living. Students will learn by applying critical thinking, reading, writing, listening, and problem solving skills to the biological concepts and principles presented in this course.

1. Interactive lectures, including where appropriate:
   - Use of flex cam
   - Computer-TV interface
   - Digital projector
   - PowerPoint presentations
   - Overhead transparencies
   - Handouts
   - Demonstrations
   - Textbook CD-Rom
2. Problem-solving activities, such as:
   - Model building
   - Cooperative group work
   - Bio-ethics debates
3. Computer programs to:
   - Run simulations
   - Generate and evaluate data
   - Run review-CD applications
4. Laboratory investigations, including:
   - Observation
   - Experimental design

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Hypothesis testing
Dissections

5. Internet resources, used to:

   Supplement textbook on Exploring Life web-site
   Search medical and other science related databases
   Perform literature searches
   Obtain current information
   Run on-line lab activities

6. Videos

   PBS Scientific American Explorers
   Discovery channel
   NOVA
   National Geographic

7. Independent projects
8. Make the appropriate accommodations for special needs and ELL students:

   Additional time and other IEP stated accommodations

   Audio text resources

   Varied assessment

VI. EVALUATION

Assessment may include:

Exams
Quizzes
Lab reports
Notebook
Performance Assessment
Homework
Class Participation

Students will also be expected to design and execute projects and/or original research.

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: Campbell, Neil, Biology, 7th edition, Pearson – Benjamin Cummings, New York, 2004.
2. Lab manual: Holt, Rinehart, Winston, Holt Bio sources Laboratory Program. Harcourt, 2002.
3. Technology

   Word Processing and Data Base programs: Microsoft Office

   Internet Resources: various

   Virtual Dissections

   Laptop cart

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VIII. SCOPE AND SEQUENCE

September

Molecules and Cells

Biological chemist

Review of atoms, molecules, bonding, pH, and water.
Carbon, functional groups
Carbohydrates, lipids, proteins, nucleic acids
Chemical reactions, free-energy changes, equilibrium.
Enzymes: coenzymes, cofactors, rates of activity, regulation.

Cells

Prokaryotic and eukaryotic cells
Plant and animal cells.
Structure and function of cell membranes.
Structure and function of organelles, subcellular components of motility, cytoskeleton.
Cell cycle: mitosis and cytokinesis.

October

Energy transformations

ATP, energy transfer, coupled reactions, chemiosmosis.
C-3 and C-4 photosynthesis
Glycolysis, fermentation, and aerobic respiration.

Heredity

Meiosis
Mendel's Laws, probability
Inheritance patterns: chromosomes, genes, alleles; interactions.
Human genetic defects

Unit Exam

November

Genetics

Molecular genetics

DNA: structure and replication
Eukaryotic chromosomal structure, nucleosome, and transposable elements
RNA: transcription, mRNA editing and translation
Regulation of gene expression

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Mutations
Recombinant DNA, DNA cloning, hybridization and DNA sequencing
DNA and RNA viruses.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Evolution

Origin of life
Evidence for evolution
Natural selection
Hardy-Weinberg principle, factors influencing allelic frequencies
Speciation: isolating mechanisms, allopatry, sympatry, and adaptive radiation
Patterns of evolution, gradualism, punctuated equilibrium
Organisms and Populations

Principles of taxonomy and systematic, five kingdom system
Survey of Monera, Protista, and Fungi

January

Plants

Diversity; classification; phylogeny; adaptations to land, alterations of generations in moss, fern, pine, and flowering plants
Structure and physiology of vascular plants
Seed formation; germination and growth in seed plants
Hormonal regulation of plant growth
Plant response to stimuli tropisms and periodicity

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/March

Animals

Diversity; classification; phylogeny; survey of acoelomate; pseudocoelomate; protostome and deuterostome phyla
Structure and function of tissues, organs and systems (emphasis on vertebrates), homeostasis and immune response

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Gametogenesis, fertilization, embryogeny and development
Behavior

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April

Ecology

Population dynamics; biotic potential and limiting factors
Ecosystems and community dynamics; energy flow, productivity, species interactions, and biomes
Biogeochemical cycles.

May/June

Research Project - TBA

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Course: AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Sept.	**A-1**. How do the unique properties of water make life on earth possible? **A-2**. How do the structures of biologically important molecules account for their functions? **A-3**. How do the laws of thermodynamics relate to the processes that provide energy to living systems? **A-4**. How do enzymes regulate the rate of chemical reactions? **B-1**. What are the similarities and differences between prokaryotic and eukaryotic cells? **B-2**. How does the structural organization of membranes provide for cellular transport and recognition? **B-3**. How do organelles function together in cellular processes? **B-4**. How does the cell cycle assure genetic continuity?	**A. Chemistry of Life:** 1. Water 2. Organic molecules 3. Free Energy 4. Enzymes **B. Cells:** 1. Prokaryotic vs. Eukaryotic 2. Membranes 3. Subcellular organization 4. Cell cycle and its regulation **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**A:** 1. Explain the relationship between the polar nature emergent properties essential to life. 2. Explain the importance of the carbon atom to organic compounds. 3. Explain how organic polymers contribute to biological diversity. 4. Discuss the importance of organic polymers in relation to cellular structure and function. 5. Explain the role of ATP and enzymes in metabolic reactions. **B:** 1. Describe the structure and relationships among the components of the endomembrane system. 2. Describe the fluid-mosaic model of the cell membrane. 3. Describe several mechanisms of cellular transport. 4. Describe the phases of	**A-B:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs (1A,2, and 3A) 4. Homework Questions (Free response and multiple choice)

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			the cell cycle		

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Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Oct.	**C-1**. How are organic molecules broken down by catabolic pathways? **C-2**. What is the role of oxygen in energy-yielding pathways? **C-3**. How do cells generate ATP in the absence of oxygen? **C-4**. How does photosynthesis convert light energy into chemical energy? **C-5**. What kinds of photosynthetic adaptations have evolved in response to different environmental conditions? **D-1**. Why is meiosis important in heredity? **D-2**. How is genetic information organized in the eukaryotic chromosome? **D-3**. How does this organization contribute to both continuity and variability of genetic information? **D-4**. What are the principal patterns of	**C. Cellular Energetics:** 1. Coupled Reactions 2. Cellular respiration and fermentation 3. Photosynthesis **D. Heredity:** 1. Meiosis 2. Eukaryotic chromosomes 3. Inheritance patterns **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**C:** 1. Explain energy flow through the biosphere. 2. Distinguish between substrate-level phosphorylation and oxidative phosphorylation. 3. Explain why fermentation is necessary. 4. List the components of a photosystem and explain their function. 5. Describe the light and dark reactions of photosynthesis. 6. Describe two important photosynthetic adaptations to minimize photorespiration. **D:** 1. List the phases of Meiosis I and II and describe the events characteristic of each phase. 2. State Mendel's three laws and indicate the evidence that led him to each. 3. Explain the chromosomal basis of	**C-D:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs (4A and 5) 4. Homework Questions (Free response and multiple choice)

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	inheritance?		inheritance		

Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Nov-Dec.	**E-1.** How do the structures of nucleic acids relate to their functions of information storage and protein synthesis? **E-2.** What are the mechanisms by which gene expression is regulated in prokaryotes and eukaryotes? **E-3.** In what ways can genetic information be altered and what are their possible effects? **E-4.** What are the major steps in viral reproduction? **E-5.** What are some current recombinant DNA technologies and what are their applications? **F-1.** What are the current models that explain the origins of prokaryotic and eukaryotic cells? **F-2.** What types of evidence support	**E. Molecular Genetics:** 1. RNA and DNA structure and function 2. Gene regulation 3. Mutation 4. Viral structure and replication 5. Nucleic acid technology and applications **F. Evolutionary Biology:** 1. Early evolution of life 2. Evidence for evolution 3. Mechanisms of Evolution.	**E:** 1. Describe the structure of DNA and RNA. 2. Describe the processes of DNA replication, RNA transcription, and protein synthesis. 3. Describe how mutagenesis can occur and their potential effects. 4. Distinguish between the lytic and lysogenic reproductive cycles of a virus. 5. Describe the operon model of gene regulation. 6. Describe some practical applications of recombinant DNA technology. **F:** 1. Provide evidence to support the hypothesis that chemical evolution resulting in life's origin occurred in four stages. 2. Discuss evidence that	**E-F:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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	evolutionary theory? **F-3.** What mechanisms account for speciation and macroevolution?	**Resources:** Campbell's Biology 4th edition AP Lab Curriculum	is used to support evolutionary change. 3. Describe mechanisms of evolutionary change.		

Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Jan.	**G-1.** What are the distinguishing characteristics of each kingdom, and the major phyla of each? **G-2.** How are evolutionary relationships determined among organisms and how is this information used in classification? **H-1.** What is the adaptive significance of alternation of generations in the major groups of plants? **H-2.** What are the patterns of reproduction and development in plants? **H-3.** How does the organization of cells, tissues, and organs determine structure and function in plant systems? **H-4.** What are the	**G. Diversity of Life** 1. Evolutionary patterns. 2. Survey of the diversity of life. 3. Phylogenetic classification. 4. Evolutionary relationships. **H. Structure and Function of Plants** 1. Reproduction, growth, and development. 2. Structural, physiological, and behavioral adaptations. 3. Response to the environment.	**G:** 1. Trace the evolutionary history of life on earth. 2. Identify the distinguishing characteristics of each kingdom and their major phyla. **H:** 1. Describe the structure and arrangement of the three plant tissues systems in roots and shoots. 3. Describe how primary and secondary growth occur. 4. Describe differences between monocots and dicots. 5. Describe the mechanisms of plant transport. 6. Describe fertilization in flowering plants. 7. Describe adaptations that promote the dispersal of seeds. 8. Describe the process	**G-H:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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	responses of plants to environmental cues, and how do hormones mediate them?	**Resources:** Campbell's Biology 4th edition AP Lab Curriculum	of seed germination in monocots and dicots. 9. Describe the role of plant hormones in environmental response.		

Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Feb.	**I-1.** How are structure and function related in the various organ systems? **I-2.** How do the organ systems of animal interact? **I-3.** What adaptive features have contributed to the success of animal life? **I-4.** What are the responses of animals to environmental cues, and how do hormones mediate them?	**I. Structure and Function of Animals** 1. Nutrition, Circulation, and Gas Exchange. 2. Defense mechanisms and homeostasis.	**I:** 1. Describe some advantages that complete digestive tracts have over gastrovascular cavities. 2. Name and describe the structure and functions of the major organs of the mammalian digestive system. 3. Distinguish between open and closed circulatory systems. 4. Identify ways in which the structures of the circulatory and respiratory systems are related to their functions of transport and gas exchange. 5. Describe the multiple mechanisms of mammalian defense	**I:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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		Resources: Campbell's Biology 4th edition AP Lab Curriculum	against infectious disease. 6. Describe the various means of osmoregulation and thermoregulation in animals.		

Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
March.	**I-1.** How are structure and function related in the various organ systems? **I-2.** How do the organ systems of animals interact? **I-3.** What adaptive features have contributed to the success of animal life? **I-4.** What are the responses of animals to environmental cues, and how do hormones mediate them?	**I. Structure and Function of Animals** 3. Chemical signals in animals. 4. Reproduction, growth, and development. 5. Nervous systems and sensory mechanisms.	**I:** 7. Describe the structural and functional relationships among endocrine system components. 8. Describe the structures and functions of the male and female reproductive systems, as well as the phases of the menstrual cycle. 9. Describe the process of fertilization and the development of the human embryo and fetus during the three trimesters of pregnancy. 10. Describe the structural and functional relationships among nervous system components. 11. Describe the structural and functional	**I:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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		Resources: Campbell's Biology 4th edition AP Lab Curriculum	relationship between the sensory organs and the central nervous system. 12. Describe the functions of the skeleton and the structural and functional relationship of skeletal muscle and movement.		

Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
April	**J-1.** What models are useful in describing the growth of a population? **J-2.** How is population size regulated by abiotic and biotic factors? **J-3.** How is energy flow through an ecosystem related to trophic structure? **J-4.** How do elements cycle through an ecosystem? **J-5.** How do biotic and abiotic factors affect community structure and ecosystem function? **J-6.** How do organisms affect biogeochemical cycles? **J-7.** What current theories explain the	**J. Ecology:** 1. Population dynamics 2. Communities and ecosystems 3. Global issues 4. Behavior	**J:** 1. Differentiate between J-shaped and S-shaped population growth curves, and explain the phases of population growth they illustrate. 2. Distinguish between density-dependent and density-independent factors, and explain how each may limit population growth. 3. Distinguish between intraspecific and interspecific competition. 4. Distinguish between primary and secondary succession and give examples of each. 5. Define trophic level	**J:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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May	observed behaviors of animals? **K.** Review for AP Exam	**K. Units A-J (I-X):** 1. Practice Tests 2. Topic Outline **Resources:** Campbell's Biology 4th edition AP Lab Curriculum Released AP Exams	and describe their importance to understanding the structure of an ecosystem. 6. Define biogeochemical cycle and describe the four types. 7. Discuss the various theories of behavioral ecology.		

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Chemistry Academic

3400

10th & 11th Grades

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Reviewed by Science Supervisor

Barbara Hamill, Steve Nagiewicz, John Edmunds

(Revised July 2016)

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I. OVERVIEW

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with the periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions. The course will also incorporate the study of thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reaction. Students will be introduced to acids and bases, oxidation and reduction reactions and be able distinguish a fission reaction from a fusion reaction

II. RATIONALE

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 7/2009)

IV. CHEMISTRY CORE CURRICULUM CONTENT STANDARDS

5.1.A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.12.A.1 Content Statement

Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.

> **Cumulative Progress Indicator (CPI)** Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.12.A.2 Content Statement

Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.

> **CPI** Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.12.A.3 Content Statement

Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

> **CPI** Use scientific principles and theories to build and refine standards for data

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collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.12.B.1 Content Statement

Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.

CPI Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.12.B.2 Content Statement

Mathematical tools and technology are used to gather, analyze, and communicate results.

CPI Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Content Statement

Empirical evidence is used to construct and defend arguments.

CPI Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Content Statement

Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

CPI Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C REFLECT ON SCIENTIFIC KNOWLEDGE: Scientific knowledge builds on itself over time.

5.1.12.C.1 Content Statement

Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

CPI Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Content Statement

Data and refined models are used to revise predictions and explanations.

CPI Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Content Statement

Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

CPI Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D PARTICIPATE PRODUCTIVELY IN SCIENCE: The growth of scientific knowledge involves

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critique and communication, which are social practices that are governed by a core set of values and norms

5.1.12.D.1 Content Statement

Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

> **CPI** Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.12.D.2 Content Statement

Science involves using language, both oral and written, as a tool for making thinking public.

> **CPI** Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.12.D.3 Content Statement

Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

> **CPI** Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.1 Content Statement

Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.

> **CPI** Use atomic models to predict the behaviors of atoms in interactions..

5.2.12.A.2 Content Statement

Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.

> **CPI** Account for the differences in the physical properties of solids, liquids, gases.

5.2.12.A.3 Content Statement

In the Periodic Table, elements are arranged according to the number of protons (the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.

> **CPI** Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties..

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5.2.12.A.4 Content Statement

In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.

> **CPI** Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.

5.2.12.A.5 Content Statement

Solids, liquids, and gases may dissolve to form solutions. When combining a solute and solvent to prepare a solution, exceeding a particular concentration of solute will lead to precipitation of the solute from the solution. Dynamic equilibrium occurs in saturated solutions. Concentration of solutions can be calculated in terms of molarity, molality, and percent by mass..

> **CPI** Describe the process by which solutes dissolve in solvents

5.2.12.A.6 Content Statement

Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.

> **CPI** Relate the pH scale to the concentrations of various acids and bases

5.2.12.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.1 Content Statement

An atom's electron configuration, particularly of the outermost electrons, determines how the atom interacts with other atoms. Chemical bonds are the interactions between atoms that hold them together in molecules or between oppositely charged ions

> **CPI** Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form.

5.2.12.B.2 Content Statement

A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond..

> **CPI** Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.2.12.B.3 Content Statement

The conservation of atoms in chemical reactions leads to the ability to calculate the mass of products and reactants using the mole concept..

> **CPI** Balance chemical equations by applying the law of conservation of mass.

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5.2.12.C. Forms of Energy: Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.

5.2.12.C.1 Content Statement

Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy.

> **CPI** Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.

5.2.12.C.2 Content Statement

Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts.

> **CPI** Account for any trends in the melting points and boiling points of various compounds.

5.2.D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.

5.2.12.D.2 Content Statement

The driving forces of chemical reactions are energy and entropy. Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).

> **CPI** Describe the potential commercial applications of exothermic and endothermic reactions.

5.2.12.D.3 Content Statement

Nuclear reactions (fission and fusion) convert very small amounts of matter into energy.

> **CPI** Describe the products and potential applications of fission and fusion reactions.

5.2.12.D.4 Content Statement

Energy may be transferred from one object to another during collisions

> **CPI** Measure quantitatively the energy transferred between objects during a collision

5.2.12.D.5 Content Statement

Chemical equilibrium is a dynamic process that is significant in many systems, including biological, ecological, environmental, and geological systems. Chemical reactions occur at different rates. Factors such as temperature, mixing, concentration, particle size, and surface area affect the rates of chemical reactions.

> **CPI** Model the change in rate of a reaction by changing a factor.

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IV. STUDENT OUTCOMES

A. *KNOWLEDGE (Information and Concepts)*

The student will:

1. design investigations, collect evidence, analyze data, and evaluate evidence to determine causal/correlational relationships and anomalous data. (5.1.12.B.1)
2. develop an understanding of the relationships among facts, concepts, principles, theories, and models and use these relationships to understand phenomena in the natural world. (5.1.12.A.1)
3. use tools, evidence, and data to observe, measure, and explain phenomena in the natural world. (5.1.12.A.2)
4. construct and refine explanations, arguments or models of the natural world through the use of quantitative and qualitative evidence and data. (5.1.12.A.2)
5. use scientific principles and theories to build and refine standards for data collection, posing controls, and representing evidence. (5.1.12.A.3)
6. build, refine, and represent evidence-based models using mathematical, physical and computational tools (5.1.12.B.2)
7. demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.(5.1.12.D.3)
8. reflect on and revise understandings as new evidence emerges. (5.1.12.C.1)
9. use data representations and new models to revise predictions and explanations. (5.1.12.C.2)
10. revise predictions and explanations using evidence, and connect explanations/ arguments to established scientific knowledge, models and theories. (5.1.12.B.3)
11. develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (5.1.12.B4)
12. consider alternative theories to interpret and evaluate evidence-based arguments. (5.1.12.C.3)
13. engage in multiple forms of discussions in order to process, make sense of, and learn from others' ideas, observations, and experiences. (5.1.12.D.1)
14. represent ideas using literal representations such as graphs, tables, journals, concept maps, and diagrams. (5.1.12.D.2)
15. demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. (5.2.12.B)
16. show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations.
17. demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws.
18. communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table.
19. using the Periodic Table, explain the periodic trends in specific properties of elements, i.e.

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ionization energy, electronegativity, electron affinity, atomic and ionic radii

20. demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, metallic.

21. demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter.

22. show knowledge of chemical equilibrium, reaction rates, reaction Mechanisms. acids, bases, and salts.

23. write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory.

24. design experiments to solve a specific problem relating to chemical principles.

25. build models and name common organic compounds such as hydrocarbons and simple polymers.

26. distinguish between types of radiation and the energy associated with each

27. describe the postulates of quantum theory.

28. predict the products formed by common reactants, write and balance equations for the reactions.

29. Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes

30. Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel

31. Describe the products and potential applications of fission and fusion reactions

B. ATTITUDES

The student will:

1. develop an appreciation for the study of chemistry and how it relates to his/her everyday life.
2. research and investigate possible careers in chemistry.
3. recognize the impact of chemistry on every aspect of daily life.

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C. SKILLS AND BEHAVIORS

The student will:

1. demonstrate good problem-solving techniques.
2. write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory.
3. demonstrate effective listening and note taking skills in lecture and discussion situations.
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments.
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions.
6. demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology.
7. write and balance equations for a variety of chemical reactions.
8. work cooperatively in small groups to solve problems or perform experiments.
9. design and interpret graphs using empirical and experimental data.
10. use spreadsheet and graphing software to report results of laboratory investigations.
11. design and produce presentations using Power Point presentation software.
12. set up and perform experiments using computer interfaced sensors to collect data.
13. Use internet search engines to locate chemistry related websites for research and review.
14. be aware of the connection between educational activities and the world of work

V. STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*

- Audio visual media
- Charts, handouts, graphs
- Class & individual assignments
- Cooperative activities
- Critical thinking:
  - decision making
  - compare & contrast
  - reliable sources
  - causal explanation
  - prediction
- Debates & panel discussion
- Demonstrations(teacher/student led)
- Direct instruction
- Discussion(teacher/student led)
- Drill practice
- Extra credit project or presentation
- Homework
- Investigation

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Laboratory experiment
Lecture
Library and resource documents
Oral reading
Periodicals
Questioning techniques
Research paper
Reviews
Self-instructional instruments
Textbook: Wilbraham, Chemistry, 2008. Pearson
Textbook supplements
Tutoring(peer & teacher)

VI. EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include
DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper*.

Tests
Quizzes
Homework
Benchmark assessment

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.

Class participation
Teacher observation
Infusion exercises
Portfolios
Varied approach projects

PERFORMANCE ASSESSMENT *authentic assessment specific to chemistry*.

Laboratory

VII. REQUIRED RESOURCES

Students Resources
TEXTBOOK: Wilbraham, A., Staley, D., Matta, M., Waterman, E. (2008). Chemistry. Boston: Pearson Prentice Hall.

Laptop Cart
Microsoft office
CD-Rom Chemistry
Internet resources
Virtual Labs

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VIII. SCOPE AND SEQUENCE

NOTE: Days in parenthesis are departmental guidelines and should not significantly vary. Minor adjustments may be necessary to accommodate student needs and unforeseen circumstances. Given months are based on start dates of units and coincide with the school calendar.

Suggested Pacing Guide

Chapter 1-INTRODUCTION TO CHEMISTRY (3 Days)

Section 1.1 Chemistry

Objectives

1.1.1 Identify five traditional areas of study in chemistry
1.1.2 Relate pure chemistry to applied chemistry
1.1.3 Identify reasons to study chemistry

Topics & Subtopics

- What is Chemistry?
- Areas of Study
- Pure and Applied Chemistry (Nylon; Aspirin; Technology)
- Why Study Chemistry? Explaining the Natural World; Preparing for Careers; Being and Informed Citizen

Section 1.2 Chemistry Far & Wide

Objectives

1.2.1 Identify some areas affected by chemistry research
1.2.2 Describe some examples of research in chemistry
1.2.3 Distinguish between macroscopic and microscopic views

Topics & Subtopics

- Materials
- Energy (Conservation; Production; Storage)
- Medicine & Biotechnology (Medicines; Materials; Biotechnology)
- Agriculture (Productivity; Crop Protection)
- The Environment (Identify Pollutants; Prevent Pollution)
- The Universe

Section 1.3 Thinking Like A Scientist

Objectives

1.3.1 Describe how Lavoisier transformed chemistry
1.3.2 Identify three steps in the scientific method
1.3.3 Explain why collaboration and communication are important in science

Topics & Subtopics

- Alchemy
- An Experimental Approach to Science
- Scientific Method (Making Observations; Testing Hypotheses; Developing Theories; Scientific Laws)
- Collaboration & Communication (Collaboration; Communication)

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Section 1.4 Problem Solving in Chemistry

Objectives

1.4.1 Identify two general steps in problem solving
1.4.2 Describe three steps for solving numeric problems
1.4.3 Describe two steps for solving conceptual problems

Topics & Subtopics

- Skills Used in Problem Solving
- Solving Numeric Problems (Analyze; Calculate; Evaluate)
- Solving Conceptual Problems

Chapter 1A-LAB EQUIPMENT & LAB SAFETY & LAB REPORTS

Section 1A.1 Lab Equipment

Objectives

1A.1a—recognize lab equipment
1A.1b—use the laboratory burner
1A.1c—use the balance
1A.1d—handle chemical reagents
1A.1e—measure liquids
1A.1f—filter a mixture
1A.1g—work with glass tubing

Section 1A.2 Lab Safety

Objectives

1A.2a—follow general safety guidelines
1A.2b—handle chemicals
1A.2c—handle glassware
1A.2d—heat substances
1A.2e—identify caution alert symbols
1A.2f—dispose of chemicals properly
1A.2g—administer first aid
1A.2h—clean lab area

Section 1A.3 Lab Manual

Objectives

1A.3a—follow the general format for maintaining a lab notebook
1A.3b—correctly identify the seven steps of the scientific method
1A.3c—differentiate between qualitative data and quantitative data.
1A.3d—perform mass, volume, temperature, and other calculations as needed.
1A.3e—record experimental data
1A.3f—draw logical conclusions based on experimental data
1A.3g—identify sources of error in an experiment
1A.3h—calculate percent error when conclusions are based on quantitative data

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Chapter 2-MATTER & CHANGE

Section 2.1 Matter

Objectives

2.1.1 Identify properties of matter as extensive or intensive
2.1.2 Define physical property and list several common physical properties of substances
2.1.3 Differentiate among three states of matter
2.1.4 Describe a physical change

Topics & Subtopics

- Describing Matter (Extensive Properties; Intensive Properties)
- Identifying Substance
- States of Matter (Solids; Liquids; Gases)
- Physical Changes

Section 2.2 Mixtures

Objectives

2.2.1 Categorize a sample of matter as a substance or a mixture
2.2.2 Distinguish between homogeneous and heterogeneous samples of matter
2.2.3 Describe two ways that components of mixtures can be separated

Topics & Subtopics

- Classifying Mixtures (Heterogeneous Mixtures; Homogeneous Mixtures)
- Separating Mixtures (Filtration; Distillation)

Section 2.3 Elements & Compounds

Objectives

2.3.1 Explain the difference between an element and a compound
2.3.2 Distinguish between a substance and a mixture
2.3.3 Identify the chemical symbols of elements and name elements given their symbols

Topics & Subtopics

- Distinguishing Elements & Compounds (Breaking Down Compounds; Properties of Compounds)
- Distinguishing Substances & Mixtures
- Symbols & Formulas

Section 2.4 Chemical Reactions

Objectives

2.4.1 Describe what happens during a chemical change
2.4.2 Identify four possible clues that a chemical change has taken place
2.4.3 Apply the law of conservation of mass to chemical reactions

Topics & Subtopics

- Chemical Changes
- Recognizing Chemical Changes
- Conservation of Mass

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Chapter 3-SCIENTIFIC MEASUREMENT

Section 3.1 Measurements and Their Uncertainty

Objectives

3.1.1 Convert measurements into scientific notation
3.1.2 Distinguish among accuracy, precision, and error of a measurement
3.1.3 Determine the number of significant figures in a measurement and in a calculated answer

Topics & Subtopics

- Using & Expressing Measurements
- Accuracy, Precision, and Error (Accuracy & Precision; Determining Error)
- Significant Figures in Measurements
- Significant Figures in Calculations (Rounding; Addition & Subtraction; Multiplication & Division)

Section 3.2 International System Of Units

Objectives

3.2.1 List SI units of measurement and common SI prefixes
3.2.2 Distinguish between the mass and weight of an object
3.2.3 Convert between the Celsius and Kelvin temperature scales

Topics & Subtopics

- Measuring with SI Units
- Units & Quantities (Units of Length; Units of Volume; Units of Mass; Units of Temperature; Units of Energy)

Section 3.3 Conversion Problems

Objectives

3.3.1 Construct conversion factors from equivalent measurements
3.3.2 Apply the technique of dimensional analysis to a variety of conversion problems
3.3.3 Solve problems by breaking the solution into steps
3.3.4 Convert complex units using dimensional analysis

Topics & Subtopics

- Conversion Factors
- Dimensional Analysis
- Converting Between Units (Multistep Problems; Converting Complex Units)

Section 3.4 Density

Objectives

3.4.1 Calculate the density of a material from experimental data
3.4.2 Describe how density varies with temperature

Topics & Subtopics

- Determining Density
- Density & Temperature

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Chapter 4-ATOMIC STRUCTURE

Section 4.1 Defining The Atom

Objectives

4.1.1 Describe Democritus's ideas about atoms
4.1.2 Explain Dalton's atomic theory
4.1.3 Identify what instrument is used to observe individual atoms

Topics & Subtopics

- Early Models of the Atom (Democritus's Atomic Philosophy; Dalton's Atomic Theory
- Sizing up the Atom

Section 4.2 Structure of the Nuclear Atom

Objectives

4.2.1 Identify three types of subatomic particles
4.2.2 Describe the structure of atoms according to the Rutherford atomic model

Topics & Subtopics

- Subatomic Particles (Electrons; Protons & Neutrons)
- Atomic Nucleus (Rutherford's Gold Foil Experiment; Rutherford Atomic Model)

Section 4.3 Distinguishing Among Atoms

Objectives

4.3.1 Explain what makes elements and isotopes different from each other
4.3.2 Calculate the number of neutrons in an atom
4.3.3 Calculate the atomic mass of an element
4.3.4 Explain why chemists use the periodic table

Topics & Subtopics

- Atomic Number
- Mass Number
- Isotopes
- Atomic Mass
- The Periodic Table—A Preview

Supplementary Unit 1 Nuclear Applications (2 days)

Objectives

- Explain the role of the strong nuclear force in overcoming the repulsion between protons and neutrons in a nucleus.
- Explain radioactivity as resulting from the instability of some isotopes of elements, either naturally occurring or formed in nuclear reactions.
- Describe alpha, beta, and gamma radiation, and identify equations illustrating alpha, beta, and gamma radioactive decay, including any nuclear changes and products.
- Differentiate the characteristics (e.g., penetrating ability) of alpha, beta, and gamma radiation, and explain consequences of exposure.
- Calculate the amount of radioactive substance remaining after an integral number of half-lives have passed.

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- Consider problems involving nuclear binding energy.
- Predict nuclear stability and mode of decay using N/Z ratio.
- Assess problems involving half-life.
- Differentiate various balanced nuclear equations**.**

Topics & Sub Topics

- Natural vs. artificial radioactivity
- Rate of radioactive decay and half-life calculations
- Mass and energy relationships
- Fission and fusion
- How a nuclear power plant produces electricity
- Radon and exposure to radiation
- Nuclear Structure
- Nuclear equations
- Half-life

Chapter 5-ELECTRONS IN ATOMS

Section 5.1 Models of the Atom

Objectives

5.1.1 Identify the inadequacies in the Rutherford atomic model

5.1.2 Identify the new proposal in the Bohr model of the atom

5.1.3 Describe the energies /positions of electrons according to the quantum mechanical model

5.1.4 Describe how the shapes of orbitals related to different sub-levels differ

Topics & Subtopics

- Development of Atomic Models
- Bohr Model
- Quantum Mechanical Model
- Atomic Orbitals

Section 5.2 Electron Arrangement in Atoms

Objectives

5.2.1 Describe how to write the electron configuration for an atom

5.2.2 Explain why the actual electron configurations for some elements differ from those predicted by the Aufbau principle

Topics & Subtopics

- Electron Configurations (Aufbau Principle; Pauli Exclusion Principle; Hund's Rule)
- Exceptional Electron Configurations

Section 5.3 Physics and the Quantum Mechanical Model

Objectives

5.3.1 Describe the relationship between the wavelength and frequency of light

5.3.2 Identify the source of atomic emission spectra

5.3.3 Explain how the frequencies of emitted light are related to changes in electron energies

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5.3.4 Distinguish between quantum mechanics and classical mechanics

Topics & Subtopics

- Light
- Atomic Spectra
- Explanation of Atomic Spectra
- Quantum Mechanics

Chapter 6-PERIODIC TABLE

Section 6.1 Organizing the Elements

Objectives

6.1.1 Explain how elements are organized in a periodic table

6.1.2 Compare early and modern periodic tables

6.1.3 Identify three broad classes of elements

Topics & Subtopics

- Searching for an Organizing Principle
- Mendeleev's Periodic Table
- Periodic Law
- Metals, Nonmetals, and Metalloids (Metals; Nonmetals; Metalloids)

Section 6.2 Classifying the Elements

Objectives

6.2.1 Describe the information in a periodic table.

6.2.2 Classify elements based on electron configuration

6.2.3 Distinguish representative elements and transition metals

Topics & Subtopics

- Squares in the Periodic Table
- Electron Configurations in Groups (Noble Gases; Representative Elements)
- Transition Elements (Blocks of Elements)

Section 6.3 Periodic Trends

Objectives

6.3.1 Describe trends among the elements for atomic size

6.3.2 Explain how ions form

6.3.3 Describe periodic trends for first ionization energy, ionic size, and electronegativity

Topics & Subtopics

- Trends in Atomic Size (Group Trends in Atomic Size; Periodic Trends in Atomic Size)
- Ions
- Trends in Ionization Energy (Group /Periodic Trends in Ionization Energy)
- Trends in Ionic Size
- Trends in Electronegativity
- Summary of Trends

Chapter 7-IONIC & METALLIC BONDING

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Section 7.1 Ions

Objectives

7.1.1 Determine the number of valence electrons in an atom of a representative element

7.1.2 Explain how the octet rule applies to atoms of metallic and nonmetallic elements

7.1.3 Describe how cations form

7.1.4 Explain how anions form

Topics & Subtopics

- Valence Electrons
- Octet Rule
- Formation of Cations
- Formation of Anions

Section 7.2 Ionic Bonds & Ionic Compounds

Objectives

7.2.1 Explain the electrical charge of an ionic compound

7.2.2 Describe three properties of ionic compounds

Topics & Subtopics

- Formation of Ionic Compounds (Ionic Bonds; Formula Units)
- Properties of Ionic Compounds

Section 7.3 Bonding In Metals

Objectives

7.3.1 Model the valence electrons of metal atoms

7.3.2 Describe the arrangement of atoms in a metal

7.3.3 Explain the importance of alloys

Topics & Subtopics

- Metallic Bonds and Metallic Properties
- Crystalline Structure of Metals
- Alloys

Chapter 8-COVALENT BONDING

Section 8.1 Molecular Compounds

Objectives

8.1.1 Distinguish between the melting points and boiling points of molecular compounds and ionic compounds

8.1.2 Describe the information a molecular formula provides

Topics & Subtopics

- Molecules and Molecular Compounds
- Molecular Formulas

Section 8.2 Nature of Covalent Bonding

Objectives

8.2.1 Describe how electrons are shared to form covalent bonds and identify exceptions to the octet rule

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8.2.2 Demonstrate how electron dot structures represent shared electrons
8.2.3 Describe how atoms form double or triple covalent bonds
8.2.4 Distinguish between a covalent bond and a coordinate covalent bond and describe how the strength of a covalent bond is related to its bond dissociation energy
8.2.5 Describe how oxygen atoms are bonded in ozone

Topics & Subtopics

- Octet Rule in Covalent Bonding
- Single Covalent Bonds
- Double and Triple Covalent Bonds
- Coordinate Covalent Bonds
- Bond Dissociation Energies
- Resonance
- Exceptions to the Octet Rule

Section 8.3 Bonding Theories

Objectives

8.3.1 Describe the relationship between atomic and molecular orbitals
8.3.2 Describe how VSEPR theory helps predict the shapes of molecules

Topics & Subtopics

- Molecular Orbitals (Sigma Bonds; Pi Bonds)
- VSEPR Theory

Section 8.4 Polar Bonds & Molecules

Objectives

8.4.1 Describe how electronegativity values determine the distribution of charge in a polar molecule
8.4.2 Describe what happens to polar molecules when they are placed between oppositely charged metal plates
8.4.3 Evaluate the strength of intermolecular attractions compared with the strength of ionic and covalent bonds
8.4.4 Identify the reason why network solids have high melting points

Topics & Subtopics

- Bond Polarity
- Polar Molecules
- Attractions Between Molecules (van der Waals Forces; Hydrogen Bonds)
- Intermolecular Attractions and Molecular Properties

Chapter 15-WATER AND AQUEOUS SYSTEMS

Section 15.1 Water And Its Properties

Objectives

15.1.1 Explain the high surface tension and low vapor pressure of water in terms of the structure of the water molecule and hydrogen bonding
15.1.2 Describe the structure of ice

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Topics & Subtopics

- Water in the Liquid State (Surface Tension; Vapor Pressure)
- Water in the Solid State

Chapter 9-CHEMICAL NAMES & FORMULAS

Section 9.1 Naming Ions

Objectives

9.1.1 Identify the charges of monatomic ions by using the periodic table and name the ions
9.1.2 Define a polyatomic ion and write the names and formulas of the most common polyatomic ions
9.1.3 Identify the two common endings for the names of most polyatomic ions

Topics & Subtopics

- Monatomic Ions (Cations; Anions; Ions of Transition Metals)
- Polyatomic Ions

Section 9.2 Naming & Writing Formulas for Ionic Compounds

Objectives

9.2.1 Apply the rules for naming and writing formulas for binary ionic compounds
9.2.2 Apply the rules for naming and writing formulas for compounds with polyatomic ions

Topics & Subtopics

- Binary Ionic Compounds (Naming Binary Ionic Compounds; Writing Formulas for Binary Ionic Compounds)
- Compounds with Polyatomic Ions (Naming Compounds with Polyatomic Ions)

Section 9.3 Naming & Writing Formulas for Molecular Compounds

Objectives

9.3.1 Interpret the prefixes in the names of molecular compounds in terms of their chemical formulas
9.3.2 Apply the rules for naming and writing formulas for binary molecular compounds
15.2.4 Demonstrate how the formula for a hydrate is written

Topics & Subtopics

- Naming Binary Molecular Compounds
- Writing Formulas for Binary Molecular Compounds
- Hydrates (Efflorescent Hydrates; Hygroscopic Hydrates; Deliquescent Compounds) ***Inserted from Section 15.2***

Section 9.4 Naming & Writing Formulas for Acids & Bases

Objectives

9.4.1 Apply three rules for naming acids
9.4.2 Apply the rules in reverse to write formulas of acids
9.4.3 Apply the rules for naming bases

Topics & Subtopics

- Naming Acids

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• Writing Formulas for Acids
• Names and Formulas for Bases

Section 9.5 Laws Governing Formulas & Names

Objectives

9.5.1 Define the laws of definite proportions and multiple proportions
9.5.2 Apply the rules for naming chemical compounds by using a flow chart
9.5.3 Apply the rules for writing the formulas of chemical compounds by using a flowchart

Topics & Subtopics

• Laws of Definite and Multiple Proportions (Law of Definite Proportions; Law of Multiple Proportions)
• Practicing Skills: Naming Chemical Compounds
• Practicing Skills: Writing Chemical Formulas

Chapter 11-CHEMICAL REACTIONS

Objectives

11.1.1 Describe how to write a word equation.
11.1.2 Describe how to write a skeleton equation
11.1.3 Describe the steps for writing a balanced chemical equation

Topics & Subtopics

• Writing Chemical Equations (Word Equations; Chemical Equations)
• Balancing Chemical Equations

Section 11.2 Types of Chemical Reactions

Objectives

11.2.1 Describe the five general types of reactions
11.2.2 ~~Predict~~ Recognize the products of the five general types of reactions

Topics & Subtopics

• Classifying Reactions (Combination Reactions; Decomposition Reactions; Single-Replacement Reactions; Double Replacement Reactions; Combustion Reactions
• Predicting the Products of a Chemical Reaction

Supplementary Unit 2 Oxidation/Reduction

Objectives

- Generate and evaluate scientific evidence and explanations.
- Participate productively in scientific practices and discourse.
- Distinguish among the different ways objects can move.
- Recognize that forces exist in the natural world that can influence the movement of objects.
- Observe and understand the scientific process
- Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another

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- Recognize that energy is needed to cause a physical or chemical change

Topic & Sub Topics

- Balance reduction-oxidation reactions
- Oxidizing and reducing agents
- Describe the processes of oxidation and reduction.
- Identify oxidizing and reducing agents.
- Determine the oxidation number of an element in a compound.
- Interpret redox reactions in terms of change in oxidation states.
- Relate changes in oxidation number to the transfer of electrons.
- Oxidation-reduction reactions involve electron transfer, the net release or net absorption of the energy can occur in the form of electrical energy rather than as heat.
- Know that the branch of chemistry that deals with electricity-related application of oxidation-reduction reactions is called electrochemistry.
- Interpret an activity series.
- Describe applications of REDOX.
- Balance REDOX

Supplementary Unit 3 Kinetics, Equilibrium & Thermodynamics

Objectives

- Generate and evaluate scientific evidence and explanations.
- Participate productively in scientific practices and discourse.
- Distinguish among the different ways objects can move.
- Recognize that forces exist in the natural world that can influence the movement of objects.
- Observe and understand the scientific process
- Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another
- Recognize that energy is needed to cause a physical or chemical change

Identify that not all matter can respond in the same manner when exposed to similar conditions

Topics & Sub Topic

- Rate law
- Mechanisms
- Reaction order
- Equilibrium
- Equilibrium constant
- LeChatelier's Principle
- 1st Law of Thermodynamics,2nd Law of Thermodynamics and 3rd Law of Thermodynamics
- Kinetic and potential energy

- Calorimetry
- Calculate the rate law of a reaction
- Describe the order for the rate law
- Describe the rate law from a mechanism
- Identify rate constants
- Write equilibrium constant expressions
- Analyze and describe the value of an equilibrium constant
- Predict the equilibrium concentrations of reactions and products
- Determine the direction in which a reaction must proceed in order to achieve equilibrium
- Recognize the symbols for the enthalpy, entropy, and Gibb's Free Energy of a reaction
- Assess the spontaneity of a chemical reactions

Section 11.3 Reactions in Aqueous Solutions

Objectives

11.3.2 Recognize the formation of a precipitate in a double replacement reaction

Topics & Subtopics

- Net Ionic Equations
- Predicting the Formation of a Precipitate

Chapter 10-CHEMICAL QUANTITIES

Section 10.1 The Mole: Measurement of Matter

Objectives

10.1.1 Describe methods of measuring the amount of something

10.1.2 Define Avogadro's number as it relates to a mole of substance

10.1.3 Distinguish between the atomic mass of an element and its molar mass

10.1.4 Describe how the mass of a mole of a compound is calculated

Topics & Subtopics

- Measuring Matter
- What Is a Mole (Converting Number of Particles to Moles; Converting Moles to Number of Particles)
- Mass of a Mole of an Element
- Mass of a Mole of Compound

Section 10.2 Mole-Mass & Mole-Volume Relationships

Objectives

10.2.1 Describe how to convert the mass of a substance to the number of moles of a substance and moles to mass

10.2.2 Identify the volume of a quantity of gas at STP

Topics & Subtopics

- Mole-Mass Relationship

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• Mole-Volume Relationship (Calculating Volume at STP; Calculating Molar Mass from Density
• Mole Road Map

Section 10.3 Percent Composition & Chemical Formulas

Objectives

10.3.1 Describe how to calculate the percent by mass of an element in a compound
10.3.2 Interpret an empirical formula
10.3.3 Distinguish between empirical and molecular formulas

Topics & Subtopics

• Percent Composition of a Compound (Percent Composition from Mass Data; Percent Composition from the Chemical Formula; Percent Composition as a Conversion Factor)
• Empirical Formulas
• Molecular Formulas

Chapter 12-STOICHIOMETRY

Section 12.1 Arithmetic of Equations

Objectives

12.1.1 Explain how balanced equations apply to both chemistry and everyday life
12.1.2 Interpret balanced chemical equations in terms of moles, , mass, and
12.1.3 Identify the quantities that are always conserved in chemical reactions

Topics & Subtopics

• Using Everyday Equations
• Using Balanced Chemical Equations
• Interpreting Chemical Equations (Number of Atoms; Number of Molecules; Moles; Mass; Volume)
• Mass Conservation in Chemical Reactions

Section 12.2 Chemical Calculations

Objectives

12.2.1 Construct mole ratios from balanced chemical equations and apply these ratios in stoichiometric calculations
12.2.2 Calculate stoichiometric quantities from balanced chemical equations using units of moles, mass,

Topics & Subtopics

• Writing and Using Mole Ratios (Mole-Mole Calculations; Mass-Mass Calculations)
• Other Stoichiometric Calculations

Section 12.3 Limiting Reagent & Percent Yield

Objectives

12.3.1 Conceptualize the limiting reagent in a reaction
12.3.2 Understand terms theoretical yield, actual yield, or percent yield given appropriate information

Topics & Subtopics

• Limiting and Excess Reagents

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• Percent Yield

Chapter 13-STATES OF MATTER
Section 13.1 Nature of Gases
Objectives
13.1.1 Describe the assumptions of the kinetic theory as it applies to gases
13.1.2 Interpret gas pressure in terms of kinetic theory
13.1.3 Define the relationship between Kelvin temperature and average kinetic energy
Topics & Subtopics
• Kinetic Theory and a Model for Gases
• Gas Pressure
• Kinetic Energy and Temperature (; Average Kinetic Energy and Kelvin Temperature)

Section 13.2 Nature of Liquids
Objectives
13.2.1 Identify factors that determine physical properties of a liquid
13.2.2 Define evaporation in terms of kinetic energy
13.2.3 Describe the equilibrium between a liquid and its vapor
13.2.4 Identify the conditions at which boiling occurs
Topics & Subtopics
• A Model for Liquids
• Evaporation
• Vapor Pressure (Vapor Pressure and Temperature Change; Vapor Pressure Measurements)
• Boiling Point (Boiling Point and Pressure Changes; Normal Boiling Point)

Section 13.3 Nature of Solids
Objectives
13.3.1 Evaluate how the way particles are organized explains the properties of the solids
13.3.3 Explain how allotropes of an element are different
Topics & Subtopics
• A Model for Solids
• ~~Crystal Structure and Unit Cells (Crystal Systems~~; Allotropes; ~~Non-Crystalline Solids~~)

Section 13.4 Changes of State
Objectives
13.4.1 Identify the conditions necessary for sublimation
13.4.2 Describe how equilibrium conditions are represented in a phase diagram
Topics & Subtopics
• Sublimation
• Phase Diagrams

Chapter 14-BEHAVIOR OF GASES
Section 14.1 Properties of Gases

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Objectives
14.1.1 Explain why gases are easier to compress than solids or liquids are
14.1.2 Describe three factors that affect gas pressure
Topics & Subtopics
- Compressibility
- Factors Affecting Gas Pressure (Amount of Gas; Volume; Temperature)

Section 14.2 Gas Laws
Objectives
14.2.1 Describe the relationships among the temperature, pressure, and volume of gas
14.2.2 Use the combined gas law to solve problems qualitatively
Topics & Subtopics
- Boyle's Law: Pressure and Volume
- Charles's Law: Temperature and Volume
- Gay-Lussac's Law: Pressure and Temperature
- Combined Gas Law

Section 14.3 Ideal Gases
Objectives
14.3.1 Compute the value of an unknown using the ideal gas law
14.3.2 Compare and contrast real and ideal gases
Topics & Subtopics
- Ideal Gas Law
- Ideal Gases and Real Gases

Section 14.4 Gases: Mixtures & Movements
Objectives
14.4.1 Relate the total pressure of a mixture of gases to the partial pressures of the component gases
14.4.2 Explain how the molar mass of a gas affects the rate at which the gas diffuses and effuses
Topics & Subtopics
- Dalton's Law
- Graham's Law (Thomas Graham's Contribution; Comparing Effusion Rates)

Chapter 15-WATER AND AQUEOUS SYSTEMS / Chapter 16-SOLUTIONS
Chapter 15 + Chapter 16 shall be consolidated.
~~Section 15.1 Water and Its Properties~~
Moved to Chapter 8 and included with Section 8.4 Polar Bonds & Molecules

Section 15.2 Homogeneous Aqueous Systems
Objectives
15.2.1 Distinguish between a solvent and a solute

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15.2.2 Describe what happens in the solution process
15.2.3 Explain why all ionic compounds are electrolytes
15.2.4 ***Moved to Section 9.3***

Topics & Subtopics

- Solvents & Solutes
- Solution Process
- Electrolytes & Nonelectrolytes

Section 15.3 Heterogeneous Aqueous Systems

Objectives

15.3.1 Distinguish between a suspension and a solution
15.3.2 Identify the distinguishing characteristic of a colloid

Topics & Subtopics

- Suspensions
- Colloids (Tyndall Effect; Brownian Motion; Coagulation; Emulsions)

Section 16.1 Properties of Solutions

Objectives

16.1.1 Identify the factors that determine the rate at which a solute dissolves
16.1.2 Identify the units usually used to express the solubility of a solute
16.1.3 Identify the factors that determine the mass of solute that will dissolve in a given mass of solvent

Topics & Subtopics

- Solution Formation (Stirring and Solution Formation; Temperature and Solution Formation; Particle Size and Solution Formation)
- Solubility
- Factors Affecting Solubility (Temperature; Pressure)

Section 16.2 Concentrations of Solutions

Objectives

16.2.1 Solve problems involving the Molarity of a solution
16.2.2 Describe the effect of dilution on the total moles of solute in solution
16.2.3 Define percent by volume and percent by mass solutions

Section 16.3 Colligative Properties of Solutions

Objectives

16.3.1 Identify three colligative properties of solutions
16.3.2 Explain why the vapor pressure, freezing point, and boiling point of a solution differ from those properties of the pure solvent

Topics & Subtopics

- Vapor-Pressure Lowering
- Freezing Point Depression
- Boiling Point Elevation

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Supplementary Unit 4 Acids and Bases

Objectives

• Calculate the pH of an acidic or basic solution
• Determine the strength of an acid based upon its chemical formula
• Distinguish between weak and strong electrolytes
• Investigate concentrations of solutions
• Identify the properties of acids and bases
• Know and calculate the role of pH in solution chemistry

Topics and Sub Topics

- Relative strength of Acids and Bases
- Acid/Base theory
- pH and pOH calculations

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Chemistry Honors

3410

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Reviewed by Science Supervisor

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(Revised July 2016)

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I. OVERVIEW

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with the periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions. The course will also incorporate the study of thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reaction. Students will be introduced to acids and bases, oxidation and reduction reactions and be able distinguish a fission reaction from a fusion reaction

II. RATIONALE

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 7/2009)

IV. CHEMISTRY CORE CURRICULUM CONTENT STANDARDS

5.1.A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.12.A.1 Content Statement

Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.

> **Cumulative Progress Indicator (CPI)** Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.12.A.2 Content Statement

Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.

> **CPI** Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.12.A.3 Content Statement

Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

> **CPI** Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.12.B.1 Content Statement

Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.

> **CPI** Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.12.B.2 Content Statement

Mathematical tools and technology are used to gather, analyze, and communicate results.

> **CPI** Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Content Statement

Empirical evidence is used to construct and defend arguments.

> **CPI** Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Content Statement

Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

> **CPI** Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C REFLECT ON SCIENTIFIC KNOWLEDGE: Scientific knowledge builds on itself over time.

5.1.12.C.1 Content Statement

Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

> **CPI** Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Content Statement

Data and refined models are used to revise predictions and explanations.

> **CPI** Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Content Statement

Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

CPI Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D PARTICIPATE PRODUCTIVELY IN SCIENCE: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms

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5.1.12.D.1 Content Statement

Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

> **CPI** Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.12.D.2 Content Statement

Science involves using language, both oral and written, as a tool for making thinking public.

> **CPI** Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.12.D.3 Content Statement

Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

> **CPI** Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.1 Content Statement

Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.

> **CPI** Use atomic models to predict the behaviors of atoms in interactions..

5.2.12.A.2 Content Statement

Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.

> **CPI** Account for the differences in the physical properties of solids, liquids, gases.

5.2.12.A.3 Content Statement

In the Periodic Table, elements are arranged according to the number of protons (the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.

> **CPI** Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties..

5.2.12.A.4 Content Statement

In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of

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neutrons are called isotopes.

CPI Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.

5.2.12.A.5 Content Statement

Solids, liquids, and gases may dissolve to form solutions. When combining a solute and solvent to prepare a solution, exceeding a particular concentration of solute will lead to precipitation of the solute from the solution. Dynamic equilibrium occurs in saturated solutions. Concentration of solutions can be calculated in terms of molarity, molality, and percent by mass..

CPI Describe the process by which solutes dissolve in solvents

5.2.12.A.6 Content Statement

Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.

CPI Relate the pH scale to the concentrations of various acids and bases

5.2.12.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.1 Content Statement

An atom's electron configuration, particularly of the outermost electrons, determines how the atom interacts with other atoms. Chemical bonds are the interactions between atoms that hold them together in molecules or between oppositely charged ions

CPI Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form.

5.2.12.B.2 Content Statement

A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond..

CPI Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.2.12.B.3 Content Statement

The conservation of atoms in chemical reactions leads to the ability to calculate the mass of products and reactants using the mole concept..

CPI Balance chemical equations by applying the law of conservation of mass.

5.2.12.C. Forms of Energy: Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.

5.2.12.C.1 Content Statement

Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy.

CPI Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.

5.2.12.C.2 Content Statement

Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts.

CPI Account for any trends in the melting points and boiling points of various compounds.

5.2.D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.

5.2.12.D.2 Content Statement

The driving forces of chemical reactions are energy and entropy. Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).

CPI Describe the potential commercial applications of exothermic and endothermic reactions.

5.2.12.D.3 Content Statement

Nuclear reactions (fission and fusion) convert very small amounts of matter into energy.

CPI Describe the products and potential applications of fission and fusion reactions.

5.2.12.D.4 Content Statement

Energy may be transferred from one object to another during collisions

CPI Measure quantitatively the energy transferred between objects during a collision

5.2.12.D.5 Content Statement

Chemical equilibrium is a dynamic process that is significant in many systems, including biological, ecological, environmental, and geological systems. Chemical reactions occur at different rates. Factors such as temperature, mixing, concentration, particle size, and surface area affect the rates of chemical reactions.

CPI Model the change in rate of a reaction by changing a factor.

IV. STUDENT OUTCOMES

A. *KNOWLEDGE (Information and Concepts)*

The student will:

1. design investigations, collect evidence, analyze data, and evaluate evidence to determine causal/correlational relationships and anomalous data. (5.1.12.B.1)

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2. develop an understanding of the relationships among facts, concepts, principles, theories, and models and use these relationships to understand phenomena in the natural world. (5.1.12.A.1)

3. use tools, evidence, and data to observe, measure, and explain phenomena in the natural world. (5.1.12.A.2)

4. construct and refine explanations, arguments or models of the natural world through the use of quantitative and qualitative evidence and data. (5.1.12.A.2)

5. use scientific principles and theories to build and refine standards for data collection, posing controls, and representing evidence. (5.1.12.A.3)

6. build, refine, and represent evidence-based models using mathematical, physical and computational tools (5.1.12.B.2)

7. demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.(5.1.12.D.3)

8. reflect on and revise understandings as new evidence emerges. (5.1.12.C.1)

9. use data representations and new models to revise predictions and explanations. (5.1.12.C.2)

10. revise predictions and explanations using evidence, and connect explanations/ arguments to established scientific knowledge, models and theories. (5.1.12.B.3)

11. develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (5.1.12.B4)

12. consider alternative theories to interpret and evaluate evidence-based arguments. (5.1.12.C.3)

13. engage in multiple forms of discussions in order to process, make sense of, and learn from others' ideas, observations, and experiences. (5.1.12.D.1)

14. represent ideas using literal representations such as graphs, tables, journals, concept maps, and diagrams. (5.1.12.D.2)

15. demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. (5.2.12.B)

16. show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations.

17. demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws.

18. communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table.

19. using the Periodic Table, explain the periodic trends in specific properties of elements, i.e. ionization energy, electronegativity, electron affinity, atomic and ionic radii

20. demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, metallic.

21. demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter.

22. show knowledge of chemical equilibrium, reaction rates, reaction Mechanisms. acids,

bases, and salts.

23. write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory.
24. design experiments to solve a specific problem relating to chemical principles.
25. build models and name common organic compounds such as hydrocarbons and simple polymers.
26. distinguish between types of radiation and the energy associated with each
27. describe the postulates of quantum theory.
28. predict the products formed by common reactants, write and balance equations for the reactions.
29. Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes
30. Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel
31. Describe the products and potential applications of fission and fusion reactions

B. ATTITUDES

The student will:

1. develop an appreciation for the study of chemistry and how it relates to his/her everyday life.
2. research and investigate possible careers in chemistry.
3. recognize the impact of chemistry on every aspect of daily life.

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C. SKILLS AND BEHAVIORS

The student will:

1. demonstrate good problem-solving techniques.
2. write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory.
3. demonstrate effective listening and note taking skills in lecture and discussion situations.
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments.
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions.
6. demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology.
7. write and balance equations for a variety of chemical reactions.
8. work cooperatively in small groups to solve problems or perform experiments.
9. design and interpret graphs using empirical and experimental data.
10. use spreadsheet and graphing software to report results of laboratory investigations.
11. design and produce presentations using Power Point presentation software.
12. set up and perform experiments using computer interfaced sensors to collect data.
13. Use internet search engines to locate chemistry related websites for research and review.
14. be aware of the connection between educational activities and the world of work

V. STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*

- Audio visual media
- Charts, handouts, graphs
- Class & individual assignments
- Cooperative activities
- Critical thinking:
  - decision making
  - compare & contrast
  - reliable sources
  - causal explanation
  - prediction
- Debates & panel discussion
- Demonstrations(teacher/student led)
- Direct instruction
- Discussion(teacher/student led)
- Drill practice
- Extra credit project or presentation
- Homework
- Investigation
- Laboratory experiment

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Lecture
Library and resource documents
Oral reading
Periodicals
Questioning techniques
Research paper
Reviews
Self-instructional instruments
Textbook
Textbook supplements
Tutoring(peer & teacher)

VI. EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include

DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper*.

Tests
Quizzes
Homework
Benchmark assessment

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.

Class participation
Teacher observation
Infusion exercises
Portfolios
Varied approach projects

PERFORMANCE ASSESSMENT *authentic assessment specific to chemistry*.

Laboratory

VII. REQUIRED RESOURCES

Students Resources

TEXTBOOK: Holt, Rinehart and Winston 2006 Modern Chemistry

Laptop Cart
Microsoft office
CD-Rom Chemistry
Internet resources
Virtual Labs

VIII. SCOPE AND SEQUENCE

NOTE: Days in parenthesis are departmental guidelines and should not significantly vary. Minor adjustments may be necessary to accommodate student needs and unforeseen circumstances. Given months are based on start dates of units and coincide with the school calendar.

Suggested Pacing Guide

Chapter 1-MATTER AND CHANGE
Section 1.1-Chemistry Is A Physical Science
1.1a—define chemistry
1.1b- list examples of the branches of chemistry
1.1c—compare and contrast basic research, applied research, and technological development
Topics & Subtopics
• Branches of chemistry (Basic research, applied research; Technological development)
1.2-Matter and Its Properties
1.2a—distinguish between the physical properties and chemical properties of matter.
1.2b—classify changes of matter as physical or chemical
1.2c—explain the gas, liquid, and solid states in terms of particles.
1.2d—explain how the law of conservation of energy applies to changes of matter.
1.2e—distinguish between a mixture and a pure substance.
Topics & Subtopics
• Basic Building Blocks of Matter
• Properties and Changes in Matter (Physical Properties and Physical Changes; Chemical Properties and Chemical
• Changes; Energy and Changes in Matter)
• Classification of Matter (Mixtures; Pure Substances; Laboratory Chemical and Purity)
Section 1.3-Elements
1.3a—use a periodic table to name elements given their symbols.
1.3b—use a periodic table to write the symbols of elements, given their names.
1.3c—describe the arrangement of the periodic table.
1.3d—list the characteristics that distinguish metals, nonmetal, and metalloids
Topics & Subtopics
• Introduction to the Periodic Table
• Types of Elements (Metals)
• Copper: A Typical Metal (Nonmetals; Phosphorus: A Typical Nonmetal; Metalloids; Noble Gases)
Section 1.4- Removed

.

Chapter 1A-LAB EQUIPMENT & LAB SAFETY & LAB REPORTS
Section 1A.1 Lab Equipment
Objectives
1A.1a—recognize lab equipment
1A.1b—use the laboratory burner
1A.1c—use the balance
1A.1d—handle chemical reagents
1A.1e—measure liquids
1A.1f—filter a mixture

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1A.1g—work with glass tubing

Section 1A.2 Lab Safety

Objectives

1A.2a—follow general safety guidelines
1A.2b—handle chemicals
1A.2c—handle glassware
1A.2d—heat substances
1A.2e—identify caution alert symbols
1A.2f—dispose of chemicals properly
1A.2g—administer first aid
1A.2h—clean lab area

Section 1A.3 Lab Manual

Objectives

1A.3a—follow the general format for maintaining a lab notebook
1A.3b—correctly identify the seven steps of the scientific method
1A.3c—differentiate between qualitative data and quantitative data.
1A.3d—perform mass, volume, temperature, and other calculations as needed.
1A.3e—record experimental data
1A.3f—draw logical conclusions based on experimental data
1A.3g—identify sources of error in an experiment
1A.3h—calculate percent error when conclusions are based on quantitative data

2-MEASUREMENTS & CALCULATIONS(1of 14)

Section 2.1 Scientific Method

2.1a—describe the purpose of the scientific method
2.1b—distinguish between qualitative and quantitative observations.
2.1c—describe the differences between hypotheses, theories, and models.

Topics & Subtopics

• Observing and Collecting Data
• Formulating Hypotheses
• Testing Hypotheses
• Theorizing

Section 2.2 Units of Measurement Objectives

2.2a—distinguish between a quantity, a unit, and a measurement standard.
2.2b—name and use SI units for length, mass, time, volume, and density.
2.2c—distinguish between mass and weight.
2.2d—perform density calculations.
2.2e—transform a statement of equality into a conversion factor.

Topics & Subtopics

• SI Measurement
• SI Base Units (Mass; Length)
• Derived SI Units (Volume; Density)
• Conversion Factors (Deriving Conversion Factors)

Section 2.3 Using Scientific Measurements

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Objectives
2.3a—distinguish between accuracy and precision.
2.3b—determine the number of significant figures in a measurement.
2.3c—perform mathematical operations involving significant figures.
2.3d—convert measurements into scientific notation.
2.3e—distinguish between inversely and directly proportional relationships.
Topics & Subtopics
• Accuracy and Precision (Percentage Error; Error in Measurement)
• Significant Figures (Determining the Number of Significant Figures; Rounding; Addition or Subtraction with Significant Figures; Multiplication and Division with Significant Figures; Conversion Factors and Significant Figures)
• Scientific Notation (Mathematical Operations Using Scientific Notation)
• Using Sample Problems (Analyze; Plan; Compute; Evaluate)
• Direct Proportions
• Inverse Proportions

Chapter 3-ATOMS BUILDING BLOCKS OF MATTER
Section 3.1 The Atom: From Philosophical Idea to Scientific Theory
Objectives
3.1a—explain the law of conservation of mass, the law of definite proportions, and the law of multiple proportions.
3.1b—summarize the five essential points of Dalton's atomic theory.
3.1c—explain the relationship between Dalton's atomic theory and the law of conservation of mass, the law of definite proportions, and the law of multiple proportions.
Topics & Subtopics
• Foundations of Atomic Theory
• Dalton's Atomic Theory
• Modern Atomic Theory
Section 3.2 The Structure of the Atom Objectives
3.2a—summarize the observed properties of cathode rays that led to the discovery of the electron.
3.2b—summarize the experiment carried out by Rutherford and his co-workers that led to the discovery of the nucleus.
3.2c—list the properties of protons, neutrons, and electrons.
3.2d—define atom.
Topics & Subtopics
• Discovery of the Electron (Cathode Rays and Electrons; Charge and Mass of the Electron)
• Discovery of the Atomic Nucleus
• Composition of the Atomic Nucleus (Forces in the Nucleus)
• Sizes of Atoms

Section 3.3 Counting Atoms
Objectives
3.3a—explain what isotopes are.
3.3b—define atomic number and mass number and describe how they apply to isotopes.
3.3c—given the identity of a nuclide, determine its number of protons, neutrons, and electrons.
3.3d—define mole, Avogadro's number, and molar mass and state how all three are related.
3.3e—solve problems involving mass in grams, amount in moles, and number of atoms of an element.

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Topics & Subtopics
• Atomic Number
• Isotopes
• Mass Number
• Designating Isotopes
• Relative Atomic Masses
• Average Atomic Masses of Elements (Calculating Average Atomic Mass)
• Relating Mass to Numbers of Atoms (The Mole; Avogadro's Number; Molar Mass; Gram/Mole Conversions; Conversions with Avogadro's Number)

Supplementary Unit 1 Nuclear Applications (2 days)

Objectives

- Explain the role of the strong nuclear force in overcoming the repulsion between protons and neutrons in a nucleus.
- Explain radioactivity as resulting from the instability of some isotopes of elements, either naturally occurring or formed in nuclear reactions.
- Describe alpha, beta, and gamma radiation, and identify equations illustrating alpha, beta, and gamma radioactive decay, including any nuclear changes and products.
- Differentiate the characteristics (e.g., penetrating ability) of alpha, beta, and gamma radiation, and explain consequences of exposure.
- Calculate the amount of radioactive substance remaining after an integral number of half-lives have passed.
- Consider problems involving nuclear binding energy.
- Predict nuclear stability and mode of decay using N/Z ratio.
- Assess problems involving half-life.
- Differentiate various balanced nuclear equations**.**

Topics & Sub Topics

- Natural vs. artificial radioactivity
- Rate of radioactive decay and half-life calculations
- Mass and energy relationships
- Fission and fusion
- How a nuclear power plant produces electricity
- Radon and exposure to radiation
- Nuclear Structure
- Nuclear equations
- Half-life

Chapter 4-ARRANGEMENT OF ELECTRONS IN ATOMS
Section 4.1 The Development of a New Atomic Model
Objectives
4.1a-explain the mathematical relationship among the speed, wavelength, and frequency of electromagnetic radiation.
4.1b-discuss the dual wave-particle nature of light.

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4.1c-discuss the significance of the photoelectric effect and line-emission spectrum of hydrogen to the development of the atomic model. 4.1d-describe the Bohr model of the hydrogen atom.

Topics & Subtopics

• Properties of Light (Wave Description of Light)
• Photoelectric Effect (Particle Description of Light)
• Hydrogen-Atom Line-Emission Spectrum
• Bohr Model of the Hydrogen Atom

Section 4.2 The Quantum Model of the Atom

Objectives

4.2a—discuss Louis de Broglie's role in the development of the quantum model of the atom.
4.2b—compare and contrast the Bohr model and the quantum model of the atom.
4.2c—explain how the Heisenberg uncertainty principle and the Schrodinger wave equation led to the idea of atomic orbitals.
4.2d—list the four quantum numbers and describe their significance.
4.2e—relate the number of sublevels corresponding to each of an atom's main energy levels, the number of orbitals per sublevel, and the number of orbitals per main energy level.

Topics & Subtopics

• Electrons as Waves
• Heisenberg Uncertainty Principle
• Schrodinger Wave Equation
• Atomic Orbitals and Quantum Numbers (Principal Quantum; Angular Momentum Quantum Number; Magnetic Quantum Number; Spin Quantum Number)

Section 4.3 Electron Configurations

Objectives

4.3a—list the total number of electrons needed to fully occupy each main energy level.
4.3b—state the Aufbau principle, the Pauli exclusion principle, and Hund's rule.
4.3c—describe the electron configuration for the atoms of any element using orbital notation, electron configuration notation, and when appropriate, noble-gas notation.

Topics & Subtopics

• Rules Governing Electron Configurations
• Representing Electron Configurations (Orbital Notation; Electron Configuration Notation)
• Elements of the Second Period
• Elements of the Third Period (Noble-Gas Notation)
• Elements of the Fourth Period
• Elements of the Fifth Period
• Elements of the Sixth and Seventh Periods

Chapter 5-PERIODIC LAW

Section 5.1 History of the Periodic Table

Objectives

5.1a—explain the roles of Mendeleev & Moseley in the development of the periodic table.
5.1b—describe the modern periodic table.
5.1c—explain how periodic law can be used to predict the physical and chemical properties of elements.

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5.1d—describe how the elements belonging to a group of the periodic table are interrelated in terms of atomic number.

Topics & Subtopics

• Mendeleev and Chemical Periodicity
• Moseley and the Periodic Law
• Modern Periodic Table (Noble Gases; Lanthanides; Actinides; Periodicity)

Section 5.2 Electron Configuration & the Periodic Table

Objectives

5.2a—describe the relationship between electrons in sublevels and the length of each period of the periodic table.
5.2b—locate and name the four blocks of the periodic table and explain the reasons for these names
5.2c—discuss the relationship between group configurations and group numbers.
5.2d—describe the locations in the periodic table and the general properties of the alkali metals, the alkaline earth metals, the halogens, and the noble gases.

Topics & Subtopics

• Periods and Blocks of the Periodic Table (s-Block Elements: Groups 1 and 2;Hydrogen and Helium; d-Block Elements: Groups 3-12; p-Block Elements: Groups 13-18; f-Block Elements: Lanthanides/Actinides)

Section 5.3 Electron Configuration & Periodic Properties

Objectives

5.3a—define atomic and ionic radii, ionization energy, electron affinity, and electronegativity.
5.3b—compare the periodic trends of atomic radii, ionization energy, and electronegativity and state the reasons for these variations.
5.3c—define valence electrons and state how many are present in atoms of each main-group element.
5.3d—compare the atomic radii, ionization energies, and electronegativities of the d-block elements with those of the main-group elements.

Topics & Subtopics

• Atomic Radii (Period Trends; Group Trends)
• Ionization Energy (Period Trends; Group Trends; Removing Electrons from Positive Ions)
• Electron Affinity (Period Trends; Group Trends; Adding Electrons to Negative Ions)
• Ionic Radii (Period Trends; Group Trends)
• Valence Electrons
• Electronegativity (Period Trends)
• Periodic Properties of the d- and f-Block Elements (Ionization Energy; Ion Formation and Ionic Radii; Electronegativity)

Chapter 6-CHEMICAL BONDING

Section 6.1 Introduction to Chemical Bonding

Objectives

6.1a—define chemical bond.
6.1b—explain why most atoms form chemical bonds.
6.1c—describe ionic and covalent bonding.
6.1d—explain why most chemical bonding is neither purely ionic nor purely covalent.
6.1e—classify bonding type according to electronegativity differences

Topics & Subtopics

• Types of Chemical Bonding (Ionic or Covalent?)

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Section 6.2 Covalent Bonding and Molecular Compounds

Objectives

6.2a—define molecule and molecular formula.
6.2b—explain the relationships among potential energy, distance between approaching atoms, bond length, and bond energy.
6.2c—state the octet rule.
6.2d—list the six basic steps used in writing Lewis structures.
6.2e -explain how to determine Lewis structures for molecules containing single and/or multiple bonds.
6.2f—explain why scientists use resonance structures to represent some molecules.

Topics & Subtopics

- Formation of a Covalent Bond
- Characteristics of the Covalent Bond
- The Octet Rule (Exceptions to the Octer Rule)
- Electron-Dot Notation
- Lewis Structures
- Multiple Covalent Bonds
- Resonance Structures
- Covalent-Network Bonding

Section 6.3 Ionic Bonding and Ionic Compounds

Objectives

6.3a—compare and contrast a chemical formula for a molecular compound with one for an ionic compound.
6.3b—discuss the arrangements of ions in crystals.
6.3c—define lattice energy and explain its significance.
6.3d—list and compare the distinctive properties of ionic and molecular compounds.
6.3e—write the Lewis structure for a polyatomic ion given the identity of the atoms combined and other appropriate information.

Topics & Subtopics

- Formation of Ionic Compounds (Characteristics of Ionic Bonding)
- Comparison of Ionic and Molecular Compounds
- Polyatomic ions

6.4 Metallic Bonding

Objectives

6.4a—describe the electron-sea model of metallic bonding and explain why metals are good electrical conductors.
6.4b—explain why metal surfaces are shiny.
6.4c—explain why metals are malleable and ductile but ionic crystalline compounds are not.

Topics & Subtopics

- Metallic-Bond Model (Metallic Properties; Metallic Bond Strength)

6.5 Molecular Geometry

Objectives

6.5a—explain VSEPR theory.
6.5b—predict the shapes of molecules or polyatomic ions using VSEPR theory.
6.5c—explain how the shapes of molecules are accounted for by hybridization theory.
6.5d—describe dipole-dipole forces, hydrogen bonding, induced dipoles, and London dispersion forces and their effects on properties such as boiling and melting points.

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6.5e—explain what determines molecular polarity.

Topics & Subtopics
• VSEPR Theory (VSEPR Theory and Unshared Electron Pairs)
• Hybridization
• Intermolecular Forces (Molecular Polarity and Dipole-Dipole Forces; Hydrogen Bonding; London Dispersion Forces)

Chapter 7-CHEMICAL FORMULAS & CHEMICAL COMPOUNDS
Section 7.1-Chemical Names and Formulas
Objectives
7.1a—explain the significance of a chemical formula.
7.1b—determine the formula of an ionic compound formed between two given ions.
7.1c—name an ionic compound given its formula.
7.1d—name binary molecular compounds from formulas.
7.1e—write the formula of a binary molecular compound given its name.
Topics & Subtopics
• Significance of a Chemical Formula
• Monatomic Ions (Naming Monatomic Ions)
• Binary Ionic Compounds • Naming Binary Ionic Compounds (Stock System of Nomenclature; Compounds Containing Polyatomic Ions)
• Naming Binary Molecular Compounds
• Covalent-Network Compounds
• Acids and Salts

Section 7.2-Oxidation Numbers
Objectives
7.2a—list the rules for assigning oxidation numbers.
7.2b—give the oxidation number for each element in the formula of a chemical compound.
7.2c—name binary molecular compounds using oxidation numbers and the Stock system.

Topics & Subtopics
• Assigning Oxidation Numbers
• Using Oxidation Numbers for Formulas and Names

Section 7.3-Using Chemical Formulas
Objectives
7.3a—calculate the formula mass or molar mass of any given compound.
7.3b—use molar mass to convert between mass in grams and amount in moles of a chemical compound.
7.3c—calculate the number of molecules, formula units, or ions in a given molar amount of a chemical compound.
7.3d—calculate the percentage composition of a given chemical compound.

Topics & Subtopics
• Formula Masses
• Molar Masses
• Molar Mass as a Conversion Factor
• Percentage Composition

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Section 7.4-Determining Empirical Formulas Objectives
7.4a—define empirical formula and explain how the term applies to ionic and molecular compounds.
7.4b—determine an empirical formula from either a percentage or a mass composition.
7.4c—explain the relationship between the empirical formula and the molecular formula of a given compound.
7.4d—determine a molecular formula from an empirical formula.
Topics & Subtopics
• Calculation of Empirical Formulas
• Calculation of Molecular Formulas

Chapter 8-CHEMICAL EQUATIONS & REACTIONS
Section 8.1-Describing Chemical Reactions
Objectives
8.1a—list three observations that suggest that a chemical reaction has taken place.
8.1b—By the end of class today, list three requirements for a correctly written chemical equation.
8.1c—write a word equation and a formula equation for a given chemical reaction.
8.1d—balance a formula equation by inspection.

Topics & Subtopics ▯ Indications of a Chemical Reaction ▯ Characteristics of Chemical Equations (Word and Formula Equations; Additional Symbols Used in Chemical Equations ▯ Significance of a Chemical Equation ▯ Balancing Chemical Equations

Section 8.2-Types of Chemical Reactions
Objectives
8.2a—define and give general equations for synthesis, decomposition, single-replacement, and double-replacement reactions.
8.2b—classify a reaction as a synthesis, decomposition, single-replacement, double-replacement, or combustion reaction.
8.2c—list three kinds of synthesis reactions and six kinds of decomposition reactions.
8.2d—list four kinds of single-replacement reactions and three kinds of double-replacement reactions.
8.2e—predict the products of simple reactions given the reactants.

Topics & Subtopics
• Synthesis Reactions (Reactions of Elements with oxygen and Sulfur; Reactions of Metals with Halogens; Synthesis Reactions with Oxides)
• Decomposition Reactions (Decomposition of Binary Compounds; Decomposition of Metal Carbonates; Decomposition of Metal Hydroxides; Decomposition of Metal Chlorates; Decomposition of Acids)
• Single-Displacement Reactions (Displacement of a Metal in a Compound by Another Metal; Displacement of Hydrogen in Water by a Metal; Displacement of Hydrogen in an Acid by a Metal; Displacement of Halogens)
• Double-Displacement Reactions (Formation of a Precipitate; Formation of a Gas; Formation of Water)
• Combustion Reactions

Section 8.3-Activity Series of the Elements
Objectives
8.3a—explain the significance of an activity series.
8.3b—use an activity series to predict whether a given reaction will occur and what the products will be.
Topics & Subtopics

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Supplementary Unit 2 Oxidation/Reduction

Objectives

- Generate and evaluate scientific evidence and explanations.
- Participate productively in scientific practices and discourse.
- Distinguish among the different ways objects can move.
- Recognize that forces exist in the natural world that can influence the movement of objects.
- Observe and understand the scientific process
- Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another
- Recognize that energy is needed to cause a physical or chemical change

Topic & Sub Topics

- Balance reduction-oxidation reactions
- Oxidizing and reducing agents
- Describe the processes of oxidation and reduction.
- Identify oxidizing and reducing agents.
- Determine the oxidation number of an element in a compound.
- Interpret redox reactions in terms of change in oxidation states.
- Relate changes in oxidation number to the transfer of electrons.
- Oxidation-reduction reactions involve electron transfer, the net release or net absorption of the energy can occur in the form of electrical energy rather than as heat.
- Know that the branch of chemistry that deals with electricity-related application of oxidation-reduction reactions is called electrochemistry.
- Interpret an activity series.
- Describe applications of REDOX.
- Balance REDOX

Supplementary Unit 3 Kinetics, Equilibrium & Thermodynamics

Objectives

- Generate and evaluate scientific evidence and explanations.
- Participate productively in scientific practices and discourse.
- Distinguish among the different ways objects can move.
- Recognize that forces exist in the natural world that can influence the movement of objects.
- Observe and understand the scientific process
- Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another
- Recognize that energy is needed to cause a physical or chemical change

Identify that not all matter can respond in the same manner when exposed to similar conditions

Topics & Sub Topic

- Rate law
- Mechanisms
- Reaction order
- Equilibrium
- Equilibrium constant
- LeChatelier's Principle
- 1st Law of Thermodynamics,2nd Law of Thermodynamics and 3rd Law of Thermodynamics
- Kinetic and potential energy
- Calorimetry
- Calculate the rate law of a reaction
- Describe the order for the rate law
- Describe the rate law from a mechanism
- Identify rate constants
- Write equilibrium constant expressions
- Analyze and describe the value of an equilibrium constant
- Predict the equilibrium concentrations of reactions and products
- Determine the direction in which a reaction must proceed in order to achieve equilibrium
- Recognize the symbols for the enthalpy, entropy, and Gibb's Free Energy of a reaction
- Assess the spontaneity of a chemical reactions

Chapter 9-STOICHIOMETRY

Section 9.1 Introduction to Stoichiometry

Objectives

9.1a—define stoichiometry.

9.1b—describe the importance of the mole ratio in stoichiometric calculations.

9.1c—write a mole ratio relating two substances in a chemical equation.

Topics & Subtopics

• Reaction Stoichiometry Problems (Mole Ratio; Molar Mass)

Section 9.2 Ideal Stoichiometric Calculations

Objectives

9.2a—calculate the amount in moles of a reactant or product from the amount in moles of a different reactant or product.

9.2b—calculate the mass of a reactant or product from the amount in moles of a different reactant or product.

9.2c—calculate the amount in moles of a reactant or product from the mass of a different reactant or product.

9.2d—calculate the mass of a reactant or product from the mass of a different reactant or product.

Topics & Subtopics

• Conversions of Quantities in Moles • Conversion of Amounts in Moles to Mass • Conversions of Mass to Amounts in Moles • Mass-Mass Calculations

Section 9.3 Limiting Reactants and Percentage Yield

Objectives
9.3a—describe a method for determining which of two reactants is a limiting reagent.
9.3b—calculate the amount in moles or mass in grams of a product, given the amounts in moles or masses in grams of two reactants, one of which is in excess.
9.3c—distinguish between theoretical yield, actual yield, and percentage yield.
9.3d—calculate percentage yield, given the actual yield and quantity of reactant.

Topics & Subtopics
• Percentage Yield

Chapter 10-STATES OF MATTER
Section 10.1-Kinetic-Molecular Theory of Matter
Objectives
10.1a-state the kinetic-molecular theory of matter and describe how it explains certain properties of matter.
10.1b—list the five assumptions of the kinetic-molecular theory of gases. Define the terms ideal gas and real gas.
10.1c—describe each of the following characteristic properties of gases: expansion, density, fluidity, compressibility, diffusion, and effusion.
10.1d—describe the conditions under which a real gas deviates from ideal behavior.
Topics & Subtopics
• Kinetic-Molecular Theory of Gases
• Kinetic-Molecular Theory and the Nature of Gases (Expansion; Fluidity; Low Density; Compressibility; Diffusion and Effusion)
• Deviation of Real Gases from Ideal Behavior

Section 10.2-Liquids
Objectives
10.2a—describe the motion of particles in liquids and the properties of liquids according to the kinetic-molecular theory.
10.2b—discuss the process by which liquids can change into a gas; define vaporization.
10.2c—discuss the process by which liquids can change into a solid; define freezing.
Topics & Subtopics
• Properties of Liquids and the Kinetic-Molecular Theory (Relatively High Density; Relative Incompressibility; Ability to Diffuse; Surface Tension; Evaporation and Boiling; Formation of Solids)

Section 10.3-Solids
Objectives
10.3a—describe the motion of particles in solids and the properties of solids according to the kinetic-molecular theory.
10.3b—distinguish between the two types of solids.
10.3c—describe the different types of crystal symmetry; define crystal structure and unit cell.
Topics & Subtopics
• Properties of Solids and the Kinetic-Molecular Theory (Definite Shape and Volume; Definite melting Point; High Density and Incompressibility; Low Rate of Diffusion)
• Crystalline Solids (Building Forces in Crystals)
• Amorphous Solids

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Section 10.4-Changes of State

Objectives

10.4a—explain the relationship between equilibrium and changes of state.
10.4b—interpret phase diagrams.
10.4c—explain what is meant by equilibrium vapor pressure.
10.4d—describe the process of boiling, freezing, melting, and sublimation.

Topics & Subtopics

• Changes of State and Equilibrium (Equilibrium Vapor Pressure of a Liquid)
• Boiling (Energy and Boiling; Molar Enthalpy of Vaporization)
• Freezing and Melting (Molar Enthalpy of Fusion; Sublimation and Deposition)
• Phase Diagrams

Section 10.5-Water

Objectives

10.5a—describe the structure of a water molecule
10.5b—discuss the physical properties of water and explain how they are determined by the structure of water.
10.5c—calculate the amount of energy absorbed or released when a quantity of water changes state.

Topics & Subtopics

• Structure of Water
• Physical Properties of Water

Chapter 11-GASES

Section 11.1 Gases & Pressure

Objectives

11.1a—define pressure and give the units of pressure and describe how pressure is measured.
11.1b—state the standard conditions of temperature and pressure and convert units of pressure.
11.1c—Use Dalton's law of partial pressures to calculate partial pressures and total pressures.

Topics & Subtopics

• Pressure and Force (Measuring Pressure; Units of Pressure; Standard Temperature and Pressure)
• Dalton's Law of Partial Pressures (Gases Collected by Water Displacement)

Section 11.2 Gas Laws

Objectives

11.2a—use the kinetic molecular theory to explain the relationships between gas volume, temperature, and pressure.
11.2b—use Boyle's law to calculate volume-pressure changes at constant temperature.
11.2c—use Charles's law to calculate volume-temperature changes at constant pressure.
11.2d—use Gay-Lussac's law to calculate pressure-temperature changes at constant volume.
11.2e—use the combined gas law to calculate volume-temperature-pressure changes.

Topics & Subtopics

• Boyle's Law: Pressure-Volume Relationship • Charles's Law: Volume-Temperature Relationship • Guy-Lussac's Law: Pressure-Temperature Relationship • Combined Gas Law

Section 11.3 Gas Volumes & Ideal Gas Law

Objectives

11.3a—state the law of combining volumes.

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11.3b—state Avogadro's law and explain its significance.
11.3c—define standard molar volume of a gas and use it to calculate gas masses and volumes.
11.3d—state the ideal gas law.
11.3e—use the ideal gas law to calculate pressure, volume, temperature, or amount of gas when the other three quantities are known.

Topics & Subtopics
• Measuring and Comparing the Volumes of Reacting Gases
• Avogadro's Law
• Molar Volume of a Gas
• Gas Stoichiometry
• Ideal Gas Law
• Ideal Gas Constant

Section 11.4 Diffusion & Effusion
Objectives
11.4a—describe the process of diffusion.
11.4b—state Graham's law of effusion.
11.4c—state the relationship between the average molecular velocities of two gases and their molar masses.
Topics & Subtopics
• Graham's Law of Effusion

Chapter 12-SOLUTIONS
Section 12.1 Types of Mixtures
Objectives
12.1a—distinguish between heterogeneous and homogeneous mixtures.
12.1b—list three different solute-solvent combinations.
12.1c—compare the properties of suspensions, colloids, and solutions.
12.1d—distinguish between electrolytes and nonelectrolytes.

Topics & Subtopics
• Solutions (Components of Solutions; Types of Solutions)
• Suspensions
• Colloids (Tyndall Effect)
• Solutes: Electrolytes Versus Nonelectrolytes

Section 12.2 The Solution Process
Objectives
12.2a—list and explain three factors that affect the rate at which a solid solute dissolves in a liquid solvent.
12.2b—explain solution equilibrium and distinguish among saturated, unsaturated, and supersaturated solutions.
12.2c—explain the meaning of "likes dissolve likes" in terms of polar and nonpolar substances.
12.2d—list three interactions that contribute to the enthalpy of solution and explain how they combine to cause dissolution to be exothermic or endothermic.
12.2e—compare the effects of temperature and pressure on solubility.
Topics & Subtopics

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• Factors Affecting the Rate of Dissolution (Increasing the Surface Area of the Solute; Agitating a Solution; Heating a Solvent)
• Solubility (Saturated Versus Unsaturated Solutions; Supersaturated Solutions; Solubility Values)
• Solute-Solvent Interactions (Dissolving Ionic Compounds in Aqueous Solution; Nonpolar Solvent; Liquid Solutes and Solvents; Effects of Pressure on Solubility; Henry's Law; Effects of Temperature on Solubility)
• Enthalpies of Solution

Section 12.3 Concentration of Solutions

Objectives

12.3a—calculate the concentration of a solution given the mass of solute and volume of solvent.
12.3b—determine the amount of solute in a given amount of solution given the concentration of a solution.
12.3c—determine the amount of solution that contains a given amount of solute given the concentration of a solution.

Topics & Subtopics

• Molarity
• Molality

Chapter 13-IONS IN AQUEOUS SOLUTIONS & COLLIGATIVE PROPERTIES

Section 13.1 Compounds in Aqueous Solutions

Objectives

13.1a—write equations for the dissolution of soluble ionic compounds in water.
13.1b—predict whether a precipitate will form when solutions of soluble ionic compounds are combined, and write net ionic equations for precipitation reactions.
13.1c—compare dissociation of ionic compounds with ionization of molecular compounds
13.1d—draw the structure of the hydronium ion, and explain why it is used to represent the hydrogen ion in solution.
13.1e—distinguish between strong electrolytes and weak electrolytes.

Topics & Subtopics

• Dissociation (Precipitation Reactions; Net Ionic Equations)
• Ionization (Hydronium Ion)
• Strong and Weak Electrolytes (Strong Electrolytes; Weak Electrolytes)

Section 13.2 Colligative Properties of Solutions

Objectives

13.2a—list four colligative properties and explain why they are classified as colligative properties.
13.2b—calculate freezing-point depression, boiling-point elevation, and solution Molality of nonelectrolyte solutions.
13.2c—calculate the expected changes in freezing point and boiling point of an electrolyte solution.
13.2d—discuss causes of the differences between expected and experimentally observed colligative of electrolyte solutions.

Topics & Subtopics

• Vapor-Pressure Lowering
• Freezing-Point Depression
• Boiling-Point Elevation
• Osmotic Pressure
• Electrolytes and Colligative Properties (Calculated Values for Electrolyte Solutions; Actual Values for Electrolytes Solutions)

Supplementary Unit 4 Acids and Bases

Objectives

• Calculate the pH of an acidic or basic solution
• Determine the strength of an acid based upon its chemical formula
• Distinguish between weak and strong electrolytes
• Investigate concentrations of solutions
• Identify the properties of acids and bases
• Know and calculate the role of pH in solution chemistry

Topics and Sub Topics

- Relative strength of Acids and Bases
- Acid/Base theory
- pH and pOH calculations

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AP Chemistry

11th & 12th Grades

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(Revised July 2016)

I. OVERVIEW

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions, The course will also incorporate the study of Thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reactions and equilibrium. Properties of acids and bases will be introduced.

II. RATIONALE

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. . Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

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5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

IV. STUDENT OUTCOMES

A. *KNOWLEDGE (Information and Concepts)*

The student will:

1. demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. [8.1,8.2, 5.1.A, 5.2.1, 5.2.B, 5.7.A, 5.8]*
2. show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations. [8.1, 5.1.A, 5.1.B, 5.3, 5.6.B]
3. demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws. [8.1, 5.1.A,5.1.B, 5.3, 5.6, 5.8.B]
4. communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table. [8.1, 5.2, 5.6.A, 5.8.A]
5. using the Periodic Table, explain the periodic trends in specific properties of elements, i.e. ionization energy, electronegativity, electron affinity, atomic and ionic radii. [8.1, 5.6.A, 5.8.A, 5.7.B]
6. demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, metallic. [8.1, 5.6, 5.7.B, 5.1.A, 5.1.B]
7. demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter. [8.1, 5.6, 5.7.B, 5.3.B-D]
8. show knowledge of chemical equilibrium, reaction rates, reaction Mechanisms. acids, bases, and salts. [8.1, 5.6.B, 5.3, 5.4]
9. write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory. [8.2,8.1, 5.4, 5.1, 5.3]
10. design experiments to solve a specific problem relating to chemical principles. [8.1, 5.4, 5.3, 5.1]
11. build models and name common organic compounds such as hydrocarbons and simple polymers. [8.1, 5.4, 5.3, 5.5.A, 5.6.A]
12. distinguish between types of radiation and the energy associated with each. [8.1, 5.7.B, 5.8.A, 5.10.B]
13. define and distinguish between entropy and enthalpy. [8.1, 5.7.B, 5.10.A, 5.6.B]

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14. describe the postulates of quantum theory. [5.1.A, 5.7.B, 5.6.A]
15. predict the products formed by common reactants, write and balance equations for the reactions. [8.1, 5.6.B, 5.1.A]
16. Demonstrate knowledge of properties of acids, bases and salts.[8.1, 5.6.B, 5.3, 5.4]

B. ATTITUDES

The student will:
1. develop an appreciation for the study of chemistry and how it relates to his/her everyday life. [8.1,8.2, 5.1, 5.2, 5.4.A, 5.10.B]
2. research and investigate possible careers in chemistry. [9.1, 9.2, 8.1,8.2,8.6, 5.2, 5.4, 5.10]
3. recognize the impact of chemistry on every aspect of daily life. [8.1, 8.2, 5.1, 5.2, 5.4.A, 5.10.B]

C. SKILLS AND BEHAVIORS
The student will:
1. demonstrate good problem-solving techniques. [8.1,8.2, 5.1, 5.3, 5.4]
2. write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory. [8.1, 5.1, 5.2, 5.6]
3. demonstrate effective listening and note taking skills in lecture and discussion situations. [8.1, 5.1.A]
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments. [8.1, 5.1.C, 5.1.A]
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions. [8.1, 5.1 A, 5.1 B]
6. demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology. [8.1, 5.1.A, 5.1.B, 5.4]
7. write and balance equations for a variety of chemical reactions. [8.1, 5.1.A, 5.6.B]
8. work cooperatively in small groups to solve problems or perform experiments. [8.1, 5.1.A, 5.1.B]
9. design and interpret graphs using empirical and experimental data. [8.1,8.2, 5.4, 5.1]
10. use spreadsheet and graphing software to report results of laboratory investigations. [8.1,8.2, 5.4, 5.1)
11. design and produce presentations using Power Point presentation software. [8.1, 5.4]
12. set up and perform experiments using computer interfaced sensors to collect data. [8.1,8.2, 5.4, 5.1)
13. utilize Internet search engines to locate chemistry related websites for research and review. [8.1,8.2]
14. be aware of the connection between educational activities and the world of work [9.1, 9.2]

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IV. STRATEGIES

The following strategies/activities will be used:

Interactive lectures
Problem solving activities
Power point presentations
Labs
Group work
Use of computer interfaced data collection sensors
Peer review
Make the appropriate accommodations for special needs and ELL students
Additional time and other IEP stated accommodations
Audio text resources
Varied assessments

IV. EVALUATION

Assessments may include

Tests and quizzes
Lab reports
Laboratory practicum
Homework
Other class work
Notebook evaluation
Class participation
Student projects
Computer driven spreadsheets and graphs
Oral and/or Power Point presentations
Students will also be expected to design and execute projects and/or original research.

VI. REQUIRED RESOURCES

Students Resources
Textbook: - Halliday & Resnick, Fundamentals of Physics 10th edition. 2014 Wiley…(Electronic version only)
Laptop Cart
Microsoft office
CD-Rom Chemistry
Internet resources
Virtual Labs

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VII. SCOPE AND SEQUENCE

September

AP REVIEW UNIT VI: Solids and Liquids
Kinetic Molecular Theory; phase diagrams for one-component systems; changes of state; structure of solids.
Liquids and solids form the kinetic-molecular viewpoint
Phase diagrams of one-component systems
Changes of state, including critical points and triple points
Structure of solids; lattice energies

AP REVIEW UNIT VII: Solutions and Their Properties

Investigate the properties of solutions; factors affecting solubility; methods of expressing concentration; colligative properties.
Types of solutions and factors affecting solubility
Methods of expressing concentration (The use of normalities is not tested.)
Raoult's law and colligative properties (non-volatile solutes); osmosis
Non-ideal behavior (qualitative aspects)

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

October

AP REVIEW UNIT I: Chemical Fundamentals

Describe the properties of matter; use significant figures correctly; perform basic scientific calculations and measurements.

AP REVIEW UNIT II: Atomic Structure and The Periodic Table

Account for the periodicity of the elements in terms of modern atomic theory; use atomic numbers, mass numbers and isotopes; understand electron energy levels, quantum numbers and atomic orbitals.
Evidence for the atomic theory
Atomic masses; determination by chemical and physical means
Atomic number and mass number; isotopes
Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
Periodic relationships including, for example, atomic radii, ionization energies, electron affinities, oxidation states

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Chemical reactivity and products of chemical reactions
Relationships in the periodic table: horizontal, vertical, and diagonal with examples from alkali metals, alkaline earth metals, halogens, and the first series of transition elements

November

AP REVIEW UNIT III: Chemical Bonding

Understand binding forces (ionic, covalent, metallic, network covalent, and Van der Waals) and their relationships to states, structure and properties of matter; polarity of bonds; electronegativities; molecular models; Lewis structures; Valence Bond theory (hybridization); resonance, sigma and pi bonds; VSEPR; Molecular Orbital theory.
Binding forces
Types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion forces)
Relationships to states, structure, and properties of matter
Polarity of bonds, electronegativities
Molecular models
Lewis structures
Valence bond: hybridization of orbitals, resonance, sigma and pi bonds
VSEPR
Geometry of molecules and ions, structural isomerism of simple organic molecules and coordination complexes, dipole moments of molecules, relation of properties to structure

December

AP REVIEW UNIT IV: Chemical Compounds, Reactions and Stoichiometry

Calculate quantities of materials reacted or produced in chemical reactions; use mole concept to determine empirical formulas; be able to write formulas and name various inorganic compounds using IUPAC standards; be able to write and read chemical reactions.
Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism
Precipitation reactions
Oxidation-reduction reactions
Oxidation number
The role of the electron in oxidation-reduction

Ionic and molecular species present in chemical systems: net ionic equations
Balancing of equations including those for redox reactions
Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

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AP REVIEW AND NEW UNIT V: Thermochemistry

Relate the fundamental aspects of the energy changes that accompany chemical reactions.

January

AP REVIEW UNIT VI: Gases
Investigate the laws and models that describe the properties and behaviors of gases;
Kinetic Molecular Theory
Laws of ideal gases
Equation of state for an ideal gas
Partial pressures
Kinetic-molecular theory
Interpretation of ideal gas laws on the basis of this theory
Avogadro's hypothesis and the mole concept
Dependence of kinetic energy of molecules on temperature
Deviations from ideal gas laws
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

AP NEW UNIT VIII: Kinetics

Measure, alter, and predict the rates of a chemical reaction.
Concept of rate of reaction
Use of differential rate laws to determine order of reaction and rate constant from experimental data
Effect of temperature change on rates
Energy of activation; the role of catalysts
The relationship between the rate-determining step and a mechanism

February

AP NEW UNIT IX: Chemical Equilibrium

Investigate the characteristics of chemical equilibrium; Le Chatelier's principle; equilibrium constant.
Concept of dynamic equilibrium, physical and chemical; Le Chatelier's principle; equilibrium constants
Quantitative treatment
Equilibrium constants for gaseous reactions: Kp, Kc
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

AP NEW UNIT X: Thermodynamics

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State functions; First Law; Second Law; Third Law; relationship of change in free energy to equilibrium constants.
State functions
First law: change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry
Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes
Relationship of change in free energy to equilibrium constants and electrode potentials
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

March

AP NEW UNIT XI: Electrochemistry

Apply the theoretical basis of oxidation-reduction reactions; electrolytic and galvanic cells; Faraday's Law; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions. Electrolytic and galvanic cells; Faraday's laws; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions

AP NEW UNIT XII: Complex Ions and Coordination Compounds

Describe the chemical properties of some of the transition metals with an emphasis on the nomenclature of complex ions and compounds.

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

April

AP NEW UNIT XIII: Nuclear Chemistry

Nuclear equations; half-lives; radioactivity; chemical applications.

AP NEW UNIT XIV: Acids and Bases

Acid-base reactions; concepts of Arrhenius, Bronsted-Lowry, and Lewis; amphoterism; pK; pH and pOH; common ion effect; buffers; hydrolysis.
Equilibrium constants for reactions in solution
Constants for acids and bases; pK; pH
Common ion effect; buffers; hydrolysis

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Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

May

AP NEW UNIT XV: Solubility Product and Complex Ion Equilibrium

Calculate the solubility product of a salt given its solubility and vice versa; predict the relative solubilities from K_{sp} values; explain the effect of pH and a common ion on the solubility of a salt.
Solubility product constants and their application to precipitation and the dissolution of slightly soluble compound

AP NEW UNIT XVI: Organic Chemistry

Become familiar with basic hydrocarbon chemistry, properties, and nomenclature.

June

Students will work on remaining lab assignments while synthesizing the course material and preparing for course final.

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

SUGGESTED LABS FOR USE DURING THE YEAR
SOLIDS & LIQUIDS: Molar Mass via Freezing Point Depression

Melting Point of an Organic Compound.
Qualitative Analysis: Anions.
Qualitative Analysis: Cations.
Determination of Electrochemical (Activity) Series.
ATOMIC THEORY PERIODICITY Analytical Gravimetric Determination
Determination of the Formula of a Compound.
Determination of the Percentage of Water in a Hydrate.
Determination of Mass and Mole Relationships in a Chemical Reaction.
Determination of Concentration by Oxidation-Reduction Titration.
Enthalpy of Neutralization.
Molar Volume of a Gas
Molar Mass Determination via Vapor Density
Determination of the Rate of a Chemical Reaction and its Order.
Determination of the Equilibrium Constant for a Chemical Reaction.

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Investigation of Voltaic Cells-The Nernst Equation.
Synthesis of a Coordination Compound and its Chemical Analysis (if time permits).
Investigation of a Buffer System.
Determination of K_a of a Weak Acid.
Determination of pH.
Determination of K_{sp} of a Salt.
Synthesis, Purification, and Analysis of Aspirin.
Preparation of an Ester.

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CURRICULUM MAPPING - September
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the major principles of the molecular theory? How do intermolecular forces relate to physical properties such as boiling point and vapor pressure? What is a phase diagrams and what do the terms triple point, critical temperature, and critical pressure represent? How do crystalline and amorphous solid compare? What effects solubility? What are electrolytes? How are molarity, molality, % composition and mol fraction calculated? What are colligative properties and how Are related problems solved? What are factors affecting and properties of solutions, suspensions and colloids?	***AP REVIEW UNIT VI: Solids and Liquids*** Kinetic Molecular Theory; Phase diagrams for one component systems; Changes of state Structure of solids Liquids and solids form the Kinetic-molecular viewpoint Phase diagrams of one-component systems Changes of state, Critical points Triple points Structure of solids; lattice energies ***AP REVIEW UNIT VII: Solutions and Their Properties*** Properties of solutions; Factors affecting solubility; Concentration; Colligative properties. Types of solutions Raoult's law Osmosis Non-ideal behavior (qualitative aspects)	State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to liquids and solids, as well as gases. Discuss intermolecular forces and relate them to physical properties such as boiling point and vapor pressure. Interpret heating curves as to melting point, boiling point, and specific heat. Interpret phase diagrams and correctly define terms such as triple point, critical temperature, and critical pressure. Discuss the phenomena of boiling, and be able to relate it to pressure. Distinguish between crystalline and amorphous solids. Define solution vocabulary. Discuss the effect that physical conditions have on solubility. Use the concepts of intermolecular forces in discussing the dissolving process and heat of solution. Separate compounds into electrolytes and non-electrolytes; separate electrolytes into ionic salts, acids, bases, acid anhydrides, and basic anhydrides. Solve problems involving molarity, molality, % composition, and mole fraction; to be able to convert between concentration designations. List the colligative properties and solve problems involving depression of freezing point, elevation of boiling point, lowering of vapor pressure, and increasing of osmotic pressure. Distinguish between an ideal and a non-ideal solution. Explain Brownian movement and the Tyndall Effect.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Lab: **SOLIDS & LIQUIDS** **Power Points Notes** **Over head notes** **Board Notes** **Homework**

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CURRICULUM MAPPING - October
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures? What are the parts of the atom? What are the difference between the past and present models of the atom? What principles dictate the configuration of the atom? What is the basis for the periodic law and how does it apply to periodic trends?	***AP REVIEW UNIT I: Chemical Fundamentals*** Significant Figures Measurement Metric Relationships Scientific Notation Dimensional Analysis Graphing Lab Safety Percent Error Lab Techniques ***AP REVIEW UNIT II: Atomic Structure and The Periodic Table*** Periodicity Modern atomic theory Atomic numbers Mass numbers Isotopes Energy levels, Quantum numbers Atomic orbitals. Evidence for the atomic theory Atomic mass Periodic relationships, Atomic radii, Ionization energies, Electron affinities, oxidation states Chemical reactivity Products of chemical reactions Relationships in the periodic table: Alkali metals Akaline earth metals,	Define terms such as matter, energy, element, compound, mixture, solution. Work comfortably with the metric system Work problems using dimensional analysis. Understand and work with the proper number of significant figures. Apply knowledge of significant figures to laboratory work. Correctly use an analytical balance, a vacuum flask, and Buchner funnel. Know the name and application of the common laboratory equipment used in this course. Identify the proper safety rules and procedures to be used in experimental situations. Name the major subatomic particles in an atom. List the types of radioactive emissions. Discuss the Bohr model of the atom, and compare it to the quantum mechanical model of the atom. Discuss the major differences in the classical mechanical model and the quantum mechanical model. Work problems involving quantum numbers and energies of electron transitions. Define and discuss the following terms or concepts: Heisenberg Uncertainty Principle, Pauli Exclusion Principle, wave-particle duality of matter, Wave function of electrons (Y), radial probability, density, orbitals, aufbau process, and Hund's rule. Know the shapes of the s, p, and d orbitals. Understand the basis for the periodic law, and apply it to periodic trends such as atomic radii, ionization energy, electron affinity, melting point, oxidation states, and electronegativity.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Lab: Melting Point of an Organic Compound. Qualitative Analysis: Anions. Qualitative Analysis: Cations. Lab: ATOMIC THEORY: Lab: PERIODICITY:

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	Halogens, Transition elements			

CURRICULUM MAPPING - November
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are Lewis structures? How do electronegativy trends help to predict bond type? How does VESPR theory help to predict molecular geometry? What are physical and chemical properties of substance using intra and intermolecular bonding?	***AP REVIEW UNIT III: Chemical Bonding*** Binding forces (ionic, covalent, metallic, network covalent, and Van der Waals) Relationships to states, structure and properties of matter; polarity of bonds; Electronegativities; Molecular models; Lewis structures; Valence Bond theory Hybridization Resonance, sigma and pi bonds; VSEPR; Molecular Orbital theory. Polarity of bonds, Geometry of molecules Ions, Structural isomerism of simple organic molecules and coordination complexes, dipole moments of molecules, relation of properties to structure	Draw Lewis structures for the common atoms, ions, and molecules. Use periodic trends of electronegativity to predict bond type. Distinguish between polar and non-polar molecules. Use electronegativity values and bonding concepts to determine oxidation states on atoms. Draw resonance structures and assign formal charges. Use the VSEPR model to predict molecular geometry. Use the hybridization theory to predict molecular geometry. Explain physical and chemical properties of substance using intra and intermolecular bonding. Draw and describe isomerism in organic and coordination complexes. .	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	generate graphs from experimental data Lab: Uncertainty Lab: Density of Liquid or Solid Demo: How to make a salad (heterogeneous) and iced tea (homogeneous) Soil vs. Salad vs. Solution compare and contrast Using MSDS labels to identify different chemical compounds and elements Demo: m & m mixtures (homogeneous/heterogeneous) Demo: Flirtation of sand and water

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CURRICULUM MAPPING - December
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
How are Chemical formulas written as word equations? How are limiting and excess reactants calculated? What is the difference between a state function	***AP REVIEW UNIT IV: Chemical Compounds,*** *Reactions and Stoichiometry* Quantities of materials reacted or produced in chemical reactions; mole concept empirical formulas; write formulas Name various inorganic compounds Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism Precipitation reactions Oxidation-reduction reactions Oxidation number Ionic and molecular species present in chemical systems: net ionic equations Balancing of equations including those for redox reactions Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants ***AP REVIEW AND NEW UNIT V: Thermochemistry***	Name the polyatomic ions, Name inorganic compounds, including acids, using the Stock system. Write formulas for inorganic compounds. Work problems involving mole concepts, molarity, percent composition, empirical formulas, and molecular formulas. Balance equations given both reactants and products Solve stoichiometric problems involving percent yield, and limiting reagents. Apply these concepts to the laboratory setting. Apply the periodic law to chemical reactivity in predicting reaction products. Discuss the activity series of the elements. Distinguish between metals and nonmetals. Classify compounds as to acids, bases, acid anhydrides, basic anhydrides, salts, and covalent molecules. Use the properties of metals and nonmetals to predict reaction products. Write chemical equations for synthesis, decomposition, single replacement, metathetical, redox, combustion, and acid-base reactions. Use the Periodic Table to predict common oxidation states. Use the Activity series of elements to predict single replacement reactions. List and define the meanings and common units for the common thermodynamic symbols. Learn the meaning of the following thermodynamic terms: enthalpy, exothermic, endothermic, system, surroundings, universe, and heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar enthalpy of formation, molar heat of	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Determination of the Formula of a Compound.** **Determination of the Percentage of Water in a Hydrate.** **Determination of Mass and Mole Relationships in a Chemical Reaction.** **Determination of Concentration by Oxidation-Reduction Titration.**

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and a path function? How is Hess' law used to solve entropy, enthalpy and free energy problems? What is specific heat and how is it calculated?	Relate the fundamental aspects of the energy changes that accompany chemical reactions.	combustion, entropy, absolute entropy, free energy. Distinguish between a state function and a path function. Define internal energy, PV work, enthalpy, entropy, and free energy. Use Hess's law to solve problems of energy, entropy, and free energy. Solve calorimetry problems involving specific heat.		

CURRICULUM MAPPING - January
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the basic principles of the kinetic theory? How do intermolecular forces and relate to physical properties such as boiling point and vapor pressure? What are the laws that explain the behavior of gases and how are they used in calculations?	***AP REVIEW UNIT VI:*** *Gases* Laws and models that describe the properties and behaviors of gases; Kinetic Molecular Theory Laws of ideal gases Equation of state for an ideal gas Partial pressures Kinetic-molecular theory Ideal gas laws Avogadro's hypothesis The mole concept Dependence of kinetic energy of molecules on temperature Deviations from ideal gas laws	State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to liquids and solids, as well as gases. Discuss intermolecular forces and relate them to physical properties such as boiling point and vapor pressure. Work problems using Dalton's Law. the Ideal Gas Law, and van der Waal's equation. State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to gases. Discuss the methods and units for measuring pressure; convert between units. Work problems using: Charles' law, Boyle's law, Gay-Lussac's Law, Avogadro's Law, Dalton's Law, the Ideal Gas Law, and van der Waal's equation.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Labs** **Molar Volume of a Gas** **Molar Mass Determination via Vapor Density** **Determination of the Rate of a Chemical Reaction and its Order**
What are the factors that influence the rate of a chemical reaction? How do zero, first, and second order reactions compare and contrast in terms of the plot needed to give a straight line, the relationship of the rate constant to the slope of the straight line, and the half-life of the reaction.	***AP NEW UNIT VIII: Kinetics*** Measure, alter, and predict the rates of a chemical reaction. Concept of rate of reaction Use of differential rate laws to determine order of reaction and rate constant from experimental data Effect of temperature change	List the factors that influence the rate of a chemical reaction. Use experimental data to determine the rate law, determine the order of the reaction, and to define proper units for the constant. Compare and contrast zero, first, and second order reactions in terms of the plot needed to give a straight line, the relationship of the rate constant to the slope of the straight line, and the half-life of the reaction. Use experimental data to postulate a reaction mechanism. Interpret how changing the conditions of the		

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What affects both the rate and the rate constant of the reaction. What is the role of a catalyst in the rate and mechanism of a reaction;	on rates Energy of activation; the role of catalysts The relationship between the rate-determining step and a mechanism	reaction (i.e. temperature, pressure, concentration, and addition of a catalyst) affects both the rate and the rate constant of the reaction. Discuss the role of a catalyst in the rate and mechanism of a reaction; distinguish between a homogeneous and a heterogeneous catalyst. Interpret data from a first order reaction to determine its half-life. Solve problems involving activation energy and the Arrhenius equation.		

CURRICULUM MAPPING - February
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the characteristics of chemical equilibrium? What is the meaning of equilibrium constant and quotient (Q) How does Le Chatelier's Principle predict the direction a system in equilibrium will shift in order to re-establish equilibrium? . What effect does a catalyst will not have on the equilibrium constant rule? What is the difference between a state function and a path function? What are some common thermodynamic symbols?	***AP NEW UNIT IX:*** Chemical Equilibrium; Le Chatelier's principle; Equilibrium constant. Concept of dynamic equilibrium, physical and chemical; Quantitative treatment Equilibrium constants for gaseous reactions: Kp, Kc ***AP NEW UNIT X: Thermodynamics*** State functions; First Law; Second Law; Third Law; relationship of change in free energy to equilibrium constants. Change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry Second law: entropy; free	Describe the meaning of physical and chemical equilibrium, and give real life examples of each. Write the law of mass action for any system at equilibrium. Understand the meaning of equilibrium constant and reaction quotient (Q). Interpret the position of equilibrium from the size of the equilibrium constant. Use Le Chatelier's Principle to predict the direction a system in equilibrium will shift in order to re-establish equilibrium. Know that temperature, pressure, and concentration will shift the position of equilibrium. Understand that a catalyst will not have an effect of the equilibrium constant. rule. List and define the meanings and common units for the common thermodynamic symbols. Learn the meaning of the following thermodynamic terms: enthalpy, exothermic, endothermic, system, surroundings, universe, and heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar enthalpy of formation, molar heat of combustion, entropy, absolute entropy, free energy. Distinguish between a state function and a path function. Define internal energy, PV work, enthalpy, entropy, and free energy. Use Hess's law to solve problems of energy, entropy,	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Determination of the Equilibrium Constant for a Chemical Reaction**.**

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What causes spontaneity in a reaction? What is the relationship between free energy change and equilibrium constants?	energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes Relationship of change in free energy to equilibrium constants and electrode potentials	and free energy. Define the terms exothermic & endothermic. Determine the spontaneity of a reaction. Discuss the laws of thermodynamics (in order). Understand the relationship between free energy change and equilibrium constants.		

CURRICULUM MAPPING - March
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
How is the the half-reaction method to balance redox equations ? How is electrolytic cell distinguished from a voltaic cell in terms of function, direction and ΔG. How is Faraday's law used in solving problems? How are reaction products predicted for both electrolytic and voltaic cells? How do you name and write formulas for coordination complexes?	***AP NEW UNIT XI: Electrochemistry*** Oxidation-reduction reactions; electrolytic and galvanic cells; Faraday's Law; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions. ***AP NEW UNIT XII: Complex Ions and Coordination Compounds*** Describe the chemical properties of some of the	Use the half-reaction method to balance redox equations. Define electrochemical terms: redox, anode, anion, cathode, cation, oxidizing agent, reducing agent, emf, electrode. Distinguish between an electrolytic cell and a voltaic cell in terms of function, direction and ΔG. Solve problems using Faraday's law. Predict reaction products for both electrolytic and voltaic cells. Use a table of Standard Reduction Potentials to compute cell voltages. Solve problems using the Nernst's equation. Diagram voltaic cells using proper notation. Establish the relationship between the free energy change, the cell potential, and the equilibrium constant. Discuss and give examples of dry cells, batteries and fuel cells. Define the following: central ion or atom, coordination sphere, coordination number, polydentate ligand, ligand, chelating agent, cis and trans isomers.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Investigation of Voltaic Cells-The Nernst Equation.** **Synthesis of a Coordination Compound and its Chemical Analysis**

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	transition metals with an emphasis on the nomenclature of complex ions and compounds.	Name and write formulas for coordination complexes.		

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CURRICULUM MAPPING - April
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	***AP NEW UNIT XIII: Nuclear Chemistry*** Nuclear equations; half-lives; radioactivity; chemical applications. ***AP NEW UNIT XIV: Acids and Bases*** Acid-base reactions; concepts of Arrhenius, Bronsted-Lowry, and Lewis; amphoterism; pK; pH and pOH; common ion effect; buffers; hydrolysis. Equilibrium constants for reactions in solution Constants for acids and bases; pK; pH Common ion effect; buffers; hydrolysis	1. Work problems involving nuclear binding energy. 2. Predict nuclear stability and mode of decay using N/Z ratio. 3. Work problems involving half-life. 4. Balance nuclear equations. Distinguish between the various modern theories of acids and bases. 2. Name and write formulas for normal salts, hydrogen salts, hydroxy salts, oxysalts and acids. 3. Perform a titration and solve for the appropriate concentration. 4. Use the concept of conjugate acid-base pairs to predict reaction products. 5. Define and give examples of amphiprotic species. 6. Identify weak electrolytes. 7. Write a law of mass action for any reaction in equilibrium. 8. Know and use the water constant, K_w. 9. Define pH, pOH, pK, K_a, K_b, ionization constant, percent ionization, K_{sp}. 10. Convert from $[H_3O^+]$ or $[OH^-]$ to pH or pOH. 11. Use a pH meter to determine a titration curve and an ionization constant. 12. Pick a suitable indicator for a titration. 13. Recognize salts that undergo hydrolysis and write a reaction for the ion with water. 14. Given the concentration and amount of weak acids or bases and an appropriate titrant, calculate	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Labs:** **Investigation of a Buffer System.** **Determination of K_a of a Weak Acid.** **Determination of pH.**

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CURRICULUM MAPPING - May
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	***AP NEW UNIT XV: Solubility Product and Complex Ion Equilibrium*** Calculate the solubility product of a salt given its solubility and vice versa; predict the relative solubilities from K_{sp} values; explain the effect of pH and a common ion on the solubility of a salt. Solubility product constants and their application to precipitation ***AP NEW UNIT XVI: Organic Chemistry*** Become familiar with basic hydrocarbon chemistry, properties, and nomenclature.	Write solubility product expressions for slightly soluble compounds. 2. Solve problems involving: (a) solubility product constants from solubility; (b) molar solubility from K_{sp}; (c) concentrations of substances necessary to produce a precipitate; (d) concentrations of ions involved in simultaneous equilibrium. Define the following: cis and trans isomers, alkane, alkene, alkyne, alcohol, aldehyde, ketone, carboxylic acid, ether, ester, ammine, aromatic. 2. Name and write formulas for major functional groups. 3. Name and draw structures of basic organic compounds.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Determination of K_{sp} of a Salt** **Synthesis, Purification, and Analysis of Aspirin.** **Preparation of an Ester.**

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CURRICULUM MAPPING - June
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	**Students will work on remaining lab assignments while synthesizing the course material and preparing for course final.**		Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	generate graphs from experimental data

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SUPPLEMENTAL UNIT CHEMISTRY

ACIDS AND BASES

ATLANTIC CITY HIGH SCHOOL

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Acids and Bases

VOCABULARY

1. **Buffer-a buffer is a solution containing a weak acid and its conjugate base or a weak base and its conjugate acid. Buffers resist changes in pH when acids or bases are added. The pH will still change, but much less than if it was plain water.**

2. **Electrolyte - a substance that forms ions in solution and can conduct electricity.**

3. **Non-electrolyte – a substance that does not form ions in solution and does not conduct electricity. (The particles stay together as molecules.)**

4. **Dissociation – is when an ionic substance is pulled apart by water molecules in solution. These ions are surrounded by water molecules and are called hydrated ions.**

$$Na_2SO_4\,(aq) \rightarrow 2Na^{+}\,(aq) + SO_4^{2-}\,(aq)$$

5. **Ionization – the formation of ions by the reaction between water and a molecular substance.**

$$CH_3COOH\,(aq) + H_2O\,(l) \leftrightarrow H_3O^{+}\,(aq) + CH_3COO^{-}\,(aq)$$

***Weak acids and bases – form only a few ions.**

6. **Salts-A salt is formed when an acid and a base are mixed and the acid releases H^+ ions while the base releases OH^- ions. This process is called hydrolysis. The pH of the salt depends on the strengths of the original acids and bases.**

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7. **pH scale – logarithmic scale from 0 to 14.**

***Acids have pH < 7 and bases have pH > 7, Neutral=7.**

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Acids and Bases	
• **Generate and evaluate scientific evidence and explanations.** • **Participate productively in scientific practices and discourse.** • **Distinguish among the different ways objects can move.**	**PROCESS SKILLS**
What distinguishes acids and bases from other substances? **How do we describe the relative strength of acids and bases?** **What is the composition of a buffer and how can a buffer be beneficial to our everyday lives?** **What are the similarities and differences between the 3 acid base theories?** **What makes one acid strong and another weak?** **What are the general products that form when an acid reacts with a base?** **What is the pH scale and how is it used to determine acidity or basicity?** **What is meant by neutralization?**	**ESSENTIAL QUESTIONS**
• **Acid/Base theory** • **pH and pOH calculations** • **Relative strength of Acids and Bases**	**CONTENT**
• **Calculate the pH of an acidic or basic solution** • **Determine the strength of an acid based upon its chemical formula** • **Distinguish between weak and strong electrolytes** • **Investigate concentrations of solutions** • **Identify the properties of acids and bases** • **Know and calculate the role of pH in solution chemistry**	**SKILLS (What the students will be able to do)**
Acid, Base, pH, pOH, buffer, titration, strong acid, weak acid, electrolytes, non-electrolytes	**Scientific Literacy**
5.2.12.A.6 : Relate the pH scale to the concentrations of various acids and bases. **5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.** **5.1.12.A.2: Develop and use mathematical, physical, and computational tools t o build evidence-based models and to pose theories.**	**NJ Standards**

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5.1.12.A.3 **Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.** **5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational rel ationships, and anomalous data.** **5.1.12.B.2: Build, refine, and represent evidence-based models using math-ematical, physical, and computational tools.** **5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.** **5.1.12.C.1: Reflect on and revise understandings as new evidence emerges.** **5.1.12.C.2: Use data representations and new models to revise predictions and explanations.** **5.1.12.C.3: Consider alternative theories to interpret and evaluate evidence-based arguments** **5.1.12.D.1: Engage in multiple forms of discussion in order to process, make se nse of, and learn from others' ideas, observations, and experiences.** **5.1.12.D.2: Represent ideas using literal representations, such as graphs, table s, journals, concept maps, and diagrams.** **5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.**	
Diagnostic Tests (pre and post) **Unit Assessment by Teacher** **Differentiated Strategies for Instruction/Assessment** **Laboratory/Demos** **Classroom worksheets** **Homework**	**Assessments**

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PROPERTIES OF ACIDS AND BASES

Acids:

1) Sour taste
2) React with most metals
3) Conducts electricity
4) Turns litmus paper from blue to red
5) Keeps phenolphthalein clear
6) Corrosive

Bases:

1) Bitter taste
2) Do not react with metals
3) Conducts electricity
4) Turns litmus paper from red to blue
5) Turns phenolphthalein pink
6) Feel slippery

****DO NOT TASTE CHEMICALS IN THE LABORATORY!!**

Common Acids:

Citrus fruits

Milk

Soda-pop

Vinegar

Tomatoes

pH < 7

Common Bases:

Antacids

Soaps and detergents

Baking soda

Drain cleaners

Window cleaners

pH > 7

*Neutral substances have a pH = 7

Example: distilled water

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DEFINITIONS OF ACIDS AND BASES

Three models of acids and bases:

l. Arrhenius Model

Basis for the model--action in water

Acids produce H^+ (or H_3O^+) ions when dissolved in water:

$$HCl\ (g) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$$

Bases produce OH^- ions when dissolved in water:

$$NH_3\ (g) + H_2O\ (l) \leftrightarrow NH_4^+\ (aq) + OH^-\ (aq)$$

(water splits into H^+ and OH^-)

Acids and bases are electrolytes because they form ions when they are dissolved in water.

When acids and bases neutralize each other they produce an ionic substance called salt.

$$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + HOH\ (l)$$

hydrochloric acid **sodium hydroxide** **salt** **water**

$$HNO_3\ (aq) + KOH\ (aq) \rightarrow KNO_3\ (aq) + HOH\ (l)$$

nitric acid **potassium hydroxide** **potassium nitrate** **water**

2. BRØNSTED-LOWRY

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Basis for the model-- proton transfer

Acids are substances that donate a proton (H^+) and bases are substances that accept a proton (H^+). Their definition allows for more substances to be considered acids and bases.

$$HCl\ (g) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$$

donates H^+	**accepts H^+**	**donates H^+**	**accepts H^+**
acid	***base***	***conjugate acid***	***conjugate base***

$$NH_3\ (g) + H_2O\ (l) \leftrightarrow NH_4^+\ (aq) + OH^-\ (aq)$$

donates H^+	**accepts H^+**	**donates H^+**	**accepts H^+**
acid	***base***	***conjugate acid***	***conjugate base***

Substances that can act both as an acid and a base, such as water (above examples), are called amphoteric.

3. Lewis Model

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Basis for model--electron pair transfer

- **acid definition: accepts a pair of electrons**

  Cations: (transition metal cations and metal cations with high, positive charge)

- **base definition: donates a pair of electrons**

  Anions that contain at least one unshared electron pair

Monoprotic and Polyprotic Acids

Consider the following acids:

HF CH_3COOH H_2SO_4

HF has only one H+ to ionize while CH_3COOH, H_2SO_4, have several hydrogen atoms to ionize.

The hydrogen(s) that will ionize must be bonded to electronegative elements by polar covalent bonds.

***In acetic acid (CH_3COOH), only the H bonded to the oxygen can ionize:**

$$CH_3COOH\ (aq) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + CH_3COO^-\ (aq)$$

***In H_2SO_4 two hydrogens can ionize. This happens in steps:**

$$H_2SO_4\ (aq) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + HSO_4^-\ (aq)$$

$$HSO_4^-\ (aq) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + SO_4^{2-}\ (aq)$$

Definitions of acidic, basic, and neutral solutions based on the hydrogen ion concentration,$[H^+]$, in units of mol/Liter.

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acidic: if $[H^+]$ is **greater** than 1×10^{-7} M

basic: if $[H^+]$ is **less** than 1×10^{-7} M

neutral: if $[H^+]$ if **equal** to 1×10^{-7} M

The relationship between $[H^+]$ and pH:

$$pH = -\log_{10}[H^+]$$

By convention, the definition of acidic, basic, and neutral solutions based on pH

acidic: if pH is less than 7
basic: if pH is greater than 7
neutral: if pH is equal to 7

***The $[H^+]$ can be calculated from the pH by taking the antilog of the negative pH**

***The smaller the negative exponent, the larger the number, pH is.**

***How can pH be determined experimentally? By using pH paper or a pH meter**

ACIDS, BASES, pH, and pOH

Ionization of water:

$$H_2O\ (l) \leftrightarrow H^+\ (aq) + OH^-\ (aq)$$

K_w = ion product constant for water **$K_w = [H^+]\ [OH^-]$**

At 25°C the $K_w = 1x10^{-14}$

K_w = [H+] [OH-]

x x

$1x10^{-14} = x^2$

$x = 1x10^{-7}$

This means both ions have a concentration of $1x10^{-7}$*M*.

If an acid is present then the $[H^+]$ increases and the $[OH^-]$ decreases to keep the ion product constant.

If a base is present then the $[H^+]$ decreases and the $[OH^-]$ increases to keep the ion product constant.

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pH relationships

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pH is from the French (pouvior hydrogen) or power of hydrogen.

pH is an easier way of expressing the $[H^+]$. Here are the mathematical relationships between pH and $[H^+]$.

pOH also exists and is used sometimes to express the $[OH^-]$

$$pH + pOH = 14.00$$

$$[H^+]\,[OH^-] = 1.0X10^{-14}$$

$$pH = -\log_{10}[H^+] \qquad pOH = -\log_{10}[OH^-]$$

$$[H^+] = 10^{-pH} \qquad [OH^-] = 10^{-pOH}$$

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Example:

If a solution has a pH of 2.4, what is the pOH, $[H^+]$, and $[OH^-]$?

$$2.4 + pOH = 14$$

$$pOH = 11.6$$

$$[H^+] = 10^{-2.4} \qquad [OH^-] = 10^{-11.6}$$

$$[H^+] = .00398M \qquad [OH^-] = 2.51 \times 10^{-12}\ M$$

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Strengths of acids and bases

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1. Strong Acids:

- ***completely*** **dissociate in water, forming H^+ and an anion.**

  example: $HN0_3$ dissociates completely in water to form H^+ and $N0_3^{1-}$.

  The reaction is

  $$HNO_{3(aq)} \rightarrow H^+_{(aq)} + N0_3^-{}_{(aq)}$$

  A 0.01 M solution of nitric acid contains 0.01 M of H^+ and 0.01 M $N0_3^-$ ions and almost no $HN0_3$ molecules. The pH of the solution would be 2.0.

- **There are only 6 strong acids: You <u>must</u> learn them. The remainder of the acids therefore are considered weak acids.**
  1. **HCl**
  2. **H_2SO_4**
  3. **HNO_3**
  4. **$HClO_4$**
  5. **HBr**
  6. **HI**

2. Weak acids:

- **a weak acid only *<u>partially</u>* dissociates in water to give H^+ and the anion**

  for example, HF dissociates in water to give H^+ and F^-. It is a weak acid. with a dissociation equation that is

  $$HF_{(aq)} \leftrightarrow H^+_{(aq)} + F^-_{(aq)}$$

- **Note the use of the double arrow with the weak acid. That is because an equilibrium exists between the dissociated ions and the undissociated molecule. In the case of a strong acid dissociating, only one arrow ($\rightarrow$) is required since the reaction goes virtually to completion.**
- **An equilibrium expression can be written for this system:**

  $$K_a = [H^+][F^-] / [HF]$$

- **Which are the weak acids? Anything that dissociates in water to produce H^+ and is not one of the 6 strong acids**

3. Strong Bases:

- **They dissociate 100% into the cation and OH^- (hydroxide ion).**

  example: $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

  a. 0.010 M NaOH solution will contain 0.010 M OH^- ions (as well as 0.010 M Na^+ ions) and have a pH of 12.

- **Which are the strong bases?**

  The hydroxides of Groups I and II.

- **Note: the hydroxides of Group II metals produce 2 mol of OH^- ions for every mole of base that dissociates. These hydroxides are not very soluble, but what amount that does dissolve completely dissociates into ions.**

  example: $Ba(OH)_{2(aq)} \rightarrow Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$

  A 0.000100 M $Ba(OH)_2$ solution will be 0.000200 M in OH^- ions (as well as 0.00100M in Ba^{2+} ions) and will have a pH of 10.3.

4. Weak Bases:

What compounds are considered to be weak bases?

1. **Most weak bases are anions of weak acids.**
2. **Weak bases do not furnish OH^- ions by dissociation. They react with water to furnish the OH^- ions.**

   Note that like weak acids, this reaction is shown to be at equilibrium, unlike the dissociation of a strong base which is shown to go to completion.

3. **When a weak base reacts with water the OH^- comes from the water and the remaining H^+ attaches itself to the weak base, giving a weak acid as one of the products. You may think of it as a two-step reaction similar to the hydrolysis of water by cations to give acid solutions.**

examples:

$NH_{3(aq)} + H_2O_{(aq)} \rightarrow NH_4^+{}_{(aq)} + OH^-(aq)$

methylamine: $CH_3NH_{2(aq)} + H_20_{(l)} \rightarrow CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$

acetate ion: $C_2H_3O_2^-{}_{(aq)} + H_2O(aq) \rightarrow HC_2H_30_{2(aq)} + OH^-{}_{(aq)}$

General reaction: weak base$_{(aq)}$ + $H_2O_{(aq)}$ → weak acid$_{(aq)}$ + $OH^-{}_{(aq)}$

Since the reaction does not go to completion relatively few OH- ions are formed.

The strength of an acid or base can be determined by the size of the acid constant (K_a) or the base constant (K_b). The K_a and K_b values include the K_{eq} and the concentration of water which is also constant.

A K_a or K_b value > 1 means a strong acid or base.

A K_a or K_b value < 1 means a weak acid or base.

1*M* HCl ionizes completely in water---it is a strong acid.

1*M* CH_3COOH only forms a few ions---it is a weak acid.

NH_3 (ammonia) is used to clean windows---it is a weak base.

NaOH is used in drain cleaners---it is a strong base.

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Acid-Base Reactions

When an acid and a base are placed together, they react to neutralize the acid and base properties, producing a salt. The H(+) cation of the acid combines with the OH(-) anion of the base to form water. The compound formed by the cation of the base and the anion of the acid is called a salt. The combination of hydrochloric acid and sodium hydroxide produces common table salt, NaCl:

$$\underset{\text{acid}}{HCl} + \underset{\text{base}}{NaOH} \rightarrow \underset{\text{water}}{H_2O} + \underset{\text{salt}}{NaCl}$$

The word salt is a general term which applies to the products of all such acid-base reactions.

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PRACTICE PROBLEMS

Acids, Bases, & Salts: Question 1 of 13

This question may require the use of the *Chemistry Reference Tables* or the *Periodic Table of Elements*.

Which formula represents a salt?

1. KOH
2. KCl
3. CH_3OH
4. CH_3COOH

Correct Answer Number: 2

Explanation: See Ref. Table K. CH_3COOH is an organic acid, acetic acid also called ethanoic acid. Choice 1 will yield the OH^- ion in solution (this compound is therefore a base, See Table L). Choice 3 is an alcohol, See Table R. Salts are ionic compounds that do not form OH^- or H^+ ions. KCl forms K^+ and Cl^- ions. Therefore it is a salt.

Acids, Bases, & Salts: Question 2 of 13

Which substance can be classified as an Arrhenius acid?

1. HCL
2. NaCl
3. LiOH
4. KOH

Correct Answer Number: 1

Explanation: By definition an Arrhenius acid yields hydrogen ions as the only positive ions in aqueous solution. Choice 2 is a salt. Choice 3 forms Li^+ and OH^- ions; choice 4 also forms OH^- ions: these compounds are Arrhenius bases. Choice 1 forms H^+ ions and is therefore an Arrhenius acid.

Acids, Bases, & Salts: Question 3 of 13

Which solution will change red litmus to blue?

1. HCl(aq)
2. NaCl(aq)
3. CH_3OH(aq)
4. NaOH(aq)

Correct Answer Number: 4

Explanation: Red litmus turns blue when a base is present. Hint: blue for base. Choice 1 is an acid; choice 2 is a salt and salts neutralize acids and bases. The litmus does not change color with salts. Choice 3 is an alcohol not a base. It is not found on Ref. Table L. NaOH is a strong base and will change red litmus to blue.

Acids, Bases, & Salts: Question 4 of 13

An acidic solution could have a pH of

1. 7
2. 10
3. 3
4. 14

Correct Answer Number: 3

Explanation: On the pH scale, a pH of less than 7 is acidic; a pH of more than 7 is basic. A neutral solution such as pure water has a pH of 7.

Acids, Bases, & Salts: Question 5 of 13

What is the pH of a 0.00001 molar HCl solution?

1. 1
2. 9
3. 5
4. 4

Correct Answer Number: 3

Explanation: By definition pH is the negative log (logarithm) of the hydronium ion concentration. A 0.00001 molar solution has a H^+ concentration of 10^{-5} M (move the decimal point 5 places to the right). The value of the negative exponent ($^{-5}$) gives a pH of 5.See also #7 and #19, this topic.

Acids, Bases, & Salts: Question 6 of 13

What is the pH of a solution with a hydronium ion concentration of 0.01 mole per liter?

1. 1
2. 2
3. 10
4. 14

Correct Answer Number: 2

Explanation: By definition pH is the negative log (logarithm) of the hydronium ion concentration. A 0.01 molar solution has a H^+ concentration of 10^{-2} (move the decimal point 2 places to the right). The value of the negative exponent ($^{-2}$) gives a pH of 2. See also #6 and #19, this topic.

Acids, Bases, & Salts: Question 7 of 13

There are alternate acid base theories that define an acid as any species that can

1. donate a proton
2. donate an electron
3. accept a proton
4. accept an electron

Correct Answer Number: 1

Explanation: According to Bronsted-Lowry theory, an acid is any species that can donate a proton to another species.

Acids, Bases, & Salts: Question 8 of 13

Which 0.1 M solution will turn phenolphthalein pink?

1. HBr(aq)
2. CO_2(aq)
3. LiOH(aq)
4. CH_3OH(aq)

Correct Answer Number: 3

Explanation: Different indicators change color at differing concentrations of hydrogen ions. Phenolphthalein turns pink in basic solutions that range from about 8.2 to 10 and colorless in acid solutions.(See Table M) Since the question wants it to turn pink, you are looking for a base.
Choice 4 is an alcohol: it is neutral in water. Locate choices 1 and 2 on Ref. Table K. Note that they are acidic in water. Group 1 elements of the Periodic Table (Li, Na and K) form strong bases when combined with hydroxide $(OH)^-$. When dissolved in water, LiOH makes a strongly basic solution.(Table L) It will turn phenolphthalein pink.

Acids, Bases, & Salts: Question 9 of 13

Given the equation: $H^+ + OH^- <-> H_2O$
Which type of reaction does the equation represent?

1. esterification
2. decomposition
3. hydrolysis
4. neutralization

Correct Answer Number: 4

Explanation: By definition neutralization occurs when equal quantities of an acid (H^+) react with equal quantities of a base (OH^-) to form water.

Acids, Bases, & Salts: Question 10 of 13

When HCl(aq) is exactly neutralized by NaOH(aq), the hydrogen ion concentration in the resulting mixture is

1. always less than the concentration of the hydroxide ions
2. always greater than the concentration of the hydroxide ions
3. always equal than the concentration of the hydroxide ions
4. sometimes greater and sometimes less than the concentration of the hydroxide ions

Correct Answer Number: 3

Explanation: Answer 4 is impossible. Neutralization means equivalent amounts of hydronium and hydroxide ions react in solution to produce water. Water has a pH of 7. By definition, only answer 3 is correct.

Acids, Bases, & Salts: Question 11 of 13

As the hydrogen ion concentration of an aqueous solution increases, the hydroxide ion concentration of this solution will

1. decrease
2. increase
3. remain the same

Correct Answer Number: 1

Explanation: (OH^-) multiplied by (H_3O^+) is a constant number equal to 1×10^{-14} for aqueous solutions. In other words, (A) (B) = -14. Substituting numbers, (-7) (2) = -14.
But if 7 is increased to 14, 2 must decrease to -1 to keep the answer -14. (14) (-1) =-14.
If (H_3O^+) increases, (OH^-) must decrease.

Acids, Bases, & Salts: Question 12 of 13

A student wishes to prepare approximately 100 milliliters of an aqueous solution of 6M HCl using 12 M HCl. Which procedure is correct?

1. adding 50 mL of 12 M HCl to 50 mL of water while stirring the mixture steadily.
2. adding 50 mL of 12 M HCl to 50 mL of water and then stirring the mixture steadily.
3. adding 50 mL of water to 50 mL of 12 M HCl while stirring the mixture steadily.
4. adding 50 mL of water to 50 mL of 12 M HCl and then stirring the mixture steadily.

Correct Answer Number: 1

Explanation: Safety Rule: always add acid to water; This prevents the acid from splattering.*Never add water to acid*. Place a glass stirring rod in the water and slowly pour the acid along the rod. Some concentrated acids like HCl have an exothermic reaction in water, releasing a large amount of heat and causing the water-acid solution to boil. Constant stirring diffuses the acid throughout the solution, helping to evenly distribute the generated heat.

Acids, Bases, & Salts: Question 13 of 13

The following data were collected at the endpoint of a titration performed to find the molarity of an HCl solution.

Volume of acid (HCl) used = 14.4 mL
Volume of base (NaOH) used = 22.4 mL
Molarity of standard base (NaOH) = 0.20 M

What is the molarity of the acid solution?

1. 1.6 M
2. 0.64 M
3. 0.31M
4. 0.13M

Correct Answer Number: 3

Explanation: Using the titration method, the volume of acid x the molarity of the acid neutralizes an equal volume of base x the molarity of the base. Or
V_{Acid} x M_{Acid} = V_{Base} x M_{Base} where V = volume and M = molarity of HCl and NaOH.
You are looking for the molarity of HCL or
(14.4 mL) (M of HCl) = (22.4 mL) (0.20M).
Rearranging terms, M of NaOH = (22.4 mL) (0.20 M) / 14.4 mL = 0.31 M.
See #12 , Acids and Bases. See also Reference Table T for formulas.

1. **I am pure water. When heated my pH (increases, decreases), because more of my water molecules dissociate.**
2. **I am a 0.020 M solution of weak acid, HA. If I only dissociate to the extent of 1.50%, what is the value of my Ka?**
3. **I am a 0.20 M solution of hydrocyanic acid, HCN, with a Ka of 4.93×10^{-10}. What is my pH?**
4. **I am a buffer made from 0.10 M acetic acid and 0.15 M sodium acetate. If the Ka for acetic acid is 1.77×10^{-5}, what is my pH?**
5. **I am a substance who turns blue litmus red, neutralizes bases, and tastes sour. What am I?**
6. **I am a species who turns red litmus blue, neutralizes acids, and tastes bitter. What am I?**
7. **I am a 0.020 M solution of a weak acid, HA, who dissociates to the extent of 3.5%. What is the value of my Ka?**
8. **I am a Bronsted-Lowry acid. Therefore, I am a _____donor.**
9. **I am a Bronsted-Lowry base. As a result, I am a proton _____.**
10. ***I am a bicarbonate ion, HCO_3^-. Because I can both donate and accept a proton under certain conditions, I am called a(n) _____ species.***

True and False

11. Water is neither an acid nor a base in the Arrhenius system.
12. The $[H^+]$ in pure water is normally 1.00×10^{-7}.
13. The reaction of an acid with a base to produce a salt and water is an endothermic reaction.
14. The larger the value of Ka, the stronger the acid.
15. The stronger an acid, the stronger its conjugate base.
16. The $[H^+]$ in pure water is normally 1.00×10^{-14}.
17. The strongest base that can exist in aqueous solutions is the OH^- ion.
18. A solution with a pH of 13 would be acidic.
19. A solution with a pOH of 12 would be basic.
20. The hydrogen ion concentration in a solution with a pH of 5.65 is ten times that of one with a pH of 6.65.

Choose the correct word

21. A(n) (Bronsted-Lowry, Lewis, Arrhenius) acid is an electron pair acceptor.
22. CH_3COOH, acetic acid, is a (weak, strong) acid.
23. C_2H_5OH is a(n) (acid, base, salt, alcohol).
24. The greater the degree of dissociation, the (stronger, weaker) the acid.
25. Acids, bases, and salts are (electrolytes, nonelectrolytes).
26. Neutralization is a (fast, slow) reaction.
27. The (Arrhenius, Bronsted-Lowry, Lewis, Usanovich) theory is the most conservative acid-base theory and also the oldest.
28. The aquated proton is often called the (hydronium, hydroxide) ion.

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29. A definition which applies a list of properties is called a(n) (conceptual, operational) definition.
30. A definition which gives a reason for a set of properties is called a(n) (conceptual, operational) definition.
31. CH_3COOH is a(n) (acid, base, salt).
32. NH_4Cl is a(n) (acid, base, salt).
33. The stronger the acid, the (weaker, stronger) the conjugate base.
34. pH values (can, cannot) go off the 0-14 scale of Sorenson.
35. Buffers maintain a(n) (definite, indefinite) pH.
36. A pH of 2 is (100, 10, 2) times (more, less) acidic than a pH of 4.

Answers

1) decreases	15) false	29) operational
2) 4.5×10^{-6}	16) false	30) conceptual
3) 5.00	17) true	31) acid
4) 4.92	18) false	32) salt
5) acid	19) false	33) weaker
6) base	20) true	34) can
7) 2.5×10^{-5}	21) Lewis	35) definite
8) proton	22) weak	36) 100, more
9) acceptor	23) alcohol	
10) amphiprotic	24) stronger	
11) true	25) electrolytes	
12) true	26) fast	
13) false	27) Arrhenius	
14) true	**28) hydronium**	

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REVIEW for Acid-Base Unit

1. _____ Solution *A* has a pH of 3 and solution *Z* has a pH of 6. How many times greater is the hydronium ion concentration in solution *A* than the hydronium ion concentration in solution *Z*?
(a) 100 (b) 2 (c) 3 (d) 1000

2. _____ An Arrhenius base yields which ion as the only negative ion in an aqueous solution?
(a) hydride ion (b) hydroxide ion (c) hydronium ion (d) hydrogen ion

3. _____ Which reactants form the salt CaSO4(s) in a neutralization reaction?

(a) H2S(g) and Ca(ClO4)2(s)
(b) H2SO3(aq) and Ca(NO3)2(aq)
(c) H2SO4(aq) and Ca(OH)2(aq)
(d) SO2(g) and CaO(s)

4. _____ A student tested a 0.1 M aqueous solution and made the following observations:
• conducts electricity
• turns blue litmus to red
• reacts with Zn(s) to produce gas bubbles
Which compound could be the solute in this solution?
(a) CH3OH (b) LiBr (c) HBr (d) LiOH

5. _____ What volume of 0.500 M HNO3(aq) must completely react to neutralize 100.0 milliliters of 0.100 M KOH(aq)?
(a) 10.0 mL (b) 20.0 mL (c) 50.0 mL (d) 500. mL

6. _____ Which compound is an Arrhenius acid?
(a) $HC2H_3O2$ (b) NaOH (c) KCl (d) NH3

7. _____ One acid-base theory states that an acid is
(a) an H^- donor (b) an H^+ donor (c) an H^- acceptor (d) an H^+ acceptor

8. _____ Which of these pH numbers indicates the strongest acid?
(a) 1 (b) 3 (c) 8 (d) 12

9. _____What color is methyl orange in a solution that has a pH of 5?
(a) red (b) orange (c) blue (d) yellow

10. _____Which pH change represents a hundredfold increase in the concentration of H_30^+?
(a) pH 3 to pH 2 (b) pH 7 to pH 9 (c) pH 5 to pH 3 (d) pH 13 to pH 14

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11. _____ The pH of a pond water is 9.0, after a spill of acid the pond is 1000 more acidic. What is the new pH of the pond?

(a) 12 (b) 6 (c) 7 (d) 5

12. _____ As pH decreases

(a) $[H^+]$ increases only (b) $[H^+]$ decreases only (c) $[OH^-]$ increases only

(d) $[H^+]$ increases and $[OH^-]$ decreases

13. _____ Which substance acts as an acid in the reverse reaction?

HI(g) + H2O(l) <--> H3O+(aq) + I-(aq)

(a) H_20 (b) I^- (c) H_3O^+ (d) HI

14. ___Given the reaction below, HNO2 + F- <--> HF + NO2

in the reverse reaction, HF is a/an

(a) acid by accepting H+ (b) base by accepting H+ (c) base by donating H+

(d) acid by donating H+

15. _____ In MaVa=MbVb, what is Mb?

(a) molarity of OH- (b) molarity of H+ (c) molarity of H- (d) molarity of O2

16. _____ What is the molarity of HCl(aq) if 25. milliliters of 8.0M NaOH(aq) neutralizes exactly 20. milliliters of HCl(aq)?

(a) 5M (b) 10M (c) 15M (d) 20M

17. _____ When NaOH and HCl react, what will be on the product side?

(a) only NaCl (b) only HOH (c) NaCl and HOH

(d) NaCl and Cl2

18. _____ At a pH of 7

(a) $[H^+]$ is greater that $[OH^-]$ (b) $[OH^-]$ is greater that $[H^+]$

(c) $[H^+]$ is equal to $[OH^-]$

19. _____ In the process of neutralization, an Arrhenius acid and an Arrhenius base react to form which of the following?

(a) Water only (b) Salt and Carbon dioxide

(c) Water and Carbon dioxide (d) Water and Salt

20. _____ Which of the following can conduct an electric current?

(a) Mg(OH)2(s) (b) H2O(s) (c) NaOH(aq) (d) NH4Cl(s)

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ADDITIONAL RESOURCES

http://www.bu.edu/gk12/billy/Lessons/handouts/AcidsBases.pdf

http://www.nclark.net/AcidsBases

http://content.lincolninteractive.com/I013sc/Unit%203/Lesson%2010/Chapter_8_Word_Wise_ans..pdf

SUGGESTED ACTIVITIES/LABS

http://www.veronaschools.org/cms/lib02/NJ01001379/Centricity/Domain/165/CHEM12_C1900_SWBT.pdf

http://net.mkcl.org/WebFiles/Acids%20bases%20and%20salts.pdf

http://sarisley.weebly.com/uploads/3/1/9/7/3197256/gpe704cr2.pdf

http://www.oakland.k12.mi.us/Portals/0/Learning/acidbase.pdf

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SUPPLEMENTAL UNIT
CHEMISTRY

OXIDATION AND REDUCTION (REDOX)

ATLANTIC CITY HIGH SCHOOL

Oxidation and Reduction

VOCABULARY

1. **Oxidation-reduction reactions**: **Reactions that involves the transfer of electrons between reactants.**

2. **Redox reactions**: **Another name for an oxidation-reduction reaction.**

3. **Oxidation**: **A process that involves complete or partial loss of electrons.**

4. **Reduction**: **A process that involves complete or partial gain of electrons.**

5. **Reducing agent**: **The substance in a redox reaction that donates electrons; in the reaction, the reducing agent is oxidized.**

6. **Oxidizing agent**: **The substance in a redox reaction that accepts electrons; in the reaction, the oxidizing agent is reduced.**

7. **Electrochemistry**: **A branch of chemistry that studies how chemical and electrical energy are converted.**

Oxidation and Reduction	
• **Generate and evaluate scientific evidence and explanations.** • **Participate productively in scientific practices and discourse.** • **Distinguish among the different ways objects can move.** • **Recognize that forces exist in the natural world that can influence the movement of objects.** • **Observe and understand the scientific process** • **Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another** • **Recognize that energy is needed to cause a physical or chemical change**	**PROCESS SKILLS**
How do we identify oxidation-reduction reactions? **What are REDOX reactions?** **What are oxidizers and reducers?** **How can a redox equation be balanced by applying the half-reaction method?** **What is the oxidation number for each element in a compound?** **What are the oxidizing and reducing agents in a chemical reaction?**	**ESSENTIAL QUESTIONS**
• **Reduction-oxidation reactions.** • **Oxidation numbers.** • **Electrons lost must equal electrons gained for any redox reaction.** • **If the electrons transferred in a redox reaction can be harnessed, then they can be used to do work.**	**CONTENT**
• **Balance reduction-oxidation reactions** • **Oxidizing and reducing agents** • **Describe the processes of oxidation and reduction.** • **Identify oxidizing and reducing agents.** • **Determine the oxidation number of an element in a compound.** • **Interpret redox reactions in terms of change in oxidation states.** • **Relate changes in oxidation number to the transfer of electrons.** • **Oxidation-reduction reactions involve electron transfer, the net release or net absorption of the energy can occur in the form of electrical energy rather than as heat.** • **Know that the branch of chemistry that deals with electricity-related application of oxidation-reduction reactions is called electrochemistry.** • **Interpret an activity series.** • **Describe applications of REDOX.** • **Balance REDOX**	**SKILLS (What the students will be able to do)**
oxidation number, oxidation reaction, reduction reaction, oxidizing agent, reducing agent, electrochemistry.	**Scientific Literacy**

5.2.12.B.2. Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel. **5.2.12.B.3 Balance chemical equations by applying the law of conservation of mass.** **5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.**	**NJ Standards**
Diagnostic Tests (pre and post) **Unit Assessment by Teacher** **Differentiated Strategies for Instruction/Assessment** **Laboratory/Demos** **Classroom worksheets** **Homework**	**Assessments**

INTRODUCTION

- **When black silver sulfide forms on your favorite piece of silver jewelry, a redox reaction has occurred.**
- **When rust forms on your Ford Mustang, a redox reaction has occurred.**
- **When you fuel your iPod using batteries, a redox reaction has occurred.**
- **Hydrogen peroxide on a wound**
- **Old fashioned film developing photography**
- **Chlorine bleach to whiten laundry**
- **Corrosion**
- **Decay**
- **When gasoline combusts with oxygen and fuels your car, a redox reaction has occurred.**
- **When the natural gas you use to heat your home during the winter reacts with oxygen gas, a redox reaction has occurred.**
- **The process of photosynthesis in plants that produces the air we breathe is a redox reaction.**

More often than not, redox reactions can be the culprit or the cure for many of the chemical reactions you observe in everyday life.

There are several types of chemical reactions: Synthesis, decomposition, single replacement, double-replacement, combustion and acid-base. Interestingly, most of these reactions (with the exception of double replacement and acid-base) are oxidation-reduction (redox) reactions. Redox reactions are classified by having both an oxidation reaction and a reduction reaction, and hence, an oxidizing agent and a reducing agent. This makes sense since as one reactant is losing electrons (being oxidized), the other is gaining electrons (being reduced). Oxidation numbers can be helpful in determining whether a reaction is redox or non-redox. When a change in oxidation number occurs in a reaction, with both an increase in number and a decrease in number, then the reaction is classified as redox. If this does not occur, then the reaction is non-redox.

GENERAL INFORMATION

Oxidation-reduction, or redox reactions are an important category of chemical reactions. Oxidation is losing electrons, and reduction is gaining electrons. Oxidation is considered to be any shift of electrons away from an atom. Reduction includes any shift of electrons toward an atom. An oxidation reaction is always accompanied by a reduction reaction. *In other words, oxidation and reduction always occur simultaneously*. The substance gaining oxygen is oxidized, while the substance losing oxygen is reduced. The substance that does the oxidizing (the oxidizing agent) is reduced. The substance that does the reducing (the reducing agent) is oxidized.

Redox reaction – a reaction in which electrons are transferred from one atom to another

Oxidation – loss of electrons from atoms of a substance

Example $Na \rightarrow Na^+ + e^-$

Sodium is oxidized

Reduction – gain of electrons by atoms of a substance

Example $Cl_2 + 2e^- \rightarrow 2Cl^-$

Chlorine is reduced

***Memory technique* LEO GER (Loss of Electrons is Oxidation, Gain of Electrons is Reduction) "LEO THE LION GOES GER"**

OXIDATION NUMBER

The oxidation number (or state) of an element indicates the number of electrons lost, gained, or shared as a result of chemical bonding.

The change in the oxidation number of a species lets you know if it has undergone oxidation or reduction.

Oxidation can be defined as "an increase in oxidation number".

In other words, if a species starts out at one oxidation state and ends up at a higher oxidation state it has undergone oxidation.

Conversely,

Reduction can be defined as "a decrease in oxidation number".

Any species whose oxidation number is lowered during the course of a reaction has undergone reduction.

Example:

$$Na + Cl_2 \text{ -----> } 2\ NaCl$$

- **The Na starts out with an oxidation number of zero (0) and ends up having an oxidation number of 1+. It has been oxidized from a sodium atom to a positive sodium ion.**

- **The Cl_2 also starts out with an oxidation number of zero (0), but it ends up with an oxidation number of 1-. It, therefore, has been reduced from chlorine atoms to negative chloride ions.**

The substance bringing about the oxidation of the sodium atoms is the chlorine, thus the chlorine is called an oxidizing agent. In other words, the oxidizing agent is being reduced (undergoing reduction).

The substance bringing about the reduction of the chlorine is the sodium, thus the sodium is called a reducing agent. Or in other words, the reducing agent is being oxidized (undergoing oxidation).

RULES FOR FINDING AN OXIDATION NUMBER

There are several rules for assigning the oxidation number to an element. Learning these rules will simplify the task of determining the oxidation state of an element, and thus, whether it has undergone oxidation or reduction.

1. **The oxidation number of an atom in the elemental state is zero.**
   <u>Example</u>: Cl_2 and Al both are 0
2. **The oxidation number of a monatomic ion is equal to its charge.**
   <u>Example</u>: In the compound NaCl, the sodium has an oxidation number of 1+ and the chlorine is 1-.
3. **The algebraic sum of the oxidation numbers in the formula of a compound is zero.**
   <u>Example</u>: the oxidation numbers in the NaCl above add up to 0
4. **The oxidation number of hydrogen in a compound is 1+, except when hydrogen forms compounds called hydrides with active metals, and then it is 1-.**
   <u>Examples</u>: H is 1+ in H_2O, but 1- in NaH (sodium hydride).
5. **The oxidation number of oxygen in a compound is 2-, except in peroxides when it is 1-, and when combined with fluorine. Then it is 2+.**
   <u>Example</u>: In H_2O the oxygen is 2-, in H_2O_2 it is 1-.
6. **The algebraic sum of the oxidation numbers in the formula for a polyatomic ion is equal to the charge on that ion.**
   <u>Example</u>: in the sulfate ion, SO_4^{2-}, the oxidation numbers of the sulfur and the oxygens add up to 2-. The oxygens are 2- each, and the sulfur is 6+.

Application Problems:

1. What is the oxidation number of chromium in

Na_2CrO_4

$Cr_2O_7^{2-}$

2. Given the unbalanced equation below:

$Cr_2O_{3(s)} + Al_{(s)} \longrightarrow Cr_{(s)} + Al_2O_{3(s)}$

a. identify the oxidation state of each element

b. identify the oxidizing agent

c. identify the reducing agent

BALANCING REDOX REACTIONS

Redox reactions often can be most easily balanced by

a. First dividing them into half-reactions; that is, the oxidation reaction and the reduction reaction.

$$Cr^{3+}_{(aq)} + Cl^{-}_{(aq)} \text{ ----> } Cr_{(s)} + Cl_{2(g)}$$

Oxidation: $Cl^{-}_{(aq)} \text{ ----> } Cl_{2(g)} + 2e^{-}$

Reduction: $Cr^{3+}_{(aq)} + 3e^{-} \text{ ----> } Cr_{(s)}$

b. Balance each half-reaction with respect to atoms first, then with respect to electrons.

Oxidation: $3(2Cl^{-}_{(aq)} \text{ ----> } Cl_{2(g)} + 2e^{-})$

Reduction: $2(Cr^{3+}_{(aq)} + 3e^{-} \text{ ----> } Cr_{(s)})$

Oxidation: $6Cl^{-}_{(aq)} \text{ ----> } 3Cl_{2(g)} + 6e^{-}$

Reduction: $2Cr^{3+}_{(aq)} + 6e^{-} \text{ ----> } 2Cr_{(s)}$

c. Add the two half-reactions together cancelling the electrons which are now equal on each side of the arrow.

Final Equation: $2Cr^{3+}_{(aq)} + 6Cl^{-}_{(aq)} \text{ -----> } 2Cr_{(s)} + 3Cl_{2(g)}$

Granted, this example is a simple one, however, the same basic procedure is carried out for most redox reactions, with the addition of a couple of other steps, depending on the reaction conditions.

Example: copper metal added to concentrated nitric acid

$$Cu_{(s)} + HNO_{3(aq)} \text{ -----> } Cu(NO_3)_{2(aq)} + NO_{2(g)}$$

a. First divide the equation into half-reactions (notice that the copper is going from a 0 oxidation state to 2+ which is oxidation, and some of the nitrogen is being reduced from 5+ in the nitrate ion to 4+ in the nitrogen dioxide).

Oxidation: $Cu_{(s)} \text{ -----> } Cu^{2+}_{(aq)} + 2e^{-}$

Reduction: $NO_3^{-}{}_{(aq)} + e^{-} \text{ -----> } NO_{2(g)}$

b. Balance each half-reaction with respect to atoms first, then with respect to electrons.

Oxidation: $Cu_{(s)}$ -----> $Cu^{2+}_{(aq)} + 2e^-$

Reduction: $2NO_3^-{}_{(aq)} + 2\ e^-$ -----> $2NO_{2(g)})$

Notice that this time there are oxygen atoms in the reduction step that are not balanced. When this happens, add as many water molecules on the right as are needed to balance the total oxygens on the left. Then add hydrogen ions on the left side of the arrow to balance the number of hydrogen atoms that were introduced with the water molecules.

Oxidation: $Cu_{(s)}$ -----> $Cu^{2+}_{(aq)} + 2e^-$

Reduction: $2NO_3^-{}_{(aq)} + 2\ e^- + 4H^{1+}_{(aq)}$ -----> $2NO_{2(g)}) + 2H_2O_{(l)}$

c. add the two half-reactions together cancelling the electrons which are now equal on each side of the arrow.

$$Cu_{(s)} + 2NO_3^-{}_{(aq)} + 4H^+_{(aq)} \text{ -----> } Cu^{2+}_{(aq)} + 2NO_{2(g)}) + 2H_2O_{(l)}$$

Note that this is a Net Ionic Equation for the reaction. The other two nitrate ions that would be with the four hydrogen ions in the nitric acid would remain unchanged and provide the nitrate ions that would form copper (II) nitrate.

PRACTICE WITH EXPLANATIONS

#1. $Mg_{(s)} + Cl_{2\ (g)} \rightarrow MgCl_{2\ (s)}$

In this reaction, Mg is oxidized and Cl is reduced. You may find it useful to use oxidation numbers to help you determine this. Mg changes from 0 to +2; Cl changes from 0 to -1.

When we write the half-reactions, we break apart compounds that contain either of the key elements (elements undergoing oxidation or reduction). Oxidation numbers are written as if they were ion charges. Notice that the chlorine from $MgCl_2$ is written as two separate ions, not combined as is Cl_2. Balance the two reactions for atoms.

$$Mg \rightarrow Mg^{+2} \qquad Cl_2 \rightarrow 2\ Cl^-$$

Next balance the equations for charge by adding electrons. Remember - one half-reaction will be an oxidation reaction (electrons on the product side) and the other will be reduction (electrons will be on the reactant side)

$$Mg \rightarrow Mg^{+2} + 2\ e^- \qquad Cl_2 + 2\ e^- \rightarrow 2\ Cl^-$$

oxidation **reduction**

In this example, balancing for charge results in both sides, of both equations, having net charges of 0. That won't always be the case. Be sure you see in this example how charges are balanced.

We then compare the two equations for numbers of electrons. We see that both equations have 2 electrons so we do not need to make any adjustments for that.

Finally, add the two equations together: $Mg + Cl_2 \rightarrow Mg^{+2} + 2\ Cl^-$

and reform any compounds broken apart in the earlier steps: $Mg + Cl_2 \rightarrow MgCl_2$

We see that the original equation was already balanced, not just for atoms but for electrons as well.

#2. $Cu_{(s)} + AgNO_{3\ (aq)} \rightarrow Cu(NO_3)_{2\ (aq)} + Ag_{(s)}$

Identify the elements undergoing oxidation (Cu) and reduction (Ag). The nitrate group (NO_3) is a spectator ion which we will not include in our half-reactions.

$$Cu \rightarrow Cu^{+2} + 2\ e^- \qquad Ag^+ + 1\ e^- \rightarrow Ag$$

oxidation **reduction**

After balancing for atoms and for charge, we see that the two equations do not have the same number of electrons - there are 2 in the copper reaction but only one in the silver reaction. Multiply everything in the silver reaction by 2, then we will add the equations together:

Step 1	Step 2	Step 3
Write the balanced half-reactions	**Balance electrons**	**Add half-reactions**
$Cu \rightarrow Cu^{+2} + 2\ e^-$		$Cu \rightarrow Cu^{+2} + \cancel{2\ e^-}$
$Ag + 1\ e^- \rightarrow Ag^-$	$\times 2$	$2\ Ag^+ + \cancel{2e^-} \rightarrow 2\ Ag$
Add equations together		$Cu + 2\ Ag^+ \rightarrow Cu^{+2} + 2\ Ag$
Reform compound/return spectator ions		$Cu + 2\ AgNO_3 \rightarrow Cu(NO_3)_2 + 2\ Ag$

#3. Here is a reaction occurring in an acid solution, which accounts for the presence of the H^+ ions. This example adds a little more complexity to our problem.

$$MnO_4^- + Fe^{2+} + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$$

In this example, spectator ions have already been removed. Even though hydrogen and oxygen do not undergo changes in oxidation number they are not spectators and we need to work with them in our half-reactions.

We determine that Mn undergoes reduction (+7 to +2) while Fe undergoes oxidation (+2 to +3). The iron half-reaction is straight forward, but the manganese reaction is more complex - we must include hydrogen and oxygen in its half-reaction:

$Fe^{2+} \rightarrow Fe^{+3} + 1e^-$	$MnO_4^- + 8\ H^+ + 5\ e^- \rightarrow Mn^{2+} + 4\ H_2O$
oxidation	**reduction**

To balance the manganese half-reaction - first balance for Mn and O atoms. Next balance the H atoms, and finally add enough electrons to balance the charge on both sides of the equation. Be sure you see what has been done so you can do it on your own.

Step 1	Step 2	Step 3
Write the balanced half-reactions		**Add half-reactions**
$Fe^{2+} \rightarrow Fe^{+3} + 1e^-$	× 5	$5Fe^{2+} \rightarrow 5Fe^{+3} + \cancel{5}e^-$
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$		$MnO_4^- + 8\ H^+ + \cancel{5}e^- \rightarrow Mn^{2+} + 4\ H_2O$
Add equations together		$MnO_4^- + 5\ Fe^{2+} + 8\ H^+ \rightarrow Mn^{2+} + 5\ Fe^{3+} + 4H_2O$

#4. $HNO_3 + Cu + H^+ \rightarrow NO_2 + Cu^{2+} + H_2O$

1. **Determine what is oxidized, what is reduced, and write the two balanced half-reactions (Step 1)**
2. **Balance for electrons lost = electrons gained (Step 2)**
3. **Add equations together**

Step 1	Step 2	Step 3
Write the balanced half-reactions		**Add half-reactions**
$Cu \rightarrow Cu^{+2} + 2e^-$		$Cu \rightarrow Cu^{+2} + \cancel{2e^-}$
$HNO_3 + H^+ + 1\ e^- \rightarrow NO_2 + H_2O$	$\times 2$	$2HNO_3 + 2H^+ + \cancel{2e^-} \rightarrow 2NO_2 + 2H_2O$
Add equations together		$2HNO_3 + Cu + 2H^+ \rightarrow 2NO_2 + Cu^{2+} + 2H_2O$

When balancing redox reactions, either the oxidation number method or the half-reaction method may be used. Often you'll find that one method works best for some equations, while the other method is more suited for other reactions. Or you may find one method just easier to use. The practice exercises and assignments tell you which method to use for a reaction, but as you get get more experience you'll be able to make your own decision as to which method to use.

REACTIVITY

It is possible to organize a group of similar chemicals that undergo either oxidation or reduction according to their relative reactivity. Oxidation (and reduction) is a competition for electrons. The oxidizing species (agents) remove electrons from other species and can force them to become reducing agents (releasers of electrons)

A good example of this competition for electrons is the behavior of metals. Metals always react by losing electrons (oxidation) they are then reducing agents. However if a metals is in competition with metal ions the more reactive metal can oblige the less reactive metal (in the form of ions) to accept electrons. This is called a displacement reaction.

Example: Zinc reacts with a solution containing copper ions.

The zinc metal is more reactive than copper metal and so it can force the copper metal ions to accept electrons and become metal atoms.

$$Zn(s) \rightleftharpoons Zn^{2+}_{(aq)} + 2e$$

$$Cu^{2+}_{(aq)} + 2e \rightleftharpoons Cu(s)$$

The zinc metal passes its electrons to the copper ions. We observe that the zinc develops a pink layer of copper on its surface and the blue copper ion solution fades in color.

We say that the zinc displaces the copper ions from solution.

Experimental observations

If we observe that there is a reaction between a metal and another metal ion in solution this tells us that the solid metal is more reactive than the metal of the dissolved metal ions.

- **Iron displaces copper from a solution of copper II sulfate**
- **Copper displaces silver from a solution of silver nitrate**

Given this information we can deduce that the most reactive of the three metals is iron, followed by copper, followed by silver. This allows us to arrange the metals into a reactivity series based on these specific reactions.

Reduction of metal oxides by metals

$$\text{metal A + metal B oxide} \longrightarrow \text{metal A oxide + metal B}$$

When a metal A is heated with a metal B oxide there will be a reaction if the free metal A is more reactive than the metal B of the metal B oxide. This is because the metal B in the metal B oxide is in the form of a metal ion - it has already lost electrons.

There is a competition between the metal ion (in the oxide) and the free metal for the electrons. The more reactive of the two metals will win the competition. Consequently if there is a reaction between a metal and a metal oxide then this tells us that the free metal is more reactive than the metal in the metal oxide.

Experimental observations

- **Magnesium reacts with zinc oxide:-** $Mg + CuO \longrightarrow MgO + Cu$
- **Sodium reacts with magnesium oxide:** $2Na + MgO \longrightarrow Na_2O + Mg$
- **Zinc reacts with copper oxide:-** $Zn + CuO \longrightarrow ZnO + Cu$

We can use this information to arrange the metals in order of reactivity

Sodium	**most reactive**
Magnesium	
Zinc	
Copper	**least reactive**

Sodium has the greatest electron releasing power (and conversely the copper ions - Cu^{2+} - would have the greatest electron attracting power)

Reactivity series involving non-metals

Metals react by losing electrons - they are reducing agents. Non-metals react by gaining electrons - they are oxidizing agents. In the same way that metals can be ordered in terms of reducing strength, the non-metals can be ordered in terms of their oxidizing strength. The halogens are a typical example of a non-metal reactivity series.

Reactivity of the halogens

Fluorine	**most reactive**
Chlorine	
Bromine	
Iodine	**least reactive**

Fluorine is so reactive that we cannot isolate it in the laboratory very easily, as it reacts with both water and glass. As a result we don't usually deal with fluorine at the high school level but compare only the other three (astatine is very rare and radioactive)

Do not confuse this order of reactivity with that of the metals - these are non-metals, their reactivity is in terms of oxidizing power - i.e. chlorine is the best oxidizing agent out of chlorine, bromine and iodine.

1. Chlorine will displace bromine from solutions containing bromide ions:

$$Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$$

In this reaction the chlorine is oxidizing the bromide ions by removing an electron from them. Bromine is liberated from the solution and may be detected by its orange/red color.

2. Bromine will displace iodine from solutions containing iodide ions:

$$Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$$

In this reaction the bromine is oxidizing the iodide ions by removing an electron from them. Iodine is liberated from the solution and may be detected by its orange/brown color which turns blue/black in the presence of starch indicator.

It is predictable, then, that chlorine will also displace iodine from a solution containing iodide ions.

ELECTROCHEMICAL CELLS AND OTHER APPLICATIONS

An important application of oxidation-reduction reactions is in electrochemical cells. (These types of cells should not be confused with biological cells. The word cell comes from *cella*, Latin for chamber or small room.)

In an electrochemical cell, the oxidation reaction is physically separated from the reduction reaction, and the electrons pass between the two reactions through a conductor.

Oxidation occurs at the anode and reduction occurs at the cathode.

Electrochemical cells can produce electricity or consume it.

Batteries and dry cells are commonly used electrochemical cells that produce electricity. The battery for your car is probably a 12 volt battery, made from a combination of six cells producing two volts each.

Cells that use electricity can be used to deposit metals onto surfaces in a process known as electroplating. Electroplating can be used to make jewelry, mirrors, and shiny surfaces resistant to abrasion, tarnishing and corrosion. Metal salts in a solution called the plating bath are reduced to metal at the cathode of the electro-chemical cell.

Oxidation-reduction reactions are widely used to produce chemicals that are used in manufacturing. The chemical that is produced in the most volume in the United States is sulfuric acid. It is made by oxidizing sulfur with oxygen to produce sulfur trioxide (SO_3). This is dissolved in water to give sulfuric acid, H_2SO_4.

Not all important oxidation-reduction reactions involve oxygen. A commonly produced chemical that does not contain oxygen is ammonia. To produce ammonia, NH_3, by an oxidation-reduction reaction, nitrogen and hydrogen are combined together under pressure at 932°F (500°C) with a catalyst. The nitrogen is oxidized and the hydrogen is reduced. The resulting ammonia can then be used to make fertilizers, dyes, explosives, cleaning solutions, and polymers.

Hydrogen acts as a reducing agent in many manufacturing processes. It can be used to make shortening from vegetable oils in a process known as hydrogenation. It can even reduce ions of metals such as silver and tungsten to pure metals.

Oxidation-reduction reactions are an important component of chemical analysis. Potassium permangante and cerium (IV) solutions can be used as strong oxidizing agents in the analysis of iron, tin, peroxide, vanadium, molybdenum, titanium, and uranium. Potassium dichromate is an oxidizing agent used in the analysis of organic materials in water and wastewater.

Oxidation-reduction reactions can be used for bleaching materials and sanitizing water. Sodium hypochlorite is used in solution as a liquid laundry bleach and as a solid component of dishwasher powders and cleansers. Calcium hypochlorite is often used for swimming pool sanitation. The hypochlorites kill bacteria in water by oxidizing them. Ozone is a powerful oxidizing agent that can also be used to purify water. The ozone destroys bacteria and organic pollutants. Water that has been sanitized by ozone is free of the unpleasant taste, smell, and byproducts associated with chlorinated water.

Metals are rarely found free in nature, but occur in ores. The metals are in their oxidized form in the ores and must be reduced to the metals (oxidation number zero) in order to be used. Some metals are easily reduced. For example, mercury can be produced from a mercury sulfide ore simply by heating it in air. Iron is produced from ore by heating with coke (impure carbon) and oxygen. The coke reduces the iron in the ore. Other metals are more difficult to reduce and are only obtained after electrons are pumped into their ores using electricity. Aluminum is such a metal. As long as oxygen is around, corrosion will act to reverse the reduction of the metals achieved in metallurgy. Metals that are most resistant to corrosion are those with high standard reduction potentials such as gold and platinum.

Oxidation-reduction reactions are responsible for food spoilage. The main source of oxidation is oxygen from the air. Preservatives that are added to foods are often reducing agents.

Oxidation reactions are important in many reactions that keep our bodies going. But oxidation has also been blamed for aging, cancer, hardening of the arteries, and rheumatoid arthritis. Research is being done to evaluate the benefits of antioxidants in foods and dietary supplements. Antioxidants are natural reducing agents such as fat soluble vitamin E and vitamin C (ascorbic acid). These substances might inhibit damaging byproducts of oxidation reactions that can occur in the human body after exposure to some toxic chemicals. One concern that scientists studying antioxidants have is that substances do not always act the same way in the human body that they do outside of it. For example, vitamin C is a reducing agent. If lemon juice is squirted on a cut apple, the vitamin C in the juice will prevent the browning of the apple that is caused by oxidation of the apple by the air. However, vitamin C might act as an oxidizing agent in the body.

The reaction can be harnessed as a source of energy. When hydrogen and oxygen are carefully fed into an electrochemical cell called a fuel cell, the oxidation-reduction reaction can be used to provide electrical power, for example, for space craft. The only byproduct of the reaction between hydrogen and oxygen is non-polluting water. Another application of the hydrogen/oxygen reaction is to use hydrogen combustion to power vehicles. Currently, hydrogen is produced from water using electricity and it takes more energy to make the hydrogen than is obtained from its combustion. In the future, hydrogen might be made using solar energy and would provide a non-polluting fuel.

The natural ability of algae and other water plants to oxidize harmful materials in sewage has been used in sewage lagoons, also known as oxidation pond systems. Small volumes of raw sewage can be treated simply by directing the sewage into shallow ponds containing algae and other water vegetation.

PRACTICE PROBLEMS

Oxidation-Reduction: Question 1 of 18

This question may require the use of the *Chemistry Reference Tables* or the *Periodic Table of Elements*.

A battery consists of which type of cells?

1. electrolytic
2. electrochemical
3. electroplating
4. electromagnetic

Correct Answer Number: 2

Explanation: Electrochemical cells do what their names suggests: they make electricity from chemicals stored in the cell by redox reactions. A battery is a great example of this. The chemicals are stored in the cell until you complete the connection (turn on the flashlight, boom box, or car). Choices 1 and 3 *use electricity* for electrolysis and plating metal on objects (gold and silver plating). Electromagnetic usually refers to electric and magnetic fields oscillating at right angles to each other.

Oxidation-Reduction: Question 2 of 18

Given the reaction: ZnO + X + heat -> Zn + XO

Which element, represented by X, is used industrially to reduce the ZnO to Zn?

1. Cu
2. C
3. SN
4. Pb

Correct Answer Number: 2

Explanation: Carbon is a readily available reducing agent widely used in industry. Hydrogen is another industrial reducing agent. Remember: carbon forms four covalent or shared bonds with other carbon atoms as well as many other kinds of atoms. It has an almost limitless ability to bond with other carbon atoms, making possible a very large number of compounds. These compounds are used in many reactions in nature and industry.

Oxidation-Reduction: Question 3 of 18

Given the lead-acid battery reaction:

$Pb + PbO_2 + H_2SO_4 \xrightarrow{\text{Discharge}} \underset{\text{Charge}}{\leftarrow} 2PbSO_4 + 2H_2O$

Which species is oxidized during battery discharge?

1. Pb
2. PbO_2
3. SO_4^{2-}
4. $2H_2O$

Correct Answer Number: 1

Explanation: At the anode Pb is oxidized to $PbSO_4$ and the oxidation number of Pb changes from 0 to +2. This happens when the battery is discharging.

Oxidation-Reduction: Question 4 of 18

Which type of reaction is occurring when a metal undergoes corrosion?

1. oxidation-reduction
2. neutralization
3. polymerization
4. saponification

Correct Answer Number: 1

Explanation: When certain metals combine with oxygen in the air, a metallic oxide results. Iron oxide is commonly called rust. Other metals such as copper also oxidize. (The Statue of Liberty in NY Harbor was not always green). The term oxidation-reduction is used to describe the addition-removal of oxygen. Oxidation is the process by which a substance loses one or more electrons.

Oxidation-Reduction: Question 5 of 18

Which substance functions as the electrolyte in an automobile battery?

1. PbO_2
2. $PbSO_4$
3. H_2SO_4
4. H_2O

Correct Answer Number: 3

Explanation: An electrolyte is a substance that releases ions in aqueous solutions. This makes it possible for electrolytes to conduct electricity in solutions. During discharge, the concentration of sulfuric acid (H_2SO_4) decreases as lead sulfate slowly forms on the plates.

Oxidation-Reduction: Question 6 of 18

Given the reaction for the nickel-cadmium battery:

$2NiOH + Cd + 2H_2O \rightarrow 2Ni(OH)_2 + Cd(OH)_2$

What species is oxidized during the discharge of the battery?

1. Ni^{3+}
2. Ni^{2+}
3. Cd
4. Cd^{2+}

Correct Answer Number: 3

Explanation: The NiCd battery is a rechargeable battery used in cordless appliances and tools. During discharge the Cd^o is oxidized to form Cd^{2+}. Cd loses 2 electrons to become positively charged. Remember in oxidation atoms lose (or seem to lose) electrons.

Oxidation-Reduction: Question 7 of 18

Given the redox reaction:

$2I^-(aq) + Br_2(l) \rightarrow 2Br^-(aq) + I_2(s)$

What occurs during this reaction?

1. The I^- ion is oxidized, and its oxidation number increases.
2. The I^- ion is oxidized, and its oxidation number decreases.
3. The I^- ion is reduced, and its oxidation number increases.
4. The I^- ion is reduced, and its oxidation number decreases.

Correct Answer Number: 1

Explanation: First, determine what happens to the I^- ion. On the left side of the equation, the I ion is negatively charged. On the right side of the equation, the I ion is neutral. The I ion lost its negative charge by losing an electron. By definition oxidation occurs when electrons are lost .The ion becomes more positive (has a higher oxidation state). Pretend electrons are dollars. If you lose a dollar, you have less money. If you find a dollar or are given one, you no longer have a negative cash flow. You can also look at the half reaction of the I^- ion:
$2I^-(aq) \rightarrow I_2(s) + 2\ e^-$:
each I^- ion loses an electron, increasing its oxidation number from -1 to 0.

Oxidation-Reduction: Question 8 of 18

Which half-reaction correctly represents reduction?

1. $Cr^{3+} + 3e^- \rightarrow Cr(s)$
2. $Cr^{3+} + \rightarrow Cr(s) + 3e^-$
3. $Cr(s) \rightarrow Cr^{3+} + 3e^-$
4. $Cr(s) + 3e^- \rightarrow Cr^{3+}$

Correct Answer Number: 1

Explanation: In reduction half reactions, the oxidation number is lowered because electrons are added. When Cr^{3+} gains electrons, the negative charge of the electron cancels out the positive charge and an uncharged Cr (Cr^o) atom results.

Oxidation-Reduction: Question 9 of 18

What is the oxidation number of carbon in $NaHCO_3$?

1. +6
2. +2
3. -4
4. +4

Correct Answer Number: 4

Explanation: In a compound, the sum of the oxidation numbers equals zero. The oxidation number of oxygen is always -2 unless it is a peroxide (oxidation number of -1) or when oxygen combines with fluorine. In O_3, O (-2) x 3 oxygen atoms = a charge of -6. Na is always +1. When H acts as a metal, the charge is +1.
+2 plus -6 results in a charge of -4. Therefore each carbon atom must have a charge of +4 to result in 0 charge.
(+1) plus (+1) plus (+4) = +6 and (-2)(3) = -6
or +6 plus -6 = 0

Oxidation-Reduction: Question 10 of 18

Which statement correctly describes a redox reaction?

1. The oxidation half-reaction and the reduction-half reaction occur simultaneously.
2. The oxidation half-reaction occurs before the reduction half reaction
3. The oxidation half-reaction occurs after the reduction half-reaction
4. The oxidation half-reaction occurs spontaneously but the reduction half-reaction does not

Correct Answer Number: 1

Explanation: Both reactions occur at the same time in a reduction reaction: as one atom losses the electron(s), another atom gains the electron(s).

Oxidation-Reduction: Question 11 of 18

Which quantities are conserved in all oxidation-reduction reactions?

1. charge, only
2. mass only
3. both charge and mass
4. neither charge and mass

Correct Answer Number: 3

Explanation: Matter can never be created or destroyed but it can change its form. Mass is always conserved in chemical reactions. Because the loss of electrons (by oxidation) must equal the gain of electrons (by reduction), charge must also be conserved. Only choice 3 includes conservation of charge and mass.

Oxidation-Reduction: Question 12 of 18

Given the reaction:

$2Li(s) + Cl_2(g) \rightarrow 2LiCl(s)$

As the reaction takes place, the $Cl_2(g)$ will

1. gain electrons
2. lose electrons
3. gain protons
4. lose protons.

Correct Answer Number: 1

Explanation: Eliminate choices 3 and 4 because only electrons are lost or gained in oxidation-reduction reactions. Write the half reaction for $Cl_2(g)$:

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(s)$

(In 2LiCl(s), Li has an oxidation number of +1. 2 times +1 = +2; therefore Cl must have an oxidation number of -2). Cl on the left side of the equation had an oxidation number of 0. It has to gain 2 electrons to have an oxidation of -2.

Oxidation-Reduction: Question 13 of 18

Given the balanced equation:

$2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2$

When 2 moles of Al(s) completely reacts, what is the total number of moles of electrons transferred from Al(s) to $H^+(aq)$?

1. 5
2. 6
3. 3
4. 4

Correct Answer Number: 2

Explanation: The left side of the equation shows $6H^+(aq)$ combines with 2 Al(s). Another way to view this is to look at the half reactions:

$2\ Al(s) \rightarrow 2Al^{3+}(aq) + 6\ e^-$

$6H_2 + 6\ e^- \rightarrow 3H_2$

Or 6 moles of e- are transferred from Al(s) to $H^+(aq)$.

Oxidation-Reduction: Question 14 of 18

Which statement best describes how a salt bridge maintains electrical neutrality in the half cells of an electrochemical cell?

1. It prevents the migration of electrons.
2. It permits the migration of ions.
3. It permits the two solutions to mix completely.
4. It prevents the reaction from occurring spontaneously.

Correct Answer Number: 2

Explanation: In oxidation-reduction reactions, ions need to migrate. A salt bridge is a U-shaped tube that acts as a *porous barrier* between two half cells. It prevents the solutions from mixing but allows the ions to move (migrate) from one half cell to the other. This keeps the half cells neutral. If the solutions mixed, neutrality would not be maintained in the half cells and the reaction would stop.

Oxidation-Reduction: Question 15 of 18

In what kind of cell are the redox reactions made to occur by an externally applied electrical current?

1. galvanic cell
2. chemical cell
3. electrochemical cell
4. electrolytic cell

Correct Answer Number: 4

Explanation: Galvanic cell, chemical cell and electrochemical cell describe the *same* thing: a cell that generates electricity spontaneously. Examples include flashlight and car batteries. Electrolytic cells are connected to external sources of electrical energy and are used for redox reactions that do not occur spontaneously.

Oxidation-Reduction: Question 16 of 18

Which atoms forms an ion that would migrate toward the cathode in a electrolytic cell?

1. F
2. I
3. Na
4. C

Correct Answer Number: 3

Explanation: Reduction occurs at the negative electrode (cathode) in an *electrolytic* cell. Only positive ions will migrate toward the cathode in this type of cell. Only Na always forms positive ions; F always forms negative ions; C and I can form positive or negative ions depending on the reaction.

Oxidation-Reduction: Question 17 of 18

Given the reaction:

__Mg + __Cr^{3+} -> __Mg^{2+} + __Cr

When the equation is correctly balanced using smallest whole numbers, the sum of the coefficients will be

1. 10
2. 7
3. 5

Correct Answer Number: 1

Explanation: Correctly balancing the equation requires several steps.
First write the half reactions:
Cr^{3+} + 3e- -> Cr and Mg -> Mg^{2+} + 2 e-
Remember electrons lost must equal electrons gained.
2 (Cr^{3+} + 3e- -> Cr) equals 6 e- gained; 3(Mg -> Mg^{2+} + 2 e-) equals 6 e- lost. >BR> Last step: add the half reactions and ignore the electrons:
3Mg + 2 Cr^{3+} -> 3Mg^{2+} + 2Cr
3 plus 2 plus 3 plus 2 = 10

Oxidation-Reduction: Question 18 of 18

When a substance is oxidized, it

1. loses protons
2. gains protons
3. acts as an oxidizing agent
4. acts as a reducing agent

Correct Answer Number: 4

Explanation: Eliminate choice 1 and 2 because electrons not protons are lost or gained in oxidation-reduction reactions. Oxidation is a loss of electrons and these electrons are gained by a second substance (reduction). The oxidized substance causes reduction to occur. In other words, it is the reducing agent.

ADDITIONAL RESOURCES

http://www.quia.com/jg/476236.html

http://www.unitedstreaming.com/studentCenter/index.cfm?cdCode=TD797-3D79

http://www.slideshare.net/guest53e1dff/redox-reactions-everyday-examples

http://preparatorychemistry.com/Bishop_Book_6_eBook.pdf

http://glencoe.mcgrawhill.com/sites/007874637x/student_view0/chapter19/section1/self_check_quizzes.html

SUGGESTED ACTIVITIES/LABS

http://www.oakland.k12.mi.us/Portals/0/Learning/Electrochemistry.pdf

http://lake-central.lcsc.us/userfiles/jackie-ruiz/ch20pracprobkey.pdf

http://www.ausetute.com.au/redox.html

http://www.nuffieldfoundation.org/practical-chemistry/redox-reactions

http://papers.xtremepapers.com/CIE/Cambridge%20International%20A%20and%20AS%20Level/Chemistry%20(9701)/9701_nos_ps_15.pdf

SUPPLEMENTAL UNIT CHEMISTRY

NUCLEAR CHEMISTRY

ATLANTIC CITY HIGH SCHOOL

NUCLEAR CHEMISTRY

VOCABULARY

1. **Absorber**
   Any material that stops ionizing radiation. Lead, concrete, and steel attenuate gamma rays. A thin sheet of paper or metal will stop or absorb alpha particles and most beta particles.

2. **Alpha particle (alpha radiation, alpha ray)**
   A positively charged particle (a Helium-4 nucleus) made up of two neutrons and two protons. It is the least penetrating of the three common forms of radiation, being stopped by a sheet of paper. It is not dangerous to living things unless the alpha-emitting substance is inhaled or ingested or comes into contact with the lens of the eye.

3. **Atom**
   A particle of matter indivisible by chemical means. It is the fundamental building block of elements.

4. **Atomic number**
   The number assigned to each element on the basis of the number of protons found in the element's nucleus.

5. **Atomic mass**
   Approximately the sum of the number of protons and neutrons found in the nucleus of an atom.

6. **Beta particle (beta radiation, beta ray)**
   An electron of either positive charge (ß+) or negative charge (ß-), which has been emitted by an atomic nucleus or neutron in the process of a transformation. Beta particles are more penetrating than alpha particles but less than gamma rays or x-rays.

7. **Curie (Ci)**
   The basic unit used to describe the intensity of radioactivity in a sample of material. One curie equals thirty-seven billion disintegrations per second, or approximately the radioactivity of one gram of radium.

8. **Daughter**
   A nucleus formed by the radioactive decay of a different (parent) nuclide.

9. **Decay (radioactive)**
   The change of one radioactive nuclide into a different nuclide by the spontaneous emission of alpha, beta, or gamma rays, or by electron capture. The end product is a less energetic, more stable nucleus. Each decay process has a definite half-life.

10. Density
That property of a substance which is expressed by the ratio of its mass to its volume.

11. Electromagnetic radiation
Radiation consisting of electric and magnetic waves that travel at the speed of light. Examples: light, radio waves, gamma rays, x-rays.

12. Electron
An elementary particle with a unit electrical charge and a mass 1/1837 that of the proton. Electrons surround the atom's positively charged nucleus and determine the atom's chemical properties.

13. Electron capture
A radioactive decay process in which an orbital electron is captured by and merges with the nucleus. The mass number is unchanged, but the atomic number is decreased by one.

14. Excited state
The state of an atom or nucleus when it possesses more than its normal energy. The excess energy is usually released eventually as a gamma ray.

15. Fission
The splitting of a heavy nucleus into two roughly equal parts (which are nuclei of lighter elements), accompanied by the release of a relatively large amount of energy in the form of kinetic energy of the two parts and in the form of emission of neutrons and gamma rays.

16. Gamma ray
A highly penetrating type of nuclear radiation, similar to x-radiation, except that it comes from within the nucleus of an atom, and, in general, has a shorter wavelength.

17. Geiger counter
A Geiger-Müller detector and measuring instrument. It contains a gas-filled tube which discharges electrically when ionizing radiation passes through it and a device that records the events.

18. Half-life
The time in which half the atoms of a particular radioactive nuclide disintegrate. The half-life is a characteristic property of each radioactive isotope.

19. Ion
An atomic particle that is electrically charged, either negative or positive.

20. Ionizing radiation
Radiation that is capable of producing ions either directly or indirectly.

21. Irradiate
To expose to some form of radiation.

22. Isotope
Isotopes of a given element have the same atomic number (same number of protons in their nuclei) but different atomic weights (different number of neutrons in their nuclei). Uranium-238 and uranium-235 are isotopes of uranium.

23. K-capture
The capture by an atom's nucleus of an orbital electron from the first K-shell surrounding the nucleus.

24. Neutrino
An electrically neutral particle with negligible mass. It is produced in many nuclear reactions such as in beta decay.

25. Neutron
One of the basic particles which make up an atom. A neutron and a proton have about the same weight, but the neutron has no electrical charge.

26. Nuclear reactor
A device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential components are fissionable fuel, moderator, shielding, control rods, and coolant.

27. Nucleon
A constituent of the nucleus; that is, a proton or a neutron.

28. Nucleus
The core of the atom, where most of its mass and all of its positive charge is concentrated. Except for hydrogen, it consists of protons and neutrons.

29. Nuclide
Any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic weight, atomic number, and energy state.

30. Parent
A radionuclide that decays to another nuclide which may be either radioactive or stable.

31. Photon
A quantity of electromagnetic energy. Photons have momentum but no mass or electrical charge.

32. Proton
One of the basic particles which makes up an atom. The proton is found in the nucleus and has a positive electrical charge equivalent to the negative charge of an electron and a mass similar to that of a neutron: a hydrogen nucleus.

33. Radioactive dating
A technique for estimating the age of an object by measuring the amounts of various radioisotopes in it.

34. Radioactive waste
Materials which are radioactive and for which there is no further use.

35. Radioactivity
The spontaneous decay of disintegration of an unstable atomic nucleus accompanied by the emission of radiation.

36. Radioisotope
A radioactive isotope. A common term for a radionuclide.

37. Radionuclide
A radioactive nuclide. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.

38. Scintillation counter
An instrument that detects and measures gamma radiation by counting the light flashes (scintillations) induced by the radiation.

39. Shielding
A protective barrier, usually a dense material, which reduces the passage of radiation from radioactive materials to the surroundings.

40. Source
A radioactive material that produces radiation for experimental or industrial use.

41. Spill
The accidental release of radioactive materials.

42. Stable
Non-radioactive.

43. Transmutation
The transformation of one element into another by a nuclear reaction.

Nuclear Chemistry	
• **Generate and evaluate scientific evidence and explanations.** • **Participate productively in scientific practices and discourse.** • **Distinguish among the different ways objects can move.**	**PROCESS SKILLS**
What makes something radioactive? **How is half- life determined?** **How do radioactive emissions occur?** **How is nuclear chemistry beneficial and harmful to our lives?** **How do chemical and nuclear reactions differ?** **How are alpha, beta, and gamma particles different?** **How does a nuclear power plant produce electricity?** **How are fission and fusion both able to generate energy?**	**ESSENTIAL QUESTIONS**
• **Natural vs. artificial radioactivity** • **Rate of radioactive decay and half-life calculations** • **Mass and energy relationships** • **Fission and fusion** • **How a nuclear power plant produces electricity** • **Radon and exposure to radiation** • **Nuclear Structure** • **Nuclear equations** • **Half-life**	**CONTENT**
• **Explain the role of the strong nuclear force in overcoming the repulsion between protons and neutrons in a nucleus.** • **Explain radioactivity as resulting from the instability of some isotopes of elements, either naturally occurring or formed in nuclear reactions.** • **Describe alpha, beta, and gamma radiation, and identify equations illustrating alpha, beta, and gamma radioactive decay, including any nuclear changes and products.** • **Differentiate the characteristics (e.g., penetrating ability) of alpha, beta, and gamma radiation, and explain consequences of exposure.** • **Calculate the amount of radioactive substance remaining after an integral number of half-lives have passed.** • **Consider problems involving nuclear binding energy.** • **Predict nuclear stability and mode of decay using N/Z ratio.** • **Assess problems involving half-life.** • **Differentiate various balanced nuclear equations.**	**SKILLS (What the students will be able to do)**
Radioactive decay and half-life, nuclear transformations, products of nuclear fission and fusion, nuclear energy, fission reactors, fusion research, effects of radiation	**Scientific Literacy**

5.2.12.A.4. Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes. **5.2.12.D.2. Describe the potential commercial applications of exothermic and endothermic reactions.** **5.2.12.D.3. Describe the products and potential applications of fission and fusion reactions.**	**NJ Standards**
Diagnostic Tests (pre and post) **Unit Assessment by Teacher** **Differentiated Strategies for Instruction/Assessment** **Laboratory/Demos** **Classroom worksheets** **Homework**	**Assessments**

THE NUCLEUS: TERMS AND NOTATION

Recall that the atom is an electrically neutral, spherical species that contains a positively charged nucleus surrounded by one or more negatively charged electrons. The electrons move rapidly around the nucleus and are held there in space by attraction with the positively charged nucleus. The nucleus takes up 1 ten-trillionth of the volume but makes up 99.97% of the atom's mass and is therefore incredibly dense. The atom's total diameter is about 10,000 times the diameter of the nucleus! The nucleus is composed of neutrons and protons. The protons are positively charged and the neutrons have no charge at all, they just contribute to the overall mass of the atom. The magnitude of the charge of a proton is equal to that of an electron, but the electron is negatively charged. An atom is neutral because the number of protons ALWAYS equals the number of electrons.

Protons and neutrons are collectively termed nucleons. Most elements exist in nature as a mixture of isotopes, which are species that are the same atom (they have the same number of protons and electrons if neutral!) but different numbers of neutrons. A complimentary term to the isotope is the nuclide, which represents the isotopes of an element. It refers to the variety of nuclei with a particular composition of nucleons (the differing numbers of protons and neutrons). Each isotope is a nuclide. This means that ^{16}O – which has 8 protons and 8 neutrons is a nuclide, and ^{17}O – which has 8 protons and 9 neutrons, is a nuclide of oxygen.

Recall that we can write the element or a particular isotope from the periodic table using a variety of notations.

Atomic Notation: 3 Types
A = Atomic Mass = protons + neutrons
Z = Atomic Number = protons
X = Atomic Symbol = the elements letter designation

Type 1 Nuclide	$^{A}_{Z}X$	$^{12}_{6}C$	**This type came first and gives the most information**
Type 2 Nuclide	^{A}X	^{12}C	**This type came second as the first type is redundant. You do not need to tell me carbon has an atomic number of 6, all carbons atomic numbers are 6.**
Type 3 Nuclide	**X – A**	**C -12**	**This type came last and is the easiest to type, and still relays all the info you need. This symbol is spoken, "carbon twelve."**

The same type of notation can and will be applied to the subatomic particles in the nucleus. Thus, a neutron that has a mass of 1 (due to the neutron itself) and a charge of zero will be written as $^{1}_{0}n$. A proton, that has a mass of 1 (due to the proton itself) and a charge of +1 will be written as $^{1}_{1}p$. And an electron, that has a mass of zero (due to the electron itself) and a charge of -1 will be written as $^{0}_{-1}e$.

$^{1}_{0}n$ **(neutron)** $^{1}_{1}p$ **(proton)** $^{0}_{-1}e$ **(electron)**

It is important to be very familiar with this notation, as we will use it in nuclear reactions. It is important to remember how to determine the numbers of protons, neutrons, and electrons in particular nuclides (or isotopes) in order to understand what type of nuclear reaction is taking place.

HISTORY

In 1896, Antoine-Henri Bacquerel discovered that uranium minerals emitted a penetrating radiation that produced images on photographic plates, even though the plates were covered with paper to prevent them from developing in the presence of light – but somehow, the radiation penetrated the paper and developed the plate! Several years later, Marie Curie began a search for other mineral that emitted radiation.

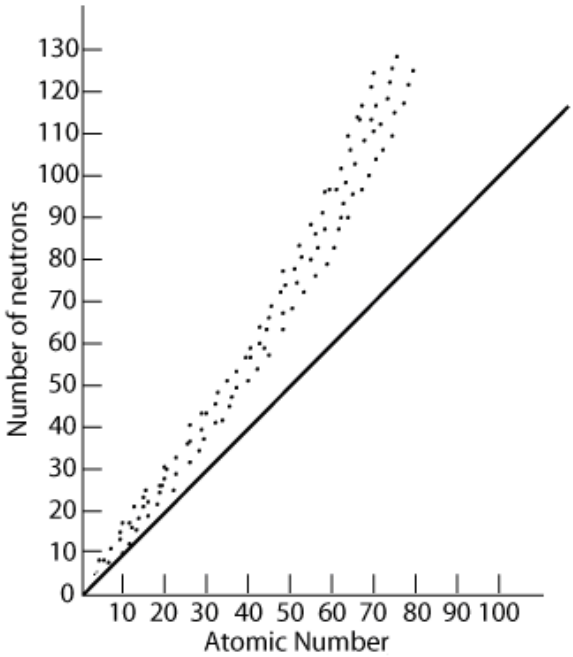
Marie Curie found that thorium minerals emit radiation. She also showed that the intensity of radiation depended on the concentration of the radioactive element in the mineral, not on the nature of the compound. Marie Curie and her husband, Pierre, through their examination of uranium minerals, discovered two other radioactive elements, one was named Polonium (after her native Poland), and the other was named Radium.

During the next few years, Bacquerel, the Curies, and Rutherford began to study the nature of radioactive emissions. Rutherford observed that elements other than radium were formed as radium decayed. In 1902, they proposed that radioactive emission results as an element changes from one element into another, completely different element. To many, at this time, this sounded like the revival of alchemy. And it was met with ridicule. Now, however, we know this to be true! Under most circumstances when a nuclide (isotope) of a one element decays, it changes into a nuclide (isotope) of a different element.

Their work led to an understanding of the three most common types of radioactive emission.

NUCLEAR STABILITY

A common way to tabulate the isotopes and their stability is to make a plot of the atomic number vs number of neutrons for each isotope. When done, a band of stable isotopes is observed. At low molecular weights this band lies along the line that shows a ratio of 1 neutron to 1 proton. As the atomic number increases more neutrons are needed to form a stable isotope and the band of stability curves upward.



The following statements can be made regarding the stability of these isotopes:

1. Only two stable isotopes have more protons than neutrons ($^{1}_{1}H$ and $^{3}_{2}He$).

2. All nuclides with ≥ 84 protons are unstable and will decay.

3. Light nuclides – isotopes with up 20 neutrons. These are stable when the neutron:proton ratio is 1:1.

4. Heavy nuclides – isotopes with more than 20 neutrons. These need to have a neutron:proton ratio of greater than 1:1.

5. Isotopes with the following numbers of protons tend to be stable: 2,8,20,28,50,82,126

6. Isotopes with an even number of protons and neutrons tend to be stable

What is the difference between radioactivity and radiation?

Radiation is the energy or particles that are released during radioactive decay. The radioactivity of a material refers to the rate at which it emits radiation.

The activity of a sample of radioactive material is determined by measuring the number of disintegrations per unit of time. A disintegration occurs each time a nucleus throws off particles or energy. Activity is measured in a unit called the Becquerel - 1 Becquerel is equivalent to 1 disintegration per second.

Is all nuclear radiation the same?

The radiation that emanates spontaneously from the nuclei of unstable isotopes (radionuclides) as the nuclei undergo radioactive decay is generally alpha-, beta-, or gamma-radiation. Similar radiations may be produced artificially in particle accelerators or x-ray generators. The naming is complicated as the radiations are often named according to their source, even when identical to similar radiations coming from other sources. For example, high-energy electromagnetic radiation (photons) coming from the atomic electrons are called x-rays whereas similar photons coming from inside the nucleus are called gamma-rays.

RADIOACTIVITY

Certain naturally occurring radioactive isotopes are unstable: Their nucleus breaks apart, undergoing nuclear decay. Sometimes the product of that nuclear decay is unstable itself and undergoes nuclear decay, too.

For example, when U-238 (one of the radioactive isotopes of uranium) initially decays, it produces Th-234, which decays to Pa-234. The decay continues until, finally, after a total of 14 steps, Pb-206 is produced. Pb-206 is stable, and the decay sequence, or series, stops.

The nucleus has positively charged protons shoved together in an extremely small volume of space. All those protons are repelling each other. The forces that normally hold the nucleus together sometimes can't do the job, and so the nucleus breaks apart, undergoing nuclear decay.

All elements with 84 or more protons are unstable; they eventually undergo decay. Other isotopes with fewer protons in their nucleus are also radioactive. The radioactivity corresponds to the neutron/proton ratio in the atom:

- **If the neutron/proton ratio is too high (there are too many neutrons or too few protons), the isotope is said to be *neutron rich* and is, therefore, unstable.**
- **If the neutron/proton ratio is too low (there are too few neutrons or too many protons), the isotope is unstable.**

The neutron/proton ratio for a certain element must fall within a certain range for the element to be stable. That's why some isotopes of an element are stable and others are radioactive.

There are three primary ways that naturally occurring radioactive isotopes decay:

- **Alpha particle emission**
- **Beta particle emission**
- **Gamma radiation emission**

In addition, there are a couple of less common types of radioactive decay:

- **Positron emission**
- **Electron capture**

Nuclear equations are typically written in the format that follows:

1. **Alpha decay follows the form:**

$$ {}^{X}_{Z}A \rightarrow \underbrace{{}^{4}_{2}He}_{\text{alpha particle}} + {}^{X-4}_{Z-2}B $$

Where A is the parent isotope (the atom being broken apart) B is the daughter isotope or the isotope formed. When an element is broken down in alpha decay it looses two neutrons and two (2) protons. This means that the name of the element will change as well, moving back two (2) places on the periodic table. Alpha decay is not very penetrating because the He atoms capture electrons before traveling very far. However it is very damaging because the alpha particles can knock atoms off of molecules. Alpha decay is the most common in elements with an atomic number greater than 83.

2. **Beta negative decay follows the form:**

$$ {}^{X}_{Z}A \rightarrow \underbrace{{}^{0}_{-1}e^{-1}}_{\text{beta particle}} + {}^{X}_{Z+1}B $$

The beta emission increases the atomic number by one (1) by adding one (1) proton. At the same time, one (1) neutron is lost so the mass of the daughter isotope is the same as the parent isotope. Beta negative decay is more penetrating than alpha decay because the particles are smaller, but less penetrating than gamma decay. Beta electrons can penetrate through about one (1) cm of flesh before they are brought to a halt because of electrostatic forces. Beta decay is most common in elements with a high neutron to proton ratio.

3. **Gamma decay follows the form:**

$$ {}^{X}_{Z}A \rightarrow \underbrace{{}^{0}_{0}\gamma}_{\text{gamma particle}} + {}^{X}_{Z}B $$

In gamma emission, neither the atomic number or the mass number is changed. A high energy gamma ray is given off when the parent isotope falls

into a lower energy state. Gamma radiation is the most penetrating of all. These photons can pass through the body and cause damage by ionizing all the molecules in their way.

4. **Positron emission (also called Beta positive decay) follows the form:**

$$ {}^{X}_{Z}A \rightarrow {}^{0}_{1}e + {}^{X}_{Z-1}B $$

positron particle

In this reaction a positron is emitted. A positron is exactly like an electron in mass and charge force except with a positive charge. It is formed when a proton breaks into a neutron with mass and neutral charge and this positron with no mass and the positive charge. Positron emission is most common in lighter elements with a low neutron to proton ratio.

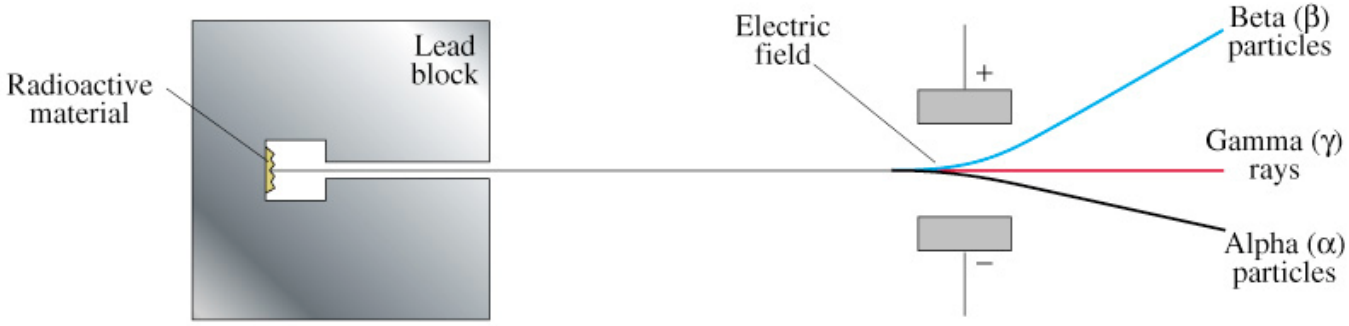
5. **Electron capture follows the form:**

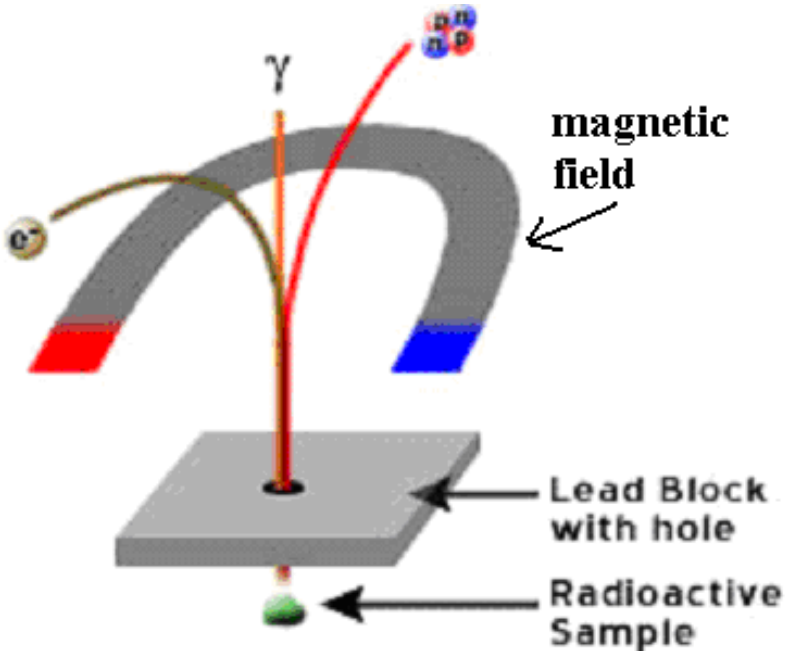
$$ {}^{X}_{Z}A + {}^{0}_{-1}e \rightarrow {}^{X}_{Z-1}B $$

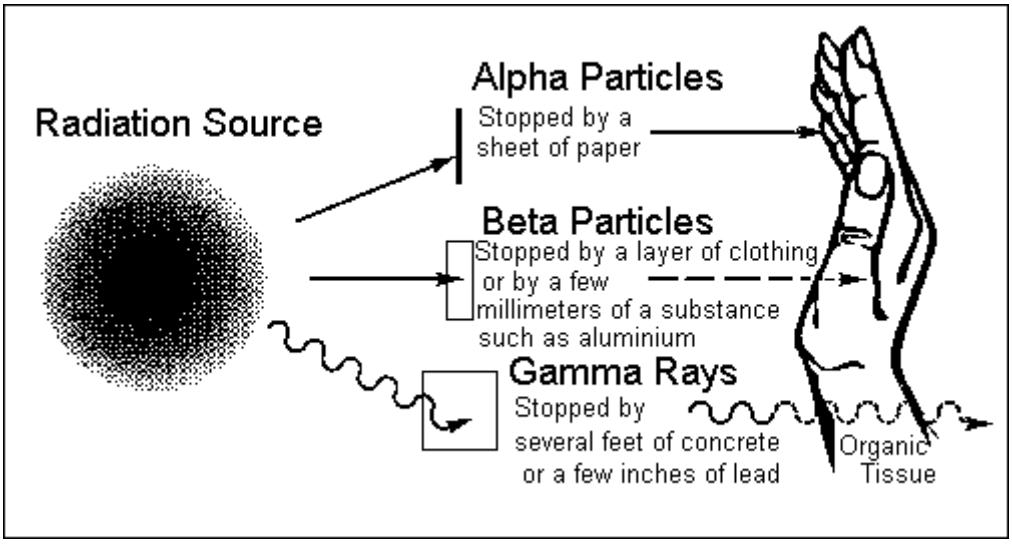
electron particle

In this reaction a nucleus captures one (1) of its own atom's inner shell electrons which reduces the atomic number by one. This captured electron joins with a proton in the nucleus to form a neutron. Electron capture is common in larger elements with a low neutron to proton ratio.

The three types of products that are emitted behave very differently in the presence of an electric field. Alpha particles are positively charged and thus bend towards the negative plate. Beta particles are negatively charged and thus bend towards the positive plate. Gamma rays have no charge and are thus not affected by the charged plates. The degree of "bending" is related to the mass of the particle. Alpha particles are heavier than beta particles and thus are less easily moved in space.


Radioactive material
Lead block
Electric field
+
−
Beta (β) particles
Gamma (γ) rays
Alpha (α) particles

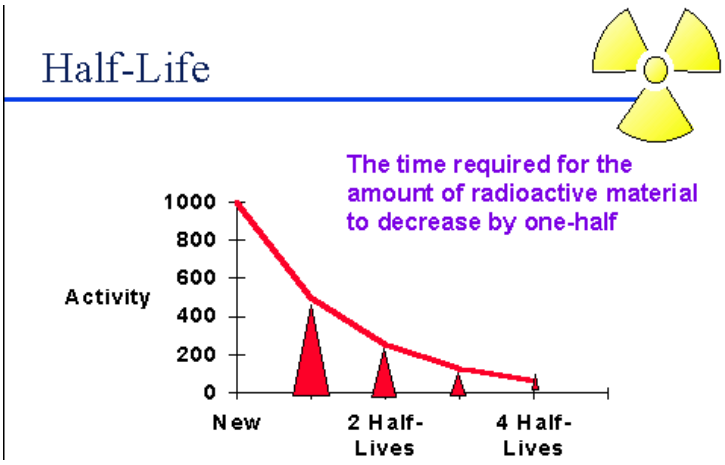

γ
magnetic field
Lead Block with hole
Radioactive Sample



HALF LIFE

The time required for half of the atoms in any given quantity of a radioactive isotope to decay is the half-life of that isotope. Each particular isotope has its own half-life.

$t_{1/2}$ is the symbol of half-life



The rate of disintegration of a nuclear isotope is constant. It is unaffected by external influences such as heat, pressure, or chemical reactions. This rate is also independent of the number of atoms, which are present. Thus, it is stated in terms of the fraction of the sample, which will decay in a certain time

period. The time required for exactly half of the radioactive atoms in a given sample to decay is convenient to use, and is called the half – life.

The relationship between the half-life of a radioactive substance and k, the rate at which it decays can also be found.

$$t_{1/2} = \frac{.693}{k}$$

CHEMICAL REACTIONS vs. NUCLEAR REACTIONS

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken.	Occur when nuclei emit particles and/or rays.
Atoms remain unchanged, though they may be rearranged.	Atoms often converted into atoms of another element.
Involve ONLY valence electrons.	May involve protons, neutrons and electrons.
Associated with small energy changes.	Associated with large energy changes.
Reaction rate influenced by T, particle size, concentration and catalysts.	Reaction rate is NOT normally influenced by T, P and catalysts.

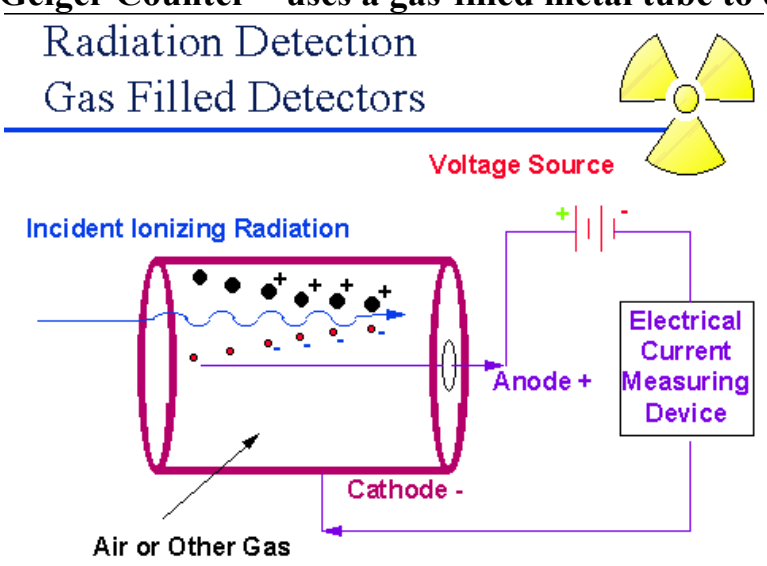
NUCLEAR ENERGY: FISSION AND FUSION

Fission: A heavier nucleus can split into lighter ones. This means that a species with too many nucleons will now split into to nuclei that have less nucleons. The product nuclei will have a greater binding energy per nucleon and thus be more stable. Energy will be released as the product is more stable (at a lower energy state) than the reactant. Nuclear power plants use fission as do atomic bombs.

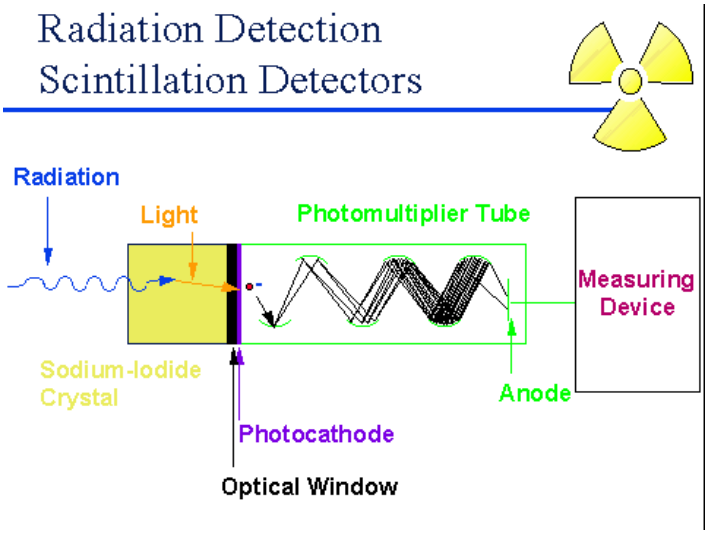
Fusion: A lighter nucleus needs to gain more nucleons. It can do so by combining with other nuclei. Again the product is more stable than the reactant, so it is at a lower energy state and that energy is released. The sun and stars generate energy through fusion as do hydrogen bombs. Current research is focusing on the fusion of hydrogen nuclei to form a stable helium nucleus as a useful source of energy.

DETECTION

1. **Geiger Counter – uses a gas-filled metal tube to detect radiation**



2. **Scintillation Counter – uses a phosphor to detect radiation**



3. **Film Badge – consists of several layers of phosphoric film covered with black lightproof paper encased in a plastic or metal holder**

HEALTH CONCERNS

One of the major concerns related to nuclear chemistry is the health effect of radiation exposure. Excessive exposure to radiation has been linked to increased rates of various cancers.

Alpha, beta, and gamma are all considered "ionizing radiation". That means that when those particles enter the human body there is a high probability they will interact with molecules in the body and ionize them. As more ions form, there is increased risk for damage to the DNA. When a cell's DNA is damaged, the cell may repair itself, the cell may die, or the cell may become cancerous.

Other types of electromagnetic energy, such as radio and microwaves, are non-ionizing. While their long-term effects are still being studied, they are generally considered safer.

To reduce the risks associated with radioactive isotopes, three important variables can be controlled:

- **<u>shielding</u>: appropriate shielding can be placed between the isotopes and people. Alpha particles can be blocked by cardboard or by thick clothing. Beta particles can be blocked by concrete blocks or sheets of metal**

  Gamma rays require thick shielding of lead blocks, or thick concrete walls

- **<u>distance</u>: radioactive materials can be stored at a distance from people**
- **<u>time</u>: store radioactive isotopes in a safe location until they have decayed to safer isotopes.**

Acute Dose-Response Effects in Humans:

Dose (mrem)	Effect
10,000,000	Immediate prostration, coma, followed by death within 1 or 2 days from severe central nervous system damage.
1,000,000	Immediate nausea, vomiting, diarrhea. Death within 1 or 2 weeks from blistering of small intestine. Complications from depressed bone marrow activity.
100,000	No overt effects. Some depression of white cell count. Statistical increase in probability of radiogenic leukemia and life shortening (1 to 5 days/rem).
10,000	Effects are difficult to measure. In early embryo, developmental defects are possible. Subtle abnormalities of brain structure and perhaps also function may occur above 10 rem.
1,000	No measurable effects except a statistical increase of tumor incidence before age of 10 in infants exposed in-utero.

RADIOACTIVE DATING

Radioactive dating uses half-lives to determine how long something has been around. All objects take in radioactive materials over the course of their lives. When they die they stop taking in these radioactive materials. The radioactive materials decay over time. If you know how much of a particular radioactive material is in a live organism you have the N_o value. You can use a detector to determine the amount of this radioactive material in the dead organism, which give you N. If you know the half-life you can calculate how long the organism has been dead. C-14 dating is most famous isotopes used for dating but it has limitations. The accuracy of half-life dating is very poor after the isotope has undergone 5 half-life cycles. So, C-14 with a half-life of 5730 years is not very accurate after 40,000 years. Potassium-40 is used to date farther back in history. K-40 has a half-life of 1.28×10^9 years this allows scientist to date much older objects, meteors, dinosaurs, crater, etc.

A table of useful isotopic decays follows.

System	Material	Half-life/years	Age range/years
C-14	organic remains	5730	200 - 50,000
U-238 to Pb-206 ratio	Minerals	4510 million	10-4500 million
U-235 to Pb-207 ratio	Minerals	704 million	10-4500 million
Rb-87 to Sr-87 ratio	Minerals	48,800 million	60-4500 million
K-40 to Ar-40 ratio	Minerals	1250 million	0.1-3000 million
Sm-147 to Nd-143 ratio	Minerals	110,000 million	1000-4500 million

MEDICAL APPLICATIONS

Radioactive tracers are used to make a part of the body temporarily opaque to radioactivity to check for a problem, like a leak in your digestive system, or to check if an organ has increased in size. The isotopes absorb the radiation and do not allow it to reach the x-ray film or detector.

X-rays can diagnose bone breaks and the CAT scan or CT (computed tomography scanning,) which is many x-rays taken with a computer used to generate an image, can diagnose internal injuries.

Radiation therapy for cancer victims is another important use of radiation. Directing gamma radiation at tumor can kill the tumor. This is sometimes the only hope for those persons with a tumor in an inoperable location, i.e. the brain.

As a side note, MRI, magnetic resonance imaging, is a big improvement over x-rays in diagnosing problems in soft tissue, muscles, organs, tendons and the like. X-rays don't show soft tissue well MRI does, the damage tissue is affected differently than healthy tissue, all based on charges, but on the computer screen it shows up as a different color.

NUCLEAR REACTORS

Nuclear reactors are not the most popular source of power in this country. There are many people who wish these power plant would be shut down. They have good reasons and bad reasons for shutting them down. One good reason is that we don't have a truly viable method for disposal of reactor fuel once it has been used. This material is called spent fuel. One bad reason is the fear of the plant becoming unstable and causing a nuclear explosion. The fuel used in a nuclear reactor is not concentrated enough for an explosion, like that in an atomic bomb, to occur.

You may be asking yourself with all the controversy why build them at all. Well, we are an electric society. All methods for producing electricity will be developed in some capacity. A tidal power plant was built in the US many years ago, at great taxpayer expense, unfortunately it failed miserably. The flow of the water in tides is just too slow to produce electricity.

Speaking of electricity, how is it generated. To produce voltage, you need 3 things. A magnetic field, a current carrying conductor (a wire) and relative motion between the two. By relative motion between the two it is meant that either the wire or the magnetic field must move so that the magnetic lines of flex cut across the wire. So, if a wire is waved it back and forth between a magnet a voltage will be generated. Seems simple enough, why build a nuclear reactor or build a dam if all that is need is to move wire? Well the wire used in electric power plants is actually a very long wire wrapped thousands of times around an axle, then large magnets are placed around the wire. The problem is how do we now spin this axle? With this amount of wire the axle can weigh quite a lot. By a lot, this means hundreds of tons.

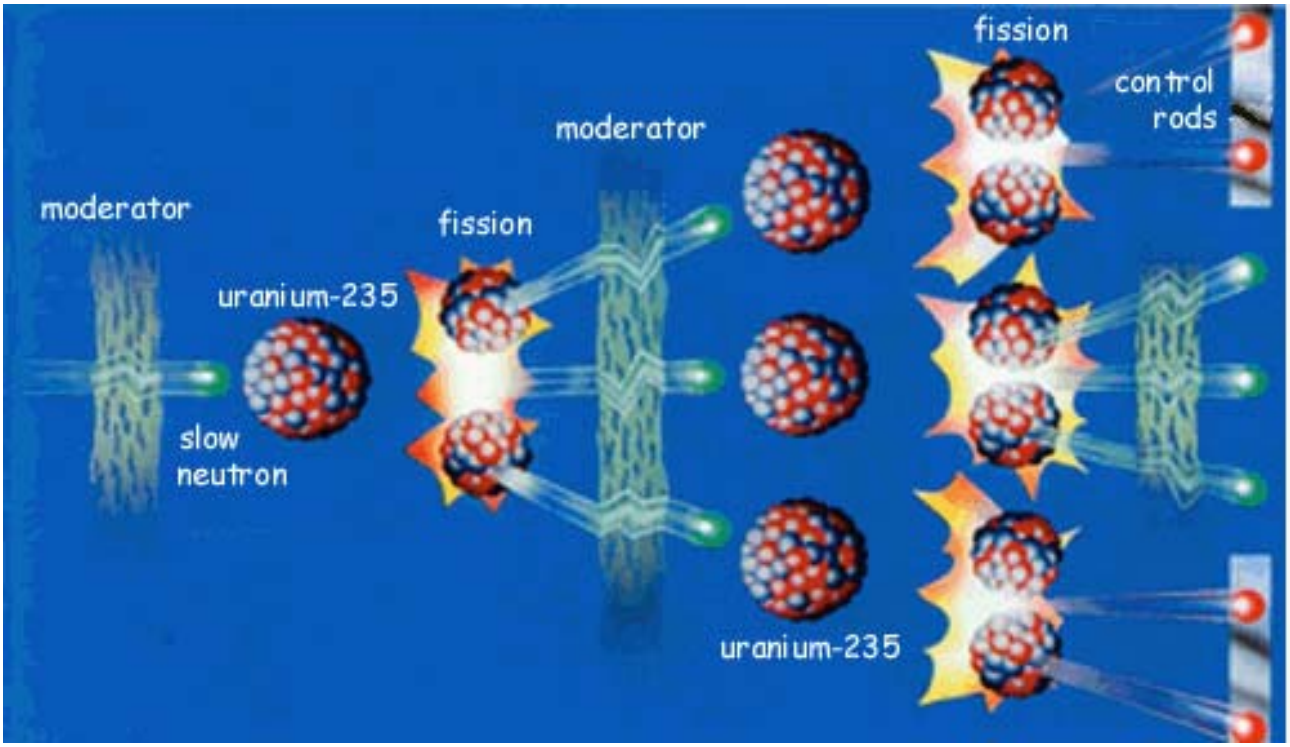
That is a man standing on the generator. The other picture is of a row of generators like those found in most dams.

The problem is how do you turn this axle? Humans have come up with a few means. First a turbine is attached to the axle. A turbine is really a large fan, but instead of these fan blades blowing air, water or steam or wind is used to push the blades. Since the turbine is attached to the axle wrapped in wire the wire turns in the magnetic field, abracadabra electricity is being generated. When water is used, this is called a hydroelectric plant, or dam. When wind is used, this is called a windmill. But these methods can only be used if there is water or wind available. The most common method used to turn the generator is with a steam turbine.

Where does the steam come from? Boiled water. It is as simple as that, if you can boil water you can generated electricity. Well how do you boil water? You must have a heat source, fire or some other heat source. The typical heat sources are coal, natural gas or oil, garbage is now being used as well. It is unclear who lives down wind of the garbage burning electrical power plant. Well there is another method, nuclear power.

There are two types of nuclear reactions that can be used to generate power. Nuclear fusion and fission. The sun uses nuclear fusion, which is the combining of two smaller nuclei to make one large nuclei. It might not seem like much energy would be given off by this reaction, but sit outside on a the first sunny day of spring with in a bathing suit and tell me the sun does not have a lot of power. This is the method we would like to use, the problem is there is too much energy given off. The fusion reaction gives off so much heat it melts every contain known to man. Humans are currently attempting to create a magnetic field which will hold the fusion reaction but this research is moving ahead very slowly. The best part of this reaction is the waste product is helium, certainly not a threat to the environment as it is a noble gas.

The other type of nuclear reaction for electrical power generation is fission. In this reaction a neutron hits and enters a large nucleus. This nucleus is split into two smaller nuclei, a few neutrons and a lot of heat, see picture below. Not as much heat as in fusion but plenty enough to boil water. The main problem with this reaction is that the two smaller nuclei produced in the splitting are very radioactive. And their half lives are very long, ranging from thousand to millions of years. It is very difficult to build a contain which will hold something for a million years. Other ideas of disposal have been considered. Shooting the waste into space or into the sun. Sounds good, the sun wouldn't mind, but what if the rocket explodes in the Earths atmosphere, not good!



Regardless of politics, these power plants exist. Here are the basics on how a nuclear reactor works and why the odds are stacked against a leak of any radioactive material reaching the environment.

The fuel used in nuclear power plants is U-235. This in itself is a problem Uranium is not a common element, and the most common isotope of uranium is U-238. Unfortunately U-238 does not fission every time a neutron hit it, normally it simply absorbs the neutron and becomes U-239. So, U-235 must be purified out of large sample of all the uranium isotopes. This is very costly. An aircraft carrier cost 2 billion dollars, the nuclear reactor U-235 fuel is 1 billion of that total cost.

The U-235 and all the radioactive products of the fission reaction are contained in fuel assemblies. The fuel assemblies are basically a bars or rods composed of very strong very corrosion resistant metal. All the radioactivity of a nuclear reactor is trapped in these assemblies. There would have to be a serious problem for the fuel assembly to break and release radioactive material.

A nuclear power plant is divided up in to loops. These loops prevent water that has touched the reactor fuel assembles from reaching the environment. This water, called primary coolant, is not actually radioactive, but it is isolated in case there is a problem. The primary coolant is contained in the primary loop. Again, this loop is wholly separated from the next loop of water called the secondary loop. The secondary loop contains the water that is actually boiled to steam and is used to turn the steam turbine. Remember that the entire purpose of the reactor is to turn the generator. The next loop is the condensing loop. It cools the spent steam from the turbine back to water to be looped back to be reboiled. The final cooling loop begins at a lake or river. This lake or river water cools the condensing loop so it can cool the spent steam.

For a reactor to release radioactive material to the environment the fuel assemblies would have to break, at the same time that the primary loop ruptures into the secondary loop which must itself leak into the condensing loop whereupon it must burst into the cooling loop. This is just not going to happen unless someone bombs the plant. Regardless, if any of these systems where to break and leak into any of the other systems the reactor would instantly and automatically shut down.

Primary Coolant:

- **normally composed of water**
- **very high pressure, 2000 lb.**
- **very high temperature, 500°F**
- **water performs 2 functions, heat exchanger and as a moderator to slow neutrons to aid in fission of U-235**

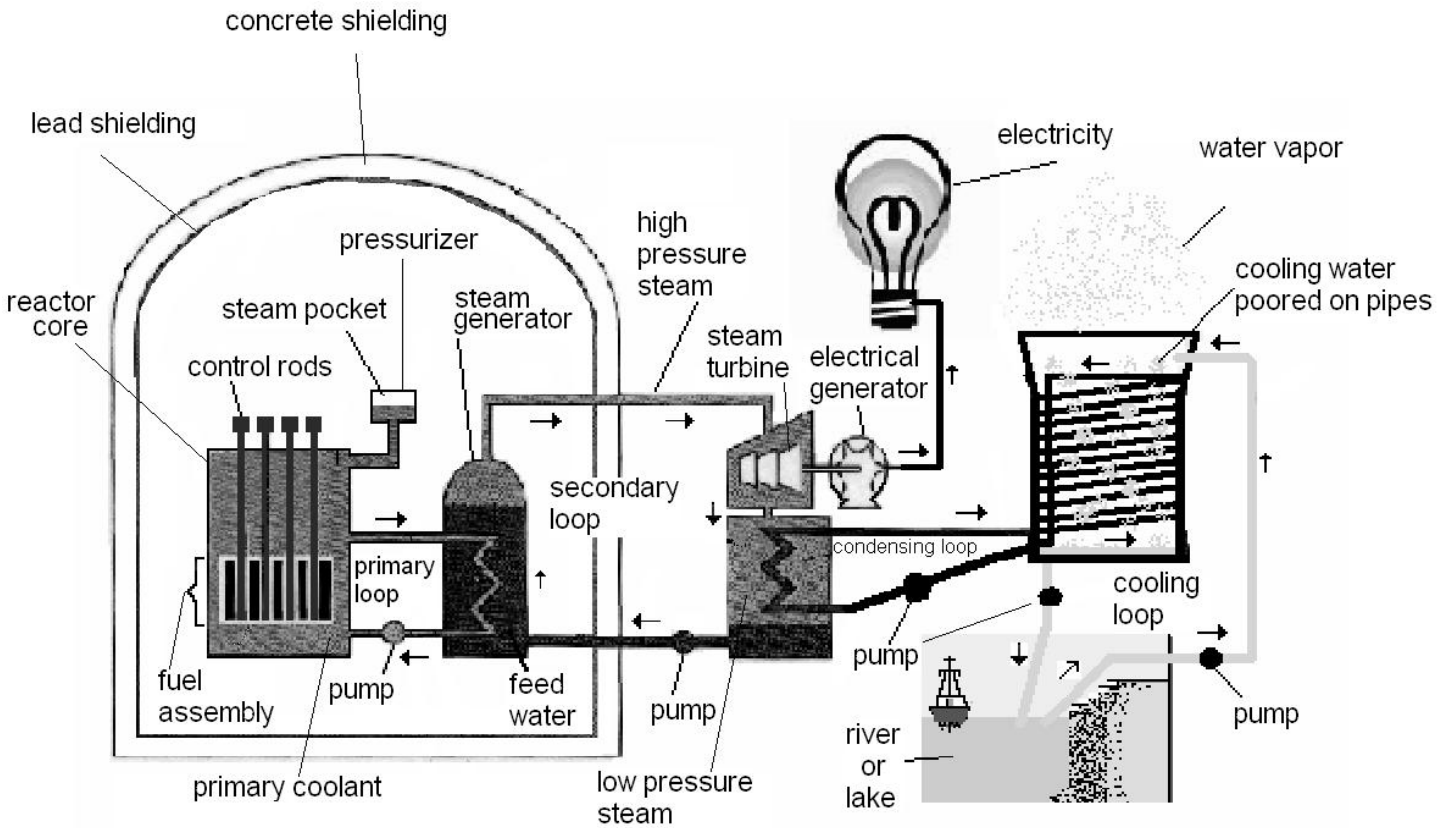
Primary Loop:

1. **begins cycle at pump**
2. **flows to reactor core and is heated by U-235 chain reaction**
3. **is piped to steam generator through U-tubes and heats secondary water**

Secondary Loop:

1. **begins at the pump under the condenser**
2. **flows to bottom of steam generator**
3. **hits U-tubes and is heated to steam**
4. **is piped to steam turbine where it strikes the turbine blades and is spins the turbine**
5. **exits the turbine and enters the condenser**
6. **hits condenser U-tubes and is condensed to wat**

Basic Diagram of a Nuclear Reactor:



Nuclear Power Plant Facility

PRACTICE PROBLEMS

Nuclear Chemistry: Question 1 of 18

This question may require the use of the *Chemistry Reference Tables* or the *Periodic Table of Elements*.
The temperature levels in a nuclear reactor are maintained primarily by the use of

1. shielding
2. coolants
3. moderators
4. control rods

Correct Answer Number: 2

Explanation: Because heat flows from warm objects to colder objects, the coolant liquid is used to absorb heat generated by the reactor. The coolant prevents temperatures in the reactor from overheating (meltdown). The coolant liquid carries the unused heat to an outside cooling tower--there is a large cooling tower at Nine Mile 2. Some of the heat will be sent to a boiler to generate steam and turn the turbines that generate electricity. Shielding prevents radiation leaks; moderators slow down nuclear reactions; control rods absorb neutrons and halt the reaction.Hint: When you have are sick and have a temperature, you need to cool down.

Nuclear Chemistry: Question 2 of 18

Which radioactive emanations have a charge of -1?

1. neutrons
2. gamma rays
3. alpha particles
4. beta particles

Correct Answer Number: 4

Nuclear Chemistry: Question 3 of 18

As the temperature of a sample of a radioactive element decreases, the half-life will

1. decrease
2. increase
3. remain the same

Correct Answer Number: 3

Explanation: Half-life depends on time. Factors like temperature, pressure, and volume have no effect.

Nuclear Chemistry: Question 4 of 18

Which sample will decay least over a period of 30 days? [Refer to Reference Table N]

1. 10 g of Au-198
2. 10 g of I-131
3. 10 g of P-32
4. 10 g of Rn-222

Correct Answer Number: 3

Explanation: The substance with the longest half-life, P-32 in this problem, will decay the least in 30 days.

Nuclear Chemistry: Question 5 of 18

What kind of radiation will travel through an electric field on a pathway that remains unaffected by the field?

1. a proton
2. a gamma ray
3. an electron
4. an alpha particle

Correct Answer Number: 2

Explanation: Particles with charges will be deflected. The only kind of radiation given that has no charge is a gamma ray. It is pure energy and therefore without charge

Nuclear Chemistry: Question 6 of 18

Which radioactive isotope is used in geological dating?

1. uranium-238
2. iodine-131
3. cobalt-60
4. technetium-99

Correct Answer Number: 1

Explanation: Use Reference Table N. Geological dating covers thousands of years. Only isotopes with long half-lives can be used. The isotope with the longest half-life is uranium-238. Uranium 238 can be used to date rocks, fossils, and meteorites. Carbon-14 is used to date matter that was once *alive* .

Nuclear Chemistry: Question 7 of 18

Which particle cannot be accelerated in a magnetic field?

1. alpha particle
2. beta particle
3. neutron
4. proton

Correct Answer Number: 3

Explanation: Only charged particles can be accelerated in a magnetic field. A neutron does not have a charge. See also #5, this topic.

Nuclear Chemistry: Question 8 of 18

In a fusion reaction, reacting nuclei must collide. Collisions between two nuclei are difficult to achieve because the nuclei are

1. both negatively charged and repel each other
2. both positively charged and repel each other
3. oppositely charged and attract each other
4. oppositely charged and repel each other

Correct Answer Number: 2

Explanation: In fusion light nuclei like hydrogen (deuterium) join to form heavier nuclei like helium. Because these nuclei are positively charged, they repel each other. Hint: law of charges states like charges repel and unlike charges attract.

Nuclear Chemistry: Question 9 of 18

A particle accelerator can increase the kinetic energy of

1. an alpha particle and a beta particle
2. an alpha particle and a neutron
3. a gamma ray and a beta particle
4. a neutron and a gamma ray

Correct Answer Number: 1

Explanation: Gamma rays are pure energy so you can eliminate answers 3 and 4. Only charged particles can have their kinetic energy increased in a particle accelerator. (Electric and magnetic fields are used to speed up the particles and these field have no effect on uncharged particles). Neutrons have no charge so only alpha particles and beta particles will be affected. See also #3, this topic.

Nuclear Chemistry: Question 10 of 18

Which nuclide is a radioisotope used in the study of organic reaction mechanisms?

1. carbon-12
2. carbon-14
3. uranium-235
4. uranium-238

Correct Answer Number: 2

Explanation: Carbon is found in all organic compounds so eliminate answers 3 and 4. Which isotope of carbon is radioactive? Carbon-14. Carbon-14 is also used to date fossils.See also #2, this topic.

Nuclear Chemistry: Question 11 of 18

To make nuclear fission more efficient, which device is used in a nuclear reactor to slow the speed of neutrons?

1. internal shield
2. external shield
3. control rod
4. moderator

Correct Answer Number: 4

Explanation: Neutrons can be quickly slowed down by colliding with particles such as graphite, heavy water (deuterium oxide), and water. These substances keep the reaction from getting out of control much like a moderator keeps both sides from getting into an argument or fight. (Sort of like talk show host Montel does). See also #13, this topic.

Nuclear Chemistry: Question 12 of 18

Which equation is an example of artificial transmutation?

1. ${}_{92}U^{238}$ -> ${}_{2}He^{4}$ + ${}_{90}Th^{234}$
2. ${}_{13}AL^{27}$ + ${}_{2}He^{4}$ -> ${}_{15}P^{30}$ + ${}_{0}n^{1}$
3. ${}_{6}C^{14}$ -> ${}_{7}N^{14}$ + ${}_{-}e^{0}$
4. ${}_{88}Ra^{226}$ -> ${}_{2}He^{4}$ + ${}_{86}Ra^{222}$

Correct Answer Number: 2

Explanation: Transmutation means to change or transform atoms of one element into atoms of another element. Transmutation can be natural or artificial. In fairy tales it was popular to try to change metal or straw into gold. This still is impossible but with artificial transmutation, nuclei in a special laboratory are bombarded by high energy particles: protons, neutrons, or alpha particles (a helium nuclei). If the nuclei becomes unstable, it can result in another form of the same element (isotope) or a different element. Answers 1, 3 and 4 are examples of*natural* transmutation.
Notice in answer 2 there are 15 protons on the left side (13 plus 2 = 15) and 15 protons on the right side; atomic mass on the left is 27 + 4 or 31 and on the right it is 30 + 1 or 31.Remember in nuclear and chemical reactions, equations must be balanced: 15 protons on the right, 15 protons on the left.

Nuclear Chemistry: Question 13 of 18

Fissionable uranium-233, uranium 235, and plutonium-239 are used in nuclear reactors as

1. coolants
2. control rods
3. moderators
4. fuels

Correct Answer Number: 4**Explanation:** The elements given are used as fuel in fission reactors. Water, heavy water, air, and molten sodium are examples of coolants. Boron and cadmium make good control rods. Moderators like graphite and heavy water slow down neutrons.

Nuclear Chemistry: Question 14 of 18

In the reaction $_4Be^9 + X \rightarrow {}_6C^{12} + {}_0n^1$, the X represents

1. an alpha particle
2. a beta particle
3. an electron
4. a proton

Correct Answer Number: 1

Explanation: Answer 2 and 3 are the same so eliminate these. The sum of the protons (sum of the atomic numbers) must be the same on the right side as on the left side. Likewise the sum of atomic masses must be the same on each side of the equation.
There are 6 protons on the right side; there must be 6 protons on the left side. Be has 4 so X must have 2 protons ($_2X$). The masses on the right (12 + 1) equal 13 so the masses on the left must equal 13. Be has a mass of 9 so X must have a mass of 4. An alpha particle or$_2He,^4$ is the only correct answer. See Ref. Chart J.

Nuclear Chemistry: Question 15 of 18

Which substance has chemical properties similar to those of radioactive ^{235}U?

1. ^{235}Pa
2. ^{233}Pa
3. ^{233}U

Correct Answer Number: 3

Explanation: Because valence electrons are directly related to chemical properties, look for an isotope of ^{235}U. Remember isotopes have the same atomic number (number of protons), the same number of electrons, but a different atomic mass because the number of neutrons is different. Eliminate answer 1, 2, and 4 because these are not isotopes of U. They are different elements. ^{233}U is an isotope of ^{235}U so the chemical properties are similar.

Nuclear Chemistry: Question 16 of 18

Control rods in nuclear reactors are commonly made of boron and cadmium because these two elements have the ability to

1. absorb neutrons
2. emit neutrons
3. decrease the speed of neutrons
4. increase the speed of neutrons

Correct Answer Number: 1

Explanation: Moderators control the speed of a reaction (answers 3 and 4) so control rods must *absorb* neutrons. Emitting more neutrons into a nuclear reaction would make the reaction out of control.

Nuclear Chemistry: Question 17 of 18

Heavy water and graphite are two examples of materials that are can be used in a nuclear reactor to slow down neutrons. These materials are called

1. fuels
2. shields
3. coolants
4. moderators

Correct Answer Number: 4

Explanation: Do not be tricked into picking water as a coolant. The question did not ask for a coolant: it asked for "traffic cops" that slow down or moderate or keep "the lid on" a reaction. See also #7, this topic.

Nuclear Chemistry: Question 18 of 18

Which reaction illustrates fusion?

1. ${}_{1}H^{2} + {}_{1}H^{2} \rightarrow {}_{2}He^{4}$
2. ${}_{0}n^{1} + {}_{13}Al^{27} \rightarrow {}_{11}Na^{24} + {}_{2}He^{4}$
3. ${}_{13}Al^{27} + {}_{2}He^{4} \rightarrow {}_{15}P^{30} + {}_{0}n^{1}$
4. ${}_{7}N^{14} + {}_{2}He^{4} \rightarrow {}_{1}H^{1} + {}_{8}O^{17}$

Correct Answer Number: 1

Explanation: Fusion is the process of joining two light nuclei to form a heavier one. High pressure and high temperatures are used to make this happen. Tremendous energy is released when the fusion takes place. Answers 2, 3, and 4 are all examples of artificial transmutation or bombardment of an element by a neutron or alpha particle. Only answer 1 shows two light elements combining.

Nuclear Chemistry Worksheet

1) The alpha decay of radon-198

2) The beta decay of uranium-237

3) Positron emission from silicon-26

4) Sodium-22 undergoes electron capture

5) What is the difference between nuclear fusion and nuclear fission?

6) What is a “mass defect” and why is it important?

7) Name three uses for nuclear reactions.

Nuclear Chemistry Worksheet – Solutions

1) The alpha decay of radon-198

$$^{198}_{86}Rn \rightarrow ^{4}_{2}He + ^{194}_{84}Po$$

2) The beta decay of uranium-237

$$^{237}_{92}U \rightarrow ^{0}_{-1}e + ^{237}_{93}Np$$

3) Positron emission from silicon-26

$$^{26}_{14}Si \rightarrow ^{26}_{13}Al + ^{0}_{+1}e$$

4) Sodium-22 undergoes electron capture

$$^{22}_{11}Na + ^{0}_{-1}e \rightarrow ^{22}_{10}Ne$$

5) What is the difference between nuclear fusion and nuclear fission?

In nuclear fusion, small nuclei are combined to form a larger nucleus – this process releases a very large amount of energy, and is the main source of energy in the sun. In nuclear fission, large nuclei break apart to form smaller ones, releasing a large amount of energy. Fission is used in nuclear power plants to generate energy.

6) What is a "mass defect" and why is it important?

"Mass defect" refers to the difference between the mass of the nucleons (protons + neutrons) in a nucleus when weighed separately and the mass of the nucleus when it's put together. This difference is important because this missing mass is converted to energy using $E=mc^2$ that's used to hold the nucleus together.

7) Name three uses for nuclear reactions.

- **Nuclear weapons**
- **Medicine**
- **Nuclear power generation**

ADDITIONAL RESOURCES

https://staff.rockwood.k12.mo.us/grayted/apchemistry/Documents/U10 Nuclear Chemistry/NOTES Nuclear T.pdf

http://kisdwebs.katyisd.org/campuses/CRHS/teacherweb/chemistryacademic/Teacher%20Documents/Mr.%20Crump's%20Class/NOTES%20Nuclear.pdf

http://www.brightstorm.com/science/chemistry/nuclear-chemistry/

SUGGESTED ACTIVITIES/LABS

http://www.geneseocsd.org/webpages/scidepartment/files/HW%20Packet%20-%20Nuclear_STUDENT.pdf

http://www.geneseocsd.org/webpages/scidepartment/files/practice%20test%20-%20nuclear_1_anskey.pdf

http://www.oakland.k12.mi.us/Portals/0/Learning/NuclearChange.pdf

http://www.chymist.com/Nuclear%20chem.pdf

SUPPLEMENTAL UNIT
CHEMISTRY

KINETICS, EQUILIBRIUM, THERMOCHEMISTRY, AND THERMODYNAMICS

ATLANTIC CITY HIGH SCHOOL

Kinetics, Equilibrium, Thermochemistry, and Thermodynamics

VOCABULARY

1. Reaction Rate – the speed at which reactants are converted into products in a chemical reaction.

2. Collision Theory – in order for a chemical reaction/effective collision to occur, particles must collide with proper energy AND proper alignment.

3. Reaction Mechanism – the specific set of steps/reactions involved in an overall chemical reaction

4. Nature of Reactants – reactions involving ionic substances tend to have faster rates than reactions involving covalent substances.

5. Concentration – an increase in concentration of reactants will increase the rate of a chemical reaction

6. Surface Area – an increase in the surface area of reactants will increase the rate of a chemical reaction

7. Pressure – an increase in pressure will increase the rate of a chemical reaction (only for reactions involving GASES!)

8. Catalyst – a substance that is neither a reactant nor a product, but functions to speed up the rate of a chemical reaction by lowering activation energy/providing a shorter or "alternate" pathway

9. Temperature – an increase in temperature will increase the rate of a chemical reaction

10. Equilibrium – when two opposing processes are occurring at equal rates

11. Physical Equilibrium – when two opposing physical processes are occurring at equal rates; ex: phase equilibrium, solution equilibrium (saturation)

12. Phase Equilibrium – when the processes of freezing and melting or evaporating and condensing are occurring at equal rates

13. Solution Equilibrium – when the processes of dissolving and precipitating are occurring at equal rates; when a solution has reached its saturation point

14. Chemical Equilibrium – in a chemical reaction, when the forward and reverse reactions are occurring at equal rates

15. Le Chatelier's Principle – predicts that when a stress is applied to an equilibrium mixture, the equilibrium will shift to relieve the stress (stresses include temperature, pressure, concentration)

16. Enthalpy – the heat energy absorbed or released during a chemical reaction; the heat content of a system at a constant pressure.

17. Entropy – a measure of the randomness or chaos associated with a chemical reaction

18. Potential Energy Diagrams – used to illustrated the energy lost or gained (the reaction pathway) for a given chemical reaction

19. Endothermic Reactions – chemical reactions that consume or require energy; chemical reactions in which energy is a reactant

20. Exothermic Reactions – chemical reactions that produce or release energy; chemical reactions in which energy is a product

21. Activated Complex – an intermediate structure formed in the conversion of reactants to products. The activated complex is the structure at the maximum energy point along the reaction path

22. Activation Energy – The minimum energy required to convert reactants into products; the difference between the energies of the activated complex and the reactants

23. Thermochemistry- Concerned with the changes that occur during chemical reactions.

24. Energy- The capacity of doing work or supplying heat.

25. Law of Conservation of Energy- In any chemical of physical process, energy is neither created nor destroyed.

26. Endothermic- Absorbs heat

27. Exothermic- Releases heat

28. Calorie (with a big C)- 1 Calorie= 1 kilocalorie= 1,000 calories

29. calorie (with a small C)- The quantity of heat needed to raise the temperature of 1g of pure water 1 degree Celsius.

30. Joule- the S.I. unit of energy.

31. Heat Capacity- The quantity of heat required to change an objects temperature 1 degree Celsius.

32. Calorimetry- At accurate and precise measurement of a heat change for chemical and physical process.

Kinetics, Equilibrium, Thermochemistry, and Thermodynamics	
• **Generate and evaluate scientific evidence and explanations.** • **Participate productively in scientific practices and discourse.** • **Distinguish among the different ways objects can move.** • **Recognize that forces exist in the natural world that can influence the movement of objects.** • **Observe and understand the scientific process** • **Recognize that matter can exist as a solid, liquid or gas and can be transformed from one state to another** • **Recognize that energy is needed to cause a physical or chemical change** • **Identify that not all matter can respond in the same manner when exposed to similar conditions**	**PROCESS SKILLS**
What are the driving forces that control spontaneity of a chemical reaction? **Does every collision between reacting particles produce products?** **What factors influence the rate of a chemical reaction?** **How can you determine if a system is at equilibrium?** **How is a system at equilibrium affected by changes?** **What information regarding rate reaction can be derived from data?** **Are heat and temperature the same? Explain.** **What is specific heat and what role does it play in determining the materials used in products of our everyday life?** **What are the forms of energy that a system can possess?** **What is the nature of energy?** **How does total energy relate to heat and work?**	**ESSENTIAL QUESTIONS**
• **Rate law** • **Mechanisms** • **Reaction order** • **Equilibrium** • **Equilibrium constant** • **LeChatelier's Principle** • **1st Law of Thermodynamics,2nd Law of Thermodynamics and 3rd Law of Thermodynamics** • **Kinetic and potential energy** • **Calorimetry**	**CONTENT**

• **Calculate the rate law of a reaction** • **Describe the order for the rate law** • **Describe the rate law from a mechanism** • **Identify rate constants** • **Write equilibrium constant expressions** • **Analyze and describe the value of an equilibrium constant** • **Predict the equilibrium concentrations of reactions and products** • **Determine the direction in which a reaction must proceed in order to achieve equilibrium** • **Recognize the symbols for the enthalpy, entropy, and Gibb's Free Energy of a reaction** • **Assess the spontaneity of a chemical reaction**	**SKILLS (What the students will be able to do)**
Kinetics, rates of a reaction, rate constant, rate laws, order, mechanism, activation energy, transition state **equilibrium constant, LeChatelier's principle** **enthalpy, entropy, Gibb's free energy, spontaneity,** **temperature, Joules, heat, heating curve, heat of formation, calorimetry**	**Scientific Literacy**
5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. **5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.** **5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.** **5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.** **5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.** **5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.** **5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.** **5.1.12.C.1 Reflect on and revise understandings as new evidence emerges.** **5.1.12.C.2 Use data representations and new models to revise predictions and explanations.**	**NJ Standards**

5.1.12.C.3 Consider alternative theories to interpret and evaluate evidence-based arguments. **5.2.12.D.2 Describe the potential commercial applications of exothermic and endothermic reactions.** **5.2.12.D.5: Model the change in rate of a reaction by changing a factor.**	
Diagnostic Tests (pre and post) **Unit Assessment by Teacher** **Differentiated Strategies for Instruction/Assessment** **Laboratory/Demos** **Classroom worksheets** **Homework**	**Assessments**

KINETICS

Kinetics is the study of the rate of reactions, or how fast they occur under different conditions. It usually includes a study of the mechanisms of reactions, which is a look at how the reacting molecules break apart and then form the new molecules. This knowledge allows chemists to control reactions and/or design new or better ways to produce the desired products.

Reaction Rates

***What is meant by reaction rate?**

Consider the reaction: $2N_2O_{5(g)} \text{ -----> } 4NO_{2(g)} + O_{2(g)}$

The rate is defined as the change in concentration of N_2O_5 with respect to time or

rate = $-\Delta$Conc N_2O_5 / Δt

where ΔConc N_2O_5 = final conc N_2O_5 - orig. conc. N_2O_5, and

Δt = final time - initial time

Reaction rate is <u>always positive</u>

Concentration is expressed in mol/L, whereas time can be in seconds, minutes, hours, days, years, etc.

***How are Reaction Rate and Concentration Related?**

The rate decreases as the concentration of the starting materials (reactants) decreases.

plot of rate vs. conc - if straight line, then it is said to be a first order reaction: in other words the rate of the reaction is directly proportional to the concentration.

***What is the Rate Expression?**

rate = *k*[conc $N_2O_{5(g)}$]

this indicates that the rate of the reaction for $2N_2O_{5(g)} \text{ -----> } 4NO_{2(g)} + O_{2(g)}$ depends upon the concentration of reactant

"*k*" is called the rate constant. It is independent of the other quantities in the equation.

"*k*" is dependent on:

1. **the nature of the reaction**

   "fast" reactions typically have <u>large</u> rate constants
   if *k* is small, the reaction is slow at ordinary concentration

2. **the temperature**
   ordinarily, *k* increases with temperature

Reaction Order

***What is meant by Order of the Reaction?**

$aA_{(g)}$ -----> products
rate = k[conc A]^m

The power (m) to which the concentration of A is raised in the rate expression describes the <u>order</u> of the reaction.

- **If "m" = 0, the reaction is zero order**
- **If "m" = 1, it is <u>first</u> order**
- **If "m" = 2, it is <u>second</u> order**

Conditions:

- **m = 0: zero order - rate is independent of the concentration of reactant. Doubling concentration has no effect on rate.**
- **m = 1: first order - rate is directly proportional to the concentration of the reactant. Doubling the concentration increases the rate by a factor of 2.**
- **m = 2: second order - the rate is the square of the concentration of the reactant. Doubling the concentration increases the rate by a factor of 4.**

Order of a reaction must be determined experimentally. It cannot be deduced from the coefficients of a balanced equation.

Two reactant reaction:

$$\text{rate} = k[\text{conc A}]^m[\text{conc B}]^n$$

refer to "m" as "the order of the reaction with respect to A" and

"n" as "the order of the reaction with respect to B"

the overall order of the reaction is the sum of the exponents, m + n.

example: $CO + NO_2 \text{ -----> } CO_2 + NO$

$$\text{rate} = k(\text{conc CO})(\text{conc } NO_2)$$

This reaction is:

- **first order with respect to CO, m = 1**
- **first order with respect to NO_2, m = 1**
- **second order overall, m + n = 2**

****The time required for one half of a reactant to decompose via a first order reaction has a fixed value, independent of concentration. This is called the half-life and has the expression**

$$t_{1/2} = 0.693/k$$

***k* is the rate constant for the first order reaction**

half-life is inversely proportional to the rate constant *k*

if *k* is large, half-life is short; a slow reaction with a small *k* will have a relatively long half-life.

***What About Reactions with Other Integral Orders?**

Most common processes in gas phase reactions are second order. Zero order reactions are less common.
Third order reactions are rare.

Activation Energy

***What is Activation Energy?**

Chemical reactions ordinarily occur as a result of collisions between reacting particles.

Consider the reaction:

$$CO_{(g)} + NO_{2(g)} \text{ ----> } CO_{2(g)} + NO_{(g)}$$

$$\text{rate} = k(\text{conc CO})(\text{conc } NO_{2(g)})$$

- **doubling the concentration of CO, holding NO_2 constant, the number of collisions in a given time doubles.**
- **doubling the concentration of NO_2, holding CO constant, has the same effect.**

In general, the number of collisions per unit time is directly proportional to the concentration of CO or NO_2.

The fact that the rate is directly proportional to these concentrations implies that reaction occurs as a direct result of collisions between CO and NO_2 molecules.

NOT EVERY COLLISION LEADS TO REACTION!!!!!

It is possible to calculate the rate at which molecules collide with each other by using the kinetic theory.

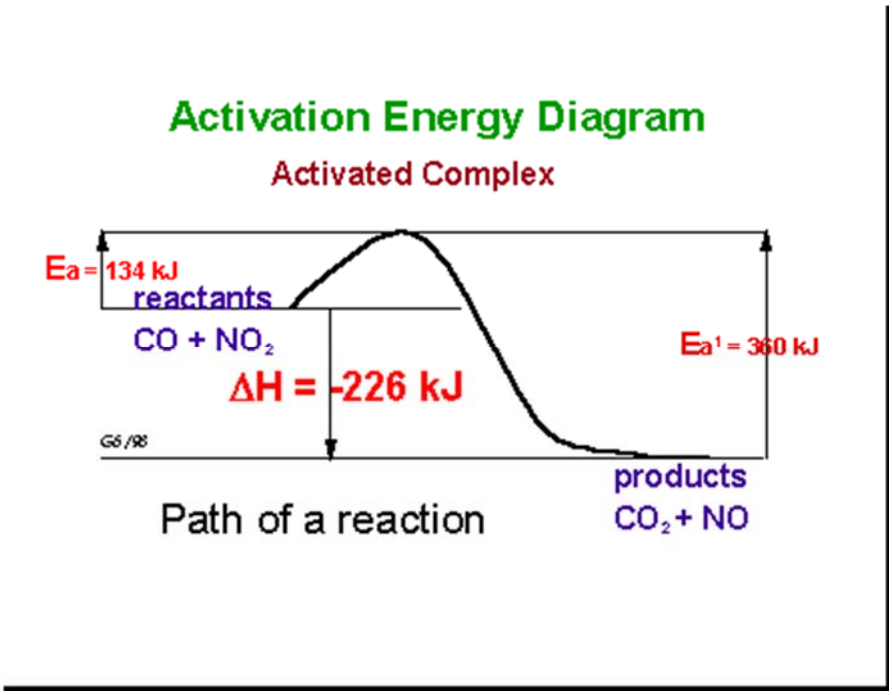
In order for collisions to be effective, there must be considerable force in the collisions. The slower moving molecules do not have enough kinetic energy to react when they collide...they bounce off one another and retain their identity.

Only those molecules moving at high speed have enough energy for collisions to result in a reaction.

Every reaction requires a certain minimum energy for the reaction to occur--it is called activation energy, E_a, and is expressed in kJ.

***What are the properties of the activation energy, E_a?**

- **it is a positive quantity, $E_a>0$**
- **it depends upon the nature of the reaction. "Fast" reactions usually have a small E_a; those with a large E_a usually proceed slowly.**
- **it is independent of temperature and concentrations.**



Activated Complex is an intermediate species that is an unstable, high energy species that must be formed before the reaction can occur.

Catalysts

***What are Catalysts?**

Certain substances, called catalysts, can increase the rate of a reaction without being consumed by it.

An example is the decomposition of H_2O_2:

> **$2H_2O_2$ ----> $2H_2O + O_2$ - this reaction is ordinarily very slow, however, add $NaI_{(aq)}$ to the H_2O_2 and the reaction becomes very fast.**

Catalysts can be described as being homogeneous or heterogeneous.

- **Homogeneous: reaction takes place within a single phase, as in the example above with the H_2O_2.**
- **Heterogeneous: reaction involves two different phases, as in the example that follows.**

  $2N_2O$ ----> $2N_2 + O_2$ - this reaction is usually slow, but if the reactants are bought into contact with a metal such as gold, the reaction speeds up considerably.

A catalyst lowers the activation energy required for the reaction.

The reduction in activation energy occurs because the catalyst provides an alternate pathway of lower energy for the reaction.

A catalyst has no effect on the relative energies of the reactants and products, or on the equilibrium constant, K_c. It merely speeds up the reaction, thus allowing it to reach equilibrium more quickly.

Temperature Effects

***How Are Reaction Rates Affected By Temperature?**

The rates of most reactions increase with a rise in temperature.

example

- **the use of a pressure cooker to cook foods faster**
- **the use of a refrigerator to store food and slow its spoilage**

The general rule is than an increase in temperature by 10°C doubles the reaction rate.

The Kinetic Theory can be used to explain the effect of temperature on reaction rates.

> **Raising the temperature increases the fraction of molecules having very high kinetic energies. These are the ones most likely to react when they collide. The higher the temperature, the larger the fraction of molecules that can provide the activation energy needed for reaction.**

The rate constant, *k*, becomes larger as the temperature increases.

Reaction Mechanisms

***What are Reaction Mechanisms?**

A reaction mechanism is a description of the path, or sequence of steps, by which a reaction occurs.

EQUILIBRIUM

The concept of equilibrium is an extremely important one to master. It helps to explain the behavior of chemical reactions and buffer systems, and can be used to drive reactions that normally don't occur, or occur to only a small extent.

The following notes describe the characteristics of gaseous systems at equilibrium, but equilibrium in aqueous solutions and the liquid phase behave in essentially the same manner.

General Facts

$aA_{(g)} + bB_{(g)}$ <------> $cC_{(g)} + dD_{(g)}$

$K_c = [C]^c [D]^d / [A]^a [B]^b$

- **K_c has a constant value at a given temperature, independent of original concentration, volume of container, or pressure.**
- **K_c depends upon the way the equation was written--given in terms of the forward (---->) reaction.**
- **For reactions involving liquids and solids, as well as gases, the pure liquids and solids are not included in the equilibrium expression; anything in aqueous solution IS INCLUDED.**
- **Any coefficients in the balanced equation are always written as a power in the equilibrium expression.**

Examples:

- **$2SO_{2(g)} + O_{2(g)}$ <-----> $2SO_{3(g)}$**

  $K_c = [SO_3]^2 /[SO_2]^2 [O_2]$

- **$SO_{2(g)} + 1/2O_{2(g)}$ <-----> $SO_{3(g)}$**

  $K_c = [SO_3] / [SO_2] [O_2]^{1/2}$

- **$4NH_{3(g)} + 5O_{2(g)}$ <-----> $4NO_{(g)} + 6H_2O_{(g)}$**

  $K_c = [NO]^4 [H_2O]^6 / [NH_3]^4 [O_2]^5$

- **$Pb(NO_3)_{2(s)}$ <-----> $PbO_{(g)} + 2NO_{2(g)} + 1/2O_{2(g)}$**

  $K_c = [PbO] [NO_2]^2 [O_2]^{1/2}$

***What K_c can tell you:**

whether a reaction is likely to be feasible.

a. a very small K_c means that a reaction is not likely to happen.

b. a very large K_c, the reaction is feasible.

Effects of Changes on an Equilibrium System
LeChatelier's Principle

LeChatelier's Principle states that whenever a system at equilibrium is subjected to a stress, then the equilibrium will shift in a direction so as to relieve that stress.

These stresses and their effects are summarized below:

A. Adding or subtracting a product or reactant

1. **if species added is a solid or liquid, there is no effect on a gaseous equilibrium.**
2. **if species added or subtracted is a gas then:**

    a. adding species shifts direction away from the species added.
    b. subtracting a species shifts direction towards the species removed.

B. Change in volume

1. **if volume is decreased, the reaction proceeds towards the side with least moles of gas.**
2. **if volume is increased, the reaction proceeds towards side with most moles of gas.**
3. **if in the balanced equation there are the same number of moles of gas on both sides, a volume change will not affect the equilibrium.**

C. Change in pressure

1. increase in pressure shifts equilibrium in direction of decrease in the number of moles of gas

2. decrease in pressure shifts equilibrium in direction of increase in number of moles of gas.

3. if in the balanced equation there are the same number of moles of gas on both sides, a pressure change will not affect the equilibrium.

D. Change in temperature:

1. If forward reaction is endothermic:

a. increase in temperature causes K_c to become larger
b. decrease in temperature causes K_c to become smaller

2. If forward reaction is exothermic:

a. increase in temperature causes K_c to become smaller
b. decrease in temperature causes K_c to become larger

K_p

A. General Reaction:

$$aA_{(g)} + bB_{(g)} \text{<----->} cC_{(g)} + dD_{(g)}$$

$$K_p = (PC)^c(PD)^d / (PA)^a(PB)^b$$

"P" is equilibrium partial pressure in atmospheres

B. K_p vs. K_c

1. **Concentration in M are used to determine K_c . Partial pressures in atmospheres are used to determine K_p.**
2. **Both are independent of:**

   a. starting amounts of reactants and products
   b. volume of the container
   c. total pressure

3. **Both vary with temperature.**

THERMOCHEMISTRY

Thermochemistry is the study of the heat released or absorbed by a chemical reaction when it is carried out under conditions of constant pressure.

***Why heat? Why constant pressure?**

Many chemical reactions either are initiated by heating under conditions of constant pressure, or release heat under constant pressure conditions. Because the amount of heat released under these conditions is so important we give it a special name, the Enthalpy, ΔH (or more archaically, heat of reaction).

***What is calorimetry?**
The measurement of the heat absorbed or released by a reaction.

Enthalpy: heat content of a system

ΔH is the change in enthalpy

q is the heat absorbed or given off

ΔH is equal in magnitude to the heat flow (q) for a reaction carried out directly at constant pressure. A calorimeter is usually used to determine ΔH of a reaction, so it is actually q for the water that is obtained, which is $-\Delta H$ for the reaction.

$$q = (m)(S.H.)(\Delta T)$$

m = mass of the substance

S.H. = specific heat of that substance

$\Delta T = T_{final} - T_{initial}$ (temperature can be in degrees Celsius or Kelvin because the size of each degree is the same)

<u>Exothermic rxns:</u>

- **enthalpy of the reaction system decreases**
- **enthalpy of the products is < that of the reactants**
- **effect is to increase the temperature of the surroundings**

$$\Delta H = \Sigma\Delta H_{f(products)} - \Sigma\Delta H_{f(reactants)} < 0$$

<u>Endothermic rxns:</u>

- **enthalpy of the reaction system increases**
- **enthalpy of the products is > that of the reactants**
- **effect is to decrease the temperature of the surroundings**

$$\Delta H = S\Delta H_{f(\text{products})} - S\Delta H_{f(\text{reactants})} > 0$$

Laws of Thermochemistry:

1. The magnitude of ΔH is directly proportional to the amount of reactant or product.

(the heat absorbed when a solid melts (solid to liquid) is referred to as the heat of fusion)

(the heat absorbed when a liquid vaporizes (liquid to gas) is called as the heat of vaporization)

2. ΔH for a reaction is equal in magnitude but opposite in sign to ΔH for the reverse reaction.

(in other words... the amount of energy given off in a reaction is exactly equal to the amount of heat absorbed in the reverse reaction.)

3. the value of ΔH for a reaction is the same whether it occurs directly or in a series of steps.

in other words...Equation 3 = Equation 1 + Equation 2 + ...

therefore: $\Delta H_3 = \Delta H_1 + \Delta H_2 + \ldots$ **This is called Hess's Law**

Most, but NOT all spontaneous rxns release energy

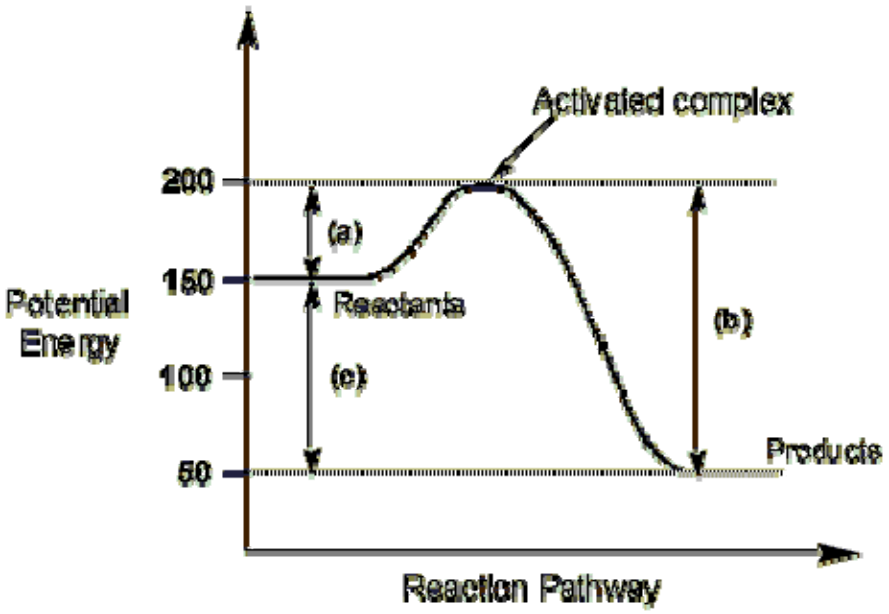
Thermodynamic standard states = 1 atm, 1 M for sol's, 25 ºC (298 K)

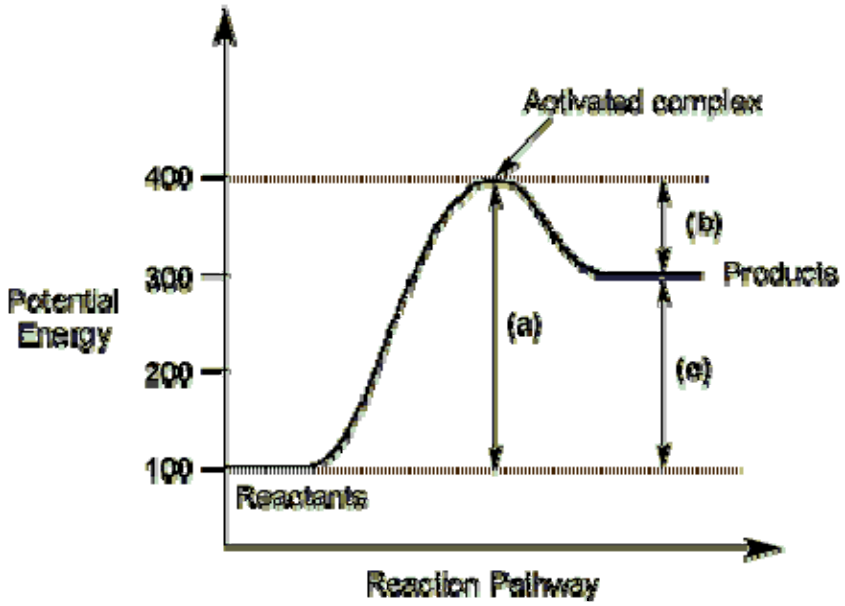
Enthalpy is relatively independent of pressure and temperature.

***Heat and Temperature**

- **Temperature reflects random motion of particles in a substance**
- **Temperature indicates the direction in which heat energy will flow**
- **Heat is a measure of energy content**
- **Heat is what is transferred during a temperature change**

Energy Diagrams





THERMODYNAMICS

The study of energy in chemical reactions is called thermodynamics, which literally means "changes in heat."

Spontaneous- a process that takes place without an input of energy from an external source.

Natural tendency --------> decrease in energy

Examples

water flows downhill, a spring unwinds

These rxns <u>do not</u> occur spontaneously in the reverse direction.

- **System--that part of the universe where the change of interest occurs**
- **Surroundings--the rest of the universe**

1st Law is of Thermodynamics: the total amount of energy in the universe is constant.

$$E_{tot} = E_k + E_p = \text{constant}$$

The Law of Conservation of Energy is a restatement of the 1st Law of Thermodynamics; energy is neither created nor destroyed in ordinary chemical reactions and physical changes.

2nd Law of Thermodynamics: Entropy

Spontaneous, unidirectional processes often are referred to as irreversible processes.

Example: scrambled eggs--don't unscramble

- **positional disorder--refers to the distribution of the particles in space**
- **thermal disorder--refers to the distribution of the available energy among the particles**

Any process that produces a more random distribution of the particles in space gives rise to an increase in the total entropy of the substance. So does any constant pressure process that increases the temperature of the particles.

3rd Law of Thermodynamics--the entropy of a perfect crystalline substance is zero at absolute zero.
There is an increase in entropy on melting & vaporization.

Generally, the more atoms of a given type there are in a molecule, the greater the capacity of the molecule to take up energy and thus the greater the entropy. For molecules with approx. the same molecular masses, the more compact the molecule, the smaller the entropy.

In general, the greater the difference between the total number of moles of gaseous products and the total number of moles of gaseous reactants, the greater the value of ΔS_{rxn}.

Tendency in nature -----> higher entropy

Processes that are both energy favored and entropy favored will be spontaneous.

Gibbs Free Energy

Gibbs energy relates the energy that can be obtained as work from a process to the change in enthalpy, change in entropy and absolute temperature.

Gibbs-Helmholtz Equation: $\Delta G_{rxn} = \Delta H_{rxn} - T\Delta S_{rxn}$

Criteria for spontaneity:

1. **if ΔG_{rxn} is less than 0, then rxn is spontaneous**
2. **if ΔG_{rxn} greater than 0, then rxn is not spontaneous**
3. **if $\Delta G_{rxn} = 0$, then rxn is at equilibrium, no net change occurs.**

PRACTICE PROBLEMS

Question 1 of 16

This question may require the use of the *Chemistry Reference Tables* or the *Periodic Table of Elements*.

When a catalyst is added to a system at equilibrium, a decrease occurs in the

1. activation energy
2. heat of reaction
3. potential energy of the reactants
4. potential energy of the products

Correct Answer Number: 1

Explanation: A catalyst speeds up a chemical reaction by lowering (decreasing) the activation energy. See also question #8, this topic.

Question 2 of 16

According to Reference Table I, which compounds form exothermically?

1. hydrogen fluoride
2. hydrogen iodide
3. ethene
4. ethyne

Correct Answer Number: 1

Explanation: Exothermic reactions have a negative H. Choices 2, 3, 4 have positive a H. Only choice 1 is negative. You could have also used Process of Elimination.

Question 3 of 16

Which statement describes characteristics of an endothermic reaction?

1. The sign of H is *positive*, and the products have *less* potential energy than the reactants.
2. The sign of H is *positive*, and the products have *more* potential energy than the reactants.
3. The sign of H is *negative*, and the products have *less* potential energy than the reactants.
4. The sign of H is *negative*, and the products have *more* potential energy than the reactants.

Correct Answer Number: 2

Explanation: Endothermic reactions absorb energy so there is more potential energy in the reactants than in the products. (Gain in Heat energy = increase in potential energy of reactants.) Table I notes endothermic reactions are positive. Eliminating choices 3 and 4, only choice 2 has a positive H and a gain in potential energy.

Question 4 of 16

Which statement explains why the speed of some chemical reactions is increased when the surface area of the reactant is increased?

1. This change increases the density of the reactant particles.
2. This change increases the concentration of the reactant.
3. This change exposes more reactant particles to a possible collision.
4. This change alters the electrical conductivity of the reactant particles.

Correct Answer Number: 3

Explanation: Reaction rate is affected by nature and concentration of reactants, temperature, surface area and a catalyst. Increasing surface area exposes more particles to contact with reactants, increasing the number of particle collisions. Imagine a cube of chocolate 3 feet by 4 feet and 2 inches thick. Take the same block and make it into a 24 candy bars. A class of chemistry students could eat the bars faster than the single chocolate block.

Question 5 of 16

Which conditions will increase the rate of chemical reaction?

1. decreased temperature and decreased concentration of reactants?
2. decreased temperature and increased concentration of reactants?
3. increased temperature and decreased concentration of reactants?
4. increased temperature and increased concentration of reactants?

Correct Answer Number: 4

Explanation: Rate or speed of reaction is influenced by temperature, concentration, surface area, nature of reactants, and presence of a catalyst. To speed up a reaction, increase the number of effective collisions between molecules. Temperature is a measure of the average kinetic energy, so increasing temperature speeds up a reaction. Increasing the concentration of the reactants adds more particles and this also increases the number of effective collisions.

Question 6 of 16

In a chemical reaction, a catalyst changes the

1. potential energy of the products
2. potential energy of the reactants
3. heat of reaction
4. activation energy

Correct Answer Number: 4

Explanation: Activation energy is the minimum amount of energy needed to start a chemical reaction. (Sort of like the minimum amount you can pay on a credit card balance each month). The total $ due has not changed but you can get by paying the smaller amount. Activation energy does not change the potential energy of the reactants or products and it has no effect on the heat of reaction. A catalyst speeds up the reaction because it decreases the amount of energy needed to start the reaction (minimum balance payment). See also question #1, this topic.

Question 7 of 16

Which is a property of a reaction that has reached equilibrium?

1. The amount of products is greater than the amount of reactants.
2. The amount of products is equal to the amount of reactants.
3. The rate of the forward reaction is greater than the rate of the reverse reaction.
4. The rate of the forward reaction is equal to than the rate of the reverse reaction.

Correct Answer Number: 4

Explanation: Equilibrium means equal reaction rates. Choices 1 and 3 are "greater than", not "equal to" and choice #2 does not mention reaction rates. Only choice 4 states
" equal reaction rates." A system in equilibrium can have unequal amounts of product and reactants; or it could have equal amounts of product and reactants. *Equal reaction rates*, however, are necessary for dynamic equilibrium to result.

Question 8 of 16

According to Reference Table G, which compound solubility decreases most rapidly as the temperature changes from 10°C to 70°C?

1. NH_4Cl
2. NH_3
3. HCl
4. KCl

Correct Answer Number: 2

Explanation: See Ref. Table G. Notice the curves for choices 1 and 4 increase. Choice 2 and 3 both decrease but choice 2 (NH_3) decreases more than 50 degrees, while HCl decreases only about 16 degrees.

Question 9 of 16

Which procedure will increases the solubility of KCl in water?

1. stirring the solute and solvent mixture
2. increasing the surface area of the solute
3. raising the temperature of the solvent
4. increasing the pressure on the surface of the solvent

Correct Answer Number: 3

Explanation: This is an easy but tricky question. Choices 1 and 2 make KCl dissolve *faster* (rate of reaction) but do not increase the solubility of KCl. A glass of soda pop goes flat as it warms up on the counter; hot chocolate can dissolves more marshmallows than a cup of cold chocolate milk can. Temperature affects solubility.
In the case of HCl, increasing the temperature, increases the solubility. Look at Ref. Table G and notice how the solubility curve of KCl increases as the temperature increases.

Question 10 of 16

Given the equilibrium system at 25°C:

$NH_4Cl(s) <-> NH_4^+(aq) + Cl^-(aq)$ (H = +3.5 kcal/mol)

What change will shift the equilibrium to the right?

1. decreasing the temperature to 15°C?
2. increasing the temperature to 35°C?
3. dissolving NaCl crystals in the equilibrium mixture?
4. dissolving NH_4NONH_3 crystals in the equilibrium mixture?

Correct Answer Number: 2

Explanation: Part 1: in the equation H = + 3.5 kcal/mol: the reaction is endothermic. If you forget that a positive H indicates an endothermic reaction, see Ref. Table I for this info. (Use the tables; they have lots of memory helps.)
Part 2: supplying heat (by increasing the temp.), favors the reaction that absorbs or uses up the extra heat (favors the endothermic reaction). Which one is that? The forward reaction or right side because H was +. This illustrates the Le Chatelier's principle: if a stress (like a change in temperature or concentration) is added to a system at equilibrium, the reaction is shifted in a way that uses up the stress.
Helpful memory hint: Increasing temperature of a system at equilibrium, favors the endothermic reaction. See also #15 and # 16 this topic.

Question 11 of 16

Given the reaction at equilibrium: $N_2(g) + O_2(g) <-> 2NO(g)$ as the concentration of $N_2(g)$ increases, the concentration of $O_2(g)$ will

1. decrease
2. increase
3. remains the same
4.

Correct Answer Number: 1

Explanation: LeChatelier's principle: if a stress (like a change in temp. or concentration) is added to a system at equilibrium, the reaction is shifted in a way that uses up the stress. Increase the left side, the right side tries to use up the extra $N_2(g)$. But to make more NO(g), you need to use some of the $O_2(g)$ from the left side--remember you did not add any extra $O_2(g)$--so the amount of $O_2(g)$ has to decrease.

Question 12 of 16

Given the reaction at equilibrium: $2CO(g) + O_2(g) <-> 2CO_2(g)$ When the reaction is subjected to stress, a change will occur in the concentration of

1. reactants, only
2. products, only
3. both reactants and products
4. neither reactants nor products

Correct Answer Number: 3

Explanation: This question can be solved several different ways. First by logic: pretend you become a new cable subscriber (a change or stress is added to your life). This will also affect the number of hours you watch TV (reaction). The reverse is also true: stop the cable and you probably will watch less TV. Only choice 3 makes sense. Remember the math rule? Whatever you do to one side of the equation, affects the other side.
Second way: Le Chatelier's principle applies here (if a stress like a change in temperature or concentration is added to a system at

equilibrium, the reaction is shifted in a way that uses up the stress). If more CO(g) and O_2(g) were added, more CO_2(g) would result. If more product, CO_2(g), was added, the concentration of the reactants would increase by using up the excess product and changing it back to CO(g) + O_2(g).

Question 13 of 16

Given the change of phase: CO_2(g) changes to CO_2(s), the entropy of the system

1. decreases
2. increases
3. remains the same
4.

Correct Answer Number: 1

Explanation: Entropy is a measure of the disorder or randomness (lack of order) of a system. Molecules in gases have no definite volume and are freer to move than molecules in solids. As molecules change phase from a gas to a solid, the molecules are becoming more orderly and therefore have less disorder, less entropy. Compare the room of a teenage to the room of a parent. The teen has a more disorderly room (higher entropy). As the teen gets older and becomes a parent, the disorder in the room decreases.

Question 14 of 16

In which reaction will the point of equilibrium shift to the left when the pressure on the system is increased?

1. $C(s) + O_2(g) <-> CO_2(g)$
2. $CaCO_3(s) <-> CaO(s) + CO_2(g)$
3. $2Mg(s) + O_2(g) <-> 2MgO(s)$
4. $2H_2(g) + O_2(g) <-> 2H_2O(g)$

Correct Answer Number: 2

Explanation: A change in pressure affects equilibrium when gases are involved. An increase in pressure favors the formation of the smaller number of moles of gas (shifts to the side with the smaller number of moles of gas).
If there is no change in the number of moles of gas, pressure has no effect on equilibrium.
There is no effect on Choice 1 because each side has only 1 mole of gas. Choice 3 has 1 mole of gas on the left, none on the right so increased pressure shifts it to the right.
Choice 4 has 3 moles of gas (2H and 1 O) on the left, 2 moles on the right, so increased pressure shifts it to the right. Choice 2 has no gas moles on the left and 1 mole of gas on the right, so increased pressure shifts equilibrium to the left. Voila: Choice 2.

Question 15 of 16

Which substance is produced by the Haber process?

1. aluminum
2. ammonia
3. nitric acid
4. sulfuric acid

Correct Answer Number: 2

Explanation: In the Haber process, ammonia is produced. Sulfuric acid is produced by the contact process. See also #14, this topic.

Question 16 of 16

Given the reaction at equilibrium: $2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$ + heat
Which change will shift the equilibrium to the right?

1. adding a catalyst
2. adding more $O_2(g)$
3. decreasing the pressure
4. increasing the temperature

Correct Answer Number: 2

Explanation: To get more product [right side, $SO_3(g)$], add more reactants (left side). As the reaction reaches equilibrium, the extra reactants are being converted into product [$SO_3(g)$ + heat] and the reaction shifts to the right.

Problem #1: How many kJ are required to heat 45.0 g of H_2O at 25.0 °C and then boil it all away?

Solution:

Comment: We must do two calculations and then sum the answers.

1) The first calculation uses this equation:

$q = (\text{mass})\ (\Delta t)\ (C_p)$

This summarizes the information needed:

$\Delta t = 75.0$ °C
The mass = 45.0 g
$C_p = 4.184\ \text{J g}^{-1}\ \text{°C}^{-1}$

2) Substituting, we have:

$q = (45.0\ \text{g})\ (75.0\ \text{°C})\ (4.184\ \text{J g}^{-1}\ \text{°C}^{-1})$

$q = 14121\ \text{J} = 14.121\ \text{kJ}$

3) The second calculation uses this equation:

$q = (\text{moles of water})\ (\Delta H_{vap})$

This summarizes the information needed:

$\Delta H_{vap} = 40.7$ kJ/mol
The mass = 45.0 g
The molar mass of H_2O = 18.0 gram/mol

4) Substituting, we obtain:

$q = (45.0\ \text{g} / 18.0\ \text{g mol}^{-1})\ (40.7\ \text{kJ/mol})$

$q = 101.75\ \text{kJ}$

5) Adding:

101.75 kJ + 14.121 kJ = 116 kJ (to three sig figs)

Problem #2: How many kJ need to be removed from a 120.0 g sample of water, initially at 25.0 °C, in order to freeze it at 0 °C? (Area three, then area two on the time-temperature graph.)

Solution:

1) The first calculation:

$q = (\text{mass})\ (\Delta t)\ (C_p)$

$q = (120.0\ \text{g})\ (25.0\ °\text{C})\ (4.184\ \text{J g}^{-1}\ °\text{C}^{-1})$

$q = 12{,}552\ \text{J} = 12.552\ \text{kJ}$

2) The second calculation:

$q = (\text{moles of water})\ (\Delta H_{vap})$

$q = (120.0\ \text{g} / 18.0\ \text{g mol}^{-1})\ (6.02\ \text{kJ/mol})$

$q = 40.13\ \text{kJ}$

3) Summing up the values from the two steps gives 52.8 kJ.

Problem #3: You are given 12.0 g of ice at -5.00 °C. How much energy is needed to melt the ice completely to water?

Solution:

1) The first calculation:

$q = (\text{mass})\ (\Delta t)\ (C_p)$

$q = (12.0\ \text{g})\ (5.0\ °\text{C})\ (2.06\ \text{J g}^{-1}\ °\text{C}^{-1})$

$q = 123.6\ \text{J} = 0.1236\ \text{kJ}$

2) The second calculation:

$q = (\text{moles of water})\ (\Delta H_{vap})$

$q = (12.0\ \text{g} / 18.0\ \text{g mol}^{-1})\ (6.02\ \text{kJ/mol})$

$q = 4.0133\ \text{kJ}$

3) Summing up the values from the two steps gives 4.14 kJ, to three significant figures.

Problem #4: Equal masses of hot water and ice are mixed together. All of the ice melts and the final temperature of the mixture is 0 °C. If the ice was originally at 0 °C, what was the initial temperature of the hot water?

Solution:

Let us assume we have 18.0 g of ice and 18.0 g of hot water present.

The key is to realize that the only thing the ice did is melt, it did not change its temperature. So, let us calculate the amount of heat needed to melt our 18.0 g (or, 1.00 mole) of ice:

$q = (6.02 \text{ kJ/mol})\ (1.00 \text{ mol}) = 6.02 \text{ kJ}$

The only source of heat is the hot water, which provides 6020 J (I converted the 6.02 kJ to J.) of heat. Let us calculate the temperature change of 18.0 g of hot water as it loses 6020 J of heat:

$6020 \text{ J} = (18.0 \text{ g})\ (x)\ (4.184 \text{ J g}^{-1} \text{ °C}^{-1})$

$x = 79.9 \text{ °C}$

The hot water was at an initial temperature of 79.9 °C (since everything ended up at a final temperature of 0 °C.

Are the following processes endo or exothermic? Explain.

a) When solid KBr is dissolved in water, the sol'n gets colder.

b) Natural gas is burned in a furnace.

c) When concentrated sulfuric acid is added to water, the solution gets very hot.

d) Water is boiled in a kettle.

e) The combustion of gasoline in a car engine.

f) Water condensing on a cold pipe.

g) $CO_2(s) \rightarrow CO_2(g)$

h) $F_2(g) \rightarrow 2\ F(g)$

a)endo (water temp decreases therefore water lost heat energy= the dissolving process required heat energy)

b)exo

c)exo

d)endo

e)exo

f)exo

g)endo

h)endo (breaking of bonds)

ADDITIONAL RESOURCES

http://www.chem1.com/chemed/tutorial.shtml#B9

http://www.oakland.k12.mi.us/Portals/0/Learning/Thermodynamics1.pdf

http://science.widener.edu/svb/tutorial/lechatelier.html

http://www.oakland.k12.mi.us/Portals/0/Learning/EquilibriumKinetics.pdf

SUGGESTED ACTIVITIES/LABS

http://dpchem.wikispaces.com/file/view/Handout-dynamic-equilibrium.original.pdf/207736062/Handout-dynamic-equilibrium.original.pdf

http://dpchem.wikispaces.com/file/view/Handout-equilibrium-and-le-chatelier-s-principle.original.pdf/207736064/Handout-equilibrium-and-le-chatelier-s-principle.original.pdf

http://dpchem.wikispaces.com/file/view/Lab-%20Alka%20Seltzer%20Gas%20Reaction%20Rate.pdf/205471884/Lab-%20Alka%20Seltzer%20Gas%20Reaction%20Rate.pdf

http://dpchem.wikispaces.com/file/view/Lab-%20ChemEqActivity.pdf/205471968/Lab-%20ChemEqActivity.pdf

Earth Science

Grades 9th through 12th

DRAFT

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(Revised July 2016)

I. **OVERVIEW**

The Earth Science curriculum is a contemporary, interdisciplinary approach to the study of earth and its environment. The program incorporates the latest thinking and theories of prominent earth scientists. The major theme of the course is the process of science and its application to solve earth science problems. The course stresses graphical analysis, reasoning skills as well as the development and recognition of conceptual relationships. The complexity of the material covered gradually increases during the year with an in-depth study of past, present and future problems and their solutions. Some of the major topics covered during the year include the following: density, astronomy, global warming, earthquakes, volcanism, plate tectonics and meteorology.

II. **RATIONALE**

The science curriculum is made up of units that encourage student interest and inquiry in the continuing pursuit of earth science. Students learn how to gather, analyze, and evaluate data that will enable them to use higher thinking skills as they continue their study of science. The major theme of the course is the process of science and its application to solve earth science problems. Additionally, an understanding of the scientific process (scientific method, rational thinking skills, etc) is essential for students to sort and evaluate incoming information.

III. **STANDARDS** (* NJ CCCS Science is no longer supported by the State of NJ DOE and have moved to NGSS Next Generation Science Standards)

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 2008).

5.1 All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem solving in science, and as a means of expressing and /or modeling scientific theories.

5.4 All students will understand the interrelationships between science and technology and develop a conceptual understanding of the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure

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of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

Next Generation Science Standards (NGSS)

High School Earth and Space Sciences

Students in high school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from middle school through more advanced content, practice, and crosscutting themes. There are five ESS standard topics in middle school: Space Systems, History of Earth, Earth's Systems, Weather and Climate, and Human Sustainability. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science

Literacy Principles is presented with a greater emphasis on an Earth Systems Science approach. There are strong connections to mathematical practices of analyzing and interpreting data. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) with an emphasis on using engineering and technology concepts to design solutions to challenges facing human society.

Space Systems: High school students can examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Others concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.

History of Earth: Students can construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space science involves making inferences about events in Earth's history based on a data record that is increasingly incomplete that farther you go back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. A key to Earth's history is the coevolution of the biosphere with Earth's other systems, not only in the ways that climate and environmental changes have shaped the course of evolution but also in how emerging life forms have been responsible for changing Earth.

Earth's Systems: Students can develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun- driven surface systems that tear down the land through weathering and erosion. Students understand the role that water plays in affecting weather. Students understand chemical cycles such as the carbon

cycle. Students can examine the ways that human activities cause feedbacks that create changes to other systems.

Weather and Climate: Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students understand the analysis and interpretation of different kinds of geoscience data allow students to construct explanations for the many factors that drive climate change over a wide range of time scales.

Human Impacts: Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the environmental impacts of human activities.

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HS. Space Systems

HS. Space Systems

Students who demonstrate understanding can:

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)

Using Mathematical and Computational Thinking
Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.
- Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars
- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3)

ESS1.B: Earth and the Solar System
- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

PS3.D: Energy in Chemical Processes and Everyday Life
- Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)

PS4.B Electromagnetic Radiation
- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)

Crosscutting Concepts

Scale, Proportion, and Quantity
- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)

Energy and Matter
- Energy cannot be created or destroyed– only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)

Connection to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4)

Connection to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

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HS. History of Earth

HS. History of Earth

Students who demonstrate understanding can:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (MS-ESS1-6)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6)
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth
- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESS2.A: Earth Materials and Systems
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep knowledge of how feedbacks work within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2.)

ESS2.B: Plate Tectonics and Large-Scale System Interactions
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1)
- Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)

PS1.C: Nuclear Processes
- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-5),(secondary to HS-ESS1-6)

Crosscutting Concepts

Patterns
- Empirical evidence is needed to identify patterns. (HS-ESS1-5)

Stability and Change
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)

HS. Earth's Systems

HS. Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]

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Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS- ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the

primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2),(HS-ESS2-4)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS- ESS2-6)
- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

---------- Connections to Engineering, Technology and Applications of Science

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists,

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HS. Earth's Systems

ESS2-3) ▪ Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3) ▪ Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)	▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) **ESS2.E: Biogeology** ▪ The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) **PS4.A: Wave Properties** Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)	engineers, and others with wide ranges of expertise. (HS-ESS2-3) **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)

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HS. Weather and Climate

HS. Weather and Climate

Students who demonstrate understanding can:

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

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Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-5)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
- Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5)
- New technologies advance scientific knowledge. (HS-ESS3-5)

Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based on empirical evidence. (HS-ESS3-5)
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4), (HS-ESS3-5)

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System
- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)

ESS2.A: Earth Materials and Systems
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)

ESS2.D: Weather and Climate
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4),(secondary to HS-ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4)

ESS3.D: Global Climate Change
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)

Crosscutting Concepts

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Stability and Change
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5)

HS. Human Impacts

HS. Human Impacts

Students who demonstrate understanding can:

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.* [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

empirical evidence, and logical arguments regarding

relevant factors (e.g. economic, societal, environmental,

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and Logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational Simulations are created and used based on mathematical models of basic assumptions.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)
- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (Secondary to HS-ESS3-6)

ESS3.A: Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and Geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)
- Scientists and engineers can make major contributions by developing technologies

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that produce less pollution and waste
and that preclude ecosystem degradation. (HS-ESS3-4)

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

ETS1.B. Designing Solutions to Engineering Problems

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HS-ESS3-2),(secondary to HS-ESS3-4)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

---------- Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)
- Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)
- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS- ESS3-2)

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*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS. Human Impacts

ethical considerations). (HS-ESS3-2) ---------- **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** ▪ Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) ▪ New technologies advance scientific knowledge. (HS-ESS3-5) ▪ Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open- mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based on empirical evidence. (HS-ESS3-5) ▪ Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS3-5)		**Connections to Nature of Science** **Science is a Human Endeavor** ▪ Scientific knowledge is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) **Science Addresses Questions About the Natural and Material World** ▪ Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2) ▪ Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2) ▪ Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

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IV. STUDENT OUTCOMES

A. **KNOWLEDGE** (Concepts) Dual Standards: **NJCCCS & NGSS**
The students will (verbally or in writing):

1. Apply scientific research material to determine the solution to a given problem in earth science: Identifying the problem, gathering research information, analyzing and interpreting research information, drawing conclusions, making inferences and predictions.
   [NJ CCCS 5.1, 5.2, 5.7, 5.8] [HS-ESS1-6]
2. Compare the various overviews of scientific theories of the origin of the universe and our solar system.
   [NJ CCCS 5.9] [HS-ESS1-4]
3. Describe the location of the earth in the solar system and the universe.
   [NJ CCCS 5.9] [HS-ESS1-6]
4. Compare the earth, its general composition and dynamic processes with other bodies in our solar system.
   [NJ CCCS 5.9] [HS-ESS-4]
5. Explain the relationship of gravity, tides and seasons to the motion and location of the earth in the solar system.
   [NJ CCCS 5.9] [HS-ESS1.B]
6. Identify and explain the integration of space technology into everyday life in modern society, including: weather satellites, Landsat imagery, communication satellites, materials developed for the space program and used today.
   [NJ CCCS 5.9;5.10] [HS_ESS1A]
7. Demonstrate the ability to make predictions regarding weather using observations from satellite imagery and weather maps.
   [NJ CCCS 5.8,5.9,5.10] [HS-ESS3-5] [HS-ESS2-2]
8. Understand the relationship between the geographic location of an area and climate with regard to the following; land and breezes, latitude and longitude, location of mountain ranges and ocean currents.
   [NJ CCCS 5.8,5.10] [HS-ESS3-6] [HS-ESS2-6
9. Demonstrate and understanding of the dynamic nature of the coastal environment and human activities. Examples are to include; beach evolution and erosion, shoreline and wetlands development, rising sea level, saltwater encroachment, waste disposal, aquaculture and storm damage.
   [NJ CCCS 5.8,5.9,5.10] [HS-ESS3-4, HS-ESS3-5, HS-ESS3-6]
10. Reconstruct geologic history, emphasizing the immensity of geologic time, by using; fossils radioactive dating, structural sequences of rocks and Doctrine of Uniformitarianism.
    [NJ CCCS 5.1,5.2,5.8,5.10] [HS-ESS1-6, HS-ESS2-E]

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11. Demonstrate understanding of various global cycles (e.g. hydrologic, Energy CO_2, O_2, N_2) and their importance in geologic processes and explain their interaction in terms of weather and oceanic circulations.
    [NJ CCCS 5.11,5.6,5.8,5.9,5.10] [HS-ESS2-5, HS-ESS2-6, HS-ESS2-67]
12. Explain in their own words, the effect of human activities on natural earth processes. Examples to include: deforestation, greenhouse effect, ozone, acid rain, non-point source pollution and litter.
    [NJ CCCS 5.1,5.2,5.8,5.10] [HS-ESS3-6]

B. **ATTITUDES**
The student will:

1. Appreciate the complexity of modern space technology and its ability to continuously gather new information through space probes, telescopes, and computer analysis.
   [NJ CCCS 5.4] [HS-ESS1-2, HS-ESS1-3]
2. Appreciate the earth's interaction with the sun, moon, and other solar system components.
   [NJ CCCS 5.9] {HS-ESS1-6]
3. Appreciate the characteristics of earth that enable it to support life.
   [NJ CCCS 5.9] [HS-ESS1-6]
4. Appreciate the enormous amount of time required for geologic changes to occur compared to man's time on earth.
   [NJ CCCS 5.8] [HS-ESS1-6, HS-ESS1-C]
5. Appreciate the time and effort that scientists put into studying the earth and its processes in order to better understand how the earth changes.
   [NJ CCCS 5.8] [HS-ESS2-2, HS-ESS2-3, HS-ESS2-7]
6. Develop a sensitivity toward the impact of man on nature and the impact of nature on itself. [5.10] [HS-ESS3-1, HS-ESS3-6]
7. Appreciate the efforts of scientists to use current technology to make predictions and improve the safety of the earth's inhabitants.
   [NJ CCCS 5.8] [HS-ESS3-6, HS-ETS-1B]

C. **SKILLS AND BEHAVIOR**
The student will:

1. Interpret a diagram that shows how the positions of the earth, sun & moon affect the tides, phases of the moon, and / or eclipses.
   [NJ CCCS 5.9] [HS-ESS1-4]
2. Explain how the motions of the earth, sun and moon define units of time including days, months, and years.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
3. Synthesize how the tilt, rotation, and orbital pattern of the earth relative to the sun produces seasons and weather patterns.

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[NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]

4. Describe the physical characteristics of the planets and other objects in the solar system, and compare the earth to other planets.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
5. Compute & express quantities using appropriate number formats including scientific notation.
   [NJ CCCS 5.3] [HS-ESS3-4]
6. Develop models, Synthesize and demonstrate understanding of the scale of the solar system that shows distance and size relationships among the sun and planets.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
7. Observe and record short-term and long term-changes in the positions of the constellations in the night sky.
   [NJ CCCS 5.9] [HS-ESS1-4]
8. Observe that the planets appear to change their positions against the background of stars.
   [NJ CCCS 5.9] [HS-ESS1-4, HS-ESS1-B]
9. Discuss the composition, circulation, and distribution of the world's oceans.
   [NJ CCCS 5.8] [HS-ESS2-C, HS-ESS2-5]
10. Describe and illustrate the water cycle.
    [NJ CCCS 5.8] [HS-ESS2-2, HS-ESS2-5]
11. Summarize the process involved in the rock cycle and describe the characteristics of the rocks involved.
    [NJ CCCS 5.8] [HS-ESS-1-5, HS-ESS1-6, HS-ESS2-B]
12. Utilize manipulatives such as technology, devices, tools, map projections and topographical maps to interpret features of the earth's surface.
    [NJ CCCS 5.8] [HS-ESS2-1, HS-ESS2-3, HS-ESS2-4]
13. Describe and synthesize conditions in the atmosphere and other processes that lead to weather systems and how these weather systems are represented on weather maps.
    [NJ CCCS 5.8] [HS-ESS2-6, HS-ESS3-6]
14. Explain, describe and discuss how the earth's landforms and materials are created through constructive and destructive forces - earthquakes and volcanoes.
    [NJ CCCS 5.8] [HS-ESS1-5, HS-ESS2-1]
15. Explain how technology designed to investigate features of the earth's surface impacts how scientists study the earth.
    [NJ CCCS 5.8] [HS-ESS3-6, HS-ETS-B]
16. Show that vibrations in materials can generate waves that can transfer energy from one place to another.

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[NJ CCCS 5.7] {HS-ESS2-A, HS-ESS2-3, HS-ESS2-4]

17. Classify a sample into one of the three major classifications of rock. [NJ CCCS 5.9] [HS-ESS2-1]
18. Argue and discuss the connections between educational activities and the world or work.
19. [NJ CCCS 9:1, 9:2] [HS-ESS3-6, HS-ETS-B]

V. STRATEGIES

The following strategies/activities will be used:

1. Inquiry - including the development of hypotheses, experiments and the resulting conclusions
2. Cooperative learning
3. Hands-on approach with the use and creation (for example) of models to represent movement of heat through a system, creation of an earthquake proof structure, and the use of model magma and soil to represent a volcano
4. Use of notebook or learning log to record hypotheses, observations, reflections, conclusions and other information gathered
5. Create tables, charts, and/or graphs to gather and present information
6. Access to internet, databases and other print and non-print resources to research further information about the topics covered
7. Various reading and writing in the content areas strategies as presented in district workshops
8. Modify lesson plans per inclusion teacher when necessary for student(s), per IEP code book.

   [Atlantic City Public School District Special Education Department]
9. Make the appropriate accommodations for special needs and ELL students:

   Additional time and other IEP stated accommodations

   Audio text resources, varied assessments

VI. EVALUATION

Assessment will include:

Unit Exams
Chapter and Vocabulary Quizzes
Lab reports
Notebook
Performance Assessment
Homework
Class Participation

Students will also be expected to design and execute projects and/or original research.

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Benchmark Exams

VII. REQUIRED RESOURCES

1. **Student resources:**
   Textbook: Earth Science, *Geology, the Environment and the Universe*
   Textbook, Authors; Hess, Kunze Leslie, et al, National Geographic Society., Glencoe Merrill 2005

2. **Other Resources**
   Holt Science Spectrum, Holt Rinehart & Winston, 2001
   Earth Science, Transparencies, Feather, et.al., Glencoe Merrill 1999
   Globe Earth Science Workbooks, Bunch, et.al., Globe-Fearon 1999
   Prentice Hall Earth Science Resources:
   http://www.phschool.com/webcodes10/index.cfm?area=view&wcprefix=cuk&wcsuffix=9999
   Media Center and classroom print and non-print resources
   Variety of materials for hands on labs and activities
   Videos/films/NBC Learn
   Computer resources including the internet and databases

3. **Technology**
   Computers/laptops
   Internet Resources
   Lab Materials/Kits

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VIII. SCOPE AND SEQUENCE

September

Introduction to Earth Science
Scientific Method
Periodic table
Measurements and metric conversions
Geography-finding positions on earth using maps, charts and globes.
Maps and plotting position

Assessments: Classwork, homework, quizzes/tests, Pre-Test, class projects-Labs

October

Meteorology-description, measurements and instruments.
Climate vs. weather
Weather forecasting
Clouds, fronts and precipitation
Ozone layer.
Layers of the atmosphere
Air currents, air masses and Coriolis Effect
La Nina-El Nino, Sea Surface Temperatures
Global warming
Severe weather-hurricanes, tornadoes storms.

Assessments: Classwork, homework, , quizzes/tests class projects, Labs

November

Ocean composition and origins
Ocean currents-gulf stream
Weather and ocean currents
Tides and oceans waves
River systems
Coral reefs and shoreline structures.
Seafloor structures.

Assessments: Classwork, homework, quizzes/tests, MP 1 Benchmark class projects, Labs

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December

Plankton and photosynthesis
Marine animals
Life processes in the ocean.
Ocean pollution
Consequences of pollution
Preventing ocean pollution

Assessments: Classwork, homework, quizzes/tests, class projects, LAbs

January

Weathering
Erosion
Deposition and landforms
Soil
Surface processes
Mass movements
Glaciers
Desertification
Rivers systems-deltas, floodplains, watersheds

Assessments: Classwork, homework, quizzes/tests, MP 2 Benchmark class projects

February

Minerals
Rock cycle
Igneous rocks
Metamorphic rocks
Sedimentary rocks
Fossils
Plate tectonics
Earth Layers

Assessments: Classwork, homework, quizzes/tests class projects

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March

Dynamic earth processes
Earth interior-lithosphere
Plate movements
Properties of the crust
Mountain formation
Earthquakes
Volcanoes
Ring of Fire

Assessments: Classwork, homework, quizzes/tests class projects

April

Volcano eruptions
Geothermal energy
Geologic time
Eras, epochs and period in time
Fossils and geology
Dinosaurs
Extinction
Human interaction with species

Assessments: Classwork, homework, quizzes/tests class projects

May-June

Earth-Moon system
Inner Planets
Outer Planets
The Sun
Solar System
Space travel
Mars exploration
Formation of the Universe, (Big Bang Theory)
Galaxies and Stars and Stellar formation and distribution
Instruments used to view and study the universe.

Assessments: Classwork, homework, quizzes/tests class projects

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Month	Essential Questions	Content	Skills	Assessment	Activities
September	What is science? What is the scientific method? What values are important in problem-solving? How do I measure and convert. What are states of matter? What is an Atom? What are the geographical areas of the earth? Latitude and Longitude How to read and use topographic maps & charts	Components of Earth Science and Science. Scientific method applications? Measurement helps science in many ways. Periodic Table How molecules form and compounds are made and how they relate to Earth Science. Physical geography of the world. Finding geographical positioning. Topographic Maps for specific purposes. Plotting features on maps & Charts	Concept mapping Critical thinking using a case study Making and using tables, line graphs, bar graphs and pie charts Formulating a hypothesis Diagramming features on a map Basic Map reading skills Calculating measurements and conversions to metric. Diagramming and computing graphs and charts for illustration of data.	Homework OEQs Classwork Current event articles Internet PowerPoint Presentation Topic Videos Tests and quizzes Labs **Pre-Test**	Video: Basic movies about the using science Converting standard units to metric Formulate hypothesis and plan an experiment Collect data and graph information Mapping & plotting Chapter review questions and case studies Topic worksheets **LAB: - Mapping & using positioning.**

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Month	Essential Questions	Content	Skills	Assessment	Activities
October	What does our atmosphere consist of? Why is the atmosphere broken down into layers? What is the Ozone Layer? How is the suns energy transferred? What are world wind patterns? What is weather? How are weather patterns created? What causes severe weather? What is forecasting? What is Global Warming vs Climate Change	Air-made up of various gases. Structure of the atmosphere and importance of each level. How Ozone protects us. Solar energy transfer-heating Coriolis Effect. Global wind patterns Weather forecasting terms and uses. Air pressure and frontal systems. Hurricanes, tornadoes and severe weather systems. La Nina – El Nino Weather vs. climate Greenhouse effect	Concept mapping Critical thinking using a case study Distinguish weather systems Describe the layers of the atmosphere. Define weather terminology Explain global winds and effect the planets rotation has on it Give an example of each type of severe weather. Learn basic weather forecasting Explain greenhouse effect, global warming, ozone protection	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes Labs **MP1 Benchmark**	Video: Various videos covering weather, severe storms and atmosphere. Case Study Atmosphere Chapter review questions Class exercise on weather fronts and winds. Internet activities Library research skills **LABS:** Name, Explain & Illustrate the Layers of Atmosphere Name & Illustrate Wind Patterns

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Month	Essential Questions	Content	Skills	Assessment	Activities
November	Where did the ocean come from? What are ocean currents and how are they formed? How do currents affect the weather/climate? What is a wave? How do waves form and move? What causes tides? Why are tides important? How do shorelines form? What does the ocean seafloor look like?	Oceans origins and compositions Major ocean currents. Oceans influence on Climate. Wave movements over land and water. Waves form in several different ways. Tidal power. Shoreline features and composition Seafloors physical structures.	Describe the features of the ocean Explain how ocean currents affect weather. Discuss the importance of weather. Discuss why tides are important. Identify features of the shorelines. Understanding basic wave movement and impact on shorelines. Explain the formation of the ocean seafloor and key features.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes Labs	Video: Various videos covering the Oceans. El Nino-La Nina Case Study Gulf Stream Chapter review questions Mapping ocean currents Seafloor topography Internet activities Library research skills Chapter worksheet and questions **LABS:** Chart Ocean Currents Read Tide Charts

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Month	Essential Questions	Content	Skills	Assessment	Activities
December	What lives in our oceans- Marine life? How do organisms live in the ocean? How does the ocean get polluted? Can we live on this planet without destroying the oceans?	Classifications of life in the oceans. Marine mammals Life processes in the ocean. Types of Ocean Pollution.	Define the types of marine life in the oceans. Discuss the process of photosynthesis in cyanobacteria. Compare and contrast the marine life Describe types of ocean pollution Describe the factors affect life in the oceans Explain how the adaptations of life need the oceans.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes **MP 2 Benchmark**	Video: Various videos marine life and pollution Case Study Oil Spills Chapter review questions LAB – Oil Spill Bio-Remediation Current event news stories review Internet activities PowerPoint presentations on oceans, marine life and pollution

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Month	Essential Questions	Content	Skills	Assessment	Activities
January	What is weathering? What is erosion? How does gravity move sediment? Why water is the most erosive agent? How does wind erode? Glacial erosion. What is soil? How is soil formed? Why is soil important? What is a hydrosphere? What is a river system? Types of Land Use	Soil loss Mass movement Erosion factors Types of erosion. Glaciers and movement. Land prone to erosion Chemical, mechanical weathering. River system development. Deltas, watersheds, floodplains, river system terms.	Discuss the differences between weathering and erosion. Explain the factors involved in weathering vs. erosion. Identify difference of types of mass movements. Name the structure of soil. Define vocab for soil, weathering and erosion. Discuss glacial erosion and long term effect on land.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes	Video: Various videos erosion and glaciers Chapter review questions Class exercise on soil formation, erosion and weathering. Case study-erosion. Internet activities Library research skills PowerPoint presentation **LAB:** Soil Sampling/Horizons Erosion **LAB:** Watersheds

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Month	Essential Questions	Content	Skills	Assessment	Activities
February	What is a mineral? How are minerals formed How to identify minerals What are minerals used for? What is a rock? What is the rock cycle? How are igneous rock formed? How are metamorphic rocks formed? How are sedimentary rocks formed? Where do we get coal? What are fossil fuels? What is our Earth made of? What are layers of the planets? What is plate tectonics? What is seafloor spreading How does the movement of these plates affect the earth?	Mineral identification process. Types of minerals and how to use them. Rocks and minerals Oil, coal and gas deposits-fossils Volcanoes and igneous rocks Formation and changes that happen deep in the Earth and cause metamorphic rocks. Earth layers and core Theory of Plate tectonics Seafloor spreading How plates move.	Explain the different types of minerals Explain the rock cycle List the characteristics of various minerals. Describe the characteristics of igneous rocks, sedimentary rocks and metamorphic rocks. Describe the formation of fossil fuels. Discuss the theory of plate tectonics and how it alters the Earth surface. Identify the boundaries of plates and the processes that happen around each.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes	Video: Various videos covering plate tectonics, minerals and geology Case Study Theory of plate tectonics Chapter review questions Class exercise on layers of the earth and plate movements Internet activities Library research skills **LAB:** Mineral identification **LAB:** Rock Cycle **LAB:** Plate Tectonics

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Month	Essential Questions	Content	Skills	Class work	Activities
March	How are mountains formed? What are the types of mountains? What are the processes that transform mountains? What are earthquakes? What are the differences in epi-center, focus? How do waves travel in the Earth layers? How is quake damage assessed? When does most loss of life occur? What are volcanoes? How are volcanoes formed and where can they usually be found? Is there a relationship between volcanoes and earthquakes?	Different types of mountains Seismic waves. Tracking and predicting earthquakes. Scale used to asses earthquakes. Seismic safe structures. Major earthquakes through time Describe the characteristics of waves and their relationship to rock layers Types of volcanoes. Location and formation of volcanoes. Damages caused by volcanoes vs. earthquakes. Major volcanic eruptions through time and their affect of society	Vocabulary for earthquakes and volcanoes. Discuss the processes of earthquakes and how they travel through the Earth and how scientists track and predict them. Discuss the damage caused by Earthquakes and what we are doing to mitigate this damage. Discuss why people live near known faults or volcanoes. Calculate seismic waves. Name the types of volcanoes, their characteristics, label parts and locations. Recognize the damage potential and be able to relate it to scale. Differentiate between types of faults and explain the resultant forces that cause them	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes	Video: Various videos covering earthquakes and volcanoes. Case Study Mt. St Helens and San Francisco quakes Chapter review questions **LAB:** building a volcano. **LAB:** Earthquakes Chapter questions and worksheets Internet activities Library research skills

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Month	Essential Questions	Content	Skills	Class work	Activities
April	Are all volcanoes the same? Why are there different types of eruptions? What is geothermal energy? What is geologic time? What are the period, epoch and eras of geologic time? How do we date rocks? Is the dating process accurate? Why do organism change through time? What are fossils? How do fossils vary? What happened to the dinosaurs? How did fossil fuels form and when? Why? Can humans slow down the rate of extinction?	Active volcanoes. Geysers and other forms of geothermic energy. Iceland's energy system Geologic time scale and where life and earth formations take place. Law of superposition. Carbon 14 dating Absolute dating Fossil types and where they can be found. Dinosaurs and geology. Asteroids and life on earth.	Explain the way we can use geothermal energy. Discuss the processes of volcanic eruptions. Explain the conditions under which fossil form. Describe how to date rock layers and events throughout the geologic time scale. Discuss and interpret different theories about fossils. Discuss why different species died off to become fossils and how we learn when, how and why they disappeared. Infer how organisms change due to environmental. Geologic or other changes to the earth. Recognize how humans have caused extinctions.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes **MP 3 Benchmark**	Video: Various videos covering Fossils and layers of the Earth. Case Study Fossils Chapter review questions Class exercise fossil types Internet activities Library research skills Chapter questions and worksheets **LAB:** Illustrate Geologic Timescale Fossil Identification

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Month	Essential Questions	Content	Skills	Class work	Activities
May	Earth-Moon system Why our moon is important? Lunar exploration. What are lunar phases and tides? Why we explore space-manned/unmanned. What is our solar system? Energy of the Sun. What are the inner planets? What are the outer planets? Exploring Mars why it's similar to Earth and different.	Tides lunar phases Apollo program and other space exploration. Inner planets. Outer planets Our sun. Fusion energy Asteroids, meteors and planetoids. Astronomy technology. Planetary geology.	Describe the characteristics of each planets of our solar system. Describe the processes of our sun and why it provides us with energy and life. Learn the vocab of space exploration and why it is important for humans to explore? Discuss the value of space exploration vs. costs. Calculate local tides based upon lunar movements and be able to explain the functions of gravity. Understand orbits and how they are calculated. Classify the types of planets and other solar system objects.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes	Video: Various videos covering The Planets, space travel. Case Study Mars Exploration Chapter review questions Class exercise on weather fronts and winds. LAB: Design planet build a space craft or space station Model our Solar System Internet activities Library research skills

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Month	Essential Questions	Content	Skills	Class work	Activities
June	What are stars? What are constellations? What technology do we use to study the stars? What are galaxies? What is the Universe? How did the universe form?	Star types and classifications. H-R diagram Hubble telescope, Satellites Radio and other types of telescopes and instruments. Black holes, galaxies, and types of galaxies.	Describe the formation of stars and how we classify them. Identify the types of galaxies. Discuss the formation of the universe. Big Bang theory. Learn how to use a star chart and find constellations.	Homework Chapter review questions and case study Topic worksheets OEQs Classwork Current event articles Topic Videos PowerPoint Internet and web-based programs Discussions Tests and quizzes **MP4 Benchmark**	Video: The Universe DVD. Chapter review questions Review for finals **Final Exam**

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Environmental Science Academic

9th – 12th Grade

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Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Steve Nagiewicz

(Revised July 2016)

I. OVERVIEW

Environmental Science is an interdisciplinary science course that will provide students with an awareness of the basic concepts of the life sciences to include; biology ecology, along with aspects of chemistry, earth science and physics and combines them with principles of social, economic, and moral ethics. The course allows each student to analyze and decide current issues concerning management of the environment in order to maintain or improve the quality of life on earth. This course is designed to provide students with the scientific principles, concepts and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems (natural and human-made), to evaluate the relative risks associated with these current problems and to examine for resolving and/or preventing them. This course meets for five single periods a week where one of the periods will be a laboratory demonstration of a key concept.

II. RATIONALE

Environmental problems and ecological limits are real and will be affecting all of us in various ways for the rest of our lives. To successfully meet these challenges, it is necessary that we, as individuals and as a society, fully understand the nature of ecological interactions and the impact humans have on ecosystems. The overall objective of this course is to describe the importance of ecological interactions, the environmental constraints which humankind confronts and to show the courses of action which may be taken in order to cope successfully with them.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 3/2009).

Science - NJ 2009 Core Curriculum Content Standards

5.1 Science Practices: All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.A.5.1.12.A.1 Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.

CPI: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.A.5.1.12.A.2 Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.

CPI: Develop and use mathematical, physical, and computational tools to

build evidence-based models and to pose theories.

5.1.A.5.1.12.A.3 Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

CPI: Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.B.5.1.12.B.1 Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.

CPI: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.B.5.1.12.B.2 Mathematical tools and technology are used to gather, analyze, and communicate results.

CPI: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.B.5.1.12.B.3 Empirical evidence is used to construct and defend arguments.

CPI: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.B.5.1.12.B.4 Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

CPI: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

5.1.C.5.1.12.C.1 Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

CPI: Reflect on and revise understandings as new evidence emerges.

5.1.C.5.1.12.C.2 Data and refined models are used to revise predictions and explanations.

CPI: Use data representations and new models to revise predictions and explanations

5.1.C.5.1.12.C.3 Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

CPI: Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

5.1.D.5.1.12.D.1 Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

CPI: Engage in multiple forms of discussion in order to process, make sense

of, and learn from others' ideas, observations, and experiences.

5.1.D.5.1.12.D.2 Science involves using language, both oral and written, as a tool for making thinking public.

CPI: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.D.5.1.12.D.3 Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

CPI: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science: All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A. Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.6 Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.

CPI: Relate the pH scale to the concentrations of various acids and bases.

5.2.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.2 A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.

CPI: Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.3 Life Science: All students will understand that life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics.

5.3.B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms.

5.3.12.B.3 Continual input of energy from sunlight keeps matter and energy flowing through ecosystems.

CPI: Predict what would happen to an ecosystem if an energy source was removed.

5.3.12.B.5 In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules.

CPI: Investigate and describe the complementary relationship (cycling of matter and flow of energy) between photosynthesis and cellular respiration

5.3.12.B.6 All organisms must break the high-energy chemical bonds in food molecules

during cellular respiration to obtain the energy needed for life processes.

CPI: Explain how the process of cellular respiration is similar to the burning of fossil fuels

5.3.C. Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs.

5.3.12.C.1 Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms.

CPI: Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem.

5.3.12.C.2 Stability in an ecosystem can be disrupted by natural or human interactions.

CPI: Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations.

5.3.E. Evolution and Diversity: Sometimes, differences between organisms of the same kind provide advantages for surviving and reproducing in different environments. These selective differences may lead to dramatic changes in characteristics of organisms in a population over extremely long periods of time.

5.3.12.E.2 Molecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.

CPI: Estimate how closely related species are, based on scientific evidence. The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.

5.4.B. History of Earth: From the time that Earth formed from a nebula 4.6 billion years ago, it has been evolving as a result of geologic, biological, physical, and chemical processes.

5.4.12.B.1 The evolution of life caused dramatic changes in the composition of Earth's atmosphere, which did not originally contain oxygen gas.

CPI: Trace the evolution of our atmosphere and relate the changes in rock types and life forms to the evolving atmosphere.

5.4.C. Properties of Earth Materials: Earth’s composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life.

5.4.12.C.1 Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere.

CPI: Model the interrelationships among the spheres in the Earth systems by creating a flow chart.

5.4.12.C.2 The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.

CPI: Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact

on life.

5.4.D. Tectonics: The theory of plate tectonics provides a framework for understanding the dynamic processes within and on Earth.

5.4.12.D.1 Convection currents in the upper mantle drive plate motion. Plates are pushed apart at spreading zones and pulled down into the crust at subduction zones.

CPI: Explain the mechanisms for plate motions using earthquake data, mathematics, and conceptual models.

5.4.12.D.2 Evidence from lava flows and ocean-floor rocks shows that Earth's magnetic field reverses (North - South) over geologic time.

CPI: Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data.

5.4.E. Energy in Earth Systems: Internal and external sources of energy drive Earth systems.

5.4.12.E.1 The Sun is the major external source of energy for Earth's global energy budget.

CPI: Model and explain the physical science principles that account for the global energy budget.

5.4.12.E.2 Earth systems have internal and external sources of energy, both of which create heat.

CPI: Predict what the impact on biogeochemical systems would be if there were an increase or decrease in internal and external energy.

5.4.F. Climate and Weather: Earth’s weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere.

5.4.12.F.1 Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun.

CPI: Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun.

5.4.12.F.2 Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate.

CPI: Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean.

5.4.12.F.3 Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally.

CPI: Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales.

5.4.G. Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity.

5.4.12.G.1 Natural and human-made chemicals circulate with water in the hydrologic cycle.

> **CPI:** Analyze and explain the sources and impact of a specific industry on a large body of water (e.g., Delaware or Chesapeake Bay)

5.4.12.G.2 Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.

> **CPI:** Explain the unintended consequences of harvesting natural resources from an ecosystem.

5.4.12.G.3 Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter.

> **CPI:** Demonstrate, using models, how internal and external sources of energy drive the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles.

5.4.12.G.4 Natural and human activities impact the cycling of matter and the flow of energy through ecosystem.

> **CPI:** Compare over time the impact of human activity on the cycling of matter and energy through ecosystems.

5.4.12.G.5 Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.

> **CPI:** Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region.

5.4.12.G.6 Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.

> **CPI:** Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy)

5.4.12.G.7 Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles.

> **CPI:** Relate information to detailed models of the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles, identifying major sources, sinks, fluxes, and residence times

STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. Define, in writing/discussion, the concept of ecosystem including identifying abiotic and biotic components, explaining the importance of recycling nutrients,

and summarizing the movement of energy.

2. Determine, from evidence given, whether an ecosystem is stable or in danger of collapse.
3. Describe, in writing/discussion, the key chemical concepts and processes responsible for maintaining environmental stability. For example, the processes of photosynthesis and respiration.
4. Explain, in writing/discussion, the dynamic balance that exists among the components that make up soil.
5. Discuss, in writing/discussion, the water cycle and how it helps connect all ecosystems together and to describe the effect that man has had on it.
6. Describe the impact of domestic wastes on the environment and the existence of humankind.
7. Summarize and state in writing, several key concepts presented in an article such as "Tragedy of the Commons" as they relate to ecology and ethics.
8. Explain, in writing, the limits to growth with respect to living with a finite quantity of resources.
9. Summarize, in writing/discussion, as many diverse opinions and scientific principles that need to be researched in order to attempt to answer questions such as "Can human growth be controlled?" and "What will future population increases do to the environment?"
10. Recognize, in writing/discussion, current and past leaders of environmental science and their contributions.

B. ATTITUDES

The student will:

1. Develop an appreciation for the study of environmental science and how it relates to his/her everyday life
2. Research and investigate possible careers in environmental science
3. Recognize the impact of environmental science on every aspect of daily life.

C. SKILLS AND BEHAVIOR

The student will:

1. Demonstrate good problem-solving techniques
2. Write essays on specific topics in environmental science demonstrating comprehension of a given topic, i.e. the historical development of the subject
3. Demonstrate effective listening and note taking skills in lecture and discussion situations
4. Demonstrate proper and safe use of laboratory equipment and chemicals during experiments
5. Use the scientific method in solving laboratory based problems and writing reports based on their solutions
6. Demonstrate in class discussion and in writing a comprehensive knowledge of environmental science

7. Work cooperatively in small groups to solve problems or perform experiments
8. Design and interpret graphs using data
9. Use spreadsheet and graphing software to report results of laboratory investigations
10. Design and produce presentations using Power Point presentation software
11. Set up and perform experiments using computer interfaced sensors to collect data
12. Utilize Internet search engines to locate environmental science related websites for research and review
13. Be aware of the connection between educational activities and the world of work

IV. ACCOMMODATIONS AND MODIFICATIONS

The New Jersey Core Curriculum Content Standards (NJCCCS) reflect concepts that all children need to grow intellectually, socially and emotionally. Goals and objectives for all students, no matter how significant their learning challenges, should be related to the NJCCCS and associated cumulative progress indicators. Working within the framework of the standards, using accommodations and modifications as needed, will prepare students to proficiently participate in the High School Proficiency Assessment (HSPA) and New Jersey Assessment of Skills and Knowledge (NJ ASK) or the Alternative Proficiency Assessment (APA).

The Special Education Department will follow the district's general education curricula, reflecting the following New Jersey Core Curriculum Content Standards (NJCCCS). These standards and related curriculum frameworks are the focus of curriculum and instruction for all students.

Curriculum and instructional adaptations may be required in order to provide meaningful assessment and exposure to the material based on the content standards. "The adaptations are not intended to compromise the content standards. Instead, adaptations provide students with disabilities the opportunity to maximize their strengths and compensate for their learning differences." (**New Jersey Department of Education** Cross-Content Framework, p 7.1, Appendix B)

Accommodations refer to the actual teaching supports and services that the student may require to successfully demonstrate learning. Accommodations should not change expectations to the curriculum grade levels. Accommodations may include but are not limited to: taped books, math charts, additional time, oral test, oral reports, preferred seating, study carrel, amplified system, braille writer, adapted keyboard, specialized software, etc.

Modifications refer to changes made to curriculum expectations in order to meet the needs of the student. Modifications are made when the expectations are beyond the students level of ability. Modifications may be minimal or very complex depending on the student performance. Modifications must be clearly acknowledged in the IEP. Modifications may include but are not limited to: second language exemptions, withdrawal for specific skills, include student in same activity but individualize the expectations and materials, student is involved in same theme/unit but provide different task and expectations, etc.

V. STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*

- Audio visual media
- Charts, handouts, graphs
- Class & individual assignments
- Cooperative activities
- Critical thinking:
  - Decision making
  - Compare & contrast
  - Reliable sources
  - Causal explanation
  - Prediction
- Debates & panel discussion
- Demonstrations (teacher/student led)
- Direct instruction
- Discussion (teacher/student led)
- Drill practice
- Extra credit project or presentation
- Homework
- Investigation
- Laboratory experiment
- Lecture
- Library and resource documents
- Oral reading
- Periodicals
- Questioning techniques
- Research paper
- Reviews
- Self-instructional instruments
- Textbook
- Textbook supplements
- Tutoring (peer & teacher)

VI. EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include

DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper.*

- Tests
- Quizzes
- Homework

Pre & Post Test assessment

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.

Class participation
Teacher observation
Infusion exercises
Portfolios

PERFORMANCE ASSESSMENT *authentic assessment specific to environmental science*.

Laboratory

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: *Environmental Science, Jay Withgott.* Pearson, 2011
2. Technology: Laptop cart or desktop computers. Word Processing and Data Base programs: Microsoft Office and Internet Resources, textbook/publisher web resources.
3. Addition resources:

Reference materials

Audio-visual materials, DVD's
Computer software
NBC Learn
Media center internet reference and data search

Alternative assessment activities

VIII. SCOPE AND SEQUENCE

UNIT 1 UNDERSTANDING SCIENCE

September Science Basics Review and Chapters 1 & 3

Steps of the Scientific Method
Science Math, Measurements & Statistics
Reading & Understanding Graphs
Lab Procedures, Safety and Reports
Solving environmental problems
What is our Ecological Footprint?
Structure of the Earth: plate tectonics-volcanoes-earthquakes
Earth 'Spheres': Geosphere-Atmosphere-Hydrosphere-Biosphere
BioGeoChemical Cycles

Assessments – Unit Pre-Test, Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports

UNITS 1 & 2 UNDERSTANDING SCIENCE & ECOLOGY

October Chapters 3 & 4

BioGeoChemical Cycles
What is a habitat?
How Ecosystems Change
Organisms and species
Communities
Population Growth
Biotic & Abiotic factors

Assessments – Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports

UNIT 2 ECOLOGY

November Chapters 4 & 5,

Species Populations
Food webs-pyramids
Energy flow in ecosystems
Producers/Consumers
Species Interactions: Predation-Competition-Parasitism-Mutualism-Commensalism

Assessments – Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports
1st MP Quarterly Post Test

December Chapters 6 & 7

Evolution by natural selection
Extinction
Ecological Successions
Invasive Species

Assessments – Unit Pre-Test, Chapter Tests, Unit Quiz, Classwork/Homework, Lab & reports

UNIT 2 & 4 ECOLOGY & EARTH's RESOURCES

January Chapters 6, 7 & 12

What is a Biome and how are they characterized?
What the main types of land and water biomes around the world?
How do they differ from each other?

Why is Soil important
Weathering & Erosion
Industrial Revolution-Agriculture based society
Biodiversity & Ecosystem Diversity
Endangered-Threatened-Protected Species
Pest Management,
Agriculture,
Food production
Sustainable agricultures
Genetically Modified Organisms
Biotechnology

Assessments – Chapter Tests, Unit Quiz, Classwork/Homework, Lab & reports

2nd MP Quarterly Post Test

UNIT 4 ECOLOGY & EARTH's RESOURCES

February Chapter 14 & 15

Water Resources
Surface water & Ground water
Solutions to water shortages
Point and Non-point source pollution
Types of Water Pollution and Preventing Ocean Pollution
How water pollution affects ecosystems
Cleaning up water pollution – Preventing Ocean Pollution
The Atmosphere
Six Primary Sources of Air Pollution
Indoor air pollution
Acid precipitation

Assessments – Unit Pre-Test, Chapter Tests, Unit Quiz, Classwork/Homework, lab & reports

UNITS 3 & 5
HUMANS and the ENVIRONMENT & TOWARDS A SUSTAINABLE FUTURE

March Chapters 9 & 16

Natural Disasters: Earthquakes, Storms, Volcanoes
Environmental Health Hazards
Climate and Global Warming
The Effects of Climate change
Ocean Currents and Climate, El Nino-La Nina
The Greenhouse Effect
The Ozone Layer and UV radiation

Assessments – Chapter Tests, Unit Quiz, Classwork/Homework, lab & reports

UNIT 3 HUMANS and the ENVIRONMENT

April Chapters 8, 9 & 10

Natural Disasters: Earthquakes, Storms, Volcanoes
Land Use & Land Management: Urban Areas and Suburban.
Infrastructure & Mass Transportation
Deforestation-clear cutting, overgrazing, desertification
Public land in the United States
US/World Population Growth
US Census
Population Demographics
Birth-Death Rates
Infant Mortality & Fertility Rates
Developed-Developing Nations
Social Factors
Impacts of Population and Technology

Assessments – Chapter Test, Unit Quiz, Classwork/Homework, lab & reports
3rd MP Quarterly Post Test

UNIT 5 TOWARDS A SUSTAINABLE FUTURE

May/June Chapters 17, 18, 19

Non-Renewable Energy
What are Fossil fuels and how are they used?
Renewable Energy
Waste Management and Landfills
Why Recycle?
Finals Review
Course Finals

Assessments – Chapter Test, Unit Quiz, Classwork/Homework, lab & reports
4th MP Unit Pre & Post Quarterly Test and Final Exams

Total Instructional Time	33 Weeks (165 days)
Finals, HSPA, STA, Pre/Post Tests	3 Weeks (15 days)
Totals	36 Weeks (180 days)

Atlantic City High School Environmental Science

9th - 12th Grade Curriculum Content

DRAFT

Steve Nagiewicz

Revised, July, 2016

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Introduction

Course Focus: An Environmental Science course is designed to immerse students in the physical, biological, and earth systems sciences that shape our environment. Scientific concepts, principles and modern science practices allow students to analyze environmental issues, both natural and human induced, and engage in evidence-based decision making in real world contexts.

Mission of Science Education: *Scientifically literate students possess the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity.*

Vision of Science Education: A quality science education fosters a population that:

- Experiences the richness and excitement of knowing about the natural world and understanding how it functions.
- Uses appropriate scientific processes and principles in making personal decisions.
- Engages intelligently in public discourse and debate about matters of scientific and technological concern.
- Applies scientific knowledge and skills to increase economic productivity.

What is a Laboratory/Inquiry-Based Science Course?

We begin to answer this question by stating that Laboratory science is a practice not a place. Laboratory/inquiry-based science courses (lab course) emphasize student sense making opportunities rather than focusing on course title or seat time.

Next, we look at the question from a structure and functional perspective. The function of our K-12 science instruction should be students becoming scientifically proficient. The definition of proficiency has evolved over the past several years. Knowing science requires individuals to integrate a complex structure of many types of knowledge. These knowledge types include the ideas of science, the relationships between the ideas, the reasons for these relationships, and the ways to use these ideas to complete the following tasks: explain and predict other phenomena, interpret situations, solve problems and participate productively in science practice and discourse (ACT, 2007; College Board, 2009; NJCCCS, 2009). Therefore rigorous instruction must evolve from a focus on learning all of the facts and specific examples about a concept to an understanding and application of core principles of the discipline and an integration of that knowledge with the processes that are necessary for practicing science discourse (ACT, 2007; College Board, 2009; NJCCCS, 2009). The requirement that all high school science courses to be laboratory/inquiry- based reflects the importance of the necessity for each of us to examine how well our instructional practices are likely to result in our students becoming scientifically literate.

From an academic perspective, contemporary views of learning prize understanding and application or knowledge in use. Learners who understand can use and apply novel ideas in diverse contexts, drawing connections among multiple representations of a given concept. They appreciate the foundations of knowledge and consider the evidence for claims. Accomplished learners know when to ask a question, how to challenge claims, where to go to learn more, and they are aware of their own ideas and how these change over time. (2007, NRC)

The classic scientific method as taught for many years provides only a very general approximation of the actual working of scientists. The process of theory development and testing is iterative, uses both deductive and inductive logic, and incorporates many tools besides direct experiment. Modeling (both mechanical models and computer simulations) and scenario building (including thought experiments) play an important role in the development of scientific knowledge. The ability to examine one's own knowledge and conceptual frameworks, to evaluate them in relation to new information or competing alternative frameworks and to alter them by a deliberate and conscious effort are key scientific practices. (2007, NRC)

The process by which scientific understandings are developed and the form that those understandings take differ from one domain of science to another, but all sciences share certain common features at the core of their problem-solving and inquiry approaches. Chief among these is that data and evidence hold a primary position in deciding any

issue. Thus, when well-established data, from experiment or observation, conflict with a theory or hypothesis, then that idea must be modified or abandoned and other explanations must be sought that can incorporate or take account of the new evidence. This also means that models, theories, and hypotheses are valued to the extent that they make testable (or in principle testable) precise predictions for as yet unmeasured or unobserved effects; provide a coherent conceptual framework that is consistent with a body of facts that are currently known; and offer suggestions of new paths for further study. (2007, NRC)

A process of argumentation and analysis that relates data and theory is another essential feature of science. This includes evaluation of data quality, modeling, and development of new testable questions from the theory, as well as modifying theories as data dictates the need. Finally, scientists need to be able to examine, review, and evaluate their own knowledge. Holding some parts of a conceptual framework as more or less established and being aware of the ways in which that knowledge may be incomplete are critical scientific practices. (2007, NRC)

Lab science courses emphasize the importance of students independently creating scientific arguments and explanations for observations made during investigations. Science courses thereby become a sense-making enterprise for students in which they are systematically provided with ongoing opportunities to:

- Interact directly with the natural and designed world using tools, data-collection techniques, models, and theories of science.
- Actively participate in scientific investigations and use cognitive and manipulative skills associated with the formulation of scientific explanations.
- Use evidence, apply logic, and construct arguments for their proposed explanations.

The lab science requirement implicitly and explicitly point to a more student-centered approach to instructional design that engages learners in inquiry. Inquiry, as defined in the revised standards, envisions learners who:

- Are engaged by scientifically-oriented questions.
- Prioritize evidence that addresses scientifically-oriented questions.
- Formulate explanations from that evidence to address those scientifically-oriented questions.
- Evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- Communicate and justify their proposed explanations.

Fundamental principles of lab science course design assist students in achieving science proficiency through sense making experiences that:

- Are designed with clear learning outcomes in mind.
- Are sequenced thoughtfully into the flow of classroom science instruction.
- Integrate learning of science content with learning about science practices.
- Incorporate ongoing student reflection and discussion (National Research Council, 2007).

If lab science is a practice not a place, then what kinds of things should my students be doing in a lab science course? Students' K-12 lab science experiences should include the following:

- **Physical manipulation of authentic substances or systems:** This may include such activities as chemistry experiments, plant and animal observations, and investigations of force and motion.

- **Interaction with simulations:** In 21st century laboratory science courses, students can work with computerized models, or simulations, that represent aspects of natural phenomena that cannot be observed directly because

they are very large, very small, very slow, very fast, or very complex. Students may also model the interaction of molecules in chemistry or manipulate models of cells, animal or plant systems, wave motion, weather patterns, or geological formations using simulations.

- **Interaction with authentic data:** Students may interact with authentic data that are obtained and represented in a variety of forms. For example, they may study photographs to examine characteristics of the moon or other heavenly bodies or analyze emission and absorption spectra in the light from stars. Data may be incorporated in films, DVDs, computer programs, or other formats.

- **Access to large databases:** In many fields of science, researchers have arranged for empirical data to be normalized and aggregated—for example, genome databases, astronomy image collections, databases of climatic events over long time periods, biological field observations. Some students may be able to access authentic and timely scientific data using the Internet and can also manipulate and analyze authentic data in new forms of laboratory experiences (Bell, 2005).

- **Remote access to scientific instruments and observations:** When available, laboratory experiences enabled by the Internet can link students to remote instruments, such as the environmental scanning electron microscope (Thakkar et al., 2000), or allow them to control automated telescopes (Gould, 2004).

Sometimes, administrative code language (structure) issued from the NJDOE results in a compliance approach to meeting the requirements rather than an approach based on the spirit and intent of the language. It is often preferable to provide teachers with the expectations for outcomes (function). In the process of transforming your course, remain focused on the desired result of student proficiency. Knowing science requires individuals to integrate a complex structure of many types of knowledge. These knowledge types include the ideas of science, the relationships between the ideas, the reasons for these relationships, and the ways to use these ideas to complete the following tasks: explain and predict other phenomena, interpret situations, solve problems and participate productively in science practice and discourse (ACT, 2007; College Board, 2009; NJCCCS, 2009). Therefore rigorous instruction must evolve from a focus on learning all of the facts and specific examples about a concept to an understanding and application of core principles of the discipline and an integration of that knowledge with the processes that are necessary for practicing science discourse (ACT, 2007; College Board, 2009; NJCCCS, 2009). The requirement that all high school science courses to be laboratory/inquiry- based reflects the importance of the necessity for each of us to examine how well our instructional practices are likely to result in our students becoming scientifically literate.

Environmental Science Core Content Outline:

B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms.

1. As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities), and between living systems and the physical environment, chemical elements are recombined into different products.

2. Each recombination of matter and energy results in storage and dissipation of energy into the environment as heat.

3. Continual input of energy from sunlight keeps matter and energy flowing through ecosystems.

C. Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life.

1. Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere. Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere.

2. The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.

F. Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere.

1. Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate.

2. The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.

G. Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity.

1. Natural and human-made chemicals circulate with water in the hydrologic cycle.

2. Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.

3. Energy in Biogeochemical Systems: Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter.

4. Human Influences: Natural and human activities impact the cycling of matter and the flow of energy through ecosystems.

5. Human Activities: Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.

6. Evidence Based Decision Making: Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.

7. Conservation of Matter: Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles.

Science Practices:

A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

1. Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.
2. Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.
3. Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

B. Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

1. Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.
2. Mathematical tools and technology are used to gather, analyze, and communicate results.
3. Empirical evidence is used to construct and defend arguments.
4. Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

C. Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

1. Refinement of understandings, explanations, and models occurs as new evidence is incorporated.
2. Data and refined models are used to revise predictions and explanations.
3. Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

D. Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

1. Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.
2. Science involves using language, both oral and written, as a tool for making thinking public.
3. Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

Understanding the Structure and Function of this Document

Standard: The Standard outlines the core understanding for each content domain. Each standard statement explains why the strands and cumulative progress indicators are important.	
Strand: The strand defines a core concept or principle in environmental science. Each strand runs throughout students' K-12 academic experience. Each of the life science strands supports the core understanding of the Standard.	
Essential Questions	**Enduring Understandings**
These questions have no 'right' or 'easy' answer, and are meant to inspire investigation and raise more questions.	These understandings are insights that a student gains through learning experiences, and are transferable to new situations.
Content Statements	**Cumulative Progress Indicators**
These statements describe the environmental science concept/content that a student needs to understand.	These statements describe how students can demonstrate their understanding of the concept/content.

Instructional Focus:

- Provides further clarification of the learning expectations for curriculum developers, teacher, assessment panels, and students
- Offers suggestions for scaffolding for instruction
- Provides boundaries for the content included in an Environmental Science End of Course Assessment
  - *Narratives identified with this symbol are details that will not be part of the statewide assessments.*

Common Student Misconceptions:

Current research in science education emphasizes the importance of knowing students' previous ideas, conceptions, and representations of scientific content. This research also identifies a considerable number and variety of student misconceptions regarding natural processes and systems, while also reporting the complexity of transforming such mistaken ideas or conceptions. Uncovering students' misconceptions are an important issue for the development of teaching strategies and for identifying students' conceptual progress. In an attempt to bridge these gaps, **Common Student Misconceptions** was included in this document to help you address these obstacles to student understanding of environmental science content.

Sample Assessment Item:

These items have been provided to give you a sample of the types of items that students should be able to answer in a locally developed benchmark assessment. These items can be used on classroom assessments or as samples for the creation of school or district items during an exercise in professional development.

Sample Integration of Science Practices and Core Content:

The 2009 Science Standards implicitly and explicitly point to a more student-centered approach to instructional design that engages learners in inquiry. Inquiry, as defined in the revised standards, envisions learners who are engaged by scientifically-oriented questions; prioritize evidence that addresses scientifically-oriented questions; formulate explanations from that evidence to address those scientifically-oriented questions; evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and communicate and justify their proposed explanations. The **Sample Integration of Science Practices and Core Content** is a brief sample description of a learning experience that integrates the environmental science content with the science practices. These experiences can be modified to meet the needs of your students.

Resources:

The National Science Digital Library (NSDL) was created by the National Science Foundation to provide organized access to high quality resources and tools that support innovations in teaching and learning at all levels of science, technology, engineering, and mathematics (STEM) education. NSDL provides an organized point of access to high-quality STEM content from a variety of other digital libraries, NSF-funded projects, and NSDL-reviewed web sites.

5.3 Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics.

B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms.

Essential Questions	Enduring Understandings
To what extent does understanding the flow of matter and energy through living systems effect personal and public policy decisions?	All organisms transfer matter and convert energy from one form to another. Both matter and energy are necessary to build and maintain living systems.

Content Statements	Cumulative Progress Indicators
As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities), and between living systems and the physical environment, chemical elements are recombined into different products.	Cite evidence that the transfer and transformation of matter and energy links organisms to one another and to their physical setting. **(5.3.12.B.1)**

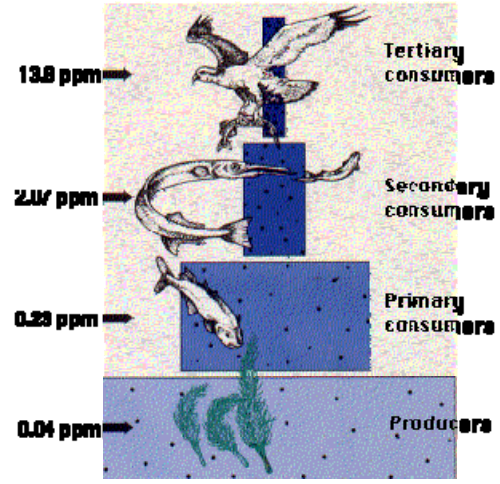
Instructional Focus:

- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways (photosynthesis, respiration, nitrogen fixation, or decomposition). *BMSL 5E/H3; NAAEE 2.1.B.2*
- At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment. Continual input of energy from sunlight keeps the process going. *BMSL 5E/H3; NAAEE 2.1.B.2*

Common Student Misconceptions:

Research indicates that few students are able to relate their ideas about feeding and energy to a framework of ideas about interactions of organisms. Many students do not recognize how organisms are connected in terms of feeding and energy, and many students cannot explain why humans cannot live in a world without plants (Smith and Anderson 1986). You can determine if students harbor this misconception by asking students to justify the statements 'all life **depends** on green plants' using scientific explanations. Students reporting that plants harness solar energy through photosynthesis, recognizing the inability of animals to 'make their own food'.

Sample Assessment Item:



The numbers are representative values of the concentration in the tissues of DDT and its derivatives (in parts per million, ppm)

Use the image to the left to answer the following question:

The image to the left is a stylized food web that illustrates the biomagnification of DDT. DDT is rapidly taken up but only slowly eliminated from the body by fish and other aquatic organisms, so each step up in the food web magnifies the concentration from the step below.

1. How could this image and the concept of biomagnification be used to illustrate that the transfer and transformation of matter links organisms to one another and to their physical setting?

2. Use your knowledge of the nitrogen cycle to describe how one atom of nitrogen could travel through and interact with: an animal, soil, a plant, a bacterium or bacteria, and the air.

3. Mercury released from coal burning power plants ends up in the ocean at very tiny concentrations. Yet eating salmon is not recommended for pregnant women because of the high concentration of mercury in these oceanic fish. How can the fish end up with high levels of mercury if the water they live in has such low levels of mercury?

4. If salmon eat smaller fish, the smaller fish eat zooplankton (tiny animals), and the zooplankton eat phytoplankton (tiny plants) then what would the level of mercury be in the salmon compared to the phytoplankton?

A. 1/10th
B. The same
C. 10 x D.
100 x E.
1000 x

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Living Environment: Flow of Matter in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-9001

The Living Environment: Flow of Energy in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-1422

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 ***BIG Question:*** *How do changes in population size relate to environmental conditions?*

Chapter 4-5-6 Science Curriculum Topic Study: Key Terms to Cover: Cycling of Matter, Trophic Transfer of Energy, Species Populations, Population Density, Distribution, birth-death rates, immigration-emigration, exponential growth, biotic/abiotic factors and potential, carry capacity. For additional resources: Chapter 1,3,9,14

Content Statements	Cumulative Progress Indicators
Each recombination of matter and energy results in storage and dissipation of energy into the environment as heat.	Use mathematical formulas to justify the concept of an efficient diet. **(5.3.12.B.2)**

Instructional Focus:

- Although the various forms of energy appear very different, each can be measured in a way that makes it possible to keep track of how much of one form is converted into another. Whenever the amount of energy in one place diminishes the amount in other places or forms increases by the same amount. *4E/H1*

- The use and transfer of energy from one trophic level to another can be calculated.
  - Rule of Ten

Common Student Misconceptions:

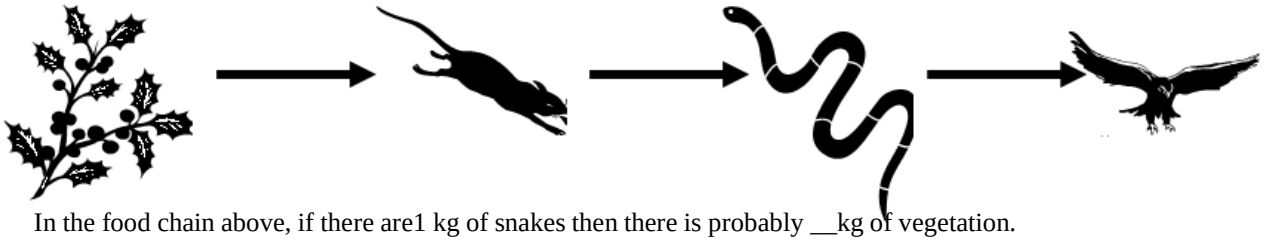
Research indicates that some students mistakenly believe that energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable (Solomon 1985). You can determine if students harbor this misconception by asking students to clearly explain the differences between energy and other concepts such as food, force, and temperature.

Sample Assessment Item:

1. You are living on an island with one hundred other people. They have asked you, as a scientist, to help them make an important decision. There is a limited amount of land to grow crops. The land is currently growing corn and beans. There are also several cows on the island, enough to establish a herd if you so desire. You can

either continue planting corn and beans and eating them directly or use some or all of the corn and beans that you grow to raise more cows for milk and meat. There is no possibility of leaving the island or getting any supplies from elsewhere. Fishing is not an option. Use your knowledge of how matter and energy move through ecosystems to describe what you would recommend doing in response to your fellow islanders request for advice. Use a mathematical argument to help make your point.

2. Some vegetarians argue that their choice of diet is not just a moral but an environmental good. Argue for or against this point of view using your knowledge of how matter and energy move through ecosystems. Use a mathematical argument to help make your point.



3. In the food chain above, if there are1 kg of snakes then there is probably __kg of vegetation.
   a. 1000
   b. 100
   c. 10 d. _____
      1
   e. .1

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Living Environment: Flow of Matter in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-9001

The Living Environment: Flow of Energy in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-1422

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: How do organisms affect one another's survival and environment?

Chapters; 4-5-6 Science Curriculum Topic Study: Key Terms to cover: Food Chains and Food Webs, Energy Transfers, Rule of Ten, Photosynthesis, adaption, evolution, extinction, species relationships, keystone species, ecological succession, and invasive species. For additional Resources: Chapters: 9-14

Additional Resource:

NOAA's The Earth's Energy Budget Demonstration: The three types of heat transfer and the processes that light as radiation can undergo: reflection, absorption, and refraction.
http://oceanservice.noaa.gov/education/lessons/earth_energy_budget_lesson.html

Content Statements	Cumulative Progress Indicators
Continual input of energy from sunlight keeps matter and energy flowing through ecosystems.	Predict what would happen to an ecosystem if an energy source was removed. **(5.3.12.B.3)**

Instructional Focus:

- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment. Continual input of energy from sunlight keeps the process going. *5E/H3*

- Living systems require a continuous input of energy to maintain their chemical and physical organizations and also understanding that with the cessation of energy input, living systems rapidly disintegrate.

- The abundance and distribution of living organisms are limited by the available energy and certain forms of matter such as water, oxygen and minerals. (NAAEE 2.2.D.3)

Common Student Misconceptions:

Research indicates that some students have difficulty in identifying the sources of energy for plants and animals. Some students confuse the concept of energy with other concepts such as food, force, and temperature. As a result, these students may not appreciate the uniqueness and importance of specific energy conversion processes like respiration and photosynthesis (Anderson et al. 1990). You can determine if students harbor this misconception by asking students to explain in detail how energy is transferred and transformed at each interaction in a food web.

Students often think that plant cells photosynthesize and that only animal cells utilize cellular respiration.

Sample Assessment Item:

1. Sunlight is necessary for photosynthesis by plants that are the base of almost every food web. Without sunlight photosynthesis stops and the whole food chain collapses. If this is true, how can a community of organisms live in a lightless subterranean cave?
2. Europa is a moon of the planet Jupiter. Like all the gas giant planets Jupiter has a much more distant orbit from the center of the solar system than Earth. Though there may be, or have been, liquid water beneath the frozen crust of the surface of the moon there is not likely to have been, or to be, much life on this moon. Since liquid water and nutrients may be plentiful, why would we not expect to find a productive ecosystem on Europa? What is missing?

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Living Environment: Flow of Matter in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-9001

The Living Environment: Flow of Energy in Ecosystems:

http://strandmaps.nsdl.org/?id=SMS-MAP-1422

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: How do organisms affect one another's survival and environment?

Chapters; 4-5-6 Science Curriculum Topic Study: **Key Terms to cover:** Food Chains and Food Webs, Energy Transfers, Rule of Ten, Photosynthesis, adaption, evolution, extinction, species relationships, keystone species, ecological succession, and invasive species.

For additional resources: Chapters: 1,3,9,14

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.	
C. Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life.	
Essential Questions	**Enduring Understandings**
Why is it important to think in terms of systems of systems when considering environmental issues?	Ecosystems are the result of the interactions among Earth's biosphere, geosphere, atmosphere, and hydrosphere.
Content Statements	**Cumulative Progress Indicators**
Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere.	Model the interrelationships among the spheres in the Earth systems by creating a flow chart. **(5.4.12.C.1)**

Instructional Focus:

- The transfer of matter and energy between the biosphere, geosphere, atmosphere, and hydrosphere often takes place in soils.
  - The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants.
  - The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics. (US Department of Agriculture, Viewed August 24, 2010,

    http://soils.usda.gov/education/facts/soil.html)
- Earth's atmosphere exchanges energy and matter within the Earth System through processes such as photosynthesis, the water cycle, biogeochemical cycles, the rock cycle and ocean currents. *5.1* (NOAA, 2008).
- The four major systems of Earth are the geosphere, hydrosphere, atmosphere, and biosphere. The geosphere includes a metallic core, solid and molten rock, soil, and sediments. The atmosphere is the envelope of gas surrounding Earth. The hydrosphere includes the ice, water vapor, and liquid water in the atmosphere, the ocean, lakes, streams, soils, and groundwater. The biosphere includes Earth's life, which can be found in many parts of the geosphere, hydrosphere, and atmosphere. Humans are part of the biosphere, and human activities have important impacts on all four spheres. *3.1* (NSF, 2009).

Common Student Misconceptions:

It is common for students to believe that soil is 'just dirt' or any 'stuff on the ground.' Students appear to be largely unaware that there a reliving organisms in the soil and unaware of the role of the living organisms in the soil. The formation of soil is strongly associated with deposition by rivers results from volcanic activity, or that soil is the precursor to rock (Happs).

Some think dead organisms simply rot away. They do not realize that the matter from the dead organism is converted into other materials in the environment. Some students see decay as a gradual, inevitable consequence of time without need of decomposing agents (Smith, E., Anderson, C., 1986). Some high-school students believe that matter is conserved during decay, but do not know where it goes (Leach, J., Driver, R., Scott, P., Wood-Robinson, C., 1992).

Students seem to know that some kind of cyclical process takes place in ecosystems (Smith, E., Anderson, C., 1986). Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants. They often think in linear terms and have trouble reasoning about cycles or systems that have multiple inputs and outputs (Jordan, R.C., Gray,S., Demeter, M., Lui, L., Hmelo-Silver, C. 2009). They

think the processes involve creating and destroying matter rather than transforming it from one substance to another. Other students recognize one form of recycling through soil minerals but fail to incorporate water, oxygen, and carbon dioxide into matter cycles. Even after specially designed instruction, students cling to their misinterpretations. Instruction that traces matter through the ecosystem as a basic pattern of thinking may help correct these difficulties (Smith, E., Anderson, C., 1986).

Sample Integration of Science Practices and Core Content:

Objectively discern scientific consensus versus other agendas present in the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report published in the July 20, 2001 issue of the journal Science. Evaluate and report on the credibility and credentials of the authoring organizations and their use of data. The Atmosphere and Climate Change http://esa21.kennesaw.edu/activities/atmosphere/atms_climatechange.pdf

Sample Assessment Item:

1. You have been provided three soil samples from the Moon and Mars. Your task is to examine the properties of the sample and identify Students will then examine and test unknown soil samples and record test observations. Using the charts, each unknown sample will be identified. Students will be asked to defend their decisions.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Weather and Climate: http://strandmaps.nsdl.org/?id=SMS-MAP-1698

The Physical Setting: Changes in the Earth's Surface http://strandmaps.nsdl.org/?id=SMS-MAP-0048

Common Themes: Systems: http://strandmaps.nsdl.org/?id=SMS-MAP-1594

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475- BIG Question: How can we balance our growing demand for food with our need to protect the environment? Chapter 3, 14. Science Curriculum Topic Study: Key Terms to cover: biosphere, hydrosphere, atmosphere, geosphere, and lithosphere. Soil formation and types, soil horizon and profile, minerals, erosion, desertification, overgrazing, soil pollution, pesticides, agriculture, foods, malnutrition, biotechnology, Genetically modified foods.

For additional resources; Chapters 9, 10, 11

Other Web Based Resources

National Science Foundation, (2009), Earth Science Literacy Principles. Published May 2009, retrieved August 2010. http://www.earthscienceliteracy.org/

Content Statements	Cumulative Progress Indicators
The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.	Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. **(5.4.12.C.2)**

Instructional Focus:

- Life is adapted to conditions on the earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of electromagnetic waves from the sun that allows water to be present in the liquid state. *4B/H1* (BSL)
- Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent too much of the incoming sunlight but not to the infrared light from the warmed surface of the earth. When greenhouse gases increase, more thermal energy is trapped in the atmosphere, and the temperature of the earth increases the light energy radiated into space until it again equals the light energy absorbed from the sun. *4B/H4* (SFAA)
- The atmosphere has mass, is bound to Earth by gravity, and exerts pressure which is greater near Earth's surface and decreases with altitude. 1.2 (NOAA, 2008)

- The atmosphere, which is very thin relative to Earth's radius, varies vertically in layers which differ in composition, density, and temperature. The lowest 8-16 km of the atmosphere - the troposphere - contains most of Earth's weather systems. *1.3* (NOAA, 2008)

Common Student Misconceptions:

Although upper elementary students may identify air as existing even in static situations and recognize that it takes space, recognizing that air has weight may be challenging even for high-school students (Sere, M., 1985). Students of all ages (including college students) may believe that air exerts force or pressure only when it is moving and only downwards (Driver, R., Squires, A., Rushworth, P., Wood-Robinson, V., 1994). Only a few middle-school students use the idea of pressure differences between regions of the atmosphere to account for wind; instead they may account for winds in terms of visible moving objects or the movement of the earth (Driver, R., Squires, A., Rushworth, P., Wood-Robinson, V., 1994).
Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming) (Andersson, B., Wallin, A., 2000). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancement of that effect (Andersson, B., Wallin, A., 2000).

Sample Integration of Science Practices and Core Content:

- What determines a planet's climate? Students seek answers and consensus by experimenting with physical and computer models, collecting and analyzing their own measurements, and conducting inter-comparisons with real world data from satellites and ground-based observations.
  (NASA's What Determines a Planet's Energy Budget? Viewed November 17, 2010 at: http://icp.giss.nasa.gov/education/modules/eccm/)

- Strange things have been happening in Earth's system. The atmosphere is losing ozone, and in the biosphere, skin cancer rates are up! One person in the United States dies each hour from these diseases, and more than 50% of new cancers in America are skin cancers.

  In the hydrosphere, ultraviolet radiation is penetrating to depths never previously seen, while the lithosphere's volcanoes periodically spew sulfates and chlorine into the atmosphere. At the same time, in the realm of humans (the anthrosphere), manmade chemicals are continually being introduced into the other spheres. Are these events happening in isolation, or are they interrelated? The answer to this question is important to the future of the entire Earth system.

  Your role is to evaluate the current status of the Montreal Protocol and determine if it adequately considers the interrelationship of Earth's spheres. To do this, you must investigate how an event in one sphere may have an effect in a second sphere, which may, in turn, affect a third sphere. You should determine if there is a need to revise the Protocol. In any event, you must be well prepared to defend your recommendations.

  (UV Menace, Wheeling Jesuit University/NASA Classroom of the Future, Viewed October 22, 2010, http://www.cotf.edu/ete/modules/ozone/uvmenace.html)

Sample Assessment Item:

1. Recent studies indicate that ozone in the upper layers of Earth's atmosphere is being depleted. What effect does the depletion of ozone have, and how is this effect harmful to humans? (NAEP)

2. What makes a planet habitable?

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Weather and Climate: http://strandmaps.nsdl.org/?id=SMS-MAP-1698

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: How can we insure everyone has clean air to breathe?

Chapters; 15, 16 Science Curriculum Topic Study: **Key Terms to cover:** Composition/layers of the atmosphere, weather-air movement and energy transfers, sources of air pollution, acid precipitation, clean air act, ozone, UV radiation.

Common Themes: Systems: http://strandmaps.nsdl.org/?id=SMS-MAP-1594

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Other Web Based Resources

National Science Foundation, National Oceanic and Atmospheric Administration, (2008). Essential Principles and Fundamental Concepts for Atmospheric Science Literacy. Published October 2008, retrieved August 2010. http://eo.ucar.edu/asl/index.html

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.

F. Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere.

Essential Questions	Enduring Understandings
Is it possible for humans to influence a system as large as climate?	Climate is influenced by interactions of multiple physical, chemical and biological factors, including human actions.

Content Statements	Cumulative Progress Indicators
Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate.	Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean. **(5.4.12.F.2)**

Instructional Focus:

- Climatic conditions result from latitude, altitude, and from the position of mountain ranges, oceans, and lakes. Dynamic processes such as cloud formation, ocean currents, and atmospheric circulation patterns influence climates as well. 4B/H5 (BSL)

- The earth's climates have changed in the past, are currently changing, and are expected to change in the future, primarily due to changes in the amount of light reaching places on the earth and the composition of the atmosphere. The burning of fossil fuels in the last century has increased the amount of greenhouse gases in the atmosphere, which has contributed to Earth's warming. 4B/H6 (BSL)

- Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms. *4C/M7* (BSL)

Sample Integration of Science Practices and Core Content:

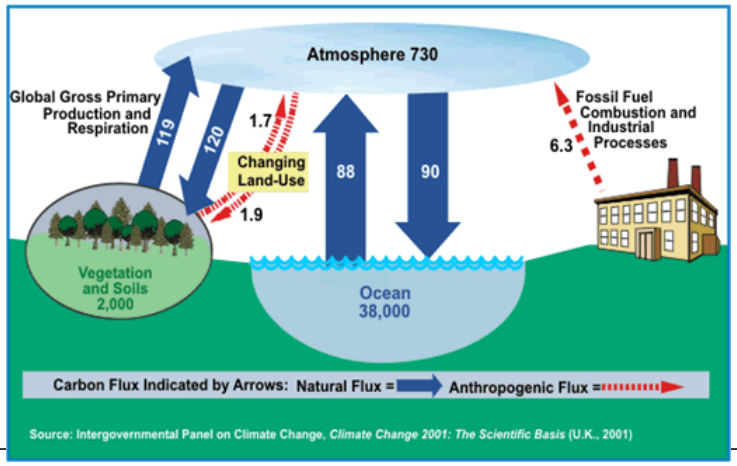
Jim Anderson, a young computer programmer, has won the lottery. After taxes, he will be getting enough money to realize his life's dream: to buy and operate a wheat farm in Kansas. Ever since he was a boy visiting his grandparent's farm, Jim has dreamed of enjoying the outdoors and the satisfaction of planting and harvesting wheat.

Jim and his wife have come to your firm, Earth Systems Science Environmental Research (ESSER) for technical advice. They want to make sure they are making a good investment. Using historical and predicted data provided in the "Remote Sensing" puzzle piece of this module, perform an Earth systems science analysis in order to determine how the yield of hard red winter wheat in Kansas will be affected by increased concentrations of atmospheric carbon dioxide as a result of its impacts on the four spheres. Provide recommendations or solutions as to whether or not Kansas wheat farmers will be able to maintain the current yields of this variety of wheat 50 years from now.

(Global Climate Change, Wheeling Jesuit University/NASA Classroom of the Future. Viewed October 21, 2010 at: http://www.cotf.edu/ete/modules/climate/GCsituation.html)

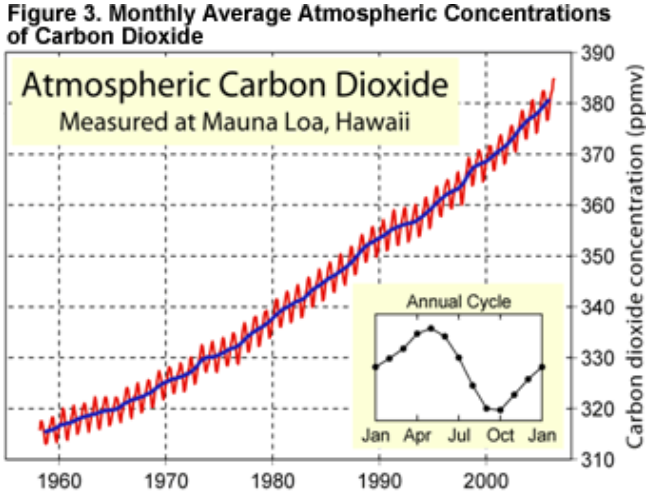
Sample Assessment Items:

Figure 1. Carbon Cycle



1. Based on Figure 1, what impact on the amount of CO_2 in the atmosphere would you expect to see if several hundred acres of forests were cut down to build houses?
   A. The oceans would absorb more CO_2 to make up for the missing trees.
   B. Primary productivity would change, but CO_2 levels would not increase.
   C. Primary productivity would change and CO_2 levels would increase.
   D. The water cycle would change.

Figure 3. Monthly Average Atmospheric Concentrations of Carbon Dioxide



Source: Mauna Loa Observatory, Hawaii

2. What generalization can you make about the amount of atmospheric carbon dioxide as represented by the graph in figure 3?
   A. CO_2 levels have decreased more than 500 pp/mv since 1960.
   B. CO_2 levels have increased more than 500 pp/mv since 1960.
   C. CO_2 levels show an increasing trend since 1960, but vary with the seasons.
   D. CO_2 levels show a decreasing trend since 1960 and show no change with the seasons.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Weather and Climate: http://strandmaps.nsdl.org/?id=SMS-MAP-1698

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: What are the consequences of a warming Earth? Chapter: 16 Science Curriculum Topic Study: Key Topics to cover: greenhouse gases and effect, wind patterns, seasons and solar energy, Oceans and climate, topography, global climate change, fossil fuels impact, effects on ecosystems, humans and organisms, diseases and health effects, water supplies and uses of land.

For additional resources to refer: Chapters: 10,11,12

Other Web Based Resources

National Science Foundation, National Oceanic and Atmospheric Administration, (2008). Essential Principles and Fundamental Concepts for Atmospheric Science Literacy. Published October 2008, retrieved August 2010. http://eo.ucar.edu/asl/index.html

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.	
G. Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity.	
Essential Questions	**Enduring Understandings**
To what extent can human behaviors impact our planet's life support system (environment)?	Human activities have physical, chemical, and biological consequences for ecosystems; the magnitude of the impact depends in part on the sensitivity of the system to perturbation.
Content Statements	**Cumulative Progress Indicators**
Natural and human-made chemicals circulate with water in the hydrologic cycle.	Analyze and explain the sources and impact of a specific industry on a large body of water (e.g., Delaware or Chesapeake Bay). **(5.4.12.G.1)**

Instructional Focus:

- The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean. *1.g* (NGS, NOAA, 2005)

- Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). *6.e* (NGS, NOAA, 2005)

- Water resources are essential for agriculture, manufacturing, energy production, and life. Earth scientists and engineers find and manage our fresh water resources, which are limited in supply. In many places, humans withdraw both surface water and groundwater faster than they are replenished. Once fresh water is contaminated, its quality is difficult to restore. *7.5* (NSF, 2009)

- Humans affect the quality, availability, and distribution of Earth's water through the modification of streams, lakes, and groundwater. Engineered structures such as canals, dams, and levees significantly alter water and sediment distribution. Pollution from sewage runoff, agricultural practices, and industrial processes reduce water quality. Overuse of water for electric power generation and agriculture reduces water availability for drinking. *9.4* (NSF, 2009)

Common Student Misconceptions:

Many students believe that anything natural is not pollution; biodegradable materials are not pollutants; solid waste in dumps is safe; and the human race is indestructible as a species. (Driver, 2006)

Confusion between ozone layer depletion and the greenhouse effect is common. (Driver, 2006)

Sample Integration of Science Practices and Core Content:

- Investigate the importance and the location of your watershed. Use GIS technology to create an interactive map of their watershed, water quality, and ongoing efforts to improve or restore the watershed. Adapted from: Know Your Watershed found at: http://gc2000.rutgers.edu/GC2000/MODULES/ENVIRONMENT/watersheds.htm. Additional resources include: Watershed Protection, http://www.cwp.org/

- Students investigate water quality parameters to study the nature of, and the cyclical changes inherent in, the chemistry of estuarine water. Students study key water quality factors at several stations in a single reserve over time—current, daily, and yearly time scales. Students also compare water quality values over a yearly time scale in three different estuaries within NOAA's National Estuarine Research Reserve System (NERR) —South Slough NERR, Oregon; Delaware NERR; and Old Woman Creek NERR, Ohio. Then students take water quality measurements at a site near them and compare their data to the water in the three geographically diverse NERR estuarine environments. NOAA's Chemistry in an Estuary investigation found at: http://estuaries.gov/estuaries101/Doc/PDF/PS1_ChemistryEstuary.pdf

- Students model estuaries, artificially enriching both fresh and salt water samples with different amounts of nutrients and observing the growth of algae over a several weeks. They relate their results to the phenomenon of algae blooms in estuaries. They then analyze data for different sites at the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) in Florida to discover the relationships between nitrogen, chlorophyll, and dissolved oxygen. Finally, they study how nutrients cycle through an estuary and suggest recommendations for reducing nutrient inputs to estuary waters. NOAA's Nutrients in an Estuary investigation found at:http://estuaries.gov/estuaries101/Doc/PDF/LS2_NutrientsEstuary.pdf

Sample Assessment Item:

1. You are shopping at the local lawn and garden store for lawn fertilizer. You notice that the maker of your favorite product has been reformulated to include less nitrogen. What is a possible impact of this reformulation beyond your property line?

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Use of Earth's Resources: http://strandmaps.nsdl.org/?id=SMS-MAP-1699

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Questions: Chapter 3;How do the non-living parts of Earth's systems provide the basic materials to support life?
Chapter 14: Why are we running out of water?
Chapters: 3, 14 Science Curriculum Topic Study: Key Topics to cover: Biogeochemical cycles, water, carbon, nitrogen, phosphorus cycles, types of water pollution, pathogens, clean water act, ocean pollution, watershed, aquifers, groundwater, runoff, dams, irrigation, agricultural uses.
For additional resources to refer: Chapters: 2, 9 & 13.

Other Web Based Resources:

NOAA's Water Cycle Learning Object found at:
http://www.montereyinstitute.org/noaa/lesson07.html
NOAA's Water, Water Everywhere where students estimate how much water they think can be found in various locations on the earth in all its states; solid, liquid, and gas. found at:
http://www.srh.noaa.gov/jetstream//atmos/ll_water.htm
Problem Based Learning Scenario titled Water Quality, Wheeling Jesuit University/NASA Classroom of the Future, Viewed October 22, 2010,
http://www.cotf.edu/ete/modules/waterq/wqsituation1.html.
Problem Based Learning Scenario titled Coral Reefs ,Wheeling Jesuit University/NASA Classroom of the Future, Viewed October 22, 2010,
http://www.cotf.edu/ete/modules/coralreef/CRsituation.html.

National Geographic Society, National Oceanic and Atmospheric Administration, (2005). Ocean Literacy: The Essential Principles of Ocean Sciences. Published July 2005, retrieved August 2010. http://oceanliteracy.wp.coexploration.org/
National Science Foundation, (2009). Earth Science Literacy Principles. Published May 2009, retrieved August 2010. http://www.earthscienceliteracy.org/

Content Statements	Cumulative Progress Indicators
Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.	Explain the unintended consequences of harvesting natural resources from an ecosystem. **(5.4.12.G.2)**

Instructional Focus:

- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the

equilibrium in ecosystems. *5D/H3* (BSL)

- Although Earth has a great capacity to absorb and recycle materials naturally, ecosystems have only a finite capacity to withstand change without experiencing major ecological alterations that may also have adverse effects on human activities. *4B/H9* (BSL)

- The concept of Ecosystem Services is becoming popular as a way to encourage discussion about the dependence of humans on nature and what that means socially and economically. Ecosystem services are transformations of natural assets (soil, water, air, and living organisms) into products that are important to humans. Examples include: provision of clean air and water; maintenance of soil fertility; maintenance of livable climates; pollination of crops and other vegetation; control of potential pests; provision of genetic resources; production of food and fiber; and provision of cultural, spiritual and intellectual experiences.

- The value of ecosystem services to humans comes from their role in supporting our lives, their cheapness, and our limited ability to replace them with human-engineered alternatives. (*Steven Cork, Ecosystem services: The many ways in which biodiversity sustains and fulfills human life.* viewed September 30, 2010 http://www.ecosystemservicesproject.org/html/publications/docs/Internet_forum_Nature_and_Society.pdf)

Sample Assessment Item:

You are considering investing in Cabot Oil & Gas Corporation who has been a leader in the extraction of natural gas from shale in the US. The ability to extract gas from shale — which can involve a process known as 'fracking' — has been welcomed as an economic windfall by some communities and has been resisted in others because of residents' concerns about the potential harm to their drinking water. As part of your due diligence research, you found an article titled When a Rig Moves In Next Door. After you read the article, craft a letter to your broker informing him of your decision to purchase the stock or not. In your letter, include your decision, the evidence that you found in the article that supports your decision, and a rationale for your decision.

(When a Rig Moves In Next Door, viewed on November 15, 2010 at:

http://www.nytimes.com/2010/11/07/business/energy-environment/07frack.html)

Sample Integration of Science Practices and Core Content:

The ancient forests of northwestern North America stretch from the redwoods of northern California to the Sitka spruce and Douglas fir of southeastern Alaska. How to utilize these natural resources has become a subject of intense debate among several competing interests.

Your group has been asked by the U.S.-Canadian Task Force on the Ancient Temperate Rainforests to study the dilemma and to submit recommendations for an international policy on the use of these forests of California, Oregon, Washington, British Columbia, and southeastern Alaska.

Where are the balance points among the competing demands and interests? Your rationale for each recommendation should be clearly stated and supported.

(Temperate Rainforest, Wheeling Jesuit University/NASA Classroom of the Future, Viewed October 22, 2010, http://www.cotf.edu/ete/modules/temprain/temprain.html)

Students use a "fish" model to simulate the tragedy of the commons, make predictions and generate conclusions about sustainable use practices. Tragedy of the Commons Activity,

http://www.scienceteacherprogram.org/biology/szerlip03.html

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Use of Earth's Resources: http://strandmaps.nsdl.org/?id=SMS-MAP-1699

Instructional Connection;

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: How does the environment effect where and how an organism lives? Chapter 6

Science Curriculum Topic Study: Key Topics to cover: biomes, Climagraph's, weather, climate, vegetation, ecosystems within biomes, biodiversity within biomes, preserving biodiversity and Human Impact on the Environment.

Content Statements	Cumulative Progress Indicators
Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter.	Demonstrate, using models, how internal and external sources of energy drive the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles. **(5.4.12.G.3)**

Instructional Focus:

- All Earth processes are the result of energy flowing and mass cycling within and between Earth's systems. This energy is derived from the sun and Earth's interior. The flowing energy and cycling matter cause chemical and physical changes in Earth's materials and living organisms. For example, large amounts of carbon continually cycle among systems of rock, water, air, organisms, and fossil fuels such as coal and oil. *3.2* (NSF, 2009)

- Earth exchanges mass and energy with the rest of the Solar System. Earth gains and loses energy through incoming solar radiation, heat loss to space, and gravitational forces from the sun, moon, and planets. Earth gains mass from the impacts of meteoroids and comets and loses mass by the escape of gases into space. *3.3* (NSF, 2009)

- The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere. Increasing carbon dioxide levels in the atmosphere is causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part. *7.D* (AAAS, NOAA, 2009)

Sample Integration of Science Practices and Core Content:

Evaluate evidence contained in data sets and current models of Water Cycles, construct an argument regarding the claim that humans have serious problems with respect to how the water cycle functions.
The Water Cycle and Global Warming, http://www.bioedonline.org/lessons/water-cycle.cfm

Sample Assessment Item:

1. Describe how you could use common household materials to model two of the following cycles and how they interact. (Choose two: hydrologic, carbon, nitrogen, phosphorous, sulfur or oxygen).
2. Create a podcast that explains the science behind the claim that each time we inhale, we literally breathe a few molecules of the same air that Einstein did.

Resources:

National Science Digital Library, Science Digital Literacy Maps. The Physical Setting: Changes in the Earth's Surface: http://strandmaps.nsdl.org/?id=SMS-MAP-0048

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: Chapter 3 How do non-living parts of Earth's systems provide the basic materials to support life?
Chapter 9. What is the relationship between environmental health and our own health?
Science Curriculum Topic Study: Key Topics to cover: Biogeochemical cycles, human health, pathogens, risk assessment, Chemical, indoor/outdoor hazards, biomagnification/bioaccumulation, natural disasters.

Content Statements	Cumulative Progress Indicators
Natural and human activities impact the cycling of matter and the flow of energy through ecosystems.	Compare over time the impact of human activity on the cycling of matter and energy through ecosystems. **(5.4.12.G.4)**

Instructional Focus:

- The transport and transformation of substances through the Earth system are known collectively as biogeochemical cycles**.** These include the hydrologic (water), nitrogen, carbon, and oxygen cycles. Human activities can, deliberating or inadvertently, alter the equilibrium of these cycles.

Sample Assessment Item:

1. The Hudson River receives large inputs of nutrients from the watershed and wastewater treatment plants. However, since the river has low water residence time, primary production remains low, and the visible effects of eutrophication are not noticeable. Use data to explore the changes that have taken place in nutrient loading over time in the Hudson River, and make recommendations about future improvements. (Viewed November 11,

2010 at: http://www.ecostudies.org/chp_waste_river.html Changing Hudson Project, Module 4 Pollution)

Sample Integration of Science Practices and Core Content:
Students model estuaries, artificially enriching both fresh and salt water samples with different amounts of nutrients and observing the growth of algae over a several weeks. They relate their results to the phenomenon of algae blooms in estuaries. They then analyze data for different sites at the Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR) in Florida to discover the relationships between nitrogen, chlorophyll, and dissolved oxygen. Finally, they study how nutrients cycle through an estuary and suggest recommendations for reducing nutrient inputs to estuary waters. NOAA's Nutrients in an Estuary
http://estuaries.gov/estuaries101/Doc/PDF/LS2_NutrientsEstuary.pdf

What are causes, impacts, and solutions to contaminated runoff? Engage students in NOAA's Where's the point? found at: http://oceanservice.noaa.gov/education/lessons/wheres_the_point.html

How does a human-caused stress placed on the environment affect the life in a food web? Engage students in NOAA's Chewin' in the Chesapeake found at:
http://oceanservice.noaa.gov/education/pd/estuaries/estuarinebio/chewin_chesapeake_lesson.html
How can resource managers and concerned public groups repair coastal resources damaged by human activity or natural events? Engage students in NOAA's Fix It! Found at:

http://coralreef.noaa.gov/education/educators/resourcecd/lessonplans/resources/fix_it_lp.pdf

Explore the biomaginification of toxic chemical, mercury, through a simple marine food chain. In this simulation, the marine environment is contaminated with mercury. Although all animals are exposed to this toxic chemical, seabirds are more severely affected than other organisms. Engage students in NOAA's Ocean Pollution found at:

http://www.montereyinstitute.org/noaa/lesson13.html

Students explore the range of ocean characteristics preferred by coral reefs. Now that students are familiar with the environmental conditions in which corals survive and thrive, they are ready to explore the factors most likely to disrupt these conditions and threaten coral health and sustainability. Engage students in NOAA's Exploring Factors that Impact Coral Health found at: http://serc.carleton.edu/earthlabs/corals/5.html (This website (serc.carleton.edu) is hosted by the Science Education Resource Center at Carleton College.)

Resources:
National Science Digital Library, Science Digital Literacy Maps

The Living Environment: Interdependence of Life: http://strandmaps.nsdl.org/?id=SMS-MAP-2122

The Physical Setting: Use of Earth's Resources: http://strandmaps.nsdl.org/?id=SMS-MAP-1699

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 ***BIG Question:***
Chapter 14 Why are we running out of water? How do non-living parts of Earth's systems provide the basic materials to support life? **Chapter 9**. What is the relationship between environmental health and our own health?

Science Curriculum Topic Study: Key Topics to cover**:** Bioaccumulation/biomagnification, food webs/food chains, estuaries, coral reefs, ocean acidification, ocean water pollution, clean water act, human health issues and water pollution.

Content Statements	Cumulative Progress Indicators
Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.	Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region. **(5.4.12.G.5)**

Instructional Focus:

- The survival of human societies is dependent on Earth's resources. Overall, there are positive correlations between population, natural resource consumption and environmental degradation, although environmental policies and technology influence these relationships. This can be applied to the regional, national and global scales. (CB, 2009)

- While urbanization may involve or provide a number of economic, social and environmental benefits, the global population demographic trend of increased urbanization that has been seen as more countries prepare to further industrialize may be associated with negative environmental and human health consequences. (CB, 2009)

- The size and rate of growth of the human population in any location are affected by economic, political, religious, technological and environmental factors. Some of these factors, in turn, are influenced by the size and rate of growth of the population. (BMSL, 7C/H1)

- Decisions to slow the depletion of energy resources can be made at many levels, from personal to national, and they always involve trade-offs involving economic costs and social values. (BMSL, 8C/H5)

Sample Assessment Item:

1. What are some reasons why approaches used by politicians and scientists to influence public policy differ? What are some unintended consequences for a watershed when one of these groups dominates decision making processes?
2. Using floodplain risk maps from your community, recommend possible sites for the following development; municipal park, retirement home village for senior citizens, apartment complex, public swimming pool, man-made levees, hospital, single family home, commuter parking lot, water-treatment plant, and communications tower. Justify your reasoning for the placements. If you think that some of these developments should be located within the limits of the map, explain why.

Sample Integration of Science Practices and Core Content:

Using historic thermal data images evaluate the effectiveness of rooftop gardens and increased green space to mitigate urban-heat-island-effects. Create a poster for a scientific "poster session" that includes: a. multiple representations of the data, b. your claim regarding the effectiveness of the rooftop garden, c. explanation of the reasoning for your claim citing your evidence,

Demonstrate understandings of how a disruption to a food chain can have a ripple effect through an ecosystem. Saved by a Shark found at:
http://www.nationalgeographic.com/xpeditions/lessons/07/g68/noaashark.html (© 1998-2008 National Geographic Society)
Why is submerged aquatic vegetation (SAV) important in coastal ecosystems, and how can SAV be restored in areas where it has been depleted? NOAA's SAV Me! found at:
http://oceanservice.noaa.gov/education/lessons/sav_me.html

A medicine man who makes his home in the tropical rainforest of the Amazon listens intently as huge trees crash to the forest's floor in the distance. He has been told that machines are being used to build roads into the forest and that many trees are being taken away on trucks. He wonders how long the plants and animals that are the sources for the potions he makes to heal and protect the members of this tribe will remain. As he looks at the ground, he notices a dart frog that provides the poisonous venom for the points of the darts and arrows the tribesmen use. By rubbing the points of the dart and arrows across the back of one of these frogs, hunters ensure a swift death to their prey.

At the same time, a medical researcher in the United States is engaged in a study to identify the medicinal properties of the dart frog's poison. Other researchers throughout the world are studying exotic vegetation that is found only in the tropical rainforests. One ethno botanist has cataloged over 200 of these exotic plants along with their medical remedies. Soothing burns, easing childbirth, and healing infections are among some of the beneficial uses derived from these plants.

Is there a problem? Is the Amazon, the richest area of biodiversity in the world, threatened by human beings? Your group has been contacted by the Global Research Information Network (G.R.I.N.), an impartial panel composed of scientists and representatives from government, business, and industry. They want you to analyze the situation and make recommendations. They aren't sure what position to take concerning poison dart frogs and other species in the Amazon.
(Tropical Poison Wheeling Jesuit University/NASA Classroom of the Future, Viewed October 22, 2010,) http://www.cotf.edu/ete/modules/troppois/troppois.html

Using NJ-GeoWeb**,** create a stream-network map for your county; compare the locations of land uses that create pollutants to land uses that require uncontaminated water. Create a multimedia tour of your county identifying the locations of land uses that cause pollution, locations of land uses that require uncontaminated water, and natural geologic features that my help to reduce water contamination. The multimedia tour needs to identify what your community has done to prevent or remediate contamination of water resources.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Living Environment: Interdependence of Life: http://strandmaps.nsdl.org/?id=SMS-MAP-2122

The Physical Setting: Use of Earth's Resources: http://strandmaps.nsdl.org/?id=SMS-MAP-1699

Instructional Connection:

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question: Chapter 10 How can we balance our needs for housing and jobs with the needs of the environment?

Science Curriculum Topic Study: Key Topics to cover: Land use, erosion by land use, urbanizations, infrastructure, urban environmental impacts, heat islands, sprawl and it's natural and human impacts, mass transportation, city planning, smart growth, and open space.

Additional resources can be found in Chapters; 6, 7, 11, 12

Content Statements	Cumulative Progress Indicators
Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.	Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy). **(5.4.12.G.6)**

Instructional Focus:

- Decisions that affect the environment are not based on scientific analysis alone, but must also incorporate social and economic considerations. (CB, 2009)
- The benefits, costs and risks of decisions may not be evenly shared among all parties. In many cases, economically disadvantaged and/or minority groups have disproportionately suffered from these decisions, leading to concerns of *environmental justice*. (CB, 2009)
- Local, national and international laws, treaties and regulations have helped to manage environmental impacts. There are many examples of damaged ecosystems that have been successfully restored. (CB, 2009)
- People sometimes consider a local natural area or broader ecosystem to be "priceless" and hence refuse to put a dollar value on it. However, amid the conflicting interests of modern economic systems, the value of such ecosystems may then in practice be considered to be zero in economic analyses and public policy decisions. (CB, 2009)
- A newer approach used by a growing number of environmental scientists, ecologists and economists has been to try to assign dollar values, not to the ecosystem itself but to the services it provides. This can be determined by estimating the cost of providing the same service through human activity. In many cases, the value of these services is found to be very high, and thus maintenance of the functioning ecosystem becomes a high priority. (CB, 2009)

Sample Assessment Item:

1. Using floodplain risk maps from your community, recommend possible sites for the following development; municipal park, retirement home village for senior citizens, apartment complex, public swimming pool, man-made levees, hospital, single family home, commuter parking lot, water-treatment plant, and communications tower. Justify your reasoning for the placements. If you think that some of these developments should be located within the limits of the map, explain why.

Using historic thermal data images evaluate the effectiveness of rooftop gardens and increased green space to mitigate urban-heat-island-effects. Create a poster for a scientific "poster session" that includes:

a. multiple representations of the data
b. your claim regarding the effectiveness of the rooftop garden
c. explanation of the reasoning for your claim citing your evidence

How and why should different perspectives be considered when deciding how to use and protect coastal resources? Students engage in NOAA's I'll Stay Here if it Kills me, http://oceanservice.noaa.gov/education/lessons/if_it_kills_me.html

Human-induced nutrient loading of the world's oceans has been linked to increased and prolonged algae blooms, sometimes with potentially deadly consequences. In this investigation, students will create their own algal blooms, analyze satellite images of chlorophyll concentrations in the Sea of Cortés, and learn about two alarming consequences of excessive algae growth—dead zones and harmful algae blooms (HABs).

(http://serc.carleton.edu/earthlabs/fisheries/7.html). This website (serc.carleton.edu) is hosted by the Science Education Resource Center at Carleton College.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Evidence and Inquiry: http://strandmaps.nsdl.org/?id=SMS-MAP-1200

The Nature of Science: Avoiding Bias: http://strandmaps.nsdl.org/?id=SMS-MAP-1224

Habits of Mind: Detecting Flaws in Arguments: http://strandmaps.nsdl.org/?id=SMS-MAP-2554

The Mathematical World: Symbolic Representation: http://strandmaps.nsdl.org/?id=SMS-MAP-1547

The Mathematical World: Graphic Representation: http://strandmaps.nsdl.org/?id=SMS-MAP-1538

Instruction Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 BIG Question:
Chapter 2 How can we best balance our own interests and needs with the health of the environment?
Science Curriculum Topic Study: Key Topics to cover: Economics and the environment, environmental ethics, US environmental policy, international environmental policy economic/environmental sustainability, risk management, environmental decision-making. Environmental justice.
Additional resources can be found in Chapter; 1

Content Statements	Cumulative Progress Indicators
Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles.	Relate information to detailed models of the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles, identifying major sources, sinks, fluxes, and residence times. **(5.4.12.G.7)**

Instructional Focus:

- Much of the complex behavior of the Earth system can be thought of as cycles involving physical, chemical and biological processes that transfer components among various storage locations over time. (CB, 2009).
- The inputs and outputs connecting such reservoirs, the changes in the physical state or chemical characteristics of the components, and the time scale of these processes can all be recognized and quantified. (CB, 2009).
- Biogeochemical cycles, such as the water cycle and carbon cycle, are driven and sustained by solar and/or geothermal energy, which is transferred, utilized and lost as an integral aspect of the cycles. (CB, 2009).

Common Student Misconceptions:

These are similar to those identified above regarding carbon cycling.

Sample Assessment Item:

1. In many textbooks, the water cycle and carbon cycle are illustrated with neat lines suggesting the movement of material though a cycle in a neat orderly progression. Explain, in terms of residence times why the idealized illustrations may lead to incorrect understandings of one of these biogeochemical systems.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Physical Setting: Conservation of Matter: http://strandmaps.nsdl.org/?id=SMS-MAP-1332

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2
BIG Questions: Chapter 17. Can we depend on nonrenewable energy resources for our energy needs?
Chapter 18. What are the potential uses and limitations of renewable energy sources?
Chapter 19. How do our choices as consumers and waste producers affect our environment?

Science Curriculum Topic Study: Key Topics to cover: geothermal, wind, solar, hydropower, biomass and hydrogen energy resources and biogeochemical cycles and human impacts. Waste and nitrogen, carbon, water and phosphorus cycles. Fossil fuels and pollution, nuclear potential energy, cost vs. benefits, environmental impacts.

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

Essential Question	Enduring Understanding
How do we build and refine models that describe and explain the natural and designed world?	Measurement and observation tools are used to categorize, represent and interpret the natural world.
Content Statement	**Cumulative Progress Indicator**
Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.	Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. **(5.1.12.A.1)**

Instructional Focus:

- Learning facts, concepts, principles, theories and models; then
- Developing an understanding of the relationships among facts, concepts, principles, theories and models; then
- Using these relationships to understand and interpret phenomena in the natural world

Misconceptions:

Students of all ages find it difficult to distinguish between a theory and the evidence for it, or between description of evidence and interpretation of evidence. Some research suggests students can start understanding the distinction between theory and evidence after adequate instruction, as early as middle school (Roseberry, A., Warren, B., Conant, F., 1992).

When asked to use evidence to judge a theory, students of all ages may make only theory-based responses with no reference made to the presented evidence. Sometimes this appears to be because the available evidence conflicts with the students' beliefs (Kuhn, 1988).

Most high-school students will accept arguments based on inadequate sample size, accept causality from contiguous events, and accept conclusions based on statistically insignificant differences (Jungwirth, 1987, 1990, 1992). More students can recognize these inadequacies in arguments after prompting. For example, after being told that the conclusions drawn from the data were invalid and asked to state why (Jungwirth, 1992).

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Scientific Theories: http://strandmaps.nsdl.org/?id=SMS-MAP-1216

The Nature of Science: Evidence and Reasoning: http://strandmaps.nsdl.org/?id=SMS-MAP-1200

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2
Integrate textbook resources: **Central Case, A Closer look, Success Stories, Point-Counterpoint and Reading Checkpoints** throughout the textbook to meet requirements
Taking Science to School: Knowledge and Understanding of the Natural World

Content Statement	Cumulative Progress Indicator
Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.	Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. **(5.1.12.A.2)**

Instructional Focus:

- Using tools, evidence and data to observe, measure, and explain phenomena in the natural world

- Developing evidence-based models based on the relationships among fundamental concepts and principals
- Constructing and refining explanations, arguments or models of the natural world through the use of quantitative and qualitative evidence and data

Connections to the Common Core State Standards for Mathematics**:**

- Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data. **(S.10.5)**
- Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. **(S.10.7)**
- Compute (using technology) and interpret the correlation coefficient of a linear fit. **(S.10.8)**
- Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant. **(S.IC.5)**

Misconceptions:

Students who can use measuring instruments and procedures when asked to do so often do not use this ability while performing an investigation. Typically a student asked to undertake an investigation and given a set of equipment that includes measuring instruments will make a qualitative comparison even though she might be competent to use the instruments in a different context (Black, P., 1990). It appears students often know how to take measurements but not what measurements to make or when (AAAS, 2007).

Prior to instruction, or after traditional instruction, many middle- and high-school students continue to focus on perceptual rather than functional similarities between models and their referents, and think of models predominantly as small copies of real objects. Consequently, students often interpret models they encounter in school science too literally and unshared attributes between models and their referents are a cause of misunderstanding. Some middle- and high-school students view visual representations such as maps or diagrams as models, but only a few students view representations of ideas or abstract entities as models.

Many middle- and high-school students think that models are useful for visualizing ideas and for communication purposes. Only a few students think that models are useful in developing and testing ideas and that the usefulness of a model can be tested by comparing its implications to actual observations.

Middle-school and high-school students accept the idea that scientists can have more than one model for the same thing. However, having multiple models may mean for them that one could have literally a different view of the same entity, or that one could emphasize different aspects of the same entity -- omitting or highlighting certain things to provide greater clarity. Students are rarely aware that there could be different models to explain something or to evaluate alternative hypotheses. They find multiple model use in school science confusing are rarely use multiple models to think about phenomena; even if they do, the idea that one model is "right" and "real" persists. Students may know that models can be changed, but changing a model for them means (typical of high-school students) adding new information or (typical of middle-school students) replacing a part that was made wrong.

Developing and evaluating models combined with explicit instruction and reflection about the nature of models and modeling for an extended period of time can be effective in helping middle-school students make progress toward the following ideas: Models are not necessarily physical objects but could be conceptual representations that help scientists to predict and explain; there can be multiple models for the same phenomenon; and models are useful in visualization.

predicting phenomena, and conducting investigations that are not otherwise possible. The ideas that scientists revise their models in light of new insights or new data and that not all models are of equal value may be harder to develop.

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Using Tools: http://strandmaps.nsdl.org/?id=SMS-MAP-2507

Common Themes: Models: http://strandmaps.nsdl.org/?id=SMS-MAP-2408

Comparison of the Project 2061 *Benchmarks for Science Literacy* and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* was commissioned by Project 2061. The intent is to indicate, for each NCTM standard, the benchmarks that are *most nearly related to it.* We hope that educators interested in mathematical literacy and meaningful integration will find the comparison interesting and perhaps useful in thinking through their own learning goals.
Literacyhttp://www.project2061.org/publications/rsl/online/COMPARE/NCTM/N2B/M2BTOC.HTM

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2
Integrate textbook resources: Science Curriculum Topic Study: **Map-it, Real Data, Modeling and myenvironmentalscience.com on-line resources** to meet*:*
Observation, Measurement, and Tools, Evidence and Explanation and Models.

Content Statement	Cumulative Progress Indicator
Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.	Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. **(5.1.12.A.3)**

Instructional Focus:

- Understanding that data differs in quality and strength of explanatory power based on experimental design
- Evaluating strength of scientific arguments based on the quality of the data and evidence presented
- Critiquing scientific arguments by considering the selected experimental design and method of data analysis

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Detecting Flaws in Arguments: http://strandmaps.nsdl.org/?id=SMS-MAP-2554

Habits of Mind: Values in Science: http://strandmaps.nsdl.org/?id=SMS-MAP-2469

The Mathematical World: Reasoning: http://strandmaps.nsdl.org/?id=SMS-MAP-2300

Instructional Connection:
Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2
Integrate textbook resources: **Scientific Method Classroom Activities using Myenvironemtalscience.com, online resources** to cover: Experimental Design, Identifying and Avoiding Bias.

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

B. Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

Essential Question	Enduring Understanding
What constitutes useful scientific evidence?	Evidence is used for building, refining, and/or critiquing scientific explanations.
Content Statement	**Cumulative Progress Indicator**
Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.	Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. **(5.1.12.B.1)**

Instructional Focus:

- Asking a question and deciding what to measure in order to answer the question
- Developing strategies for obtaining measurements, then systematically collecting data
- Structuring the gathered data, then interpreting and evaluating the data
- Using the empirical results to determine causal/correlational relationships

Connections to the Common Core State Standards for Mathematics**:**

Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. **(6.SP.3)**

Summarize numerical data sets in relation to their context, such as by:

a. Reporting the number of observations.
b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. **(6.SP.5)**

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association. **(8.SP.1)**

Compute (using technology) and interpret the correlation coefficient of a linear fit. **(S.ID.8)**

Distinguish between correlation and causation. **(S.ID.9)**

Misconceptions:

When engaged in experimentation, students have difficulty interpreting co-variation and non-co-variation evidence (Kuhn,1998). For example, students tend to make a causal inference based on a single concurrence of antecedent and outcome or have difficulty understanding the distinction between a variable having no effect and a variable having an opposite effect.

Most high-school students will accept arguments based on inadequate sample size, accept causality from contiguous events, and accept conclusions based on statistically insignificant differences (Jungwirth, E., Dreyfus, A., 1987, 1990, 1992). More students can recognize these inadequacies in arguments after prompting. Example; after being told that the conclusions drawn from the data were invalid and asked to state why (Jungwirth, E., Dreyfus, A., 1992).

Students of all ages show a tendency to uncritically infer cause from correlation (Kuhn, D., Amsel, E., O'Loughlin, M., 1988). Some students think even a single co-occurrence of antecedent and outcome is always sufficient to infer causality. Rarely do middle-school students realize the indeterminacy of single instances, although high-school students may readily realize it. Despite that, as covariant data accumulate, even high school students will infer a causal relation based on correlations. Further, students of all ages will make a causal inference even when no variation occurs in one of the variables. For example, if students are told that light-colored balls are used successfully in a game, they seem willing to infer that the color of the balls will make some difference in the outcome even without any evidence about dark colored balls (Kuhn, D., Amsel, E., O'Loughlin, M., 1988).

Faced with no correlation of antecedent and outcome, 6th-graders only rarely conclude that the variable has no effect on the outcome. Ninth-graders draw such conclusions more often. A basic problem appears to be understanding the distinction between a variable making no difference and a variable that is correlated with the outcome in the opposite way that the students initially conceived.

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Using Tools and Devices: http://strandmaps.nsdl.org/?id=SMS-MAP-2507

The Nature of Science: Scientific Investigations: http://strandmaps.nsdl.org/?id=SMS-MAP-1207

The Mathematical World: Correlation: http://strandmaps.nsdl.org/?id=SMS-MAP-1579

Comparison of the Project 2061 *Benchmarks for Science Literacy* and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* was commissioned by Project 2061. The intent is to indicate, for each NCTM standard, the benchmarks that are *most nearly related to it.* We hope that educators interested in mathematical literacy and meaningful integration will find the comparison interesting and perhaps useful in thinking through their own learning goals.

Literacyhttp://www.project2061.org/publications/rsl/online/COMPARE/NCTM/N2B/M2BTOC.HTM

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 *All Chapters*

A.Integrate textbook resources: Central Case, A Closer look, Success Stories, Point-Counterpoint and Reading Checkpoints throughout the textbook to meet requirements,

B.Integrate textbook resources: Science Curriculum Topic Study: Map-it, Real Data, Modeling and myenvironmentalscience.com on-line resources to meet: Observation, Measurement, and Tools, Evidence and Explanation and Models.

C.Integrate textbook resources: Scientific Method Classroom Activities usin Myenvironmentalscience.com, on-line resources to cover: Experimental Design, Identifying and Avoiding Bias.

D. Integrating LAB activities and resources to include; Quick Lab, Go Outside, In your Neighborhood, Outdoors and Paper & Pencil to meet requirements.

Content Statement	Cumulative Progress Indicator
Mathematical tools and technology are used to gather, analyze, and communicate results.	Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. **(5.1.12.B.2)**

Instructional Focus:

- Using mathematics in the collection and treatment of data and in the reasoning used to develop concepts, laws and theories
- Using tools of data analysis to organize data and formulate hypotheses for further testing
- Using existing mathematical, physical, and computational models to analyze and communicate findings

Connections to the Common Core State Standards for Mathematics**:**

Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

a. Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events. *For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected.*

b. Develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process. *For example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down. Do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies?* **(7.SP.7)**

Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. **(8.F.4)**

Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line. **(8.SP.2)**

Define appropriate quantities for the purpose of descriptive modeling. **(N.Q.2)**

(+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., $\boldsymbol{v}$, $|\boldsymbol{v}|$,$||\boldsymbol{v}||$, v). **(N.VM.1)**

Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.* **(A.CED.3)**

For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums;*

symmetries; end behavior; and periodicity. **(F.IF.4)**

Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms. **(F.BF.2)**

Misconceptions:

Students have difficulty understanding how symbols are used in algebra. They are often unaware of the arbitrariness of the letters chosen to represent variables in equations. Middle-school and high-school students may regard the letters as shorthand for single objects, or as specific but unknown numbers, or as generalized numbers before they understand them as representations of variables. Students' lack of awareness of the arbitrariness of the letters chosen to represent variables in equations tends to persist even after instruction in algebra. Student difficulty in understanding how symbols are used in algebra is evident even in college students.

Students tend to look for or accept evidence that is consistent with their prior beliefs and either distort or fail to generate evidence that is inconsistent with these beliefs. These deficiencies tend to mitigate over time and with experience (Schauble, L., 1990).

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Using Tools and Devices: http://strandmaps.nsdl.org/?id=SMS-MAP-2507

Common Themes, Models: http://strandmaps.nsdl.org/?id=SMS-MAP-2408

The Nature of Mathematics: Mathematical Models: http://strandmaps.nsdl.org/?id=SMS-MAP-1240

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Literacyhttp://www.project2061.org/publications/rsl/online/COMPARE/NCTM/N2B/M2BTOC.HTM

Science Curriculum Topic Study:
LABS: Data Collection and Analysis, Graphs and Graphing, Mathematical Modeling Observation, Measurement, and Tools

Content Statement	Cumulative Progress Indicator
Empirical evidence is used to construct and defend arguments.	Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. **(5.1.12.B.3)**

Instructional Focus:

- Making claims based on the available evidence

- Explaining the reasoning, citing evidence, behind a proposed claim
- Connecting the claim to established concepts and principles

Misconceptions:

One common misconception is the idea of representativeness, according to which an event is believed to be probable to the extent that it is "typical." For example, many people believe that after a run of heads in coin tossing, tails should be more likely to come up. Another common error is estimating the likelihood of events based on how easily instances of it can be brought to mind (AAAS, 2001).

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Scientific Theories: http://strandmaps.nsdl.org/?id=SMS-MAP-1216

The Mathematical World: Statistical Reasoning: http://strandmaps.nsdl.org/?id=SMS-MAP-1586

Science Curriculum Topic Study: Evidence and Explanation,

Content Statement	Cumulative Progress Indicator
Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.	Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. **(5.1.12.B.4)**

Instructional Focus:

- Analyzing experimental data sets using measures of central tendency
- Representing and describing mathematical relationships among variables using graphs and tables
- Using mathematical tools to construct and evaluate claims

Misconceptions:

Most high-school students will accept arguments based on inadequate sample size, accept causality from contiguous events, and accept conclusions based on statistically insignificant differences (Jungwirth, E., Dreyfus, A., 1987, 1990, 1992). More students can recognize these inadequacies in arguments after prompting (for example, after being told that the conclusions drawn from the data were invalid and asked to state why).

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Evidence and Reasoning: http://strandmaps.nsdl.org/?id=SMS-MAP-1200

The Mathematical World: Averages and Comparisons: http://strandmaps.nsdl.org/?id=SMS-MAP-1571

The Mathematical World: Correlation: http://strandmaps.nsdl.org/?id=SMS-MAP-1579

Science Curriculum Topic Study: Correlation, Scientific and Logical Reasoning, Mathematics in Science and Technology

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

C. Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

Essential Question	Enduring Understanding
How is scientific knowledge constructed?	Scientific knowledge builds upon itself over time.

Content Statement	Cumulative Progress Indicator
Refinement of understandings, explanations, and models occurs as new evidence is incorporated.	Reflect on and revise understandings as new evidence emerges. **(5.1.12.C.1)**

Instructional Focus:

- Reflecting on the status of one's own thinking and learning (i.e. uncovering how a student knows what they know and why)
- Thinking about themselves as science learners and developing an identity as someone who knows about, uses, and sometimes contributes to science.
- Understanding that scientific knowledge can be revised as new evidence emerges

Resources:

National Science Digital Library, Science Digital Literacy Maps

The nature of Science: Scientific Investigations: http://strandmaps.nsdl.org/?id=SMS-MAP-1207

The Nature of Science: Scientific Theories: http://strandmaps.nsdl.org/?id=SMS-MAP-1216

Taking Science to School: Understanding How Scientific Knowledge is Constructed,

Science Curriculum Topic Study: The Nature of Scientific Thought and Development and Science as a Human Endeavor.

Content Statement	Cumulative Progress Indicator
Data and refined models are used to revise predictions and explanations.	Use data representations and new models to revise predictions and explanations. **(5.1.12.C.2)**

Instructional Focus:

- Recognizing that predictions or explanations can be revised on the basis of seeing new data and evidence
- Using data and evidence to modify and extend investigations
- Understanding that explanations are increasingly valuable as they account for the available evidence more completely

Connections to the Common Core State Standards for Mathematics**:**

¾ Write a function that describes a relationship between two quantities.

a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

b. Combine standard function types using arithmetic operations. *For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.*

c. (+) Compose functions. *For example, if T(y) is the temperature in the atmosphere as a*

function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time. **(F.BF.1)**

¾ Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.*

b. Informally assess the fit of a function by plotting and analyzing residuals.

c. Fit a linear function for a scatter plot that suggests a linear association. **(S.ID.6)**

¾ Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. *For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5tails in a row cause you to question the model?* **(S.IC.2)**

¾ Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling. **(S.IC.4)**

¾ (+) Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value. *For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.* **(S.MD.3)**

¾ (+) Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. *For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?* **(S.MD.4)**

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Scientific Investigations: http://strandmaps.nsdl.org/?id=SMS-MAP-1207

The Nature of Science: Scientific Theories: http://strandmaps.nsdl.org/?id=SMS-MAP-1216

Comparison of the Project 2061 *Benchmarks for Science Literacy* and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* was commissioned by Project 2061. The intent is to indicate, for each NCTM standard, the benchmarks that are *most nearly related to it.* We hope that educators interested in mathematical literacy and meaningful integration will find the comparison interesting and perhaps useful in thinking through their own learning goals.

Literacyhttp://www.project2061.org/publications/rsl/online/COMPARE/NCTM/N2B/M2BTOC.HTM

Taking Science to School: Understanding How Scientific Knowledge is Constructed, pp. 168-182
Science Curriculum Topic Study: The Nature of Scientific Thought and Development and Science as a Human Endeavor

Content Statement	Cumulative Progress Indicator
Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.	Consider alternative theories to interpret and evaluate evidence-based arguments. **(5.1.12.C.3)**

Instructional Focus:

- Understanding that there might be multiple interpretations of the same phenomena
- Stepping back from evidence and explanations to consider whether another interpretation of a particular finding is plausible with respect to existing scientific evidence
- Considering alternative perspectives worthy of further investigations

See Mathematical Connections for 5.1.12.C.2

Misconceptions:

Some students of all ages believe science mainly invents things or solves practical problems rather than exploring and understanding the world. Some high-school students believe that moral values and personal motives do not influence a scientist's contributions to the public debate about science and technology and think that scientists are more capable than others to decide those issues.

Resources:

National Science Digital Library, Science Digital Literacy Maps

The Nature of Science: Scientific Investigations: http://strandmaps.nsdl.org/?id=SMS-MAP-1207

The Nature of Science: Scientific Theories: http://strandmaps.nsdl.org/?id=SMS-MAP-1216

Taking Science to School: Understanding How Scientific Knowledge is Constructed
Science Curriculum Topic Study: The Nature of Scientific Thought and Development

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

D. Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

Essential Question	Enduring Understanding
How does scientific knowledge benefit – deepen and broaden - from scientists sharing and debating ideas and information with peers?	The growth of scientific knowledge involves critique and communication - social practices that are governed by a core set of values and norms.

Content Statement	Cumulative Progress Indicator
Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. **(5.1.12.D.1)**

Instructional Focus:

- Seeing oneself as an effective participant and contributor in science
- Interacting with others to test new ideas, soliciting and providing feedback, articulating and evaluating emerging explanations, developing shared representations and models, and reaching consensus
- Developing a sense of appropriate trust and skepticism when evaluating others' claims, evidence and reasoning

Connections to the Common Core State Standards for English Language Arts Standards**:** Students must learn to read, write, speak, listen, and use language effectively in science. The Common Core State Standards specify the literacy skills and understandings required for college and career readiness in multiple disciplines, including science. The CCST can be found at:

http://www.corestandards.org/the-standards/english-language-arts-standards

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Communication Skills: http://strandmaps.nsdl.org/?id=SMS-MAP-2531

The Nature of Science: Avoiding Bias: http://strandmaps.nsdl.org/?id=SMS-MAP-1224

Pearson Textbook – Environmental Science ISBN# 978-0-13-3724475-2 All Chapters

A. Integrate textbook resources: Central Case, A Closer look, Success Stories, Point-Counterpoint and Reading Checkpoints throughout the textbook to meet requirements,

B. Integrate textbook resources: Science Curriculum Topic Study: Map-it, Real Data, Modeling and myenvironmentalscience.com on-line resources to meet: Observation, Measurement, and Tools, Evidence and Explanation and Models.

C. Integrate textbook resources: Scientific Method Classroom Activities using Myenvironmentalscience.com,
on-line resources to cover: Experimental Design, Identifying and Avoiding Bias.

D. Integrating LAB activities and resources to include; Quick Lab, Go Outside, In your Neighborhood, Outdoors and Paper & Pencil to meet requirements.

Content Statement	Cumulative Progress Indicator
Science involves using language, both oral and written, as a tool for making thinking public.	Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. **(5.1.12.D.2)**

Instructional Focus:

- Constructing literal representations from empirical evidence and observations
- Presenting and defending a scientific argument using literal representations
- Evaluating others' literal representations for consistency with their claims, evidence and reasoning
- Moving fluently between representations such as graphs, data, equations, diagrams and verbal explanations

Connections to the Common Core State Standards for Mathematics**:**

¾ Display numerical data in plots on a number line, including dot plots, histograms, and box plots. **(6.SP.4)**

¾ Summarize numerical data sets in relation to their context, such as by:

a. Reporting the number of observations.
b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. **(6.SP.5)**

¾ Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. *For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable.***(7.SP.3)**

¾ Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. *For example, decide whether the words in a chapter of a seventh-grade science book are generally longer than the words in a chapter of a fourth-grade science book.* **(7.SP.4)**

¾ Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables. *For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?* **(8.SP.1)**

¾ For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. *Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.* **(F.IF.4)**

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Communication Skills: http://strandmaps.nsdl.org/?id=SMS-MAP-2531

The Mathematical World: Mathematical Representation: http://strandmaps.nsdl.org/?id=SMS-MAP-1547

Comparison of the Project 2061 *Benchmarks for Science Literacy* and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* was commissioned by Project 2061. The intent is to indicate, for each NCTM standard, the benchmarks that are *most nearly related to it.* We hope that educators interested in mathematical literacy and meaningful integration will find the comparison interesting and perhaps useful in thinking through their own learning goals.

Literacyhttp://www.project2061.org/publications/rsl/online/COMPARE/NCTM/N2B/M2BTOC.HTM

Taking Science to School: Participation in Scientific Practices and Discourse

Science Curriculum Topic Study: Science as a Human Endeavor, Communicating with Drawings, Maps, and Physical Models, Use of Computers and Communication Technologies.

Content Statement	Cumulative Progress Indicator
Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.	Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. **(5.1.12.D.3)**

Instructional Focus:

- Selecting and using appropriate instrumentation to design and conduct investigations
- Understanding, evaluating and practicing safe procedures for conducting science investigations
- Demonstrating appropriate digital citizenship (i.e., cyber-safety and cyber-ethics) when accessing scientific data from collaborative spaces. (See NJCCCS 8.1 and 9.1)
- Ensuring that living organisms are properly cared for and treated humanely, responsibly, and ethically

Resources:

National Science Digital Library, Science Digital Literacy Maps

Habits of Mind: Public Perception of Science: http://strandmaps.nsdl.org/?id=SMS-MAP-2481

The Nature of Science: Science and Society: http://strandmaps.nsdl.org/?id=SMS-MAP-1662

Science Curriculum Topic Study: Scientific Values and Attitudes.

Council of State Science Supervisors, Science Education Safety:

http://www.csss-science.org/safety.shtml

New Jersey Department of Education, Lab Safety Resources:

http://www.state.nj.us/education/aps/cccs/science/safety.htm

STA Position Statements: Liability of Science Educators for Laboratory Safety:

http://www.nsta.org/about/positions/liability.aspx

Responsible Use of Live Animals and Dissection in the Science Classroom:

http://www.nsta.org/about/positions/animals.aspx

P.L. 2005, Chapter 266; Dissection Opt Out Law:

http://www.state.nj.us/education/aps/cccs/science/dissection/

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Pearson Environmental Science 2011 Course: Environmental Science (9th – 12th Grade)

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
September	How do you read maps and determine latitude and longitude and time zones? How do you convert English measure to metric? What is the Periodic Table and organic compounds? What is the scientific method? Why do we need the natural world? How do you use a decision-making model to make a decision about an environmental issue? What values are important in making decisions about the environment? What is your Ecological Footprint? How did the Tragedy of the Commons effect the environment? What is economics? How does economics affect the environment? Name several key international environmental protocols. What is Earth Day? Differentiate between: atom, molecule, element and a compound. Identify the properties of water.	Basic Science review Explain Ecology Solving environmental problems. Eco-Footprint A global perspective -Hypothesizing –Observing -predicting -Experimenting -interpreting data Using graphics Metric conversions Science math Environmental decision-making model How to use the decision making model Environmental Economics Environmental Policy Molecules/atom/element Hydrocarbons Properties of water pH	Concept mapping Critical thinking using central case study Making and using tables, line graphs, bar graphs and pie charts Formulating a hypothesis Using an environmental decision-making model Basic Map reading skills Understanding metric conversions Concept mapping Critical thinking using a case study Discuss economics and the environment Differentiate how atoms, molecules, compounds and elements are different. Understand where our water comes from.	Homework Classwork Current event article OEQs Lab report Discussion Chapter quizzes Chapter Test	Reading graphs and maps MATH LAB Quick Lab-Page 22 Quick Lab-Page 37 Quick Lab-Page 80	Chapter review and Central Case. Reading comprehension of selected readings. Selections from student workbook Internet Activities. ACHS Media Center Research. Formulate hypothesis and plan an experiment. Collect data and graph information. Make an environmental decision based on the decision-making model. Mapping & plotting. Lab procedures and safety. Myenvironmentalscience.com -ABC News articles/Video Video: NBC Learn-Science.

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
October	What is the distribution of water on the planet? What is groundwater? Aquifers? What are the Earth's spheres? Discuss how plate tectonics move continents. What happens at plate boundaries? Describe the Earth's Biogeochemical Cycles: Water Cycle, Carbon Cycle, Nitrogen Cycle, Phosphorus Cycle How are humans affecting the carbon cycle? What is the importance of nitrogen-fixing bacteria? Describe the photosynthesis process. What are producers, consumers, decomposers? What are the ecological organizations?	Positive feedback loops. Geosphere Lithosphere Atmosphere Biosphere Hydrosphere Cellular respiration Photosynthesis Consumers-producers Decomposers Eutrophication Nitrogen fixation Describe the roles of producers and consumers.	Describe the movement of the Earths plate and why they affect us. Understand how the earth is constructed Describe the photosynthesis process and discuss how it affects consumers and producers in the environment. Describe the steps of all 5 of the earth's biogeochemical cycles.	Homework Classwork Current event article Central Case analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test	Lab-Illustrations -Nitrogen Cycle -Carbon Cycle -Phosphorous Cycle -Water Cycle Lab: Water Cycle LAB-decomposers	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Concept Mapping Lab activities & report Science Behind the Stories Ecological Footprints Myenvironmentalscience.com -ABC News articles/Video Video: NBC Learn-Science.

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
November	What is population density and distribution and how does it affect the ecosystem? What is Carrying Capacity? What is the distinction between biotic and abiotic factors in an ecosystem? Explain the terms population and community. Explain the reasons for the rise in human populations over time. What are the recent trends in population growth? Identify characteristics of the human population that are studied by demographers. How is our population distributed throughout the world? What are Developed nations? What are Developing Nations? How does technology impact populations?	Species Populations Communities Niche Ecosystems Exponential Growth Industrial Revolution Agricultural Revolution Infant mortality Life Expectancy Growth rates Demographics Wealth Gap	Describe how populations are counted. Understand the differences between birth and death rates in population growth. Differentiate between developing countries and developed countries. List the positive and negative impacts on technology on human populations. How is the census used? How did the one child policy affect the Chinese? What are some social factors that can influence population growth?	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test **Benchmark Test**	Math Lab-graphing populations LAB-Population and habitats LAB-p102 biotic and abiotic factors around the school	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Myenvironmentalscience.com Science Behind the Stories -ABC News articles/Video Video: NBC Learn-Science. DVD-Predator/Prey,

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
December	What is the distinction between habitat and niche? What are the five major types of species interactions and what are examples of each type? How does the process of evolution by natural selection work? What is coevolution? What is extinction? What are the relationships between species in Predator-Prey, Mutualism and Commensalism? Discuss Trophic levels and energy transfer and the 10% rule. Differentiate between food chains & food webs. Describe ecological succession. What are invasive species and what is their effect on ecosystems?	Predation Competition Parasitism Mutualism Commensalism Evolution by natural selection Speciation Coevolution Extinction. Biotic/abiotic Biotic potential Trophic level Biomass Omnivores Carnivores Herbivores Detritivores Keystone species Succession Invasive Species	Trace the transfer of energy from the sun to producers and from producers to consumers. Differentiate among different types of consumers. Draw a food chain and a food web. Explain why an energy pyramid is a good representation of trophic levels. Describe secondary and primary succession. Explain the importance of pioneer species. Distinguish between the biotic and abiotic factors in an ecosystem. Describe an ecosystem. Define the terms population and community. Distinguish between a habitat and niche. Name the five major types of species interactions and give an example of each type. Describe how the process of evolution by natural selection works. Give an example of coevolution	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test	Quick Lab-Pg. 152 Lab- succession Lab-Predator-Prey	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Myenvironmentalscience.com Science Behind the Stories -ABC News articles/Video Video: NBC Learn-Science. DVD-Biomes Series

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
January	What is a biome? What is Climagraph? Explain how organisms adapt to their climates and biomes. How are plants and animals adapted to life in each kind of forest biome? What are the characteristics of the different freshwater ecosystems? How do organisms adapt to survive in moving and standing freshwater ecosystems? What are the characteristics of estuaries, coral reefs, oceans, and polar ecosystems? Explain the importance of estuaries. List the major zones within the ocean. What is Biodiversity and how does it contribute to life on earth. Why is biodiversity at risk? What are endangered, threatened or extinct species? How do we currently protect species and biodiversity? What are biodiversity hotspots What are ways soil is deposited? Eroded? Biotechnology and genetics have changed food production.	Biome Climate vs. weather Vegetation Tropical Rain Forests Temperate Rain Forests Temperate Deciduous Forests Taiga/Boreal Forests Savannas/Deserts/Tundra Temperate grasslands Lakes and ponds Wetlands Rivers Estuaries Salt Marsh Coral reefs Upwelling Ocean Currents Intertidal – Neritic Zones Salinity Photic-Benthic-littoral-limnetic zones Plankton and photosynthesis Biodiversity Endangered species CITES Biodiversity hotspots Soil Horizon/Profile Deforestation-Clear Cutting Erosion Desertification Over-grazing Agriculture types Pests/pesticides	Compare and contrast the world's forest biomes Explain how the adaptations of plants and animals in each ecosystem help them to survive Describe the characteristics of the different freshwater ecosystems. Compare survival adaptations of organisms in moving and standing freshwater ecosystems. Describe the characteristics of estuaries, coral reefs, oceans, and polar ecosystems. Describe the organisms' adaptations to different marine environments. Name the benefits of biodiversity. Discuss and list the major causes of biodiversity losses. Describe the sixth extinction. Discuss the biodiversity hotspots in specific locations on the planet. What are the main threats to species? Agricultural revolution and farming. Why do we have higher crop yields today? What are genetically modified foods?	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion Chapter quizzes Chapter Test **Benchmark Test**	Biomes Project: Research paper, or poster, PowerPoint or diorama of biome. Math Lab-graphing Climate in biomes Biomes Project: Illustration of Ocean Currents Research paper, or poster, PowerPoint or diorama of an aquatic biome. Math Lab-graphing species loss Lab-Biodiversity Lab-NJDEP endangered NJ species Quick Lab pg. 334 Math Lab-graphing soil types Lab-Local soil testing for nutrients Research Paper on Malnutrition in the US	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Myenvironmentalscience.com Science Behind the Stories -ABC News articles/Video Success Stories Point/Counterpoint Video: NBC Learn-Science. Internet: Soil Maps DVD-Aquatic Biomes Series - Invasive Species -Biodiversity Hotspots

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
February	Identify the types of rocks and stages of the rock cycle. Mining regulations and Acts. Why is fresh water a precious resource? What are our main sources of fresh water? Why is fresh water often in short supply? What is a watershed? What are point and nonpoint sources of pollution? What are the various types of water pollution? What is the impact of water pollution on people and on the environment? Why is groundwater pollution hard to clean? What are the effects of polluted oceans on humans? How can individuals prevent ocean pollution? Weathering/Erosion How does our atmosphere make life possible on Earth? How does photosynthesis and respiration balance carbon dioxide in the atmosphere? What is the structure and properties of the atmosphere? What causes the seasons? Why is the earth and its atmosphere like a greenhouse? Why are carbon dioxide levels rising? What is global warming?	Strip mining, open pit mining, mountaintop removal Surface water/Runoff Groundwater-water table Watersheds Solutions to water shortages. Groundwater pollution Point/non-point source pollution Pathogens, Algae Blooms Artificial eutrophication Thermal pollution Desalination Bottled water How pollutants get into oceans Preventing ocean pollution Atmosphere Layers: -Troposphere -Stratosphere -Mesosphere -Thermosphere Radiation-Convection-Conduction Air pollution Emissions/Smog/Acid rain Fossil Fuels Climate	How are minerals used in the environment? Describe the different methods used for mining and what they do to our environment. Define and compare point and nonpoint sources of pollution. What are the main watersheds for our area? Describe the impact of water pollution on people and on the environment. Explain why groundwater pollution is hard to clean. Explain how and why the oceans are polluted and describe the effects of pollution on marine life. Explain why fresh water is a precious resource Explain how the atmosphere makes life possible on Earth. Explain heat transfer and the interaction of air masses in the troposphere. Describe how the atmosphere is structured in layers. Explain what causes the seasons. Explain why the Earth and its atmosphere are like a greenhouse. Explain why carbon dioxide levels in the atmosphere are rising. Name the primary air pollutants. Discuss the causes of acid rain.	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test	Quick Lab-pg. 437 Lab-identifying rocks and minerals Lab-groundwater Lab-runoff-erosion Lab-ocean oil pollution Lab-oil spill bioremediation Project-Illustration of Groundwater, aquifers and watersheds. Lab-Illustration-Layers of the Atmosphere	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Point/Counterpoint Myenvironmentalscience.com Science Behind the Stories Closer Look Success Stories -ABC News articles/Video Video: NBC Learn-Science. DVD -The Last Mountain -Poisoned waters -Tapped -Gimmie Green

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
March	How does the ozone layer shield the earth from much of the sun's harmful radiation? How do CFCs damage the ozone layer? What are the damaging effects of excessive UV light? What is weather vs. Climate and how do they affect our environment Why do fossil fuels cause air pollution? What is SMOG? Discuss the Clean Air Act Reducing greenhouse gases. El Nino & La Nina Ocean Acidification and coral bleaching. What is Environmental Health? What are Epidemiology and Toxicology? What is Risk Assessment and how is it used in human health? What are teratogens, neurotoxins and carcinogens? Differentiate between Biomagnification and Bioaccumulation. How natural disasters effect society and the environment.	Greenhouse Effect Greenhouse gases The Ozone Layer Weather forecasting Clouds-storms Climate models Severe weather Kyoto Protocol Montreal Protocol Health hazards Pathogens Dose-Dose response relationship Risk Assessment Infectious Diseases Emerging diseases Radon Lead Mercury Asbestos Outdoor Chemical hazards Earthquakes Volcanoes Tsunamis Storms Hurricanes Tornados	Explain how the ozone layer shields the earth from UV rays. Explain how CFCs are damaging the ozone layer. Describe the damaging effects of excessive UV light. Discuss the causes & effects of Global Climate Change Define Risk and Risk Assessment. Name 5 infectious diseases. How have emerging diseases been affecting humans? What are chemical threats to humans?	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test **Benchmark Test**	Quick Lab pg. 459 Quick Lab pg. 486 Quick Lab - pg. 263 Research paper, or poster, PowerPoint on Diseases and indoor pollutants Lab-growing disease Lab-indoor air pollution	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Myenvironmentalscience.com Science Behind the Stories Closer Look Success Stories Point/Counterpoint -ABC News articles/Video Video: NBC Learn-Science. DVD-The Pinelands of New Jersey - Soil -Dirt, The Movie

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
April	What is the difference between Land cover and land use and how does each affect people? Explain where and why Urbanization occurs. What are the environmental impacts of Urbanization? What is a Heat Island? What is Infrastructure? Describe the ecological footprint of cities. Why do we preserve land? What is city planning? Why do cities and towns have zoning? What is Smart Growth? What is resource management? Describe the benefits of forests. What is the National Forest Management act? What are fire polices and prescribed burns?	Land Cover Land Use Urban Area Rural Area Urbanization Infrastructure Pollution types -light pollution -noise pollution Heat Island Sprawl GIS Urban Growth Boundary Zoning Greenways Green Building design	Name 5 human uses of land cover and land use. How does Urbanization relate to Atlantic City? How do transportation and infrastructure affect urbanization? People? Describe how Atlantic City or any other regional city can become a heat island? What is the ecological footprint of a city or town in NJ?	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion/debate Chapter quizzes Chapter Test		Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Point/Counterpoint Myenvironmentalscience.com Science Behind the Stories Closer Look Success Stories -ABC News articles/Video Video: NBC Learn-Science. DVD -The Last Mountain -Poisoned waters -Tapped -Gimmie Green

Pearson Environmental Science 2011 **Course: Environmental Science – Academic** **(9th Grade)**

Month	Essential Questions	Content	Skills	Assessment	Lab	Activities
May/ June	Define energy and differentiate between kinetic and potential energy. Identify different forms of energy Describe how society uses energy. How are fossil fuels formed? Describe the uses of oil and how it is extracted What are the dangers common to oil well drilling in the oceans? What is coal and why is there so much of it in the United States? What is Natural Gas? Why are we mining for Shale in the US currently? Explain why energy conservation is so important? Discuss the effects of strip mining, groundwater pollution and the environment. Describe how geothermal energy is harnessed and used. Define biomass energy and how it is used. Discus the use of solar power, wind turbines. Methods of solid waste disposal What is recycling and biodegradable? What is source reduction? Waste Treatment Plants	Kinetic/and Potential energy Renewable Nonrenewable Combustion Electricity Fossil Fuels Oil, oil sands Petroleum and petrochemicals Methane Hydrates Energy Conservation. Nuclear energy Nuclear Waste Nuclear Fission Reactors Meltdowns. Biomass/Geothermal energies Alternative energy Hydrogen Fuel cells Hazardous waste Solid Waste Landfills Leachate Recycling	Name the major energy sources we use in modern society and compare how this has changed from 200 years ago Define current worldwide patterns of energy use. Why is the supply of fossil fuels limited? Explain how pollutants released from burning fossil fuels are harming our environment. Explain the implication of our dependence on fossil fuels. Explain the human health effects caused by burning fossil fuels. What are the advantages and disadvantages of using nuclear energy? Explain the benefits of using renewable energies. What types of renewable energies are there? Hydroelectric energy, tidal, ocean thermal energy conversion (OTEC) Discuss the use of solar and wind energies in Atlantic County and NJ Explain why waste is becoming too much for society to manage. Define the types of waste and why they are causing so much trouble. Hazardous wastes: nuclear, toxic chemicals, oil, drugs and others.	Homework Classwork Current event article Central Case Analysis OEQs Lab report Discussion Chapter quizzes Chapter Test	Quick Lab pg. 520 Quick Lab pg. 591 Map winds speeds determine where the best places for wind turbines. Lab-	Chapter Central Case. Reading comprehension of selected readings. Selections from student workbook Chapter review Internet Activities. ACHS Media Center Research. Collect data and graph information. Lab activities & report Concept Mapping Ecological Footprints Myenvironmentalscience.com Science Behind the Stories Closer Look Success Stories Point/Counterpoint -ABC News articles/Video Video: NBC Learn-Science. DVD-What Happened to the Electric car? -Crude Awakening -Gasland -Trashed

AP Physics B

12th Grade

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Prepared by
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Atlantic City Public Schools
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(Revised July 2016)

I. OVERVIEW

AP Physics B is an algebra-based course that entails coverage of a wide-ranging spectrum of topics than the B-Level course. The text being utilized, John Wiley & Sons' *Physics*. Extended 10th edition 2015. [On-Line Version] by Cutnell & Johnson, is a standard text used in many 1st year University Physics Courses. This widespread usage ensures a fairly seamless transition for students aspiring to science careers. The course structure will emphasize formulation and justification of models used to describe physical behavior and processes. This regimen will help establish multiple connections between a myriad of phenomena and inquiry-based student investigations, thereby reinforcing relevancy and real-life context. The selection of problems will be challenging, reflecting extension of models or concepts developed in class, as well as preparation for the AP exam itself. The curriculum will also be infused with web-based activities, appropriate laboratory investigations, and a historical analysis of ideas and individuals - the latter to illuminate the enterprise and triumphs of physics as a human cultural achievement. Finally, the students will conduct a “hands on” research project at the end of the scholastic year, as a culminating activity.

II. RATIONALE

The course is developed for those students contemplating science careers. This course will develop an understanding of the scientific process and the need to sort and evaluate collected information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book.

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and

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behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

IV. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of fundamental and more highly sophisticated concepts in linear and rotational Newtonian Dynamics, harmonic oscillation and resonance, and wave propagation.
[5.6.A.8, 5.7.A.1-8, 5.7.B.1-4, 5.9.A, 5.9.C, 5.9.D.1]
2. show proficiency in using vector language, and methods from differential and integral calculus, to express, model, and manipulate various physical quantities or phenomena arising in diverse areas of physics, such as velocity, linear and angular momentum.
[5.3.C.1, 8.1]
3. develop a knowledge of the history, evolution, interrelationships, and epistemology of key ideas in physics and an appreciation of the process as a cultural human achievement.
[5.1.A.4, 5.2.B. 1-3, 5.4.A.1, 5.9.D.2]

B. ATTITUDE
The students will:

1. develop an appreciation for the discipline of physics and its relationship to the evaluation and potential resolution of pressing everyday economic, technical, and commercial problems. [8.2]
2. research and investigate possible careers in physics or physics-related engineering areas. [8.2, 9.1, 9.2]

C. SKILLS AND BEHAVIORS
The student will:

1. inculcate and reinforce good problem-solving, modeling, and approximation techniques essential in formulating viable descriptions of physical systems and making meaningful predictions.
[5.1.A.1 & 3, 5.3.C.1, 5.9.D.2]
2. use spreadsheet and graphing software to analyze and report measurements and results from laboratory investigations.
[2.3, 8.1, 8.2]]

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3. set up and perform experiments using computer interfaced sensors and associated resident software to calibrate instruments and collect data in various formats. [2.3, 8.1, 8.2]
4. demonstrate proper and safe use of laboratory equipment during experiments. [5.1.C.1]
5. work cooperatively in small groups to construct models, solve problems, and perform experiments. [5.4]
6. be aware of the connection between educational activities & the world of work [9.1, 9.2]

V. STRATEGIES

Interactive lectures
Problem solving activities
Inquiry-based group investigations
Use of computer interfaced data collection sensors
Independent projects
Real-time administration of AP exam questions under actual test conditions
Internet-based assignments and investigative activities
Biographical and historical reports and presentations

VI. EVALUATION

Assessment may include:

Homework
Graded Assignments
Quizzes
Laboratory Investigations
Benchmark Tests
Tests
Projects

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: Cutnell & Johnson, Physics [Extended 10th Edition] John Wiley & Sons, Inc., © 2015
2. Lab manual: PASCO Scientific, Physics Labs with Computers: Volumes 1 & 2[1st Edition] PASCO Scientific, © 1999

   Brueningsen & Krawiec, Exploring Physics and Math with the CBL System [1st Edition] Texas Instruments Incorporated, © 1994
3. Technology:

   Technology

   Chromebook cart and Google Classroom

   EdConnect for Lesson Plans and Benchmark Assessments

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Supplemental Resources

Common science department web links (updated July 2016)
https://www.khanacademy.org/
www.bozemanscience.com
https://www.nasa.gov/
https://science360.gov/files/
https://phet.colorado.edu/en/simulations/category/physics
http://www.physics.org/

ACHS Media Center/Library:
www.Youtube.com
www.turninitin.com
NBC Learn Media - http://archives.nbclearn.com/portal/site/k-12
Purdue Writing Lab – MLA/APA Formats -
https://owl.english.purdue.edu/owl/resource/747/13/
Gale Database (On-line and phone app)
Press of Atlantic City Newspaper Program
New York Times Newspaper Program

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VIII. SCOPE AND SEQUENCE

September

Motion

- Units and Measurements
- Scalars and Vectors
- 1 Dimensional Kinematics
- 2 Dimensional / 3 Dimensional Kinematics
- Projectiles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Dynamics

- Uniform Circular Motion
- Relative Motion
- Force and Mass
- Tension & Normal Forces
- Uniform Circular Motion
- Drag Force & Differential Equation for Terminal Velocity

Work, Energy, and Power

- Work
- Energy
- Conservation of Energy
- Work Done by Conservative and Nonconservative Forces
- Work Done by Variable Forces
- Kinetic and Potential Energies
- Conservation of Mechanical Energy

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Linear Momentum

- Linear Momentum & Impulse
- Law of the Conservation of Linear Momentum
- 1-Dimensional and 2-Dimensional Collisions

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Rotation

- Angular Displacement, Velocity and Acceleration
- Relationship between Linear and Angular Variables
- Rigid Bodies
- Moment of Inertia Derivations and Torque
- Rotational Variables and Newton's Second Law
- Angular Momentum
- Conservation of Angular Momentum

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Oscillations

- Simple Harmonic Oscillations (Kinematics & Dynamics)
- The Wave Equation
- Simple Pendulum
- Spring Mass Systems
- Physical Pendulum

Fluids

- Hydrostatics
- Fluid Pressure
- Pascal's Principle
- Archimedes Principle
- Fluid Dynamics
- Continuity Equation
- Bernoulli's Equation

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Heat

- Heat & Temperature
- Thermal Expansion
- Heat Transfer
- Ideal Gas Laws and PV Diagrams
- Kinetic Theory and RMS Speed of Gas Molecules
- Laws of Thermodynamics

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Reversible Thermodynamic Processes
Heat Engines and Carnot Cycle

Electric Charge & Electric Fields

Electrostatics
Coulomb's Law
Electric Fields
Motion of Charged Particles in an Electric Field
Capacitors

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February

Electricity & Magnetism

Electric Current, Resistance and EMF
Electrical Resistivity, Power & Energy
Resistors in Series and Parallel
Kirchoff's Rules
Magnetic Fields
Magnetic Force on Electric Current
Magnetic Force Due to a Current
Magnetic Flux
Electromagnetic Induction

Sound

Traveling Waves
Properties of Sound
Standing Waves and Beat Frequencies
The Doppler Effect

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March

Optics – Reflection & Refraction

Law of Reflection
Snell's Law

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Total Internal Reflection – Fiber Optics
Image Formation by Plane & Spherical Mirrors
Image Formation by Lenses
Image Formation by a Two-Lens System

Optics – Wave Phenomena

Interference
Superposition Principle
Single & Double Slit Interference & Diffraction
Diffraction Gratings
Polarization
Electromagnetic Spectrum

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April

Light Theory

Photoelectric Effect
Energy and Linear Momentum of a Photon
Energy Level Ionization
Emission Spectrum
Absorption Spectrum
Lasers
DeBroglie Wavelength
X-Ray Production
The Compton Effect

Nuclear Physics

Mass Number & Atomic Number
Nuclear Reactions
Alpha, Beta & Gamma Decay
Neutrino
Nuclear Forces
Nuclear Fission & Chain Reactions
$E=mc^2$ and Nuclear Reaction Applications

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

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May

Review for AP B

Review for AP Test in May
Take Released AP Multiple Choice Tests
Do Released AP Free Response Questions
Take the Test

End of the Year

End of the Year Research Activity

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Academic Physics

11th & 12th Grades

Prepared by
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(Revised July 2016)

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I. OVERVIEW

Physics is a full year college preparatory course offered to students at the beginning of their high school science sequence. It is the intent of the course to develop in students a conceptual understanding of the scientific content, problem solving skills, critical thinking and inquiry skills, and an appreciation of the collaborative scientific process. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information. Topics in the course include mechanics, work and energy, electricity and magnetism, waves, and optics. Applications in Earth Science will be explored. The course provides many opportunities for students to increase their interest and appreciation of science. Activities will be realistic and meaningful to high school students, and have been selected to allow students to work individually and in groups. The course is designed to foster organization, responsibility, curiosity, and enjoyment of science.

II. RATIONALE

Physics has been developed to provide students with an introduction to the study of the physical laws of the universe which underlie the understanding of all other science disciplines. We believe that early acquisition of basic physics concepts will provide students with knowledge and skills necessary to gain a deeper understanding of chemistry and biology. The Physics curriculum incorporates the appropriate NJ Core Curriculum Content Standards and Cross Content Workplace Awareness Standards. Applications of earth science are included. This course will develop an understanding of the scientific process and the need to sort and evaluate collected information.

III. STUDENT OUTCOMES

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science

and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. understand, evaluate and practice safe procedures for conducting science investigations
[5.1.C.1, 5.3.A]
2. distinguish between vector and scalar quantities
[5.3.A]
3. recognize the variability of measured quantities. Distinguish between accuracy and precision
[5.1.B.1, 5.3.B.1]
4. define and distinguish between the following quantities: distance, displacement, speed, velocity and acceleration
[5.7]
5. describe the motion of objects in terms of displacement, velocity and acceleration
[5.7]
6. relate motion to the appropriate frame of reference (coordinate system), and in simple cases predict and compare motion in multiple frames of reference
[5.1.C, 5.7]
7. describe phenomena and perform calculations using the Law of Universal Gravitation
[5.1.A, 5.1.C.1, 5.7.A.3]
8. define and describe the relationship between impulse and momentum for a given object
[5.1.A, 5.1.C.1, 5.7.B.2]
9. describe various types of energy and energy transformations.
[5.7.A.5-6, 5.7.B.1-3]
10. describe the work-energy theorem and apply it to mechanical systems

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[5.7.B.1-3]

11. define and distinguish between thermal energy and temperature
[5.7.B.1, 5.8.B.1]
12. describe methods of heat transfer. Give examples of heat transfer into, out of and within the earth system
[5.7.B.1, 5.8.A.1, 5.8.B.1, 5.8.C.1]
13. define heat of fusion and heat of vaporization
[5.7.B.1]
14. describe Pascal's, Archimedes' and Bernoulli's principles as they relate to the behavior of fluids
15. describe waves as the transfer of energy, not matter
[5.7.B.1-4]
16. distinguish between longitudinal and transverse waves
[5.7.B.1]
17. explain how electromagnetic waves are generated and identify the components of the electromagnetic spectrum
[5.7.B.4]
18. describe the behavior of waves, including reflection, refraction and interference
[5.7.B.1]
19. describe light as a portion of the electromagnetic spectrum
[5.7.B.4]
20. explain how light is reflected, refracted or absorbed by matter and how colors appear as a result of this interaction. Describe the importance of this interaction in the energy balance of the earth
[5.7.B.1, 5.8.A.1, 5.8.B.1]
21. describe how convex and concave mirrors and lenses form images
[5.7.B.1]
22. distinguish between conductors and insulators and give examples of each
[5.7.B.1]
23. explain that charging is due to the separation of charges
[5.7.A.4]
24. define and describe electric potential and voltage. Relate to analogous potential energy concepts
[5.7.A.4, 5.7.A.6, 5.7.B.1]
25. describe electric current and the conditions necessary for its occurrence
[5.7.B.1]
26. define electrical resistance
[5.7.B.1]
27. describe magnetism and relate to the motion of charged particles
[5.7.A.7]

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28. demonstrate awareness and knowledge of careers in science through active participation in discussions, career days, field trips or other appropriate activities
[5.1.A.4]
29. recognize in writing/discussion the current and past leaders of physics
[5.2.B.1, 5.1.B.3, 9.2]
30. recognize how physics correlates with other disciplines as medicine, sports, electronics, astronomy and architecture
[5.1.A.4, 5.2.B.2, 5.4.A.1, 5.9.D.1-2, 9.1]
31. distinguish between science and technology and cite examples of each
[5.4.A.1, 9.2]

B. ATTITUDE
The students will:

1. acquire and demonstrate a positive attitude and appreciation for the study of physics
[5.3]
2. develop a scientific curiosity and sense of involvement as a result of exposure to the history of physics
[5.3]
3. discover that the physical laws studied are reflected or applied in many aspects of daily life. [5.3]
4. recognize that science is complex, understandable, fallible and ever changing
[5.3]
5. recognize that technology offers risks and benefits, and that alternate solutions of varying merit often exist to solve problems
[5.1.A.2, 5.4.B.1, 5.7.B.4]

C. SKILLS AND BEHAVIORS
The student will:

1. demonstrate organization by keeping a complete, detailed notebook and collections of news articles which will be checked or graded periodically
2. exhibit the proper and safe use of laboratory equipment and materials by successfully completing laboratory investigations
[5.1.B.1, 5.1.C.1]
3. demonstrate a thorough knowledge of SI units through the use and manipulations of units in physics applications
[5.3.A]
4. formulate models (Mathematical, conceptual, graphical) to examine and explain observed and/or measured physical quantities or

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phenomena
[5.1.A, 5.3.A, 5.3.D.1]

5. develop and implement meaningful investigations of physical phenomena based on experience and observations. Analyze and draw conclusions using computer applications based on experimental data
[5.1.A.1, 5.1.B.2, 5.3.A, 5.3.C.1, 8.1]
6. defend and critique scientific conclusions by citing evidence from data and using reasoning based on scientific principles
[5.1.A.1, 5.1.A.4]
7. present scientific investigations, analysis and conclusions in well organized laboratory reports
[5.1.A.4, 5.3.A, 5.3.B.1 5.3.C.1, 5.3.D.1]
8. work independently and in cooperative groups to successfully achieve common goals such as carrying out experiments, simulations or completing projects
[5.1.A.4]
9. add and subtract vectors using both mathematical and graphical methods
[5.3.A, 5.3.C.1]
10. perform motion calculations for constant acceleration conditions, including both one and two dimensional motion
[5.3.C.1]
11. develop and interpret graphs of motion: displacement vs. time, and velocity vs. time
[5.3.D.1]
12. describe and distinguish between Newton's Laws of Motion and use the knowledge to predict or explain observed phenomena
[5.3.A, 5.3.C.1, 5.7.A.1-2]
13. perform calculations using Newton's Laws of Motion
[5.3.A, 5.3.C.1, 5.7.A.1-2]
14. draw simple free body diagrams
[5.7.A.1-2]
15. determine the force that produces equilibrium when two other forces act on an object
[5.3.C.1]
16. analyze the forces and motion of objects on an inclined plane
[5.3.A, 5.3.C.1]
17. explain how the Law of Universal Gravitation applies to models of the origin of the universe, and current topics in astronomy
[5.7.A.3, 5.9.B.1, 5.9.C.1]
18. perform momentum calculations using the concept of a close system
[5.3.C.1]

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19. apply the principle of conservation of energy to perform calculations involving various forms and transformations of mechanical energy (potential and kinetic)
[5.3.C.1, 5.7.B.2]
20. design and assemble simple machines and determine its efficiency
21. perform calculations involving the transfer of heat and changes of state
[5.3.A, 5.3.C.1, 5.7.B.1]
22. describe energy sources and transfers to, from, and within the Earth system. Relate to weather and climate
[5.7.B.1]
23. investigate and use the theory of plate tectonics to explain the relationship among earthquakes, volcanoes, mid-ocean ridges, and deep sea trenches
[5.7.B.1-2]
24. relate wave speed, wavelength and frequency. Perform simple calculations for sound waves in air using the relationship
[5.3.A, 5.3.C.1, 5.7.B.1]
25. describe the Doppler effect and perform research to determine how it is important to theories about the origin of the universe
[5.9.D.1-2]
26. describe and calculate the forces exerted by charged particles using Coulomb's Law
[5.3.C.1, 5.7.A.4]
27. describe and diagram the electrical fields that exist around electrical charges
[5.7.B.4]
28. use the concept of electrical fields to explain and predict the behavior of objects in a field
[5.7.B.4, 5.7.B.6]
29. relate voltage, resistance, current and power in electrical circuits. Perform calculations for series and parallel circuits
[5.3.A, 5.3.C.1, 5.7.B.1]
30. draw and construct simple series and parallel circuits. Perform related laboratory predictions, measurements and analysis.
[5.3.C.1, 5.7.B.1]
31. describe and diagram magnetic fields
[5.7.B.7-8]
32. be aware of the connection between educational activities and the world of work [9.1, 9.2]

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IV. STRATEGIES

create and construct models
brainstorm ideas and formulate hypotheses
problem-solve through lab investigations
participate in group discussions
evaluate data
analyze procedures
apply student knowledge
make and test hypotheses
evaluate results and consequences

make the appropriate accommodations for special needs and ELL students:

- additional time and other IEP stated accommodations
- audio text resources
- varied assessment

V. EVALUATION

Assessment may include:

observations
notebook evaluations
student projects and activities
written homework
lab reports
quizzes
tests
benchmark assessments
oral presentations
laboratory practice

VI. REQUIRED RESOURCES

1. Textbook: Conceptual Physics , Paul Hewitt, Addison Wesley 2002, 9th Edition
2. Ancillary and enrichment resources:
   PASCO Scientific, Physics Labs with Computers: Volume 1, PASCO Scientific, 1999.

   Internet sites devoted to Physics
   Various miscellaneous teacher resources

   Active Physics, Arthur Eisenkraft, Lab Manual, It's About Time Inc., 2000

   IEP Planning Code Book, Atlantic City Public Schools, Department of Special Services, 2002; (Inclusion Teacher Modeling IEP to student within course)

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Interactive Physics, MSC Software Corp, 2000

3. Technology
    - Laptop cart
    - Word Processing and Data Base programs: Microsoft Office
    - Webassign.net
    - Computer Assisted Labs

SCOPE AND SEQUENCE

September

Introduction
- Expectations
- Safety

Linear Motion
- Units
- Displacement vs. distance
- Vector vs. scalar quantities
- Frames of reference and coordinate systems
- Velocity, speed
- Average vs. instantaneous quantities
- Acceleration
- Free fall
- Graphing and interpreting graphs of motion (displacement vs. time and velocity vs. time)
- Accuracy and precision

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Vectors
- Vector addition: graphical and numeric
- Pythagorean theorem; sine, cosine, tangent functions
- Vector components
- Resultants

Forces and Motion
- Force definition
- Newton's 1st Law
- Newton's 2nd Law

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Newton's 3rd Law
Action/Reaction pairs
Free Body diagrams
Frictional forces

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Forces and Motion in Two Dimensions

Equilibrant force
Resultant forces and motion
Motion and forces on an inclined plane
Projectile motion
Circular motion

Universal Gravitation

Law of Universal Gravitation
Scientific notation
Gravitational fields - applications to astronomy, origin of stars and planets
Kepler's laws

Assessments – Benchmark Assessment, Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Momentum

Definition of momentum, impulse
Impulse-momentum theory
Definition and identification of "closed systems"
Conservation of momentum
Collisions

Energy and Work

Mechanical energy
Work - define and calculate
Work-energy theorem - energy transfer
Power
Conservation of energy

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Energy “losses” - friction, sound, etc

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Thermal Energy

Temperature, heat
Kinetic-molecular theory
Thermometry and temperature scales
Heat transfer mechanisms
Specific heat
Heats of fusion and vaporization
Quantitative determinations of heat transfer
1st and 2nd Laws of Thermodynamics

Assessments – Benchmark Assessment, Chapter Test,
journal review, lab reports (informal)
Unit Exam

February

Fluids

Fluid properties
Pressure - Pascal’s principle
Buoyancy- Archimedes’ principle
Bernoulli’s principle

Waves

Energy Transfer
Longitudinal and transverse
Wave characteristics - wavelength, amplitude, frequency, speed, period
Interference - constructive and destructive
Reflection
Refraction
Diffraction

Sound

Description of sound
Speed in various media
Determinations of frequency, speed and wavelength
Decibel scale

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Pitch
Applications in music
Doppler shift

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March

Electromagnetic spectrum

Properties of light
Wave-particle duality
Ray model vs. wave model
Luminous flux and illuminance
Light transmission, reflection and absorption
Color
Polarization
Law of reflection
Refraction
Mirrors
Lenses
Diffraction

Assessments – Benchmark Assessment, Chapter Test,
journal review, lab reports (informal)
Unit Exam

April

Static Electricity

Charged particles
Charging objects - separation of charged particles
Conductors and insulators
Electrical forces
Coulomb's law

Electrical Fields

Definition
Diagrams of fields around charged objects
Field strength
Potential energy
Capacitance

Assessments – Chapter Test, journal review, lab reports (informal)

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Unit Exam

May/June

Current Electricity

- Definition of current
- Current in a circuit - necessary conditions Voltage and potential difference
- Resistance
- Ohm's law
- Circuit diagrams
- Series circuits
- Parallel circuits
- Power and energy
- Applications

Magnetism

- Properties of Magnets
- Magnetic fields
- Electromagnetism - fields around current carrying wires, coils
- Forces in magnetic fields
- Electromagnetic induction

Earth Science Applications

- Weather and climate - energy transfer in the atmosphere
- Astronomy

Assessments – Benchmark Assessment, Chapter Test, journal review, lab reports (informal)
Unit Exam
Final Exam

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
Sept.	What is Physics? What are the basic kinematical relationships between position, velocity and acceleration?	Introduction Review Dimensional Analysis The "MKS" system 1 D kinematics	Drawing position vs time graphs Drawing velocity vs time graphs Deriving velocity graphs from position graphs – analyzing the slope of position graph Solving 1 D kinematics problems	Notebook Homework assessment Lab reports and quizzes	Vector Walk Lab. Measuring and plotting accelerated motion with a Bell Timer. Measuring "g" with a Bell Timer. Measuring and plotting constant velocity with a Bell Timer. Conceptual graphing – relating motion to its corresponding position velocity and acceleration graph

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
Oct.	What is a vector? How do vectors combine? What are vector components? How do you determine the components of a vector? What are the application of vectors and vector components? How can motion in 2 D be analyzed?	Introduction The use of arrows to graphically represent vectors How vector addition differs from algebraic addition How vectors and vector components are used to analyze 2 D motion (projectiles)	Drawing vectors to scale Combining vectors with a ruler and triangle by the head to tail method Combing vectors by the parallelogram method Breaking vectors into components with triangle and ruler and by the use of trigonometric functions.	Notebook Homework assessment Lab reports and quizzes	Using a ruler, protractor and triangles to draw, add and resolve vectors Determining the range of a projectile.

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Course Physics Academic

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
Nov	What is mass? How is mass measured? What is the difference between inertial mass and gravitational mass? How does mass interact with force? What properties does a moving object have?	Introduction Using the force of gravity to determine the amount of matter. Using the resistance of an object to acceleration as a means of determining mass. An introduction to Newton's 3 laws of motion. Introduction to momentum and kinetic energy	Using a triple beam balance. Using and calibrating an inertial balance. Using a bell timer to measure the acceleration of an object. Using a Pasco "Smart Timer" to measure acceleration.	Notebook Homework assessment Lab reports and quizzes	Lab- Measuring mass with a triple beam balance and an inertial balance. Lab – Determining the relationship between mass, force and acceleration. Lab- Making and testing balloon rockets. (Newton's 3rd law) Lab-Measuring the momentum and kinetic energy of a lab cart./

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Course Physics Academic

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Course Physics Academic

Month	Essential Questions	Content	Skills	Assessment	Activities
Dec	How does the Center Mass of a System Behave? How is the Conservation of Linear Momentum Seen in Collisions? What is impulse and how does it relate to Momentum? What does elasticity have to do with collisions? How does rocket propulsion demonstrate the Conservation of Linear Momentum?	Systems of Particles Conservation of Linear Momentum Impulse Collisions - 1 Dimensional - 2 Dimensional - 3 Dimensional Elastic & Inelastic Collisions Rocket Propulsion	Demonstrate how systems of particles behave. Solve elastic and inelastic collision problems Determine what is conserved in various collisions Solve Rocket Problems	Work & Energy Test Rotational Kinematics Tag-Team Competition Rotational Kinematics Test Home Alone Physics Project	"Collisions" Lab "Systems of Particles Motion" Demo "Home-Alone Physics" Project

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Course Physics Academic

Month	Essential Questions	Content	Skills	Assessment	Activities
Jan	How do rotational analogues relate to translational quantities? What is torque and how is it measured? What are the dynamic implications of rotating systems? How is Rotational Inertia calculated for various objects?	Rotational Kinematics Torque – Vector Product Definition Rotational Dynamics Rotational Inertia	Establish the correlation of rotational quantities to translational quantities. Solve torque problems Determine how rotational dynamics cause motion and angular changes in rotating systems Calculate and work with the Rotational Inertia for various objects	Momentum Test Momentum Competition Rotation Test Quiz on Angular Motion Equations	"Rotational Inertia" Lab "Torque" Lab

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Course Physics Academic

Month	Essential Questions	Content	Skills	Assessment	Activities
Feb	What are the requirements and qualities of SHM? How is the Wave Equation derived from a Physical Oscillation? What factors affect the Period of a Spring-Mass Oscillator? What factors affect the Period of a Pendulum? How is Heat Energy Measured? How does a Calorimeter work? How is efficiency measured in a Heat Engine	Simple Harmonic Motion Spring-Mass Oscillations Pendular Oscillations Temperature & Heat Mechanical Equivalence of Heat Calorimetry Heat Engines	Calculate the Period of SHO Convert Temperature to various Scale Measures Calculate MCΔT for Heat Problems Solve Calorimetry Problems Calculate efficiencies of Heat Engines	Check homework solutions "The Pit & the Pendulum" Lab Report "Calorimetry" Lab Test on SHM Test on Heat	"The Pit & The Pendulum" Lab "Calorimetry" Lab

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
March	What are the postulates of Special Relativity? What was the state of knowledge in the field of physics when Einstein formulated his theory of Relativity? What is a wave? How does a wave transmit energy How is sound transmitted through air? What is resonance and natural frequency and why are these concepts important.	A historical development of the Special Theory starting with Maxwell's Equations and the problems involving the speed of light. What is time dilation and space contraction? Wave mechanics; parts of a wave and the dynamic characteristics(frequency Period etc.) Sound as a wave phenomena Use the superposition principle to determine the combine wave when waves interfere.	Explain the effect of motion on space and time. Relate the historical development of the Special Theory, being able to explain the context in which it was conceived. List the parts of a wave. Apply the equation for wave speed to determine the frequency, wavelength or speed of a wave. Explain the conditions under which resonance can occur.	Notebook Homework assessment Lab reports and quizzes	View videos on the development of Einstein's equations. Combine waves using the superposition principle. Measure the speed of sound using the resonance of a column of air.

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Course Physics Academic

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Course Physics Academic

Month	Essential Questions	Content	Skills	Assessment	Activities
Apr	What is Gauss's Law? What is a Capacitor? What is a Dielectric? How do Capacitors behave in circuits? What contributes to good conductivity in materials? What is superconductance? What is Ohm's Law? How do Series & Parallel Circuits work?	Gauss's Law Capacitors & Dielectrics Material Study Circuits	Solve Gauss's Law Problems Examine & Explain Use of Capacitors Draw Circuit Diagrams Determine Equivalent Resistances	Test on Charge Assessment from the New Jersey Science League – April Test Capacitance Quiz Circuits Test	"Series and Parallel Circuits" Lab "Battery" Lab

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
May	What is a field? What are the similarities and differences between electric and gravitational fields? What is an electric fields? What is electric potential? What is a series circuit? What is a parallel circuit? What are the rules for determining the overall resistance of an electric circuit?	Electric fields for point charges are defined using Coulombs law. Electric potential energy is defined and compared to gravitational PE. Electric potential (voltage) is defined Ohm's law is used to define resistance and the fundamental characteristics of an electric circuit. Series, parallel and combination circuits are investigated experimentally.	Students will be able to: Use Coulomb's law to calculate the force between charged objects. .List and apply the rules for electric field lines to properly diagram the electric field around a charged object. Apply Ohm's law to determine the voltage, current flow and resistance of a circuit. Compute the equivalent resistance of series and parallel circuits. Use digital multi-meters to measure current, voltage and resistance Use single use analog meters to measure current, resistance and voltage.	Notebook assessment Homework review Lab reports and lab quizzes.	Demonstration of Van de Graff machine. Lab – constructing simple parallel and series circuits with battery and light bulbs. Lab- Using digital and analog meters to confirm Ohm's law Measure and calculate the equivalent resistance of series and parallel circuits. Measure and calculate the voltage distribution in series and parallel circuits Measure and calculate the current flow in series and parallel circuits.

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Course Physics Academic

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Course Physics Academic

Month	Essential Question	Content	Skill	Assessment	Activities
June	What is a magnetic field? What are the similarities and differences between Magnetic and gravitational fields? What is an magnetic field? What is the relationship between magnetic and electric fields? How are magnetic fields produced by electric current? How is electric current induced in a wire by a magnetic fields (Faraday's law of Induction)	The discovery of magnetic fields and their relationship to electric fields is examined from a historical perspective Magnetic fields are defined and compared to electric fields, rules for drawing magnetic fields are discussed. Electromagnetic induction and Faraday's law	Students will be able to: Draw magnetic fields lines Discuss/list the conditions needed for electric current to be produced from a magnetic field	Notebook assessment Homework review Lab reports and lab quizzes.	View videos on the historical development of magnetic/electromagnetic theory Lab-Experimentally determine how magnetic field strength varies with distance Lab- Examine the conditions needed to produce electric potential and current with a magnetic field.

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