Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**- Student Activity -**

**How do you determine the precision and accuracy of different types of glassware?**

In this laboratory you will investigate the precision and accuracy of three different types of glassware. Additionally, you will investigate the density of water. By comparing your results with your classmates. You will comment on the precision of the class results, and by comparing your values to literature values, you will also comment on the accuracy of your results.

**Procedure:**

The precision and accuracy of a measurement depends on the measuring device. In lab you will be measuring volume of distilled water using a beaker, a graduated cylinder and a pipette. For the equipment you will be using the precision of the glassware is given below:

|  |  |  |  |
| --- | --- | --- | --- |
| **GLASSWARE** | **VOLUME (mL)** | **PRECISION** | **SIGNIFICANT FIGURES** |
| Beaker | 10. |  +/- 0.5 mL | 2 |
| Graduated cylinder | 10.0 | +/- 0.05 mL | 3 |
| Volumetric pipette | 10.00 | +/- 0.02 mL | 4 |

To test the accuracy and precision of different equipment, do the following:

**Each student** within a group will use **each piece of glassware once** to measure a ten milliliter sample of water. Then you will each use a balance to measure the exact mass of the water within each container. Note however, to measure the mass of water within a pipette, you will have to evacuate it into a beaker (you can't weigh water while it is the pipette). Remember to measure exactly using the meniscus.

Once you have measured the mass of the water, determine the density of the water in each sample using the formula: **D = M/V** (Use the correct number of **significant figures**!)

Calculate the average density for each piece of glassware used (again using the correct number of significant figures).

Record the temperature of your water.

**Data: Mass of Ten Milliliters of Distilled Water**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **GLASSWARE** | **Mass (grams) #1** | **Mass (grams) #2** | **Mass (grams) #3** | **Mass (grams) #4** |
| Beaker |  |  |  |  |
| Graduated cylinder |  |  |  |  |
| Volumetric pipette |  |  |  |  |

**Temperature of distilled water \_\_\_\_\_\_\_\_oC**

**Calculations:** (Show ALL of your work and don't forget your UNITS!)

 **D = M/V**

Density of water in beaker: Average:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Density of water in graduated cylinder: Average:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Density of water in volumetric pipette: Average:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Use the table below to determine the actual density of distilled water.

Density of Water (g/mL) vs. Temperature (°C)

(from Handbook of Chemistry and Physics, 53rd Edition, p. F4)

Whole degrees are listed down the left-hand side of the table, while tenths of a degrees are listed across the top

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **oC** | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 18 | 0.99860 | 0.99858 | 0.99856 | 0.99854 | 0.99852 | 0.99850 | 0.99848 | 0.99846 | 0.99844 | 0.99842 |
| 19 | 0.99840 | 0.99838 | 0.99836 | 0.99834 | 0.99832 | 0.99830 | 0.99829 | 0.99827 | 0.99824 | 0.99822 |
| 20 | 0.99820 | 0.99818 | 0.99816 | 0.99814 | 0.99812 | 0.99810 | 0.99808 | 0.99806 | 0.99804 | 0.99801 |
| 21 | 0.99799 | 0.99797 | 0.99795 | 0.99793 | 0.99790 | 0.99788 | 0.99786 | 0.99784 | 0.99782 | 0.99779 |
| 22 | 0.99777 | 0.99775 | 0.99772 | 0.99770 | 0.99768 | 0.99766 | 0.99763 | 0.99761 | 0.99758 | 0.99756 |
| 23 | 0.99754 | 0.99751 | 0.99749 | 0.99747 | 0.99744 | 0.99742 | 0.99739 | 0.99737 | 0.99734 | 0.99732 |
| 24 | 0.99730 | 0.99727 | 0.99725 | 0.99722 | 0.99720 | 0.99717 | 0.99715 | 0.99712 | 0.99710 | 0.99707 |
| 25 | 0.99704 | 0.99702 | 0.99699 | 0.99697 | 0.99694 | 0.99691 | 0.99689 | 0.99686 | 0.99684 | 0.99681 |

**RESULTS: Calculation of Accuracy**

Determine the % error for the average density of each piece of glassware using the formula:

*(Note the value for % error is recorded as an absolute value)*

*(Make sure to use the correct number of significant figures)*

**% error = | Actual - Measured | x 100**

**Actual**

**% error for the average density of water using the beaker:**

**% error for the average density of water using the graduated cylinder:**

**% error for the average density of water using the volumetric pipette:**

Precision is a measure of the extent to which consecutive determinations of the same value agree with one another. In order to evaluate the precision of your work, you will calculate the **Relative Average Deviation (RAD)** for each piece of glassware. The following is an explanation of how to calculate an RAD and an example of a sample RAD calculation:

Calculation of RAD:

1. Calculate the mean (average).

2. Calculate the deviation () for each value.

  = | mean - individual value | (Note this is an absolute value)

3. Calculate the Standard Average Deviation.

 Standard Average  = | 1 | + | 2 | + | 3 | +…+ | x |

 x

4. Calculate the Relative Average Deviation.

 RAD (in %) = Standard Average Deviation x 100

 mean

 *(Note make sure to round to the correct number of significant figures)*

EXAMPLE:

Sample Density Values: 3.02 g/mL 3.08 g/mL 3.05 g/mL

Mean: (3.02 + 3.08 + 3.05)/3 = 3.05

1| 3.05 - 3.02 | = 0.03

2| 3.05 - 3.08 | = 0.03

3| 3.05 - 3.05 | = 0.00

Standard Average  = (0.03 + 0.03 + 0.00)/3 = 0.02

RAD (in %) = 0.02/3.05 x 100 = 0.6557% rounded to **0**.**7%**

*(Note the answer has only one significant figure because the deviation values had only one significant figure)*

**RESULTS: Calculation of Precision**

Calculate the precision of each piece of glassware by finding the RAD of each density calculation for the three pieces of equipment used in this lab.

**RAD for the densities of water using the beaker:**

**RAD for the densities of water using the graduated cylinder:**

**RAD for the densities of water using the volumetric pipette:**

Summarize how the precision and accuracy of the glassware was determined. Evaluate both the precision and accuracy of each piece of glassware. Which piece of equipment was the most precise? Which was the most accurate? Use your results to justify your conclusions.

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