**What are Acids and Bases?**

There are several different meanings for acids & bases. So instead of starting with a definition, let’s describe their properties first.

**ACIDS**

* Are electrolytes (produce mobile ions in water)
* Taste sour
* React with active metals to produce hydrogen gas
* React with indicators and make them change color

(Example – Litmus paper turns red in acid)

* Have a pH between 0 – 7
* React with bases to produce salt and water

(Example – HCl + NaOH NaCl + H2O)

**BASES**

* Are electrolytes
* Taste bitter
* Feel slippery to the tocuh
* React with indicators and make them change color

(Example – Litmus paper turns blue in base)

(Example – phenolphthalein turns pink in base)

* Have a pH between 7 – 14
* React with acids to produce salt and water

(Example – NaOH + HCl NaCl + H2O)

**Arrhenius Acid** – A species that gives off H+ ions in solution.

HCl(aq) H+ + Cl-

H2SO4(aq) 2H+ + SO4-2

CH3COOH⟶ CH3COO- + H+

CH3OH ⟶ CH3OH NOT A BASE

**Arrhenius Base** – A species that gives off OH- ions in solution.

NaOH(aq) Na+  + OH-

Ca(OH)2(aq) Ca+2  + 2OH-

**Neutralization** – When equal amounts of **H+** **ions** and **OH-** **ions** are added together to completely react an acid with a base. In other words, you “neutralize” an acid with a base or vice versa.

Example: HCl + NaOH NaCl + H2O

Total Ionic: H+ + Cl- + Na+ + OH-  Na+ + Cl- + H2O

Net Ionic: H+ + OH-  H2O

**Titration** – Adding an acid to a base in order to determine the molarity of the unknown base or vice versa.

**The Titration Equation**: **MAVA = MBVB**

Where **MA**  = the molarity of the H+ ions

**VA** = the volume of the acid

**MB**  = the molarity of the OH- ions

**VB** = the volume of the base

**Example:** If 25.0 mL of 0.100 M KOH is needed to neutralize 100. mL of HNO3, calculate the concentration of the acid?

**MA**  = ???M HNO3 **VA** = 100. mL of HNO3,

**MB**  = 0.100 M KOH **VB** = 25.0 mL of KOH

**MAVA = MBVB**

(X)(100. mL) = (0.100 M)(25.0 mL)

**X= 0.0250 M HNO3**

But be careful!!! If your acid has more than one **H+** or your base has more than one **OH-**, then you need to multiply by the number of those ions.

Lets try the same example again with one major change!

**Example:** If 25.0 mL of 0.100 M KOH is needed to neutralize 100. mL of **H2SO4**, calculate the concentration of the acid?

**MA**  = ???M **H2SO4** **VA** = 100. mL of HNO3,

**MB**  = 0.100 M KOH **VB** = 25.0 mL of KOH

**MAVA = MBVB**

**2**(X)(100. mL) = (0.100 M)(25.0 mL)

**X= 0.0125 M H2SO4**

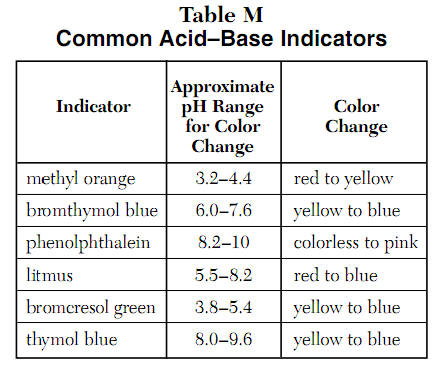
The reason for the **2** is because **H2SO4** has **2** **H+** ions not one.

So, a good thing to do is to alter the formula like this:

(# of H+ ions) x **MAVA = MBVB** x (# of OH- ions)

**Now you try one:** How many milliliters of a 0.200 M solution of H3PO4 is needed to neutralize 50.0 mL of 0.150 M Ca(OH)2?

**Indicators**: These are chemicals that you can add to an acid or base that will change colors at different pH levels.



The way you read this chart is the “Approximate pH Range” is where the color change would be seen. For example: If I used **methyl orange** in an unknown solution, the color of the solution would be **RED** if the pH of that solution was between 0 - 3.2 and it would be **YELLOW** if the pH of the solution was between 4.4 - 14. Can you guess why it’s called methyl orange?

Try this problem: An unknown solution was tested with bromothymol blue and it turned yellow. The same solution was then tested with bromocresol green and it turned blue. Can you estimate the pH range for this solution? Is it acidic, basic or neutral?

**Bronsted-Lowry Acid** – A proton (H+) donor.

HCl + H2O H3O+ + Cl-

ACID

**Bronsted-Lowry Base** – A proton (H+) accepter.

NH3 + H2O NH4+ + OH-

BASE

**Bronsted-Lowry Acid** – A proton (H+) donor.

HCl + H2O H3O+ + Cl-

ACID BASE ACID BASE

CONJUGATE PAIRS

**Bronsted-Lowry Base** – A proton (H+) accepter.

NH3 + H2O NH4+ + OH-

BASE ACID ACID BASE

CONJUGATE PAIRS

Let’s try some conjugate pair questions.

All you have to do is remove an H+ and whatever is left is your conjugate base.

What is the conjugate base of HF ? \_\_\_\_\_\_\_\_\_

What is the conjugate base of H2O ? \_\_\_\_\_\_\_\_\_

What is the conjugate base of H2PO4- ? \_\_\_\_\_\_\_\_\_

What is the conjugate base of HNO3 ? \_\_\_\_\_\_\_\_\_

Now let’s go the other way.

All you have to do is add an H+ and whatever you get is your conjugate acid.

What is the conjugate acid of Cl- ? \_\_\_\_\_\_\_\_\_

What is the conjugate acid of H2O ? \_\_\_\_\_\_\_\_\_

What is the conjugate acid of HPO4-2 ? \_\_\_\_\_\_\_\_\_

What is the conjugate acid of H2PO4- ? \_\_\_\_\_\_\_\_\_

**AMPHOTERISM**- Being both an acid and a base

H2O + H2O H3O+ + OH-

ACID BASE ACID BASE

CONJUGATE PAIRS

**Lewis Acid** – A species that accepts a pair of

electrons from another species in order

to form a bond.

**Lewis Base** – A species that donates its pair of

electrons to another species in order to

form a bond.

:NH3 + H+  NH4+

Equilibrium Constant for the ionization of water, **K***w*

H2O(l) + H2O(l) H3O+(aq) + OH-(aq)

K*w =* [H3O+][OH-] = **1.0 x 10-14**

Therefore, both [H3O+] and [OH-] have a concentration of **1.0 x 10-7 M**

K*w =* [**1.0 x 10-7 M**][**1.0 x 10-7 M**] = **1.0 x 10-14**

**What is pH?**

pH = - log [H3O+]

Therefore, if water has an [H3O+] of **1.0 x 10-7 M**

pH = - log [**1.0 x 10-7**] = 7

Now what if we had an HCl(aq) of 0.001M

HCl + H2O H3O+ + Cl-

0.001M

Since HCl is a strong acid, it completely ionizes into H3O+.  Therefore, we will make 0.001 M H3O+.

And the pH will be – log [0.001] = 3

Now what if we had a NaOH(aq) of 0.001M

NaOH Na+ + OH-

0.001M

Since NaOH is a strong base, it completely dissociates into OH-.  Therefore, we will make 0.001 M OH-.

Remember that K*w =* [H3O+][OH-] = **1.0 x 10-14**

So if we solve for [H3O+], we get

[H3O+][0.001] = **1.0 x 10-14**

**and then…**

[H3O+]= **1 x 10-11 M**

And the pH will be – log [**1 x 10-11**] = 11

There is a very special relationship between pH and Concentration of an acid. Every time an acid concentration is increased by a factor of (x10), the pH decreases by (-1).

So, if I start with water (pH=7), and I increase the acid concentration 1000 times, the pH will drop to 4.

Here is why…

1000 = 10 x 10 x 10 (Note that is three 10s)

Each time we increased the molarity by x10, the pH drops by 1.

Since we increased the molarity of the acid by 10 x 10 x 10, the

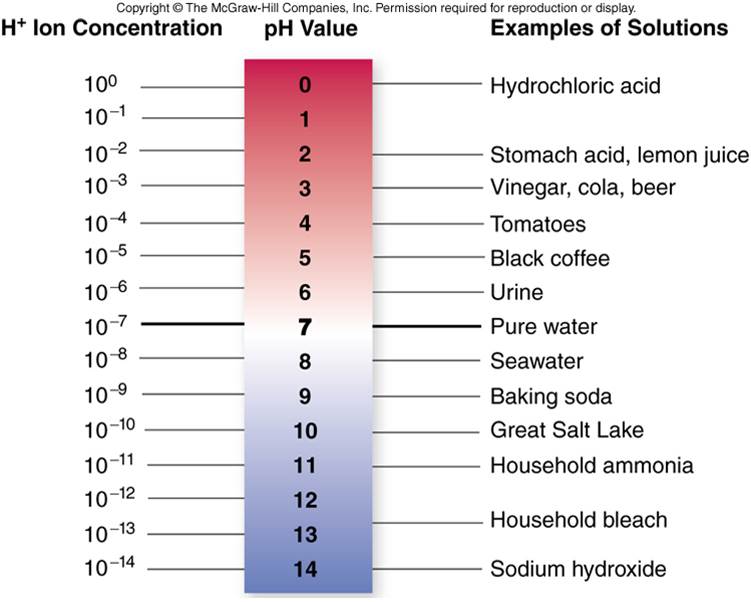
pH dropped -1 -1 -1. (or -3) 7 – 3 = pH of 4

**Now you try one:** If you added acid to your pool that caused the pH of your pool to drop from pH 6 to pH 4, by what factor did you increase the acid concentration of your pool?

What if you dumped base in you pool instead? Then pH would go up. (1 pH level for every x10 concentration of base)

What would the pH of your pool be if it started with a pH of 6, and you increased the concentration of base in your pool 1000 times?

Here is chart to help explain it better



pH = - log [H3O+]\*

pOH = - log [OH-]

\*Note that [H+] and [H3O+] are the same thing.

[H3O+] = 10-pH

[OH-] = 10-pOH

pH + pOH = 14