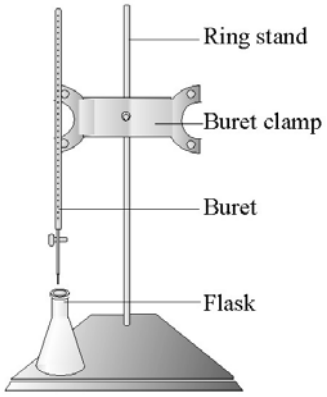
# Titration

*Aim*

- describe neutralization and titration

*Notes*

- Definition - method of determining the concentration of an acid or base by neutralizing it with a solution of known concentration
- Procedure
  - Place a measured amount of acid or base of unknown concentration in a flask and add two drops of phenolphthalein
  - Use a ring stand with a buret clamp and a buret as shown in the diagram to the right. Fill the buret with a standard solution (an acid or base of known concentration)
    - the buret is used to dispense the standard solution and measure the amount dispensed
  - Hold the flask containing the acid or base of unknown concentration under the buret. Run the standard solution slowly into the flask, mixing occasionally by swirling. When the color begins to change on contact with the standard solution, add the standard solution one drop at a time until one final drop causes a complete and permanent color change.
  - Determine the volume of standard solution used
  - Calculate the concentration of the unknown solution using the data you gathered and the equation below




- Calculation

$$\mathbf{M_a \times V_a = M_b \times V_b}$$

- Diprotic and triprotic acids/dihydroxy and trihydroxy bases
  - During a neutralization reaction each hydrogen ion (hydronium ion) is neutralized by one hydroxide ion
  - Therefore, during a titration, the concentration of hydrogen ions and hydroxide ions is more important than the concentration of the acid or base, so it is necessary to determine the effective concentration due to these ions
  - Effective concentration
    - Polyprotic acids
      - Sulfuric acid ($H_2SO_4$) is diprotic: It forms 2 *mol* of hydrogen ions (protons) per *mol* of acid
        $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
      - The effective concentration of 0.2M $H_2SO_4$ is 0.4M in titration problems

$$M_{AE} = M_A \times n_H$$

$M_{AE}$ = effective concentration of acid
$M_A$ = concentration of acid
$n_H$ = number of hydrogens

*NOTE:*

$$\mathbf{M_A = \frac{M_{AE}}{n_H}}$$

    - Polyhydroxy bases
      - Calcium hydroxide [$Ca(OH)_2$] is dihydroxy: It forms 2 *mol* of hydroxide ions per *mol* of base
        $Ca(OH)_2(aq) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$
      - The effective concentration of 0.25M $H_2SO_4$ is 0.5M in titration problems

$$M_{BE} = M_B \times n_{OH}$$

$M_{BE}$ = effective concentration of base
$M_B$ = concentration of base
$n_{OH}$ = number of hydroxides

*NOTE:*

$$\mathbf{M_B = \frac{M_{BE}}{n_{OH}}}$$

✯ Use the effective concentration for titration calculations and actual concentration for answers

**Sample Problem 1**

**Determine the concentration of $H_3PO_4$ if a 90. mL sample is neutralized by 30. mL of 0.9 M $Ca(OH)_2$.**

**Step 1:** Determine the effective concentration of the known substance

0.9 M × 2 = 1.8 M

**Step 2:** Substitute values into the equation and solve for the unknown

$\mathbf{M_A \times V_A = M_B \times V_B}$

$M_A(90.\ mL) = (1.8\ M)(30.\ mL)$

$M_A = 0.6\ M$

**Step 3:** Determine the actual concentration of the unknown from the effective concentration

$$\mathbf{M_A} = \frac{\mathbf{M_{AE}}}{n_{\mathbf{H}}} = \frac{0.6M}{3} = 0.2M$$

**Sample Problem 2**

**How much 3.0 M $H_2SO_4$ is needed to neutralize 50. mL of 1.2 M $Al(OH)_3$?**

**Step 1:** Determine the effective concentrations of the substances

$M_A = 3.0\ M \times 2 = 6.0\ M$

$M_B = 1.2\ M \times 3 = 3.6\ M$

**Step 2:** Substitute values into the equation and solve for the unknown

$\mathbf{M_A \times V_A = M_B \times V_B}$

$(6.0\ M)\ V_A = (3.6\ M)(50.\ mL)$

$V_A = 30.\ mL$

**Answer the questions below by circling the number of the correct response**

1. How much 6 M HCl is needed to neutralize 90 mL of 2 M KOH? (1) 30 mL (2) 7.5 mL (3) 270 mL (4) 78 mL

2. What concentration is $H_2SO_4$ if 10.0 mL of it can be neutralized by 15.0 mL of 2.0 M $Ca(OH)_2$? (1) 3.0 M (2) 12.5 M (3) 1.3 M (4) 10.0 M

3. A technique used to determine the concentration of a base using a standard solution of an acid is known as (1) ionization, (2) neutralization, (3) molarity, (4) titration.