Chapter 4

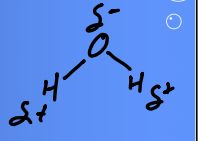
Chemical Reactions and Solution Stoiciometry

Aqueous Solutions

Water is the dissolving medium, or solvent.

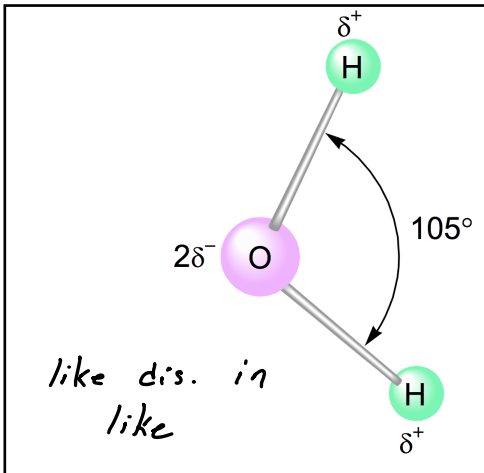
Some Properties of Water

- Water is "bent" or V-shaped.
- The O-H bonds are covalent.
- Water is a polar molecule.
- Hydration occurs when salts dissolve in water.

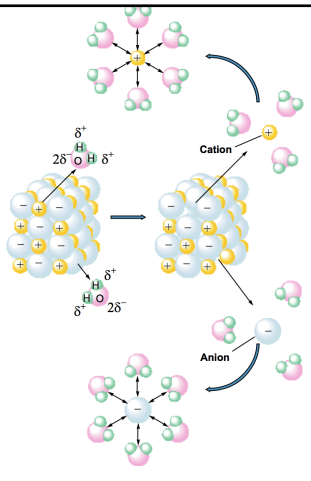


ionic

$NaCl \rightarrow Na^+ + Cl^-$



like dis. in like



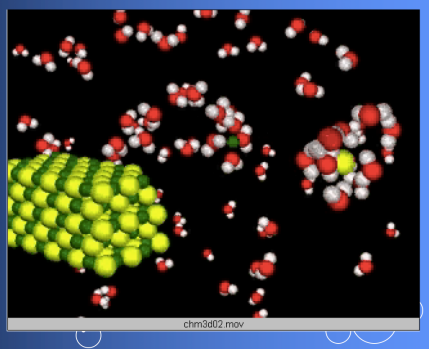
NaCl
$CaCl_2$
KBr

A Solute

- dissolves in water (or other "solvent")
- changes phase (if different from the solvent)
- is present in lesser amount (if the same phase as the solvent)

CH_3CH_2OH CH_3OH

Hydration



A Solvent

- retains its phase (if different from the solute)
- is present in greater amount (if the same phase as the solute)

Electrolytes

Strong - conduct current efficiently

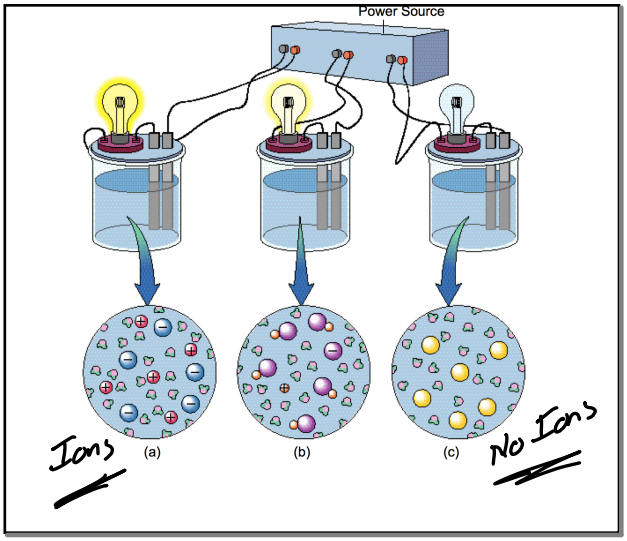
NaCl, HNO_3 $NaCl \rightarrow Na^+ + Cl^-$

Weak - conduct only a small current

vinegar, tap water $HA \rightleftharpoons H^+ + A^-$

Non - no current flows

pure water, sugar solution



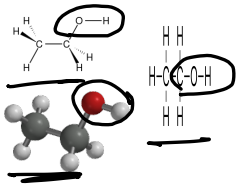
4.14 Is each of the following very soluble in water? Explain.

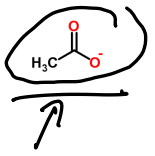
(a) Benzene, C_6H_6

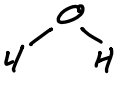
(b) Sodium hydroxide $NaOH \rightarrow Na^+ + OH^-$

(c) Ethanol, CH_3CH_2OH

(d) Potassium acetate $K^+ + CH_3O_2^-$





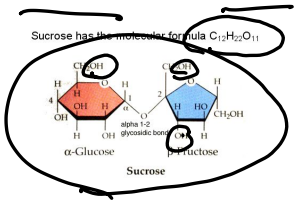


4.17 Does an aqueous solution of each of the following conduct an electric current? Explain.

(a) Potassium sulfate $K^+ \; SO_4^{2-}$ K_2SO_4

(b) Sucrose, $C_{12}H_{22}O_{11}$

$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$



Molarity

Molarity (M) = moles of solute per volume of solution in liters:

$$M = \text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$$3\ M\ \text{HCl} = \frac{6\ \text{moles of HCl}}{2\ \text{liters of solution}}$$

$$M = \frac{\text{mol solute}}{\text{L soln}}$$

4.18 How many total moles of ions are released when each of the following dissolves in water?

(a) 0.32 mol of NH_4Cl

(b) 25.4 g of $Ba(OH)_2 \cdot 8H_2O$

(c) 3.55×10^{19} formula units of LiCl

a.) $NH_4Cl \rightarrow NH_4^+ + Cl^-$

$0.32\ \text{mol}\ NH_4Cl \times \frac{2\ \text{mol ions}}{1\ \text{mol}\ NH_4Cl} =$

b. $Ba(OH)_2 \rightarrow Ba^{2+} + 2OH^-$

$25.4\ \text{g}\ Ba(OH)_2 \cdot 8H_2O \times \frac{1\ \text{mol}\ Ba(OH)_2 \cdot 8H_2O}{\text{g}}$

c.) $3.55 \times 10^{19}\ LiCl \times \frac{1\ \text{mol}\ LiCl}{6.022 \times 10^{23}\ LiCl} \times \frac{2\ \text{mol ions}}{1\ \text{mol}\ LiCl}$

$LiCl \rightarrow Li^+ + Cl^-$ $= 1.18 \times 10^{-4}$ ions

4.24 Calculate each of the following quantities:

(a) Mass (g) of solute needed to make 475 mL of 5.62×10^{-2} M potassium sulfate

(b) Molarity of a solution that contains 7.25 mg of calcium chloride in each milliliter

(c) Number of Mg^{2+} ions in each milliliter of 0.184 M magnesium bromide

a.) K_2SO_4

$M = \frac{\text{mol}\ K_2SO_4}{\text{L soln}}$

$\text{mol}\ K_2SO_4 = (M)(\text{L soln})$

$= \left(\frac{5.62 \times 10^{-2}\ \text{mol}}{\text{L}}\right)(0.475\ \text{L})$

$= 0.0267\ \text{mol}\ K_2SO_4 \times \frac{174.25\ \text{g}}{1\ \text{mol}\ K_2SO_4}$

$= 4.64\ \text{g}\ K_2SO_4$

4.31 Concentrated sulfuric acid (18.3 M) has a density of 1.84 g/mL.

(a) How many moles of H_2SO_4 are in each milliliter of solution?

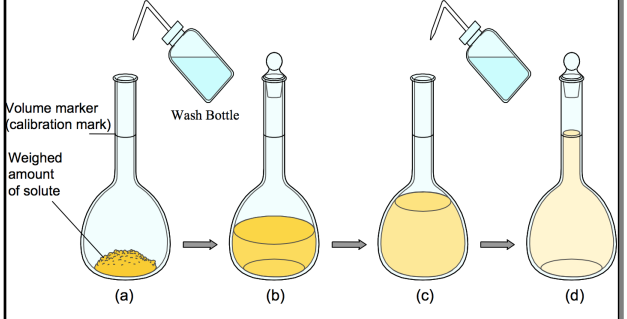
(b) What is the mass % of H_2SO_4 in the solution?

a.) $\frac{18.3\ \text{mol}\ H_2SO_4}{1\ \text{L}} \times \frac{1\ \text{L}}{1000\ \text{mL}} = 1.83 \times 10^{-2}\ \frac{\text{mol}}{\text{mL}}$

b.) $\frac{H_2SO_4\ \text{g}}{\text{soln g}} \times 100$

$\frac{1.83 \times 10^{-2}\ \text{mol}\ H_2SO_4}{1\ \text{mL soln}} \times \frac{98.12\ \text{g}\ H_2SO_4}{1\ \text{mol}\ H_2SO_4} \times \frac{1\ \text{mL soln}}{1.84\ \text{g soln}}$

$= 0.976 \times 100 = 97.6\%$



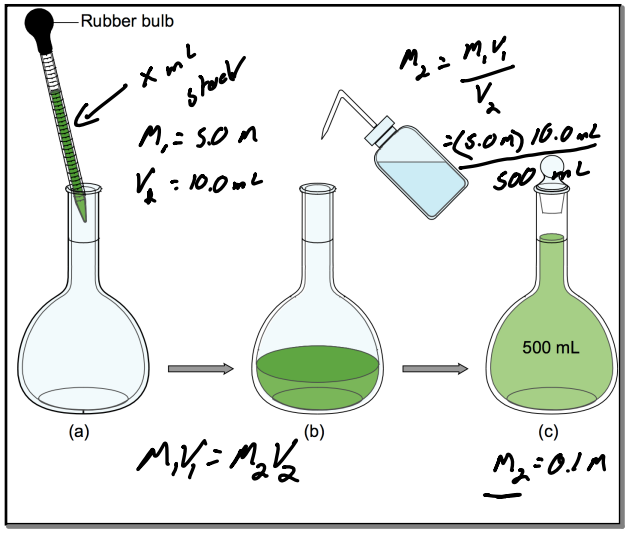
$$M = \frac{\text{mol solute}}{\text{L soln.}}$$

Common Terms of Solution Concentration

Stock - routinely used solutions prepared in concentrated form.

Concentrated - *relatively* large ratio of solute to solvent. (5.0 M NaCl)

Dilute - *relatively* small ratio of solute to solvent. (0.01 M NaCl)



4.28 Calculate each of the following quantities:

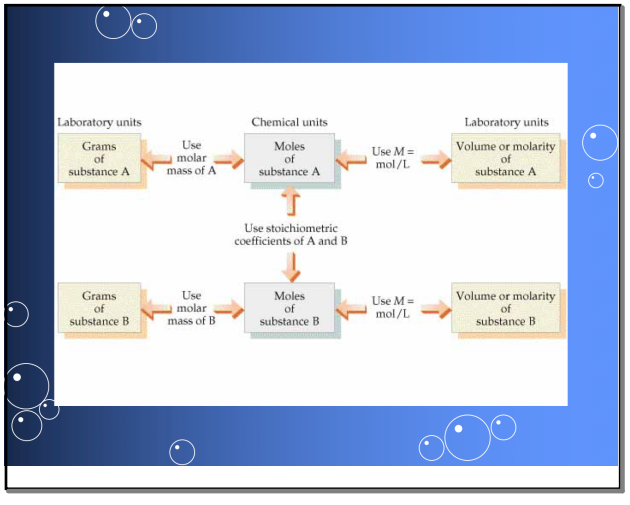
(a) Molarity of a solution prepared by diluting 37.00 mL of 0.250 *M* potassium chloride to 150.00 mL

(b) Molarity of a solution prepared by diluting 25.71 mL of 0.0706 *M* ammonium sulfate to 500.00 mL

a) $M_1V_1 = M_2V_2$

$M_1 = 0.250\ M$ $\quad V_1 = 37.00\ mL$ $\quad M_2 = ?$ $\quad V_2 = 150.0\ mL$

$M_2 = 0.062\ \frac{mol}{L}$



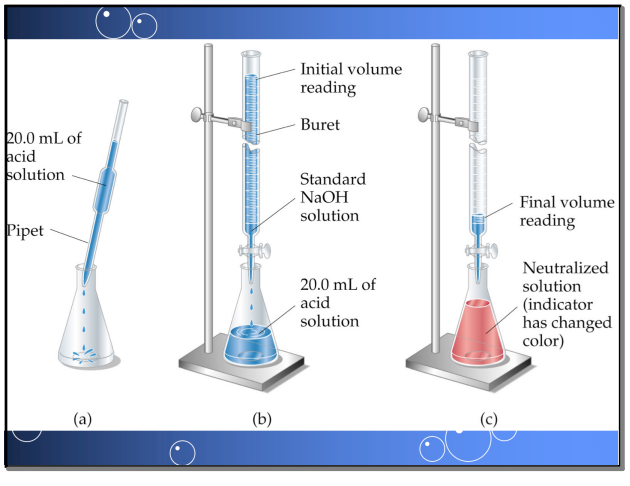
Key Titration Terms

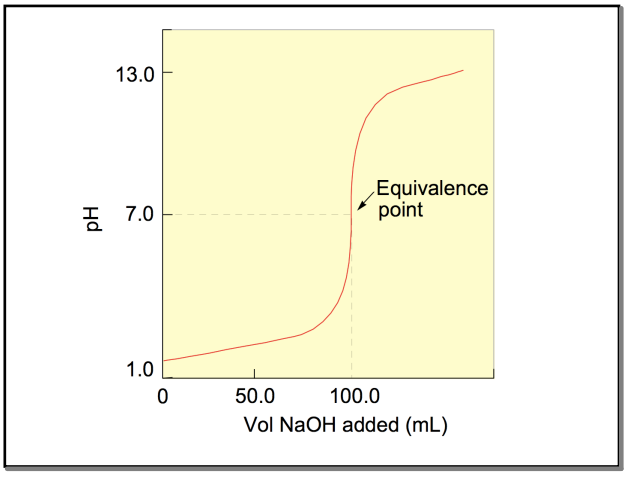
Titrant - solution of known concentration used in titration

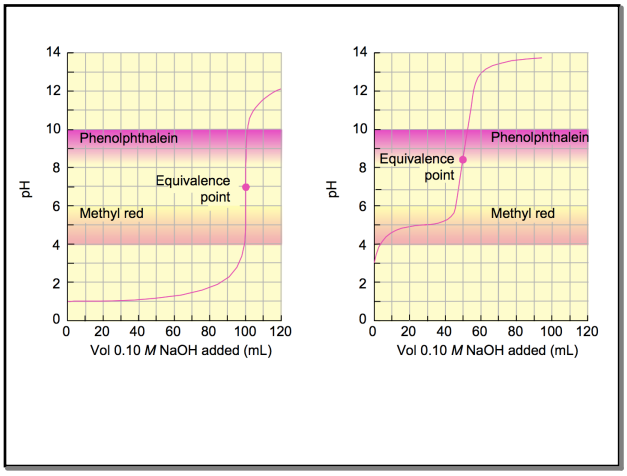
Analyte - substance being analyzed

Equivalence point - enough titrant added to react exactly with the analyte

Endpoint - the indicator changes color so you can tell the equivalence point has been reached.







4.134 To find the mass percent of dolomite [$CaMg(CO_3)_2$] in a soil sample, a geochemist titrates 13.86 g of soil with 33.56 mL of 0.2516 *M* HCl. What is the mass percent of dolomite in the soil?

Titrated to the first equivalence point