Chapter 8

Solutions:

1. Water.
   a) Properties
      1. Polar- dissolves polar substances.

2. Hydrogen-bonding. must have a H directly attached to O, N, or F sometimes S.

Weaker than a covalent or ionic bond.
H bonds important in DNA and enzymes.

b. Physical properties of water.
   1. High B.P.
   2. High heat of vap.
   3. High surface tension-water molecules are attracted to each other.

   solid---- liquid  liquid------ liquid  gas---- liquid

   Solute-is dispersed evenly in solvent  solvent—one in larger amount.

a. Likes dissolve likes-Like means polarity.
   Ethanol--- water   ammonia---- water   sugar----- water
   polar    polar    polar    polar    polar    polar
   C₅H₁₂----- water   C₅H₁₂----- CF₄
   non-polar   polar    non-polar non-polar
Solvent Cage- effective radius of ion is larger.

4. Rate of solvation.
   1. Solute is crushed- increase surface area.
   2. Mixture is stirred- increase dispersion.
   3. Mixture is heated- more solvent collisions.

Electrolytes- ion source.

Ions conduct electricity.

Strength of current is directly related to ion concentration.

Ion formation (ionic bond)

\[ XY(s) \rightarrow X^+(aq) + Y^-(aq) \]

a) Strong electrolytes- exist only as ions, usually ionic.

\[ \text{HCl(s)} \rightarrow \text{H}^+(aq) + \text{Cl}^-(aq) \quad 100\% \text{ dissociation} \]

\[ 0\% \quad 100\% \]

\[ \text{CaCl}_2(s) \rightarrow \text{Ca}^{2+}(aq) + 2\text{Cl}^-(aq) \quad 100\% \text{ dissociation} \]

\[ \text{Na}_3\text{PO}_4(s) \rightarrow 3\text{Na}^+(aq) + \text{PO}_4^{3-}(aq) \quad 100\% \text{ dissociation} \]
b) Weak electrolytes- usually polar covalent molecule- part ionization.

Reverse direction is favored

\[ \text{CH}_3\text{OH}(l) \rightleftharpoons \text{CH}_3\text{OH}(aq) \]

0% dissociation methanol.

c) Non-electrolytes- covalent polar molecule – no ions formed.

\[ \text{CH}_3\text{OH}(l) \rightleftharpoons \text{CH}_3\text{OH}(aq) \]

0% dissociation methanol.

3. Solubility- amount of solute that can dissolve in a given amount of solvent.

\[ \text{g solute/ 100 solvent} \]

a. Saturated- maximum amount of solute that can dissolve at a certain temp.

solids are usually more soluble in liquids at higher temp. (opposite of gasses)

Add anymore solute goes to bottom of solution.

b. unsaturated – not maximum amount of solute that can dissolve at a certain temp.

c. Soluble and Insoluble salts.

Some ionic compounds are soluble and some are not. To be soluble most dissociate into individual ions. If not, insoluble.
XY(s)  \[\rightarrow\] XY(s) insoluble

XY(s) \[\rightarrow\] X\(^{+}\)(aq) + Y\(^{-}\)(aq) soluble, electrolyte

Ex  AgNO\(_3\)(s) \[\rightarrow\] Ag\(^{+}\)(aq) + NO\(_3\)(aq)

\[
\text{CaSO}_4(s) \rightarrow \text{CaSO}_4(s)
\]

Mixture: Pb(NO\(_3\))\(_2\)(s) + NaCl(s)

\[
Pb(NO_3)_2(s) \rightarrow Pb^{2+}(aq) + 2NO_3^{-}(aq)
\]

\[
\text{NaCl}(s) \rightarrow \text{Na}^{+}(aq) + \text{Cl}^{-}(aq)
\]

Formation of PbCl\(_2\)(s)

Net ionic Pb\(^{2+}\)(aq) + 2Cl\(^{-}\)(aq) \[\rightarrow\] PbCl\(_2\)(s) only ions reacting.

\[
\text{NaPO}_4(s) + AgNO_3 (s)
\]

\[
\text{NaPO}_4(s) + AgNO_3(s) \rightarrow Ag_3PO_4(s) + NaNO_3(aq)
\]

Formation of Ag\(_3\)PO\(_4\)(s)

Net ionic 3Ag\(^{+}\)(aq) + PO\(_4^{3-}\)(aq) \[\rightarrow\] Ag\(_3\)PO\(_4\)(s) only ions reacting.

4. Concentration- amount of solute dissolved in a certain amount of solution.

concentration = amount of solute / amount of solution

amount of solution = solute + solvent

a. Percent concentration-

1. Mass percent-

\[
\text{mass/mass} = (m/m)\% = \frac{\text{g solute}}{\text{g solution}} \times 100
\]

\[
\text{g solution} = \text{g solute} + \text{g solvent}
\]

Ex. 8-1. Mix 110. mL of water and 10. mL of ethyl alcohol.

Calculate the (m/m)\%. Density of water = 1.0 g/mL

ethyl alcohol = 0.79 g/mL
2. Volume Percent

\[
\frac{\text{volume solute}}{\text{volume solution}} \times 100 = (v/v)\% 
\]

**Ex. 8-2.** Calculate from ex. 8-1.

**Ex. 8-3.** Wine is 12% alcohol. How much alcohol is there if there is 120. mL of water.

120. mL solvent

\[
12\text{solute} + 1440 = 100\ \text{solute}
\]

\[
1440 = 88\text{solute}
\]

\[
16.4\ \text{mL} = \text{solute}
\]
3. mass/volume (%m/v)

\[
mass/volume = (g/v)\% = \text{grams solute/mL solution} \times 100
\]

**Ex. 8-4.** Take 10. g of NaCl and mix with 119 mL of water to give a resulting solution of 120. mL. Calculate the (% m/v).


\[
10\%(m/m) = \frac{10 \text{ g solute}}{100 \text{ g solution}} \text{ or } 100 \text{ g solution}/10 \text{ g solute}
\]

**Ex. 8-5.** Antifreeze is 15% (v/v) solution. Calculate the volume of solution if you have 60.0 mL of ethylene glycol.

2. **Molarity (M)**

a) \( (M) \) molarity = moles of solute/ 1L of solution

**Ex. 8-6.** What is the molarity of 8.3 g of Ba(OH)\(_2\) in a 250. mL solution.
**Ex. 8-7.** Calculate how many grams of barium hydroxide are in 500. mL of a 0.50 M solution.

\[ M_2 = \frac{M_1 V_1}{V_2} = \frac{(5.0 \text{ mL})(2.0 \text{ M})}{10.0 \text{ mL}} = 1.0 \text{ M} \]

3. **Dilution** – addition of more solvent.

**Ex. 8-8** If you add 1.5 L of water to a 500. mL of a 2.0 M solution of barium hydroxide what is the new molarity?

\[ M_2 = \frac{M_1 V_1}{V_2} = \frac{(0.500 \text{ mL})(2.0 \text{ M})}{2.0 \text{ L}} = 0.50 \text{ M} \]
Ex. 8-9. If you want to mix up 100. mL of a 0.50 M solution how would this be accomplished by using a stock solution of 2.0 M NaOH in a 300. mL beaker?

\[ M_2V_2 = M_1V_1 \]
\[ V_1 = \frac{M_2V_2}{M_1} = \frac{(0.50 \text{ M})(100. \text{ mL})}{2.0 \text{ M}} = 25 \text{ mL} \]

Take 25 mL of the stock solution and dilute with 75 mL of water.

4. Osmosis and Dialysis -

A) Osmosis- solvent water moves through a semi-permeable membrane from low to high concentration of solute. Generates osmotic pressure.

semi-permeable membrane- lets through small particles (water) but not larger molecules.

Isotonic solution – equal concentration on the outside and inside.

hypotonic solution – greater concentration inside.

hypertonic solution – greater concentration outside.

B) Dialysis- Movement lets small molecules like ions and glucose pass through a semi-permeable membrane. Starches and proteins do not pass through.