CHEM 110 CHAPTER 4 LECTURE NOTES: PROPERTIES OF AQUEOUS SOLUTIONS

Substances dissolved in water have unique characteristics including the following:

1. Strong vs. Weak Electrolytes:
   a. Some substances break down ≈ 100% into ions in H_2O and are termed "strong electrolytes."

   Example: $HBr_{(g)} + H_2O \rightarrow H^+_{(aq)} + Br^-_{(aq)} \approx 100\%$

   HBr is termed a strong electrolyte and a strong acid due to nearly all the HBr separating into ions. H^+ ions define HBr as an acid (hydrobromic).

   b. Weak Electrolytes < 100% break down into ions

   Example: $H_2CO_3 + H_2O \rightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)} < 100\%$

   Due to H_2CO_3 (carbonic acid) not separating ≈100% into ions, it is termed a weak electrolyte and a weak acid.

Be familiar with precipitation reactions and solubility guidelines for common ionic compounds (pgs. 121 + 122 of text). You will be given an Ion Solubility Table to use for the exam.

Precipitations Reactions are Double Displacement Reactions!

Example 1:

silver (I) nitrate + sodium iodide → silver (I) iodide + sodium nitrate

Balanced Equation:

$AgNO_{3(aq)} + NaI_{(aq)} \rightarrow AgI_{(s)} + NaNO_{3(aq)}$

$A^{+} B^{-} + C^{+} D^{-} \rightarrow A^{+} D^{-} + C^{+} B^{-}$

Overall Ionic Equation:

$Ag^{+}_{(aq)} + NO_3^{-}{}_{(aq)} + Na^{+}_{(aq)} + I^{-}_{(aq)} \rightarrow AgI_{(s)} + Na^{+}_{(aq)} + NO_3^{-}{}_{(aq)}$

Spectator Ions: These do NOT form solid.

$Na^{+}_{(aq)}$, $NO_3^{-}{}_{(aq)}$

Net Ionic Equation: Shows ions forming solid.

$Ag^{+}_{(aq)} + I^{-}_{(aq)} \rightarrow AgI_{(s)}$

Example 2:

potassium sulfate + strontium chloride → potassium chloride + strontium sulfate

Balanced Equation:

$K_2SO_{4\,(aq)} + SrCl_{2(aq)} \rightarrow 2KCl_{(aq)} + SrSO_{4\,(s)}$

Overall Ionic Equation:

$2K^{+}_{(aq)} + SO_4{}^{-2}_{(aq)} + Sr^{+2}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow 2K^{+}_{(aq)} + SO_4{}^{-2}_{(aq)} + SrSO_{4\,(s)}$

Spectator Ions: These do NOT form solid.

$2K^{+}_{(aq)}$, $2Cl^{-}_{(aq)}$

Net Ionic Equation: Shows ions forming solid.

$Sr^{+2}_{(aq)} + SO_4{}^{-2}_{(aq)} \rightarrow SrSO_{4\,(s)}$

ACIDS VS. BASES

2. **Acids** are substances that produce $H^{+}_{(aq)}$ ions when placed in H_2O.

   Example 1: $HNO_{3\,(l)} \xrightarrow{H2O} H^{+}_{(aq)} + NO_3{}^{-}_{(aq)}$

   Example 2: $CH_3COOH_{(l)} \xrightarrow{H2O} H^{+}_{(aq)} + CH_3COO^{-}_{(aq)}$

3. **Bases** or **Alkalis** are substances that accept $H^{+}_{(aq)}$ ions from acids and can produce $OH^{-}_{(aq)}$ (hydroxide) ions in H_2O.

   Example 1: $NH_2{}^{-}_{(aq)} + H^{+}_{(aq)} \rightarrow NH_{3(g)}$

   Example 2: $NaOH_{(s)} \xrightarrow{H2O} Na^{+}_{(aq)} + OH^{-}_{(aq)}$

Strong acids and bases break down nearly 100% into ions.

NEUTRALIZATION REACTIONS

4. Acids and bases typically react to form a salt (ionic compound) and H_2O.

   Example: KHP (acid) + NaOH (base) → KNaP (salt) + H_2O

This is a special type of metathesis (double replacement) reaction.

Net Ionic: $H^+_{(aq)} + OH^-_{(aq)} \rightarrow HOH_{(l)}$ or H_2O

NOTE: The activity series (electromotive series) as related to single replacement reactions is also important to understand.

General Form of Single Replacement Reactions:

M1(NM) + M2 → M1 + M2(NM)

where M1 and M2 represent two different metals and NM represents a non-metal ion.

OR

M(NM1) + NM2 → NM1 + M(NM2)

where NM1 and NM2 represent two different non-metals and M represents a metal ion.

MOLARITY

a) Means of representing the concentration of a solution.
b) Symbol = M
c) Formula for finding:

$$M = \frac{Moles\ of\ Solute}{Liters\ of\ Solution}$$

Where moles of solute = $\frac{grams\ of\ solute}{gram\ formula\ (molar)mass}$

NOTE: Liters of solution is the total volume of the solution including the solute added.

Solutions of desired molarity are often prepared accurately in volumetric flasks.

Solution Stoichiometry Methods: See Figure 4.18 of Text for Procedures

Suppose you are given grams of A, but want to find the volume of B needed to react with it.

- **First, convert grams of A to moles.**
- **Second, multiply moles of A by mole ratio of unknown (B): known (A) using balanced chemical equation.**
- **Last, divide moles of B by molarity of B to obtain liters of B needed to react.**

Titration Problems

- **Need to balance equation first!**
- Determine the volume (convert to L) of titrant added from buret.
- ***Use L of titrant and molarity of known to determine moles of known.***
- **Multiply moles of known by mole ratio (from balanced equation) to obtain moles of unknown.**
- **Convert moles of unknown to desired unit (usually L or grams).**
- **For liters use M formula; for grams use molar mass.**

81 a, b.

Usually acid-base reactions are involved.

- **1:1 reaction**

a. $HClO_4 + NaOH \rightarrow NaClO_4 + HOH$

2:1 reaction

b. $2\ HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2\ HOH$