5 • Reactions in Aqueous Solution

STUDY LIST

Properties of Aqueous Solutions

- ☐ Define **solute**, **solvent**, and **solution**. Give examples.
- ☐ Define **electrolytes**. Give **operational** and **theoretical** definitions of **electrolytes**.
- ☐ Know that soluble ionic compounds and strong acids are **strong electrolytes**. Ionic compounds of low solubility [e.g. $Mg(OH)_2$] and weak acids/bases are **weak electrolytes**.
- ☐ Know that molecular compounds (except acids) are **non-electrolytes**.
- ☐ Know that **alcohols** (e.g. CH_3OH)are **not ionic hydroxides**. Bases are usually **metallic** hydroxides.
- ☐ Know the **solubility rules**. State whether an ionic compound is soluble in water.

Precipitation Reactions

- ☐ Know that ppt reactions are **double replacement** reactions that produce an insoluble product.
- ☐ Given two ionic compounds in solution, correctly **determine the products**. (Know your ions).
- ☐ Determine which products are **precipitates**. **Use (aq) and (s)** symbols correctly.
- ☐ Correctly write the **ions** in a soluble ionic compound. [e.g. $CaCl_2(aq) \rightarrow Ca^{2+} + 2Cl^-$]
- ☐ Identify **spectator ions**.
- ☐ Write **molecular, detailed ionic, and net ionic** equations for a ppt reaction.

Acids and Bases

- ☐ Give **operational** (cabbage juice) and **theoretical** (ions) definitions of acids and bases.
- ☐ Know that acids increase the **H^+ ion** concentration in an aqueous solution. (Theoretical definition)
- ☐ **Memorize** the 8 strong acids.
- ☐ Know that acids are **molecular compounds** that **form ions** when in aqueous solution.
- ☐ Be able to **name acids** according to their anion. [**ide** → hydro__ic acid; **ate** → __ic acid; **ite** → __ous acid; S: add "ur"; P: add "or"]
- ☐ Know that bases increase the **OH^- ion** concentration in an aqueous solution. (Theoretical definition)
- ☐ Memorize the **soluble hydroxides** (except NH_4OH) that are the strong bases.
- ☐ Understand that **ammonia(aq)**, $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ forms a **weak basic** solution.
- ☐ Know that **metal oxides** form **bases** [$CaO + H_2O \rightarrow Ca(OH)_2$] while **nonmetal oxides** form **acids** [$CO_2 + H_2O \rightarrow H_2CO_3$]
- ☐ Know that **acids react with bases** to form H_2O and a salt. (**Neutralization**)
- ☐ Write **equations** for acid-base reactions including **NH_3** (example on page 199) as the base.
- ☐ Know that **strong acids** and **strong bases** are **written as ions** in the ionic equations.

Gas Forming Reactions

- ☐ Recognize the six products that turn into gases. Memorize the gases formed.

Organizing Reactions in Aqueous Solution

- ☐ **Double Replacement** reactions (text calls them exchange reactions) (Fred-Wilma/Barney-Betty reactions) also have the old fashioned name: **metathesis** reactions.
- ☐ Know the **three examples** of double replacement reactions and the "driving force" for each.
  Precipitate reactions form an insoluble product. Acid-Base reactions form water (a very weak electrolyte therefore, a very stable product). Gas-forming reactions form a gas.
- ☐ Know that a **driving force** is something that keeps the new combinations of ions from reforming the old combinations of ions.
- ☐ **Oxidation-Reduction** is a fourth type of reaction driven by the **transfer of electrons**.

Oxidation-Reduction Reactions

$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe(s) + 3\ CO_2$

- ☐ Know that an important type of reaction gets its **name** from atoms that combine with **oxygen**. During the refining of iron, carbon monoxide combines with oxygen (from the iron ore), $CO \rightarrow CO_2$ and is **oxidized**. Large masses of iron ore (Fe_2O_3) are **reduced** to a smaller amount of iron metal.
- ☐ Understand that since CO helps the iron ore to be **reduced**, CO is called the **reducing agent**. Since Fe_2O_3 causes the C to be **oxidized**, iron ore is called the **oxidizing agent**. What ever is **oxidized** acts as the **reducing agent**. What ever is **reduced** acts as the **oxidizing agent**.
- ☐ Know that oxidation-reduction (redox) is driven by the **transfer of electrons**. Mnemonics to help: **GROL** (Gain=Reduce / Oxidize=Lose); **LeO** the lion says **GeR** (Losing e^-'s = Oxidation / Gaining e^-'s = Reduction); **OIL RIG** (Oxidation is Losing e^-'s / Reduction is Gaining e^-'s)
- ☐ A redox reaction can be divided into two **half-reactions**. The **oxidation** half-reaction has electrons as a **product**. The **reduction** half-reaction has electrons as a **reactant**.
- ☐ Be able to **assign oxidation numbers** to any atom in any substance. Learn the rules on page 207.
- ☐ Recognize **redox** reactions because **oxidation numbers change**. (# ↑ = oxidation / # ↓ = reduction), electrons are gained or lost, or oxygen atoms are gained or lost.
- ☐ Know several common oxidizing agents and reducing agents and what they turn into.

Measuring Concentrations of Cmpds. in Solution

- ☐ Know the definition of **molarity**, **M**, as one way to communicate **concentration** of solute.
- ☐ Know that the symbol **[X]** means the concentration of X in moles/Liter.
- ☐ Be able to determine the concentration of **ions** in an ionic compound.
  For example, in 0.25 M $AlCl_3$
  $[AlCl_3] = 0.25\ M$ $[Al^{3+}] = 0.25\ M$
  $[Cl^-] = 0.75\ M$
- ☐ Use the molarity formula to calculate **moles**, **mass**, **volume**, or **molarity** of a solution.
- ☐ Know that **Volume x Molarity = moles** of solute. **Dilution** problems use $V_iM_i = V_fM_f$.
- ☐ Describe how to **make a solution** correctly. Know what a **volumetric flask** is.

Stoichiometry of Reactions in Aqueous Solution

- ☐ Use **molarity** as another **conversion factor** to solve stoichiometry problems.
- ☐ Know that **titration** is a technique called ***quantitative*** **chemical analysis** because you are measuring. It is also called **volumetric analysis** (because you are measuring volumes).
  [Note: ***qualitative*** analysis involves no measurements such as using solubility rules to determine the identity of an unknown ionic compound.]
- ☐ Understand the terms **indicator**, **equivalence point**, **standardization**, and **primary standard**.
  [Note: you saw a titration being done in the Measurement video early in the summer. Chloride ion from the Chesapeake Bay was being titrated against silver nitrate to determine the salinity (saltiness) of the water. Yellow K_2CrO_4 was used as an indicator because it formed the reddish-brown ppt, Ag_2CrO_4 (which looked pink) when all the chloride ion was used up.]
- ☐ Know common indicators such as **phenolphthalein** for titrations with strong bases.
- ☐ Understand that a titration can be done with an **acid-base reaction** or a **redox reaction**. In each case, some sort of indicator must be used to tell when equivalent amounts of reactants have been mixed.