Exam #3 Study Guide

Covering Course Book Units/Chapter 8-10

=== FOCUS ON CALCULATIONS ===

Exam will cover the math/calculations in chemistry of

- Pressure conversions (atm, mmHg, torr, [k]Pa)
- Gas Laws: $P_1V_1=P_2V_2$, $V_1/T_1=V_2/T_2$, $P_1/T_1=P_2/T_2$, $V_1/n_1=V_2/n_2$, $PV=nRT$
- Partial Pressure: total P = P of all different gas molecules
- Concentrations:
    - percent by mass (m/m)% [gram per gram]
    - percent by volume (v/v)% [mL per mL]
    - molarity (M) [mol/L, moles per liter]
    - molality (m) [mole solute ÷ kg solvent]
- solving solution amounts using simple algebra
    - mass as moles in solution aliquot =
      solution concentration (molarity) × volume (L)
    - volume (L) = mass as moles / solution concentration (molarity)
    - concentration (molarity, mol/L) = mass as moles ÷ volume (L)
- Dilutions: $C_1V_1 = C_2V_2$
    - C_1V_1 can be more concentrated ("stock solution")
    - C_2V_2 can be less concentrated (the dilution: "working solution")
- Effective particle molality: # of particles × solution molality
- Calculating b.p., f.p. change: $\Delta T_b=k_b \times m \times i$, $\Delta T_f=k_f \times m \times i$
- Osmotic pressure: $\Pi = MRT$
- *Not really a calculation in math sense, but BALANCING chemical reaction equations is a kind of calculation that YOU MUST KNOW*
- Conversions, Scientific Notation, Significant Digits, Decimal Places: too many still do NOT understand this part, so expect INTENSE homework drilling on this!!

=== CHAPTER 8: Gases and Gas Laws ===

- Properties of gases, liquids, solids (slide #5)
- Gas laws concepts: Boyle's, Charles, Gay-Lussac's, Avogadro's [slides 9-20]
- Ideal Gas Law [slides 21-26]
- Standard Temperature and Pressure (STP): what is it? [slides 27,28]
- Density of a gas [slide 29]
- Mixtures of gases and Dalton's law of partial pressure [slides 30,31]
- Gas displacement [slides 32,33]: Experiment 8a is about that

=== CHAPTER 9: Solutions/Colligative Properties ===

- Solutions as homogeneous mixtures
- Definition/description of **solvent** and **solute** and **solution**
- What type of solute dissolves in what type of solvent: like dissolves like, nonpolar dissolves nonpolar, polar dissolves polar
- What about ionic: does ionic dissolve in polar and/or nonpolar?
- What is an electrolyte? What is a nonelectrolyte? What makes an electrolyte strong or weak?
- How do aqueous solutions of ions make it possible to have an electric current with an applied voltage?
- How do elements of ionic compounds dissolve in aqueous solutions? Understand the polar nature of water (H_2O), what the bond polarity is of the O–H bond, and how the two O–H bonds and their polarity affect overall polarity of the molecule (molecular polarity). How do H_2O molecules orient themselves around cations and anions dissolved in solution? What is **ion-dipole attraction**?
- A compound dissolves in water: will it make ions (cations + anions) or be an uncharged molecule that does not "break apart" in the solution?
- Solubility: what is it? How do you define/describe it? Understand that the numerous compounds that exist have varying solubility. What units of solubility are used: grams of substance per 100 grams of H_2O/solvent is usual. It might also be grams of substance per volume like a liter or 100 mL
- Precipitate: define and describe, and how does it relate to solubility?
- What are the Rules of Solubility? Are you able to read and understand them if you are given a compound and asked if it is solubility by your reading and understanding of the table given?
- Saturation is basically the upper limit of solubility. When substance added to the point of saturation, the excess additional substance (solute) will not dissolve further. Filtering out the excess undissolved solute creates a saturated solution. A solution that has not reached the saturation point/limit for a solute is an unsaturated solution.
- Solubility and temperature: Solubility shows a dependence on temperature. It some cases, solubility goes up with temperature, in others it goes down (solids, gases). What's the pattern?
- How is temperature important in showing the effect that is supersaturation? What happens with supersaturation?
- What explains supersaturation and gas pressure and the formation of gas bubbles when gas pressure above a supersaturated solution when the gas pressure goes from high to low(er)?
- Concentrations are described quantitatively in many ways (practice your calculations)
  - Percent by mass (for solid solutes)
  - Percent by volume (for liquid solutes)
  - Molarity: know the units (mol/L) and symbols (*M*)

- o Solutions have concentration (i.e. molarity), volume (can be mL or L). Know how to calculate the moles of solute or mass (in grams) of solute given a concentration (as mass/mass or mole/L or volume/volume) of a solution and the volume sample (aliquot). Or to calculate ONE of those THREE variables given any TWO of those variables.
  - o Understand term "stock solution" and what it refers to as the process of solution preparation. Understand "working solution" and how it is usually a dilution of a stock solution
  - o Understand the simple mathematical relationship involved in calculating and making a dilution: $C_1V_1 = C_2V_2$ where C_1 is more concentrated ("stock") and C_2 is the dilution concentration
- Colligative Properties
  - o Molality definition
  - o Boiling point elevation and freezing point depression
  - o Particles and their number in a solvent: how does molecules and ionic compounds differ when they dissolve in affecting particle number?
  - o What is effective particle molality and how does it differ between ionic compounds and molecules (non-ionic compouns)?
  - o Application of an equation to calculate changes in boiling and freezing point
  - o What is osmosis? How is osmotic pressure calculated?

=== CHAPTER 10: Chemical Reactions & Equations ===

- Concept of reactants, products
- Chemical equations: starting with Skeletal chemical equation
- The natural "elemental" forms of the elements, and how they start to form compounds
- Balancing: what are the steps [slide 10]
- Practice example of balancing [slide 11 is fixed] – more problems to come
- Reaction Types
  - o Double displacement (Double Replacement): AB + CD → CB + AD precipitation, acid-base neutralization, gas evolution, no reaction
  - o Single Displacement (Single Replacement): A + BC → B + AC
  - o Combination: A + B → AB
  - o Decomposition: AB → A + B
  - o Be able to look at a chemical reaction equation, understand the pattern, and classify/name the pattern (reaction type)
- Combustion Reactions: what is the major/primary element involved?
- Single Replacement "subtypes"
  (X = nonmetal monatomic or polyatomic ion)
  - o Metal replacement: metal1 (s) + metal2-X (aq) → metal2 (s) + metal1-X (aq)
  - o Hydrogen replacement: metal (s) + H-X (aq) → H_2 (g) + metal-X (aq)
    Y and Z are halogens (the four Group 17 elements)

- o Halogen replacement: Y_2 + 2 metal-Z → Z_2 + 2 metal-Y
  keep the order of reactivity in mind: F > Cl > Br > I
- Double Replacement "subtypes"
  UNDERSTAND THE SOLUBILITY RULES TABLE
  - o Precipitate: soluble compound (aq) + soluble compound (aq) → precipitate (s) + usually soluble compound (aq)
  - o Gas Formation: soluble compound (aq) + soluble compound (aq) → gaseous compound (g) + usually soluble compound (aq)
    - Sulfide → H_2S (hydrogen sulfide; hydrosulfuric acid)
    - Carbonates, bicarbonates → CO_2 (carbon dioxide)
    - Sulfites, bisulfites → SO_2 (sulfur dioxide)
    - Ammonium salts → NH_3 (ammonia)
  - o Molecular Compound Formation: many types,
    - Acid-Base Neutralization: H-anion (aq) + cation(metal)-OH (aq) → $cation^{n+}$ (aq) + $anion^{m-}$ + H_2O (l)
  - o Gas-evolving redox reactions: (X = anion)
    active metal (s) + H-X (aq) → H_2 (g) + metal-X (aq) [oxidation of metal and reduction of H+ ions to H_2]

- Writing Equations for Reactions
  - o Complete chemical equation
  - o Complete ionic equation
  - o Net ionic equation
  - o What is/are spectator ions?
- Oxidation and Reduction
  - o Oxidation: loss of, taking electrons (as pairs usually) from element
  - o Reduction: gain of, adding electrons to an element
    Use the mnemonics if that helps
  - o Oxidation and Reduction both have to occur: where an element is oxidized, another element is reduced
  - o How is electronegativity of an element associated with its ability to gain or lose electrons (be oxidized or be reduced)?
  - o Oxidation Number (oxidation state): how is it related to number of electrons belonging to an atom and the number of electrons an atom should have if it is neutral/zero charge state?
  - o What are the RULES for Oxidation Numbers (*ON*)?
    - ON for the pure element: ON = 0 (zero)
    - ON for monatomic ions with only one charge state: ON = ionic charge
    - ON for hydrogen (H): with nonmetal anion, always +1. With less electronegative metal cation, it is a hydride (ON = –1)
    - ON for oxygen (O): except for one compound, virtually always ON = –2. Exception is OF_2
    - SUM OF ALL ON values for a compound must end up = zero (0). Use this rule to determine ON values for typically metal, particularly transition metals

- SUM OF ALL ON values for a polyatomic ion must equal the charge of the ion
    - What are half-reactions? There are two: a half-reaction showing oxidation and a half-reaction showing reduction
    - Activity of certain elements
        - with water: four classes of reactions: with cold water, steam, no reaction with water but with acid, and unreactive with water and mild acids
        - halogen reactions
- Batteries as Redox Reactions
    - What's the anode and cathode: what gets oxidized and reduced and produces or consumes electrons
    - Dry cell batteries: Zn is oxidized (to Zn^{2+}) and Mn^{4+} gets reduced (to Mn^{3+}); not rechargeable
    - Storage batteries: Pb is oxidized to Pb^{2+} in one compartment, Pb^{4+} is reduced to Pb^{2+} in another compartment
    - Fuel cells: this is a "clean" chemical reaction of hydrogen gas and oxygen gas to water; requires a constant flow of reactants to a chamber for the reaction.
- Corrosion
    - unwanted oxidation of iron (Fe) in steel weakens steel-made structures
    - sacrificial anode: another more active metal solid (like Zn or Mg) that typically protects unwanted corrosion of iron in steel and protects steel structures