Final Exam (NOTES)

Chapter 1: The Chemical World

Matter and Molecules:

- Chemistry is the science that tries to understand what matter does by understanding what molecules do.

The Scientific Method:

- Chemists employ the scientific method, which makes use of observation, hypothesis, laws, theories, and experiments.

Law of Conservation of Mass

Atomic Theory

Chapter 3: Matter and Energy

Matter: Matter is anything that occupies space and has mass. Matter can exist as a solid, liquid, or gas. Solid matter can be either amorphous or crystalline.

Classification of Matter: Pure matter is either an element (a substance that cannot be decomposed into simpler substances) or a compound (a substance composed of two or more elements in fixed definite proportions).

Mixtures: two or more different substances, the proportions of which may vary from one sample to the next.

Homogeneous Mixture- Having the same composition throughout

Heterogeneous Mixture- Having a composition that varies from region to region

Properties and Changes of Matter:

- The physical properties of matter do not involve a change in composition
- The chemical properties of matter involve a change in composition
- In a physical change, the appearance of matter may change, but its composition does not
- In a chemical change, the composition of matter does change.

Conservation of Mass: Matter is always conserved. In a chemical change, the sum of the masses of the reactants must equal the sum of the masses of the products.

Energy: Energy is conserved—it can be neither created nor destroyed. Units of energy are the joule (J), the calorie (cal), the nutritional Calorie (Cal), and the kilowatt-hour (kWh).

- Chemical reactions that emit energy are exothermic; those that absorb energy are endothermic.

Temperature: The temperature of matter is related to the random motions of the molecules and atoms. Temperature is measured in three scales: Fahrenheit (°F), Celsius (°C),and Kelvin (K).

Heat Capacity: The temperature change that matter undergoes upon absorption of heat is related to the heat capacity of the substance composing the matter.

Chapter 4: Atoms and Elements

Ions:

- When an atoms gains or loses electrons, it becomes an ion
- Positively charged ions are called cations (metals)
- Negatively charged ions are called cations (nonmetals)
- Cations and anions occur together so that matter is charge neutral (ionic compounds)

Isotopes:

- Atoms of the same element with different number of neutrons are called isotopes
- Isotopes are characterized by their mass number (A), the sum of the protons and the neutrons in the nucleus
- Each naturally occurring sample of most elements has the same percent natural abundance of each isotope
- The atomic mass of an element is a weighted average of the masses of the individual isotopes

Chapter 5: Molecules and Compounds

Chemical Principles:

- **Compounds** display constant composition. The elements that compose a particular compound are in fixed, definite proportions in all samples of the compound.
- **Chemical formulas** indicate the elements present in the compound and the relative number of atoms of each. These formulas represent the basic units that compose a compound.
- **Chemical nomenclature (naming)** the names of simple ionic compounds, molecular compounds, and acids can all be written by examining their chemical formulas
- **Formula Mass** of a compound is the sum of the atomic masses of all atoms in the chemical formula for the compound.

Chapter 6: Chemical Composition

The Mole Concept:

- The mole is a specific number (6.022×10^{23}) that allows us to easily count atoms or molecules by weighing them.
- One mole of any element has a mass equivalent to its atomic mass in grams
- One mole of any compound has a mass equivalent to its formula mass in grams
- The mass of one mol of an element or compound is its molar mass

Chemical Formulas and Chemical Composition:

- Chemical formulas indicate the relative number of each kind of element in a compound
- These numbers are based on atoms or moles
- By using molar masses, the information in a chemical formula can be used to determine the relative masses of each kind of element in a compound
- The total masses of a sample of a compound can be related to the masses of the constituent elements contained in the compound.

Chapter 7: Chemical Reactions

- Chemical Reactions: one or more substances either elements or compounds change into a different substance.
- Evidence of a Chemical Reaction: the only absolute evidence for a chemical reaction is chemical analysis showing that one or more substances have changed into another substance.
- However, one or more of the following often accompanies a chemical reaction: a color change; the formation of a solid or precipitate; the formation of a gas; the emission of light; and the emission or absorption of heat.
- Chemical Equations: chemical equations must be balanced to reflect the conservation of matter in nature
- Aqueous Solutions and Solubility:if a substance dissolves in water, it is soluble.
- Some specific types of reactions are precipitation reaction, acid base reaction, gas-evolution reaction, redox reaction, and combustion reaction.
- Chemical reaction classifications are synthesis reaction, decomposition reactions, single-displacement reaction, and double displacement reaction.

Chapter 7: Chemical Skills Learning Objectives

1. LO: Identify a chemical reaction
2. LO: Write a balanced chemical equation
3. LO: Determine if a compound is soluble
4. LO: Predict and write equations for precipitation reactions
5. LO: Write molecular, complete ionic, and net ionic equations
6. LO: Identify and write equations for acid-base reactions
7. LO: Identify and write equations for gas-evolution reactions
8. LO: Identify redox reactions
9. LO: Identify and write equations for combustion reactions
10. LO: Classify chemical reactions.

Chapter 8: Quantities in Chemical Reactions

- Stoichiometry: A balanced chemical equation gives quantitative relationships between the amounts of reactants and products. The quantitative relationship between reactants and products in a chemical reaction is called reaction stoichiometry.

Limiting Reactant, Theoretical Yield, and Percent Yield:

- The limiting reactant in a chemical reaction is the reactant that limits the amount of product that can be made.
- The theoretical yield in a chemical reaction is the amount of product that can be made from the limiting reactant
- The actual yield in a chemical reaction is the amount of product actually produced

- The percent yield in a chemical reaction is the actual yield divided by theoretical yield times 100.

Enthalpy of Reaction:

- The amount of heat released or absorbed by a chemical reaction under conditions of constant pressure is the enthalpy of reaction (ΔH_{rxn}).
- The magnitude of ΔH_{rxn} is associated with the stoichiometric amounts of reactants and products for the reaction as written.

1. LO: Recognize the numerical relationship between chemical quantities in a balanced chemical equation.
2. LO: Carry out mole-to-mole conversions between reactants and products based on the numerical relationship between chemical quantities in a balanced chemical equation.
3. LO: Carry out mass-to-mass conversions between reactants and products based on the numerical relationship between chemical quantities in a balanced chemical equation and molar masses.
4. LO: Calculate limiting reactant, theoretical yield and percent yield for a given amount of reactants in a balanced chemical equation.
5. LO: Calculate the amount of thermal energy emitted or absorbed by a chemical reaction.

Chapter 9: Electrons in Atoms on the Periodic Table

- **Light**, a form of electromagnetic radiation, exhibits both wavelike and particle-like behavior. Particles of light are called photons.
- **The Bohr Model:** The emission spectrum of hydrogen can be explained by the Bohr model for the hydrogen atom. Each orbit is specified by a quantum number (n), which also specifies the orbit's energy.
- **The Quantum-Mechanical model-** describes electron orbitals, which are electron probability maps that show the relative probability of finding an electron in various places surrounding the atomic nucleus
- **Electron Configuration-** indicates which orbitals are occupied for a particular atom. Orbitals are filled in order of increasing energy and obey the laws of the Pauli exclusion principle, (each orbital can hold a maximum of two electrons with opposing spins) and Hund's rule (electrons occupy orbitals of identical energy singly before pairing)
- **The Periodic Table:** Elements within the same column of the periodic table have similar outer electron configurations and the same number of valence electrons and therefore have similar chemical properties.
    - The periodic table is divisible into blocks (s block, p block, d block, and f block) in which particular sublevels are filled.
    - As you move across a period to the right in the periodic table, atomic size decreases, ionization energy decreases, and metallic character increases.

Chapter 10: Chemical Bonding

- Lewis Theory: Chemical bonds are formed when atoms transfer valence electrons (ionic bonding) or share valence electrons (covalent bonding) to attain noble gasses electron configurations
- Molecular Shapes: The shapes of molecules can be predicted by combining Lewis Theory with Valence Shell Electron Pair Repulsion (VSEPR) theory, where electron groups around the central atom repel one another and determine the geometry of molecule
- Electronegativity: Electronegativity refers to the relative ability of elements to attract electrons within a chemical bond.
- Electronegativity increases as you move to the right across a period in the periodic table and decrease as you move down a column.

Final Exam Review
(Math and Concepts)

Chapter 1: The Chemical World

1. Which statement most resembles a scientific theory?

a. When the pressure on a sample of oxygen gas is increased by 10%, the volume of the gas is decreased by 10%
b. The volume of a gas is inversely proportional to pressure.
c. A gas is composed of small particles in constant motion
d. A gas sample has a mass of 15.8g and a volume of 10.5 L

2. Which statement best defines chemistry?

a. The science that studies solvents, drugs, and insecticides
b. The science that studies the connections between the properties of matter and the particles that compose matter.
c. The science that studies air and water pollution
d. The science that seeks to understand processes that occur only in chemical laboratories.

3. Which of the following is considered a hypothesis (as opposed to an observation)*

a. The Washington Monument is 555 feet tall
b. Birds can fly because they have hollow bones
c. Fresh lava from a volcano is hot
d. Spiders have 8 legs

4. Which statement about the scientific method is TRUE?*

a. The scientific method emphasizes scientific laws as the way to understand the world
b. The scientific method emphasizes reason as the way to understand the world
c. The scientific method emphasizes observation and experimentation as the way to understand the world
d. The scientific method emphasizes observation and reason as the way to understand the world

Chapter 2: Measurement and Problem Solving

1. The 2016 U.S population was estimated to be 323,000,000 people. Express this number in scientific notation.

2. The radius of a carbon atom is approximately 0.000000000070m. Express this number in scientific notation.

3. The radius of a dust speck is 4.5×10^{-3}mm. What is the correct value of this number in decimal notation (i.e, express this number without using scientific notation)?

4500mm 0.045mm 0.0045mm 0.00045mm

4. How many significant figures are in each number?

a. 0.0035
b. 1.080
c. 2371
d. 2.97×10^{5}
e. 1 dozen = 12
f. 100.00
g. 100,000

5. Perform each calculation to the correct number of significant figures.

a. $3.897 \times (782.3 - 451.88)$ b. $(4.58 \div 1.239) - 0.578$

6. List all the important units of conversion.

7. A recipe for making creamy pasta sauce calls for 0.75L of cream. Your measuring cup measures only in cups. How many cups of cream should you use? (4 cups = 1 quart)

8. One lap of a running track measures 255m. To run 10.0km, how many laps should you run?

9. A prescription medication requires 11.5 mg per kg of body weight. Convert this quantity to the number of grams required per pound of body weight and determine the correct dose (in g) for a 145-lb patient.

10. The average annual per person crude oil consumption in the United States is 15,615m^3. What is this value in cubic inches?

11. The gasoline in an automobile gas tank has a mass of 60.0kg and a density of 0.752 g/cm^3. What is its volume in cm^3?

Chapter 3: Matter and Energy

1. Describe the difference between physical and chemical changes. Highlight some common examples.

2. Classify each property as physical or chemical

a. The tendency of copper to turn green when exposed to air
b. The tendency of automobile paint to dull over time
c. The tendency of gasoline to evaporate quickly when spilled
d. The low mass (for a given volume) of aluminum relative to other metals

3. Classify each property as physical or chemical
a. The explosiveness of hydrogen gas
b. The bronze color of copper
c. The shiny appearance of silver
d. The ability of dry ice to sublime (change from solid directly to vapor)

4. A candy bar contains 225 Cal of nutritional energy. How many joules does it contain?

5. Classify each change as exothermic or endothermic
a. Wood burning in a fire
b. Ice melting

6. Convert each of the following.
a. -25℃ to Kelvins
b. 310 K to Fahrenheit

7. Discuss specific heat capacity.

8. Gallium is a solid metal at room temperature but melts at 29.9℃. If you hold gallium in your hand, it melts from your body heat. How much heat must 2.5g of gallium absorb from your hand to raise the temperature of the gallium from 25.0 ℃ to 29.9℃? The specific heat capacity of gallium is 0.372 J/g ℃

Chapter 4: Atoms and Elements

1. Discuss the parts of the Atomic Theory.

2. An atom composed of which of these particles would have a mass of approximately 12 amu and be charge-neutral?

a. 6 protons and 6 electrons
b. 3 protons, 3 neutrons, and 6 electrons
c. 6 protons, 6 neutrons, and 6 electrons
d. 12 neutrons and 12 electrons

3. Classify each element as a metal, nonmetal, or metalloid

a. Ba
b. I
c. O
d. Te

4. Discuss the difference between ions and isotopes.

5. Determine the charge of each ion.

a. A magnesium ion with 10 electrons
b. A sulfur ion with 18 electrons
c. An iron ion with 23 electrons

6. Which pair of ions has the same total number of electrons.

a. Na^{+} and Mg^{2+}
b. F^{-} and Cl^{-}
c. O^{-} and O^{2-}
d. Ga^{3+} and Fe^{3+}

7. What are the atomic number, mass, and symbols for the chlorine isotope with 18 neutrons?

8. If an atom has a mass number of 27 has 14 neutrons, it is an isotope of which element?

9. Gallium has two naturally occurring isotopes: Ga-69 with mass 68.9256 amu and a natural abundance of 60.11% and Ga-71 with mass of 70.9247 and a natural abundance of 39.89%. Calculate the atomic mass of Gallium.

10. Magnesium has three naturally occurring isotopes with masses of 23.99, 24.99, and 25.98 amu and a natural abundance of 78.99%, 10.00%, and 11.01%. Calculate the atomic mass of Magnesium.

Chapter 5: Molecules and Compounds

1. Write a chemical formula for each compound and name each.

a. The compound containing two aluminum atoms to every three oxygen atoms

b. The compound containing three oxygen atoms to every sulfur atom

c. The compound containing four chlorine atoms to every carbon atom

2. Determine the number of each type of atom in $Mg_3(PO_4)_2$

3. Write a formula for the ionic compound that forms from aluminum and oxygen and name the compound.

4. Provide the compound name for the following compounds:
   MgO

   $Ca(NO_3)_2$

   NaCl

   $CaBr_2$

5. Name the following compounds containing polyatomic ions.
   KNO_3 NH_4NO_3

   $Fe(OH)_2$

6. Naming the following acids:
   HF

   $HClO_4$

   H_2SO_3

7. Calculate the formula mass of carbon tetrachloride, CCl_4

8. Which substance has the greatest formula mass?

a. O_2
b. O_3
c. H_2O
d. H_2O_2

Chapter 6: Chemical Composition

1. A silver ring contains 65 silver atoms. How many moles of silver are in the ring?

2. Calculate the number of moles of sulfur in 57.8 g of sulfur.

3. How many aluminum atoms are in an aluminum can with a mass of 16.2 g?

4. Calculate the mass (in grams) of 1.75 mol of water.

5. Determine the number of moles of O in 1.7 mol of $CaCO_3$

6. Carvone (C10H14O) is the main component of spearmint oil. It has a pleasant aroma and mint flavor. Carvone is added to chewing gum, liqueurs, soaps, and perfumes. Calculate the mass of carbon in 55.4 g of carvone.

7. Calculate the mass percent of Cl in freon-114 ($C_2Cl_4F_2$).

8. A 3.24-g sample of titanium reacts with oxygen to form 5.40 g of the metal oxide. What is the empirical formula of the metal oxide?

9. Naphthalene is a compound containing carbon and hydrogen that is used in mothballs. Its empirical formula is C_5H_4 and its molar mass is 128.16 g/mol. What is its molecular formula?

Chapter 7: Chemical Reactions

1. Which changes involve a chemical reaction? Explain your answers.
a. Ice melting upon warming
b. An electric current passes through water, resulting in the formation of hydrogen and oxygen gas that appears as bubbles rising in the water.
c. Iron rusting
d. Bubbles forming when a soda can is opened.

2. Write a balanced equation for the combustion reaction between liquid octane (C8H18), a component of gasoline, and gaseous oxygen to form gaseous carbon dioxide and gaseous water.

3. Write a balanced equation for the reaction of solid aluminum with aqueous sulfuric acid to form aqueous aluminum sulfate and hydrogen gas.

4. Balance the chemical equation.
$Fe(s) + HCl(aq) \rightarrow FeCl_3\ (aq) + H_2\ (g)$

5. Is each compound soluble or insoluble?
AgBr

$CaCl_2$

$Pb(NO_3)_2$

$PbSO_4$

6. Write an equation for the precipitation reaction that occurs (if any) when solutions of sodium carbonate and copper (II) chloride are mixed.

7. Write an equation for the precipitation reaction that occurs (if any) when solutions of lithium nitrate and sodium sulfate are mixed.

8. Consider this precipitation reaction occurring in aqueous solution.
   $Pb(NO_3)_2\,(aq) + 2\ LiCl\ (aq) \rightarrow PbCl_2\,(s) + 2\ LiNO_3\,(aq)$
   Write a complete ionic equation and a net ionic equation for the reaction.

9. Write a molecular and a net ionic equation for the reaction between aqueous HNO_3 and aqueous $Ca(OH)_2$

10. Which of these are redox reactions?
    $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$
    $2\ HBr(aq) + Ca(OH)_2(aq) \rightarrow 2\ H_2O(l) + CaBr_2(aq)$
    $Ca(s) + Cl_2(g) \rightarrow CaCl_2(s)$
    $Zn(s) + Fe^{2+}(aq) + Zn^{2+}(aq) + Fe(s)$

Chapter 8: Quantities in Chemical Reactions

1. Sodium Chloride, NaCl, forms in this reaction between sodium and chlorine.

   $$2\ Na\ (s) + Cl_2\ (g) \rightarrow 2\ NaCl\ (s)$$

   How many moles of NaCl result from the complete reaction of 3.4 mol of Cl_2? Assume that there is more than enough Na.

2. In photosynthesis, plants convert carbon dioxide and water into glucose ($C_6H_{12}O_6$) according to the reaction:

   $$6\ CO_2\ (g) + 6\ H_2O\ (l) \rightarrow 6\ O_2\ (g) + C_6H_{12}O_6\ (aq)$$

   How many grams of glucose can be synthesized from 58.5 g of CO_2? Assume that there is more than enough water present to react with all of the CO_2.

3. Consider this reaction:

   $$2\ Al\ (s) + 3\ Cl_2\ (g) \rightarrow 2\ AlCl_3\ (s)$$

   If you begin with 0.552 mol of aluminum and 0.887 mol of chlorine, what is the limiting reactant and theoretical yield of $AlCl_3$ in moles?

4. Consider this reaction:

   $$Cu_2O\ (s) + C\ (s) \rightarrow 2\ Cu\ (s) + CO\ (g)$$

   When 11.5 g of C reacts with 114.5 g of Cu2O, 87.4 g of Cu are obtained. Determine the limiting reactant, theoretical yield, and percent yield.

Chapter 9: Electrons in Atoms and the Periodic Table

1. Describe the electromagnetic spectrum and draw the entirety of the spectrum with corresponding labels.

2. Describe in detail the relationship between frequency and wavelength.

3. Provide the electron configuration for the following elements on the periodic table:

Ca

Co

Cd

Zn

S

4. How many and what subshells are there in n=3

5. Write an orbital diagram for the following elements:
   O

   Fe

   Se

   Ti

6. Choose the element with the higher ionization energy from each pair.

a. Mg or P

b. As or Sb

c. N or Si

d. O or Cl

7. Which of the listed elements is most metallic?

a. Al
b. N
c. P
d. O

Chapter 10: Chemical Bonding

1. Write the Lewis Structure of the compound MgO.

2. Write the Lewis structure for CO_2. What is its molecular shape?

3. Predict the molecular geometry of PCl_3 and $[NO_3]^-$

4. Write the Lewis structure for the following compounds, state their molecular geometry and their bond angles.

CO_2

CCl_4

NH_4^+

SO_2