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.

8 decimal places

3.23×10^{8}

2. The radius of a carbon atom is approximately 0.00000000070m. Express this number in scientific notation.

11 decimal places

7.0×10^{-11} m

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?

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

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

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

782.3 − 451.88 = 330.42 (4 sf)

→ 1287

3.897 × 1287 = 1287.64 (4 sf)

3.69 − 0.578 = 3.112

6. List all the important units of conversion.

1 kilogram = 1000 grams
1 meter = 1000 milimeters
1 gram = 1000 miligrams
1 meter = 100 centimeters
1 in = 2.54 cm

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)

L → ML → cups

$$\frac{0.75\ \text{L}}{1\ \text{L}} \times \frac{1000\ \text{mL}}{1} \times \frac{1\ \text{cup}}{236.588\ \text{mL}} = 3.2\ \text{cups}$$

8. One lap of a running track measures 255m. To run 10.0km, how many laps should you run? 3 sf

$$\frac{10.0\ \text{km}}{1\ \text{km}} \times \frac{10000\ \text{m}}{1} \times \frac{1\ \text{lap}}{255\ \text{m}} = 39.2\ \text{laps}$$

mg → g kg → lb

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.

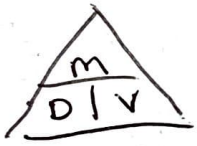
$$\frac{11.5\ \text{mg}}{1\ \text{kg}} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{kg}}{2.205\ \text{lb}} = 0.005\ \text{g per lb or } 5.22 \times 10^{-3}\ \text{g per lb}$$

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

$$\frac{15615\ \text{m}^3}{} \times \frac{39.3701\ \text{in}}{1\ \text{m}} \times \frac{39.370\ \text{in}}{1\ \text{m}} \times \frac{39.370\ \text{in}}{1\ \text{m}} =$$

$95,289,000\ \text{in}^3$ or $9.5289 \times 10^8\ \text{in}^3$

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?



$$\frac{60.0\ \text{kg}}{} \times \frac{1000\ \text{g}}{1\ \text{kg}} = \frac{60000\ \text{g}}{0.752\ \text{g/cm}^3} =$$

$79800\ \text{cm}^3$ or $7.98 \times 10^4\ \text{cm}^3$

Chapter 3: Matter and Energy

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

chemical changes lead to a new substance from change to its chemical composition
physical change alters the apperance.

2. Classify each property as physical or chemical
   a. The tendency of copper to turn green when exposed to air chemical
   b. The tendency of automobile paint to dull over time chemical
   c. The tendency of gasoline to evaporate quickly when spilled phys
   d. The low mass (for a given volume) of aluminum relative to other metals phys

Chemical changes
1) change in color
2) gas/odor
3) change in energy
4) formation of percipitate
5) emission of light

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

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

$$\frac{225\ \text{Cal}}{1}\left|\frac{1000\ \text{cal}}{1\ \text{Cal}}\right|\frac{4.184\ \text{J}}{1\ \text{cal}} = 941{,}000\ \text{J}$$

4.184 J = 1 cal
1 Cal = 1000. cal

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

6. Convert each of the following.
a. -25℃ to Kelvins $K = C° + 273$ $-25°C + 273 = \boxed{248\ K}$
b. 310 K to Fahrenheit $C = \frac{F-32}{1.8}$

$310\ K = C + 273$
$-273 \quad -273$
$(1.8)37C = \frac{F-32}{1.8}(1.8)$
$66.6 = F - 32$
$+32 \quad +32$
$\boxed{98.6 = F}$

7. Discuss specific heat capacity.

the amount of heat energy required to raise the temp of 1 gram of a substance by 1°C $\boxed{q = mc\Delta T}$

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 ℃

$q =$
$m = 2.5\ g$
$c = 0.372\ J/g\ °C$
$\Delta T = 4.9\ °C$
$\wedge$
$F - I$
$29.9 - 25.0 = 4.9$

4.557
$\downarrow$
$\boxed{4.6\ J}$

Chapter 4: Atoms and Elements

1. Discuss the parts of the Atomic Theory.

Dalton
1) each element is composed of tiny, indestructible particles called atoms. These are neither created or destroyed
2) atoms of an element have the same mass & other properties
3) atoms combine in simple, whole number ratios

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 metal
b. I nonmetal
c. O nonmetal
d. Te metalloid

4. Discuss the difference between ions and isotopes.

ions
- from different amts of electrons in an element
- cations & anions
(+) metals (-) nonmetals

vs

isotopes
- from different #s of neutrons w/ same element
- effects mass

5. Determine the charge of each ion.

a. A magnesium ion with 10 electrons $2+$
b. A sulfur ion with 18 electrons $2-$
c. An iron ion with 23 electrons $3+$

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?

atomic # : 17 → periodic table

mas = p + n → 17 + 18 = 35

$^{35}_{17}Cl$

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

27 (mass #)
− 14 (neutrons)
13 (protons) → aluminum

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.

68.9256 * 60.11% = 41.43
70.9247 * 39.89% = + 28.29
69.72 amu

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.

23.99 * 78.99% = 18.95
24.99 * 10.00% = 2.499
25.98 * 11.01% = 2.861
+ 24.3059
↓
24.31 amu

Chapter 5: Molecules and Compounds

1. Write a chemical formula for each compound and name each. Al_2O_3, aluminum oxide
   a. The compound containing two aluminum atoms to every three oxygen atoms
   b. The compound containing three oxygen atoms to every sulfur atom SO_3, sulfur trioxide
   c. The compound containing four chlorine atoms to every carbon atom CCl_4 carbon tetrachloride

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

   Mg = 3
   P = 1 x 2 = 2
   O = 4 x 2 = 8

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

   Al_2O_3
   aluminum oxide

4. Provide the compound name for the following compounds:

   MgO
   magnesium oxide

   $Ca(NO_3)_2$
   calcium nitrate

   NaCl
   sodium chloride

   $CaBr_2$
   calcium bromide

5. Name the following compounds containing polyatomic ions.

   KNO_3
   potassium nitrate

   NH_4NO_3
   ammonium nitrate

   $Fe(OH)_2$
   iron (II) hydroxide

6. Naming the following acids:

HF

hydrofluoric acid

$HClO_4$

perchloric acid

H_2SO_3

sulfurous acid

7. Calculate the formula mass of carbon tetrachloride, CCl_4

C: 12.011 x 1 = 12.011 +

Cl: 35.45 x 4 = 141.80

153.81 g/mol

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?

$$\frac{65 \text{ Ag atoms} \mid 1 \text{ mol Ag}}{\mid 6.022 \times 10^{23} \text{ atoms}} = 1.1 \times 10^{-22} \text{ mol Ag}$$

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

$$\frac{57.8 \text{ g S} \mid 1 \text{ mol S}}{\mid 32.06 \text{ g S}} = 1.80 \text{ mol S}$$

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

$$\frac{16.2 \text{ g Al} \mid 1 \text{ mol Al} \mid 6.022 \times 10^{23} \text{ atoms}}{\mid 26.982 \text{ g Al} \mid 1 \text{ mol Al}} = 3.62 \times 10^{23} \text{ atoms}$$

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

$$\frac{1.75 \text{ mol } H_2O \mid 18.02 \text{ g } H_2O}{\mid 1 \text{ mol } H_2O} = 31.54 \text{ g } H_2O$$

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

$$1.7 \text{ mol } CaCO_3 \left| \frac{3 \text{ mol O}}{1 \text{ mol } CaCO_3} \right. = \boxed{5.1 \text{ mol O}}$$

6. Carvone ($C_{10}H_{14}O$) 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.

1) Molar Mass

C: 12.011 x 10 = 120.11 g/mol

H: 1.00794 x 14 = 14.11116 g/mol +

O: 15.999 x 1 = 15.999 g/mol

150.22 g/mol

2)

$$55.4 \text{ g } C_{10}H_{14}O \left| \frac{1 \text{ mol } C_{10}H_{14}O}{150.22 \text{ g } C_{10}H_{14}O} \right| \frac{10 \text{ mol C}}{1 \text{ mol } C_{10}H_{14}O} \left| \frac{12.011 \text{ g C}}{1 \text{ mol C}} \right. = \boxed{44.3 \text{ g C}}$$

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

$$\frac{\text{part}}{\text{whole}} \times 100$$

1) molar mass

C: 12.011 x 2 = 24.022 g

Cl: 35.45 x 4 = 141.80 g +

F: 18.998 x 2 = 37.996 g

= 203.82 g/mol

$\frac{141.80 \text{ g}}{203.82 \text{ g}} = \boxed{70\%}$

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?

$\boxed{TiO_2}$

5.40 g (TiO)

- 3.24 g (Titanium)

2.16 g (oxygens)

$$3.24 \text{ g Ti} \left| \frac{1 \text{ mol Ti}}{47.867 \text{ g Ti}} \right. = \frac{0.0677}{0.0677} = 1$$

$$2.16 \text{ g O} \left| \frac{1 \text{ mol O}}{15.999 \text{ g O}} \right. = \frac{0.135}{0.0677} = 2$$

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?

$n = \frac{\text{molar mass}}{\text{emperical}}$

$\frac{128.16 \text{ g}}{64.087 \text{ g}} = 2 * C_5H_4$

$\boxed{C_{10}H_8}$

C: 12.011 x 5 = 60.055

H: 1.00794 x 4 = 4.03176

64.08676

Chapter 7: Chemical Reactions

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

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.

$$2\,C_8H_{18}(l) + 25\,O_2(g) \rightarrow 16\,CO_2(g) + 18\,H_2O(g)$$

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

$$2\,Al(s) + 3\,H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3\,H_2(g)$$

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

$$2\,Fe(s) + 6\,HCl(aq) \rightarrow 2\,FeCl_3(aq) + 3\,H_2(g)$$

5. Is each compound soluble or insoluble?
   $AgBr$ insoluble
   $CaCl_2$ soluble
   $Pb(NO_3)_2$ soluble
   $PbSO_4$ insoluble

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

$Na_2CO_3(aq) + CuCl_2(aq) \rightarrow CuCO_3(s) + 2NaCl(aq)$

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

no reaction

*everything is soluble!

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.

ionic: $Pb^{2+}(aq) + 2NO_3^-(aq) + 2Li^+(aq) + 2Cl^-(aq) \rightarrow PbCl_2^{+2}(s)$
$+ 2Li^+(aq) + 2NO_3^-(aq)$

net ionic: $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

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

molecular: $2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$

net ionic: $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$

10. Which of these are redox reactions?
$2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$ yes
$2\ HBr(aq) + Ca(OH)_2(aq) \rightarrow 2\ H_2O(l) + CaBr_2(aq)$ no
$Ca(s) + Cl_2(g) \rightarrow CaCl_2(s)$ yes
$Zn(s) + Fe^{2+}(aq) + Zn^{2+}(aq) + Fe(s)$ yes

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.

$$3.4\ mol\ Cl_2 \left| \frac{2\ mol\ NaCl}{1\ mol\ Cl_2} \right. = \boxed{6.8\ mol\ NaCl}$$

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.

$$58.5\ g\ CO_2 \left| \frac{1\ mol\ CO_2}{44.009\ g\ CO_2} \right| \frac{1\ mol\ C_6H_{12}O_6}{6\ mol\ CO_2} \left| \frac{180.155\ g\ C_6H_{12}O_6}{1\ mol\ C_6H_{12}O_6} \right.$$

$$= \boxed{39.9\ g\ C_6H_{12}O_4}$$

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?

From Al: $0.552\ mol\ Al \left| \frac{2\ mol\ AlCl_3}{2\ mol\ Al} \right. = 0.552\ mol\ AlCl_3$

From Cl: $0.887\ mol\ Cl_2 \left| \frac{2\ mol\ AlCl_3}{3\ mol\ Cl_2} \right. = 0.5913\ mol\ AlCl_3$

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.

$$\frac{\text{actual}}{\text{theoretical}} = \%\ \text{yield}$$

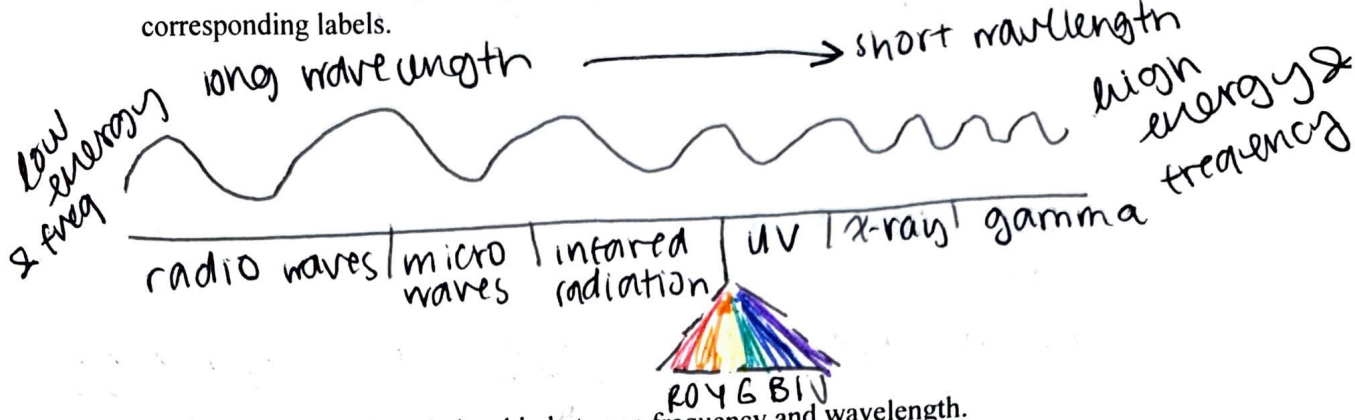
$$114.5\ g\ Cu_2O \left| \frac{1\ mol\ Cu_2O}{143.09\ g\ Cu_2O} \right| \frac{2\ mol\ Cu}{1\ mol\ Cu_2O} \left| \frac{63.546\ g\ Cu}{1\ mol\ Cu} \right.$$

$$\frac{87.4\ g}{101.7\ g} = \boxed{86\%}$$

$$= \boxed{101.7\ g\ Cu}$$

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.

as frequency ↑, wavelength ↓

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

Ca

$1s^2 2s^2 2p^6 3s^2 3p^6 \underline{4s^2}$

v.e. = 2

Co

$1s^2 2s^2 2p^6 3s^2 3p^6 \underline{4s^2} 3d^7$

ve = 2

Cd

$[Kr] 5s^2 4p^{10}$

(ground-state)

Zn

$1s^2 2s^2 2p^6 3s^2 3p^6 \underline{4s^2} 3d^{10}$

ve = 2

S

$1s^2 2s^2 2p^6 \underline{3s^2} \underline{3p^4}$

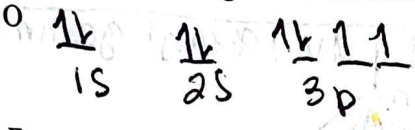
2 + 4 = 6 v.e.

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

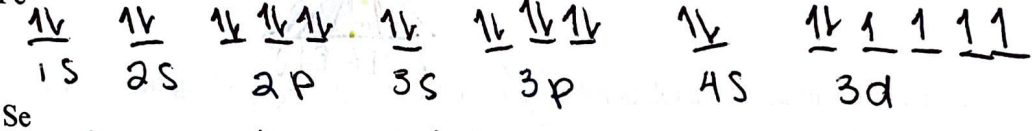
n=3 has s, p, and d subshells

5. Write an orbital diagram for the following elements:

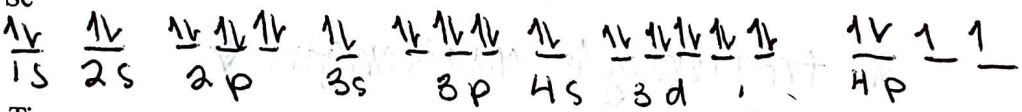
O



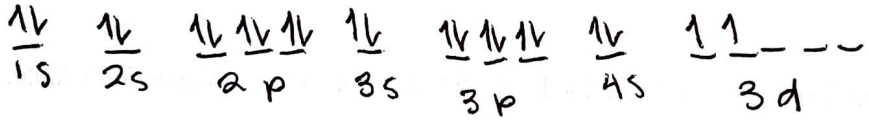
Fe



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

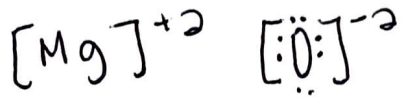
b. N

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?

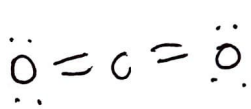
3. Predict the molecular geometry of PCl_3 and $[NO_3]^-$

PCl_3 → Trigonal pyramidal

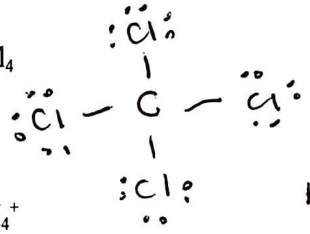
$[NO_3]^-$ → Trigonal planar

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