UNIT 3 – CHAPTER 3 STUDENT NOTES: STOICHIOMETRY

Counting Atoms:

A rubber stopper weighs 3.26 grams and a cork stopper weighs 2.18 grams.

a) How many rubber stoppers are there in 88.02 grams of rubber stoppers?

b) How many cork stoppers are there in 85.02 grams of cork stoppers?

c) What mass of cork stoppers would have to be weighed out to get the same number of cork stoppers that would be in 185.82 grams of rubber stoppers?

The mole:

Molar mass ⟷ **Mole** ⟷ **Particles**

Terms: **Mole** – 6.02×10^{23} PARTICLES

Molar mass – MASS OF 1 MOLE OF A SUBSTANCE

Atomic weight – WEIGHTED AVERAGE OF ATOMS OF AN ELEMENT (ISOTOPES)

Calculate:

a) 2.27 grams of N_2 = _____ moles

b) 0.030 moles of N_2 = _____ grams

c) 0.72 grams of N_2 = _____ particles

d) 3.00×10^{20} molecules of N_2 = _____ grams

Calculate: Aspartame $C_{14}H_{18}N_2O_5$

a) molar mass of aspartame

$14(12)+18(1)+2(14)+5(16)$

$168 + 18 + 28 + 80 = 294\ g/mol$

b) moles in 10.0 grams aspartame

$10.0\ g\ ASP \left| \frac{1\ mol\ ASP}{294\ g\ ASP} \right. = 0.0340\ mol\ ASP$

c) grams of 1.56 moles of aspartame

$1.56\ mol\ ASP \left| \frac{294\ g\ ASP}{1\ mol\ ASP} \right. = 459\ g\ ASP$

d) particles in 5.0 milligrams of aspartame

$5.0\ mg\ ASP \left| \frac{1\ g\ ASP}{1000\ mg\ ASP} \right| \frac{1\ mol\ ASP}{294\ g\ ASP} \left| \frac{6.02\times10^{23}\ PARTICLES}{1\ mol\ ASP} \right. = 1.0\times10^{19}\ PARTICLES\ (MOLECULES)\ ASP$

e) atoms of N in 1.2 grams of aspartame

$1.2\ g\ ASP \left| \frac{1\ mol\ ASP}{294\ g\ ASP} \right| \frac{6.02\times10^{23}\ PARTICLES}{1\ mol\ ASP} \left| \frac{2\ N\ ATOMS}{1\ PARTICLE\ ASP} \right. = 4.9\times10^{21}\ N\ ATOMS\ IN\ ASP$

f) grams in 1.0 X 10^9 molecules of aspartame

$1.0\times10^9\ MOLECULES\ ASP \left| \frac{1\ mol\ ASP}{6.02\times10^{23}\ MOLECULES\ ASP} \right| \frac{294\ g\ ASP}{1\ mol\ ASP} = 4.9\times10^{-13}\ g\ ASP$

g) mass, in grams, of 1 molecule of aspartame

$1\ MOLECULE\ ASP \left| \frac{1\ mol\ ASP}{6.02\times10^{23}\ MOLECULES\ ASP} \right| \frac{294\ g\ ASP}{1\ mol\ ASP} = 4.89\times10^{-22}\ g\ ASP$

Atomic weight

A class of ten students take a quiz in AP Chemistry. In this class, 9 students get a 90% and 1 student gets a 50%. What is the average score for this quiz?

Calculate the atomic weight of Mg from the following information:

Isotope	% Abundance	Atomic Mass (AMU)
Mg-24	78.99%	23.9850
Mg-25	10.00%	24.9858
Mg-26	11.01%	25.9826

The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table below.

Isotope	Mass (amu)
Ne-20	19.99
Ne-22	21.99

i) Using the information above, calculate the percent abundance of each isotope.

ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.

Determining empirical and molecular formula

Empirical formula: ATOMS IN LOWEST WHOLE-NUMBER RATIO

Molecular formula: FORMULA OF A MOLECULE (ACTUAL IDENTITY)

EX 1: C – 38.6g

H – 16.22g

N – 45.11g

Molar mass of caffeine: 194.2g/mole

C: 49.48%
H: 5.15%
N: 28.87%
O: 16.40%

1. Many homes in rural America are heated by propane gas, a compound that contains only carbon and hydrogen. Complete combustion of a sample of propane produced 2.641 g of carbon dioxide and 1.442 g of water as the only products. Find the empirical formula of propane.

$C_xH_y + O_2 \rightarrow CO_2 + H_2O$ (problem is, we don't know the coefficients to do simple stoichiometry)

2.641g 1.442g

2. Cumene is a compound containing only carbon and hydrogen that is used in the production of acetone and phenol in the chemical industry. Combustion of 47.6 mg cumene produces some CO_2 and 42.8 mg of H_2O. The molar mass of cumene is between 115 and 125 g/mol. What are the empirical and molecular formulas of cumene?

$C_xH_y + O_2 \rightarrow CO_2 + H_2O$ (again, we don't know the coefficients)

47.6mg 42.8mg

Stoichiometry

In the construction of a car, 1 body plus 4 tires will make 1 car. If 1 body weighs 1250 lbs, 1 tire weighs 45 lbs, and 1 car weighs 1430 lbs, answer the following questions:

a) the number of cars that can be made with 900 lbs of tires.

b) the mass of cars that can be built with 900 lbs of tires.

c) the pounds of tires needed if 8750 lbs of bodies are used to build cars.

d) the pounds of cars that can be made if 18750 lbs of bodies and 1980 lbs of tires are used to build cars.

Stoichiometry problems note sheet

1. Solid lithium hydroxide is used in space vehicles to remove exhaled carbon dioxide from the living environment by forming solid lithium carbonate and liquid water. What mass of gaseous carbon dioxide can be absorbed by 1.00 kg of lithium hydroxide?

$2\,Li(OH) + CO_2 \rightarrow Li_2(CO_3) + H_2O$

1.00Kg X

Li 1 x 6.941
O 1 x 15.99
H 1 x 1.0079
23.95g

C 1x12
O 2x15.99
44g

$$1.00\,Kg\,Li(OH) \left|\frac{1000g\,LiOH}{1\,Kg\,LiOH}\right| \frac{1\,mol\,LiOH}{23.95g\,LiOH} \left|\frac{1\,mol\,CO_2}{2\,Mol\,LiOH}\right| \frac{44g\,CO_2}{1\,Mol\,O_2} = 918.58g\,CO_2$$

(or $0.9186\,Kg\,CO_2$)

2. With homecoming around the corner, students will be looking to get dates to go to the dance. If a particular class is composed of 9375 lbs of girls (average weight 125 lbs) and 14760 lbs of boys (average weight 180 lbs): a) What is the maximum number of couples that can be made to go the dance and b) How much excess will be left over?

3. You have 130 g of zinc and 100 g of hydrogen chloride. Calculate a) the amount of zinc chloride that is produced in this reaction and b) the amount of excess remaining.

4. Nitrogen gas can be prepared by passing gaseous ammonia over solid copper (II) oxide at a high temperature. The other products of the reaction are solid copper and water vapor. If a sample containing 18.1 g of NH_3 is reacted with 90.4 g of CuO, which is the limiting reagent? How many grams of N_2 will be formed? If 6.6 grams of N_2 are formed, what is the percent yield of this reaction?

$$2\,\underset{\text{ER}}{\overset{18.1\text{g}}{NH_3}} + 3\,\underset{\text{LR}}{\overset{90.4\text{g}}{CuO}} \rightarrow \overset{?\text{g}}{N_2} + 3Cu + 3H_2O$$

IF NH_3: $\dfrac{18.1\text{g}\,NH_3}{17.03\text{g}\,NH_3} \cdot \dfrac{1\,\text{mol}\,NH_3}{2\,\text{mol}\,NH_3} \cdot \dfrac{1\,\text{mol}\,N_2}{1\,\text{mol}\,N_2} \cdot \dfrac{28.0\text{g}\,N_2}{1\,\text{mol}\,N_2} = 14.88\text{g}\,N_2$ ← ER

IF CuO: $\dfrac{90.4\text{g}\,CuO}{79.55\text{g}\,CuO} \cdot \dfrac{1\,\text{mol}\,CuO}{3\,\text{mol}\,CuO} \cdot \dfrac{1\,\text{mol}\,N_2}{1\,\text{mol}\,N_2} \cdot \dfrac{28.0\text{g}\,N_2}{1\,\text{mol}\,N_2} = 10.6\text{g}\,N_2$ ← LR

THEORETICAL YIELD = $10.6\text{g}\,N_2$

ACTUAL YIELD = $6.6\text{g}\,N_2$

$$\%\ \text{YIELD} = \frac{\text{ACTUAL}}{\text{THEORETICAL}} \times 100\%$$

$$\frac{6.6\text{g}\,N_2}{10.6\text{g}\,N_2} \times 100\% = 62.5\%\ \text{YIELD}$$

Hydrates: Ionic compounds often separate from water solution with molecules of water incorporated into the solid. Such compounds are referred to as **hydrates**. Certain hydrates lose all or part of their water of hydration when exposed to dry air or are heated. This process is referred to as **efflorescence**. Frequently, dehydration is accompanied by color change. Crystals of the hydrate $CoCl_2 \cdot 6\ H_2O$ change from red to purple in dry air or when heated and are used as humidity indicators and as an ingredient of invisible ink. Writing only becomes visible when the paper is heated, driving the water out and leaving a blue residue.

Hydrates are named by the number of waters attached to the anhydrous compound, using the following prefixes:

1 – mono	6 – hex
2 – di	7 – hept
3 – tri	8 – oct
4 – tetra	9 – non
5 – pent	10 – deca

Name the following hydrates:

$CuSO_4 \cdot 7\ H_2O$ _____

$BaCl_2 \cdot 3\ H_2O$ _____

$MgSO_4 \cdot 5\ H_2O$ _____

EX 2: A certain hydrate of potassium aluminum sulfate (alum) has a formula of $KAl(SO_4)_2 \cdot X\ H_2O$. When a hydrate sample weighing 5.459 g is heated to remove all water, 2.583 g of $KAl(SO_4)_2$ remains. What is the mass percent of water in the hydrate? What is the empirical formula?

5.459g HYDRATED CMPD
2.583g ANHYDROUS CMPD
2.876g H_2O

EX 2: Epsom salts are hydrates of magnesium sulfate. The name of Epsom salts is magnesium sulfate heptahydrate. A 7.834 g sample is heated until a constant mass is obtained, indicating that all the water has been evaporated off. 1) What is the formula for Epsom salts, 2) what is the mass of the anhydrous magnesium sulfate, and 3) what is the percentage of the hydrate (water)?

1) $MgSO_4 \cdot 7\ H_2O = 246.51g$
$MgSO_4 = 120.37g$
$H_2O = 126.14g$

1 Mg = 24.3
1 S = 32.07
4 O = 64
120.37

2H = 2
1 O = 16
18 x 7 = 126

2) 7.834g SAMPLE
X .4880 (48.80% $MgSO_4$)
3.825g $MgSO_4$

3) $\%H_2O = \frac{126.14g\ H_2O}{246.51g\ MgSO_4 \cdot 7H_2O}$
$= 51.2\%\ H_2O$
$= 48.8\%\ MgSO_4$