Ch.11-MOLES / Ch.12-STOICHIOMETRY Practice

Name: _____

Unit 6: Chapter 11: The MOLE

1. How many moles of water are there if you have 2.52×10^{25} molecules of water?

$$\frac{2.52 \times 10^{25}\ \text{molecules } H_2O}{1} \left| \frac{1\ \text{mol } H_2O}{6.02 \times 10^{23}\ \text{molecules } H_2O} \right. = \boxed{41.9\ \text{mol } H_2O}$$

2. How many grams of pure mercury are in 2.54×10^{23} atoms of mercury?

$$\frac{2.54 \times 10^{23}\ \text{atoms Hg}}{1} \left| \frac{1\ \text{mol Hg}}{6.02 \times 10^{23}\ \text{atoms Hg}} \right| \frac{200.59\ \text{g Hg}}{1\ \text{mol Hg}} = \boxed{84.6\ \text{g Hg}}$$

3. How many formula units (f.u.) of copper (II) sulfate are in 1.43 grams of copper (II) sulfate?

$$\frac{1.43\ \text{g } CuSO_4}{1} \left| \frac{1\ \text{mol } CuSO_4}{159.62\ \text{g } CuSO_4} \right| \frac{6.02 \times 10^{23}\ \text{f.u. } CuSO_4}{1\ \text{mol } CuSO_4} = \boxed{5.39 \times 10^{21}\ \text{f.u. } CuSO_4}$$

PERCENT COMPOSITION (% Comp) & EMPIRICAL FORMULAS (E.F.):

1. Calculate the percent composition of each element in a compound containing 1.94 g carbon, 0.480 g hydrogen, and 2.58 g sulfur.

Compound = (1.94 g C) + (0.480 g H) + (2.58 g S) = 5.00 g compound

$$C = \frac{1.94\ \text{g}}{5.00\ \text{g}} \times 100 = \boxed{38.8\%} \qquad H = \frac{0.480\ \text{g}}{5.00\ \text{g}} \times 100 = \boxed{9.60\%} \qquad S = \frac{2.58\ \text{g}}{5.00\ \text{g}} \times 100 = \boxed{51.6\%}$$

2. Quantitative analysis shows that a compound contains 32.4% Na, 22.6% S and 45.0% O. Find the empirical formula of this compound.

$$\frac{32.4\ \text{g Na}}{1} \left| \frac{1\ \text{mol Na}}{22.99\ \text{g Na}} \right. = \frac{1.41\ \text{mol Na}}{0.705} \rightarrow (2) \quad / \quad \frac{22.6\ \text{g S}}{1} \left| \frac{1\ \text{mol S}}{32.07\ \text{g S}} \right. = \frac{0.705\ \text{mol S}}{0.705} \rightarrow (1) \quad / \quad \frac{45.0\ \text{g O}}{1} \left| \frac{1\ \text{mol O}}{16.00\ \text{g O}} \right. = \frac{2.81\ \text{mol O}}{0.705} \rightarrow (4)$$

$$\boxed{E.F. = Na_2SO_4}$$

3. Determine the empirical formula of a compound containing 1.73 g carbon, 0.289 g hydrogen and 0.459 g oxygen.

$$\frac{1.73\ \text{g C}}{1} \left| \frac{1\ \text{mol C}}{12.01\ \text{g C}} \right. = \frac{0.144\ \text{mol C}}{0.0287} \rightarrow (5) \quad / \quad \frac{0.289\ \text{g H}}{1} \left| \frac{1\ \text{mol H}}{1.008\ \text{g H}} \right. = \frac{0.287\ \text{mol H}}{0.0287} \rightarrow (10) \quad / \quad \frac{0.459\ \text{g O}}{1} \left| \frac{1\ \text{mol O}}{16.00\ \text{g O}} \right. = \frac{0.0287\ \text{mol O}}{0.0287} \rightarrow (1)$$

$$\boxed{E.F. = C_5H_{10}O}$$

MOLECULAR FORMULAS *(M.F.)* & HYDRATES:

1. The mass percent of a compound is discovered to be 40.0% Carbon, 6.67% Hydrogen, and 53.3% Oxygen. Further analysis shows that the M.F. molar mass is 180. g/mol. What is the molecular formula *(M.F.)* of this sweet compound?

① $\frac{40.0\text{ g C}}{1}\left|\frac{1\text{ mol C}}{12.01\text{ g C}}\right. = \frac{3.33\text{ mol C}}{3.33}$ ↳ ① / $\frac{6.67\text{ g H}}{1}\left|\frac{1\text{ mol H}}{1.008\text{ g H}}\right. = \frac{6.62\text{ mol H}}{3.33}$ ↳ ② / $\frac{53.3\text{ g O}}{1}\left|\frac{1\text{ mol O}}{16.00\text{ g O}}\right. = \frac{3.33\text{ mol O}}{3.33}$ ↳ ①

② E.F. = CH_2O → 30.026 g/mol → $\frac{MF}{EF} = \frac{180\text{ g/mol}}{30.026\text{ g/mol}} = ⑥$ → $6 \times (CH_2O)$ = **M.F. = $C_6H_{12}O_6$**

2. The empirical formula *(E.F.)* of a compound is NO_2. The molar mass of the M.F. is 92.0 g/mol. What is the molecular formula *(M.F.)*?

E.F. = NO_2 → 46.01 g/mol

$\frac{MF}{EF} = \frac{92.0\text{ g/mol}}{46.01\text{ g/mol}} = ②$ → $2 \times (NO_2)$ = **M.F. = N_2O_4**

3. An 8.61 gram sample of hydrated beryllium oxide is heated inside a crucible. After heating, the amount of the anhydrous (dehydrated) was determined to be 3.60 grams. What is the chemical formula of this hydrate?

① (8.61 g BeO hydrate) − (3.60 g BeO anhydrous) = 5.01 g H_2O evaporated

② $\frac{3.60\text{ g BeO}}{1}\left|\frac{1\text{ mol BeO}}{25.012\text{ g BeO}}\right. = \frac{0.144\text{ mol BeO}}{0.144}$ ↳ ① / $\frac{5.01\text{ g }H_2O}{1}\left|\frac{1\text{ mol }H_2O}{18.016\text{ g }H_2O}\right. = \frac{0.278\text{ mol }H_2O}{0.144}$ ↳ ②

③ **$BeO \cdot 2H_2O$** → **Beryllium Oxide Dihydrate**

Unit 7: Chapter 12: STOICHIOMETRY

1. In a combustion reaction, how many moles of carbon dioxide will be produced in the burning of 5.65 moles of butane, C_4H_{10}, in a reaction with oxygen?

$$\_2\_\ C_4H_{10} + \_13\_\ O_2 \rightarrow \_8\_\ CO_2 + \_10\_\ H_2O$$

$$\frac{5.65\text{ mol }C_4H_{10}}{1}\left|\frac{8\text{ mol }CO_2}{2\text{ mol }C_4H_{10}}\right. = \boxed{22.6\text{ mol }CO_2}$$

2. Sodium Chlorate decomposes into sodium chloride and oxygen. How many grams of sodium chloride are produced from 7.90 grams of sodium chlorate?

$$\_2\_\ NaClO_3 \rightarrow \_2\_\ NaCl + \_3\_\ O_2$$

$$\frac{7.90\text{ g }NaClO_3}{1}\left|\frac{1\text{ mol }NaClO_3}{106.44\text{ g }NaClO_3}\right|\frac{2\text{ mol NaCl}}{2\text{ mol }NaClO_3}\left|\frac{58.44\text{ g NaCl}}{1\text{ mol NaCl}}\right. = \boxed{4.34\text{ g NaCl}}$$

3. In this single replacement reaction where zinc chloride and hydrogen are produced, how many grams of hydrogen are produced from the reaction of 3.00 moles of zinc with an excess of hydrochloric acid?

$$\_1\_\ Zn + \_2\_\ HCl \rightarrow \_1\_\ ZnCl_2 + \_1\_\ H_2$$

$$\frac{3.00\text{ mol Zn}}{1}\left|\frac{1\text{ mol }H_2}{1\text{ mol Zn}}\right|\frac{2.016\text{ g }H_2}{1\text{ mol }H_2}\right. = \boxed{6.05\text{ g }H_2}$$

LIMITING (L.R.) & EXCESS REACTANT (E.R.):

1. You synthesize 50.0 grams of sodium with 60.0 grams of chlorine gas to produce table salt, sodium chloride. Identify the following:

$$2\ Na + 1\ Cl_2 \rightarrow 2\ NaCl$$

a. What is the Limiting Reactant *(L.R.)*?

b. What is the Excess Reactant *(E.R.)*?

$$\frac{50.0\text{ g Na}}{1}\left|\frac{1\text{ mol Na}}{22.99\text{ g Na}}\right|\frac{2\text{ mol NaCl}}{2\text{ mol Na}}\left|\frac{58.44\text{ g NaCl}}{1\text{ mol NaCl}}\right. = 127\text{g NaCl}$$

$$\frac{60.0\text{ g } Cl_2}{1}\left|\frac{1\text{ mol } Cl_2}{70.9\text{ g } Cl_2}\right|\frac{2\text{ mol NaCl}}{1\text{ mol } Cl_2}\left|\frac{58.44\text{ g NaCl}}{1\text{ mol NaCl}}\right. = 98.9\text{ g NaCl}$$

> L.R. = Cl_2
> E.F. = Na

c. How many grams of sodium chloride are produced?

98.9 g NaCl Produced → Theoretical Yield from L.R. (Cl_2)

2. In a single replacement reaction between 50.0 g of zinc and 30.0 g of hydrochloric acid, identify the following:

$$1\ Zn + 2\ HCl \rightarrow 1\ ZnCl_{2\,(s)} + 1\ H_{2\,(g)}$$

a. What is the Limiting Reactant *(L.R.)*?

b. What is the Excess Reactant *(E.R.)*?

$$\frac{50.0\text{ g Zn}}{1}\left|\frac{1\text{ mol Zn}}{65.39\text{ g Zn}}\right|\frac{1\text{ mol } ZnCl_2}{1\text{ mol Zn}} = 0.765\text{ mol } ZnCl_2$$

$$\frac{30.0\text{ g HCl}}{1}\left|\frac{1\text{ mol HCl}}{36.5\text{ g HCl}}\right|\frac{1\text{ mol } ZnCl_2}{2\text{ mol HCl}} = 0.411\text{ mol } ZnCl_2$$

> L.R. = HCl
> E.R. = Zn

c. How many moles of zinc chloride are produced?

0.411 mol $ZnCl_2$ → Theoretical Yield from L.R. (HCl)

3. 45.0 g of sodium iodide are reacted with 55.0 g of silver nitrate in this D-R reaction. How many moles of silver iodide are produced?

$$1\ NaI + 1\ AgNO_3 \rightarrow 1\ NaNO_{3\,(aq)} + 1\ AgI_{\,(s)}$$

$$\frac{45.0\text{ g NaI}}{1}\left|\frac{1\text{ mol NaI}}{149.89\text{ g NaI}}\right|\frac{1\text{ mol AgI}}{1\text{ mol NaI}} = 0.300\text{ mol AgI}$$

$$\frac{55.0\text{ g } AgNO_3}{1}\left|\frac{1\text{ mol } AgNO_3}{169.91\text{ g } AgNO_3}\right|\frac{1\text{ mol AgI}}{1\text{ mol } AgNO_3} = 0.324\text{ mol AgI}$$

> L.R. = NaI
> E.R. = $AgNO_3$

PERCENT YIELD (% Yield):

1. The combustion reaction of methane (CH_4) produces carbon dioxide and water. Assume that 2.00 mol of CH_4 burned in the presence of 6.00 mol of oxygen. What is the percent yield if the reaction actually produces 68.5 g of water?

$$1\ CH_{4\,(g)} + 2\ O_{2\,(g)} \rightarrow 1\ CO_{2\,(g)} + 2\ H_2O_{(l)}$$

① $\dfrac{2.00\ mol\ CH_4}{1} \left| \dfrac{2\ mol\ H_2O}{1\ mol\ CH_4} \right| \dfrac{18.016\ g\ H_2O}{1\ mol\ H_2O} = \boxed{72.1\ g\ H_2O}$ → Theoretical Yield

$\dfrac{6.00\ mol\ O_2}{1} \left| \dfrac{2\ mol\ H_2O}{2\ mol\ O_2} \right| \dfrac{18.016\ g\ H_2O}{1\ mol\ H_2O} = 108\ g\ H_2O$

L.R. = CH_4
E.R. = O_2

② $\%\ Yield = \dfrac{Actual}{Theor} \times 100 \rightarrow \%\ Yield = \dfrac{68.5\ g\ H_2O}{72.1\ g\ H_2O} \times 100 \rightarrow \boxed{95.0\ \%\ Yield}$

b. What is the **percent error (%)** of this reaction?

$$\%\ Error = \frac{|Actual - Theor|}{Theor} \times 100 \rightarrow \%\ Error = \frac{|68.5\ g - 72.1\ g|}{72.1\ g} \times 100 \rightarrow \boxed{5.00\%\ Error}$$

2. In this single replacement reaction, aluminum reacts with copper (II) sulfate to produce copper and aluminum sulfate. If 2.95 grams of the limiting reactant, aluminum, reacts and the percent yield of copper is 90.5%, what mass of copper is actually produced?

$$2\ Al_{(s)} + 3\ CuSO_{4\,(aq)} \rightarrow 3\ Cu_{(s)} + 1\ Al_2(SO_4)_{3\,(aq)}$$

* L.R. = Al (Given)

① $\dfrac{2.95\ g\ Al}{1} \left| \dfrac{1\ mol\ Al}{26.98\ g\ Al} \right| \dfrac{3\ mol\ Cu}{2\ mol\ Al} \left| \dfrac{63.55\ g\ Cu}{1\ mol\ Cu} \right. = \boxed{10.4\ g\ Cu}$ → Theoretical Yield

② $\%\ Yield = \dfrac{Actual}{Theor} \times 100 \rightarrow \%\ Yield\ (0.905) = \dfrac{Actual\ (X)}{10.4\ g} \rightarrow \boxed{X = 9.41\ g\ Cu}$ → Actually Produced

b. What is the **percent error (%)** of this reaction?

$$\%\ Error = \frac{|Actual - Theor|}{Theor} \times 100 \rightarrow \%\ Error = \frac{|9.41\ g - 10.4\ g|}{10.4\ g} \times 100 \rightarrow \boxed{9.52\%\ Error}$$

3. If 15.0 grams of copper (II) chloride react with 20.0 grams of sodium nitrate, what is the percent yield of this reaction if 11.3 grams of sodium chloride are experimentally produced in this reaction?

$$1\ CuCl_2 + 2\ NaNO_3 \rightarrow 1\ Cu(NO_3)_2 + 2\ NaCl$$

① $\dfrac{15.0\ g\ CuCl_2}{1} \left| \dfrac{1\ mol\ CuCl_2}{134.45\ g\ CuCl_2} \right| \dfrac{2\ mol\ NaCl}{1\ mol\ CuCl_2} \left| \dfrac{58.44\ g\ NaCl}{1\ mol\ NaCl} \right. = \boxed{13.0\ g\ NaCl}$ → Theoretical Yield

$\dfrac{20.0\ g\ NaNO_3}{1} \left| \dfrac{1\ mol\ NaNO_3}{85.0\ g\ NaNO_3} \right| \dfrac{2\ mol\ NaCl}{2\ mol\ NaNO_3} \left| \dfrac{58.44\ g\ NaCl}{1\ mol\ NaCl} \right. = 13.8\ g\ NaCl$

L.R. = $CuCl_2$
E.R. = $NaNO_3$

② $\%\ Yield = \dfrac{Actual}{Theor} \times 100 \rightarrow \%\ Yield = \dfrac{11.3\ g\ NaCl}{13.0\ g\ NaCl} \times 100 \rightarrow \boxed{86.9\%\ Yield}$

b. What is the **percent error (%)** of this reaction?

$$\%\ Error = \frac{|Actual - Theor|}{Theor} \times 100 \rightarrow \%\ Error = \frac{|11.3\ g - 13.0\ g|}{13.0\ g} \times 100 \rightarrow \boxed{13.1\%\ Error}$$