ANSWER KEY

EXTRA PRACTICE: Ch. 11 – The Mole & Chemical Quantities Name: _____

Molar Mass/2-Step MOLE Conversions:

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

$$\frac{2.52\text{E}25 \text{ molecules } H_2O}{1} \cdot \frac{1 \text{ mol } H_2O}{6.02\text{E}23 \text{ molecules } H_2O} = \boxed{41.9 \text{ mol } H_2O}$$

2. How many moles of aluminum sulfite are there in 25.5 grams of aluminum sulfite?

$$\frac{25.5 \text{ g } Al_2(SO_3)_3}{1} \cdot \frac{1 \text{ mol } Al_2(SO_3)_3}{294.17 \text{ g } Al_2(SO_3)_3} = \boxed{0.0867 \text{ mol } Al_2(SO_3)_3}$$

3. Calculate the mass in grams for 0.250 moles of sodium chloride.

$$\frac{0.250 \text{ mol NaCl}}{1} \cdot \frac{58.44 \text{ g NaCl}}{1 \text{ mol NaCl}} = \boxed{14.6 \text{ g NaCl}}$$

4. Calculate the number of moles in 100. grams of sodium chloride.

$$\frac{100 \text{ g NaCl}}{1} \cdot \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} = \boxed{1.71 \text{ mol NaCl}}$$

3-Step MOLE Conversions:

1. How many grams of calcium nitrate are in 3.24×10^{23} formula units (f.u.) of calcium nitrate?

$$\frac{3.24\text{E}23 \text{ fu } Ca(NO_3)_2}{1} \cdot \frac{1 \text{ mol } Ca(NO_3)_2}{6.02\text{E}23 \text{ fu } Ca(NO_3)_2} \cdot \frac{164.088 \text{ g } Ca(NO_3)_2}{1 \text{ mol } Ca(NO_3)_2} = \boxed{88.3 \text{ g } Ca(NO_3)_2}$$

2. How many grams of sulfur dioxide are in 3.15×10^{23} molecules of sulfur dioxide?

$$\frac{3.15\text{E}23 \text{ molecule } SO_2}{1} \cdot \frac{1 \text{ mol } SO_2}{6.02\text{E}23 \text{ molecule } SO_2} \cdot \frac{64.06 \text{ g } SO_2}{1 \text{ mol } SO_2} = \boxed{33.5 \text{ g } SO_2}$$

3. How many molecules of laughing gas (dinitrogen monoxide) are in 1.78×10^{23} grams of laughing gas?

$$\frac{1.78\,E23\ g\ N_2O}{1} \cdot \frac{1\ mol\ N_2O}{44.01\ g\ N_2O} \cdot \frac{6.02\,E\,23\ molecule\ N_2O}{1\ mol\ N_2O} = \boxed{2.44\,E\,45\ molecule\ N_2O}$$

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

$$\frac{2.54\,E23\ atoms\ Hg}{1} \cdot \frac{1\ mol\ Hg}{6.02\,E\,23\ atoms\ Hg} \cdot \frac{200.59\ g\ Hg}{1\ mol\ Hg} = \boxed{84.6\ g\ Hg}$$

Percent (%) Composition:

1. Determine the percent composition for each of the elements in copper (II) sulfate. → $CuSO_4$

$Cu = 1 \times 63.55 = 63.55$

$S = 1 \times 32.06 = 32.06$

$O = 4 \times 16.00 = 64.00$

$159.61\ g/mol$

$Cu = \frac{63.55}{159.61} \times 100 \rightarrow \boxed{39.8\%}$

$S = \frac{32.06}{159.61} \times 100 \rightarrow \boxed{20.1\%}$

$O = \frac{64.00}{159.61} \times 100 \rightarrow \boxed{40.1\%}$

2. What is the percent composition of calcium in the compound calcium phosphide? → Ca_3P_2

$Ca = 3 \times 40.08 = 120.24$

$P = 2 \times 30.97 = 61.94$

$182.18\ g/mol$

$Ca = \frac{120.24}{182.18} \times 100 \rightarrow \boxed{66.0\%}$

3. Determine the percent composition for each of the elements in ammonium hydroxide. → NH_4OH

$N = 1 \times 14.01 = 14.01$

$H = 5 \times 1.008 = 5.04$

$O = 1 \times 16.00 = 16.00$

$35.05\ g/mol$

$N = \frac{14.01}{35.05} \times 100 \rightarrow \boxed{40.0\%}$

$H = \frac{5.04}{35.05} \times 100 \rightarrow \boxed{14.4\%}$

$O = \frac{16.00}{35.05} \times 100 \rightarrow \boxed{45.6\%}$

4. Determine the percent composition for each of the elements in carbon tetrachloride. → CCl_4

$C = 1 \times 12.01 = 12.01$

$Cl = 4 \times 35.45 = 141.8$

$153.81\ g/mol$

$C = \frac{12.01}{153.81} \times 100 \rightarrow \boxed{7.80\%}$

$Cl = \frac{141.8}{153.81} \times 100 \rightarrow \boxed{92.2\%}$

Empirical Formulas (E.F.):

1. Determine the empirical formula (E.F.) of a compound containing 24.7% potassium, 34.8% manganese, and 40.5% oxygen.

$\frac{24.7\text{ g K}}{1} \cdot \frac{1\text{ mol K}}{39.10\text{ g K}} = \frac{0.6317\text{ mol K}}{0.6317} \rightarrow 1$

$\frac{34.8\text{ g Mn}}{1} \cdot \frac{1\text{ mol Mn}}{54.94\text{ g Mn}} = \frac{0.6334\text{ mol Mn}}{0.6317} \rightarrow 1$

$\frac{40.5\text{ g O}}{1} \cdot \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{2.531\text{ mol O}}{0.6317} \rightarrow 4$

$\boxed{E.F. = KMnO_4}$

2. Quantitative analysis shows that a compound contains 32.4% Na, 22.7% S, and 45.0% O. Calculate the Empirical Formula (E.F.) of this compound.

$\frac{32.4\text{ g Na}}{1} \cdot \frac{1\text{ mol Na}}{22.99\text{ g Na}} = \frac{1.41\text{ mol Na}}{0.708} \rightarrow 2$

$\frac{22.7\text{ g S}}{1} \cdot \frac{1\text{ mol S}}{32.06\text{ g S}} = \frac{0.708\text{ mol S}}{0.708} \rightarrow 1$

$\frac{45.0\text{ g O}}{1} \cdot \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{2.81\text{ mol O}}{0.708} \rightarrow 4$

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

3. Determine the empirical formula (E.F.) of a compound containing 67.6% mercury, 10.8% sulfur, and 21.6% oxygen.

$\frac{67.6\text{ g Hg}}{1} \cdot \frac{1\text{ mol Hg}}{200.59\text{ g Hg}} = \frac{0.337\text{ mol Hg}}{0.337} \rightarrow 1$

$\frac{10.8\text{ g S}}{1} \cdot \frac{1\text{ mol S}}{32.06\text{ g S}} = \frac{0.337\text{ mol S}}{0.337} \rightarrow 1$

$\frac{21.6\text{ g O}}{1} \cdot \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{1.35\text{ mol O}}{0.337} \rightarrow 4$

$\boxed{E.F. = HgSO_4}$

4. A very flammable gas contains 60.0% Carbon and 40.0% Hydrogen. Calculate its Empirical Formula (E.F.).

$\frac{60.0\text{ g C}}{1} \cdot \frac{1\text{ mol C}}{12.01\text{ g C}} = \frac{4.96\text{ mol C}}{4.96} \rightarrow 1$

$\frac{40.0\text{ g H}}{1} \cdot \frac{1\text{ mol H}}{1.008\text{ g H}} = \frac{39.7\text{ mol H}}{4.96} \rightarrow 8$

$\boxed{E.F. = CH_8}$

Molecular Formulas (M.F.):

1. The compound methyl butanoate smells like apples. Given its percent composition as 58.8% carbon, 9.80% hydrogen, and 31.4% oxygen and a M.F. molar mass of 102 g/mol, what is the molecular formula (M.F.) for methyl butanoate?

$\frac{58.8\text{ g C}}{1} \cdot \frac{1\text{ mol C}}{12.01\text{ g C}} = \frac{4.90\text{ mol C}}{1.96}$ / $\frac{9.80\text{ g H}}{1} \cdot \frac{1\text{ mol H}}{1.008\text{ g H}} = \frac{9.72\text{ mol H}}{1.96}$ / $\frac{31.4\text{ g O}}{1} \cdot \frac{1\text{ mol O}}{16.00\text{ g O}} = \frac{1.96\text{ mol O}}{1.96}$

↳ 2.5(2) = 5 ↳ 5(2) = 10 ↳ 1(2) = 2

① E.F. = $C_5H_{10}O_2$

E.F. molar mass = 102.13 g/mol

② $\frac{MF}{EF} = \frac{102.13\text{ g/mol}}{102.13\text{ g/mol}} \rightarrow 1$

③ $1 \times (C_5H_{10}O_2) \rightarrow$

↳ $\boxed{MF = C_5H_{10}O_2}$

2. Calculate the Molecular Formula of a compound containing 43.6% P and 56.4% O, if the M.F. molar mass is 284 g/mol.

$\frac{43.6\text{ g P}}{1} \left| \frac{1\text{ mol P}}{30.97\text{ g P}} \right. = \frac{1.41\text{ mol P}}{1.41}$ / $\frac{56.4\text{ g O}}{1} \left| \frac{1\text{ mol O}}{16.00\text{ g O}} \right. = \frac{3.53\text{ mol O}}{1.41}$

↳ 1(2) = 2 ↳ 2.5(2) = 5

① E.F. = P_2O_5

EF Molar mass = 141.94 g/mol

② $\frac{MF}{EF} = \frac{284\text{ g/mol}}{141.94\text{ g/mol}} \rightarrow 2$

③ $2 \times (P_2O_5) \rightarrow$

↳ $\boxed{MF = P_4O_{10}}$

3. The empirical formula of a compound is C_3H_7, with a M.F. molar mass of 86.0 g/mol. Calculate the Molecular Formula (M.F).

① Given: E.F. = C_3H_7

② E.F. molar mass = 43.086 g/mol

③ $\frac{MF}{EF} = \frac{86.0\text{ g/mol}}{43.086\text{ g/mol}} \rightarrow 2$

④ $2 \times (C_3H_7) \rightarrow$

↳ $\boxed{MF = C_6H_{14}}$

4. The empirical formula of a compound is CH, with a M.F. molar mass of 26.0 g/mol. Calculate the Molecular Formula (M.F.).

① Given: E.F. = CH

② E.F. molar mass = 13.018 g/mol

③ $\frac{MF}{EF} = \frac{26.0\text{ g/mol}}{13.018\text{ g/mol}} \rightarrow 2$

④ $2 \times (CH) \rightarrow$

↳ $\boxed{MF = C_2H_2}$

Calculating Hydrates:

1. Hydrated sodium tetraborate, commonly called borax has the general formula $Na_2B_4O_7 \bullet nH_2O$. Chemical analysis indicates that this hydrate is 52.8% sodium tetraborate and 47.2% water. Determine the formula and name the hydrate.

$\frac{52.8\text{ g } Na_2B_4O_7}{1} \left| \frac{1\text{ mol } Na_2B_4O_7}{201.22\text{ g } Na_2B_4O_7} \right. = \frac{0.262\text{ mol } Na_2B_4O_7}{0.262} \rightarrow 1$

$\frac{47.2\text{ g } H_2O}{1} \left| \frac{1\text{ mol } H_2O}{18.016\text{ g } H_2O} \right. = \frac{2.62\text{ mol } H_2O}{0.262} \rightarrow 10$

* Hydrate Formula = $\boxed{Na_2B_4O_7 \bullet 10H_2O}$

* Hydrate Name = $\boxed{\text{Sodium Tetraborate Decahydrate}}$