Name: ____________________

Period: ____ Subject: Chemistry

Date: ____________________

Stoichiometry Worksheet

Please make sure that you ***show all work!*** (italics, bold and underlined – get it?) Some problems include points for intermediate steps as well as the final answer. If the intermediate step isn't shown, the points aren't given! If you need more space than that allotted for the problem, please write "work shown on last page" and show your work on the last page.

1. The combustion of heptane proceeds according to the balanced equation:

$$C_7H_{16} + 11O_2 \; ! \; 7CO_2 + 8H_2O$$

If you burn enough heptane to produce 2.85 mol of water, how many moles of carbon dioxide are produced?

$$2.85 \text{ mol } H_2O \cdot \frac{7 \text{ mol } CO_2}{8 \text{ mol } H_2O} = 2.49375 \text{ mol } CO_2 = 2.49 \text{ mol } CO_2$$

or

$$\frac{7 \text{ mol } CO_2}{8 \text{ mol } H_2O} = \frac{x \text{ mol } CO_2}{2.85 \text{ mol } H_2O}$$

$$7 \text{ mol } CO_2 \cdot 2.85 \text{ mol } H_2O = x \text{ mol } CO_2 \cdot 8 \text{ mol } H_2O$$

$$x \text{ mol } CO_2 = \frac{7 \text{ mol } CO_2 \bullet 2.85 \text{ mol } H_2O}{8 \text{ mol } H_2O} = 2.49375 \text{ mol } CO_2 = 2.49 \text{ mol } CO_2$$

2. You are a forensic consultant called to the scene of The Great Ice Cream Robbery of 2009. A purplish-green unknown substance is found on the knob of the ice cream shop's back door which leads into the alley. You analyze this substance on your North Thurston Super Mass Spectrometer 3000 and find that it is a compound made up of the following elements:

47.3 % carbon
10.6 % hydrogen
42.1 % sulfur

What is the empirical formula of the purplish-green goop you analyzed?

$$47.3 \text{ g C} \cdot \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 3.9383846794 \text{ mol C} = 3.9384 \text{ mol C}$$

$$10.6 \text{ g H} \cdot \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 10.49504950495 \text{ mol H} = 10.4950 \text{ mol H}$$

$$42.1 \text{ g S} \cdot \frac{1 \text{ mol S}}{32.06 \text{ g S}} = 1.31316281971 \text{ mol S} = 1.3132 \text{ mol S}$$

$$\frac{3.9384 \text{ mol C}}{1.3132} = 3.0 \text{ mol C}; \quad \frac{10.4950 \text{ mol H}}{1.3132} = 8.0 \text{ mol H}; \quad \frac{1.3132 \text{ mol S}}{1.3132} = 1.0 \text{ mol S}$$

Empirical formula: C_3H_8S

3. Walking out to the North Thurston Forensi-Van with your purplish-green sample, you step in a puddle of orange ooze. Being the ~~complete science nerd~~ well-respected scientist you are, you decide to analyze the orange stuff as well. Popping the orange stuff into the NTHS SMS3000, you find that your orange compound has a molecular weight of 229.58 g/mol and is made up of:

47.1 % carbon
6.6 % hydrogen
46.3 % chlorine

What are the empirical formula and the molecular formula for the orange ooze?

$$47.1 \text{ g C} \cdot \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 3.92173189009 \text{ mol C} = 3.9217 \text{ mol C}$$

$$6.6 \text{ g H} \cdot \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 6.53465346535 \text{ mol H} = 6.5347 \text{ mol H}$$

$$46.3 \text{ g Cl} \cdot \frac{1 \text{ mol Cl}}{35.45 \text{ g Cl}} = 1.30606488011 \text{ mol Cl} = 1.3061 \text{ mol Cl}$$

$$\frac{3.9217 \text{ mol C}}{1.3061} = 3.0 \text{ mol C}; \quad \frac{6.5347 \text{ mol H}}{1.3061} = 5.0 \text{ mol H}; \quad \frac{1.3061 \text{ mol Cl}}{1.3061} = 1.0 \text{ mol Cl}$$

Empirical formula: C_3H_5Cl

$$\frac{\text{Molar mass (unknown substance)}}{\text{Molar mass (empirical formula)}} = \frac{229.58 \text{ g/mol}}{76.53 \text{ g/mol}} = 3$$

Molecular formula: $C_9H_{15}Cl_3$

4. What is the percent composition by mass of the compound potassium nitrite (KNO_2)? (Please give percentages to the nearest one tenth of a percent).

KNO_2: molar mass = 85.11 g/mol

$$\text{K:} \quad \frac{39.1 \text{ g K}}{85.11 \text{ g } KNO_2} = 0.4594054753 = 45.9\% \text{ K}$$

$$\text{N:} \quad \frac{14.01 \text{ g N}}{85.11 \text{ g } KNO_2} = 0.1646105041 = 16.5\% \text{ N}$$

$$\text{O:} \quad \frac{32.00 \text{ g O}}{85.11 \text{ g } KNO_2} = 0.3759840207 = 37.6\% \text{ O}$$

5. In the reaction $2BiCl_3 + 3H_2S$! $Bi_2S_3 + 6HCl$ bismuth chloride and hydrogen sulfide undergo a double displacement reaction to form bismuth sulfide and hydrochloric acid. Initially you have 0.56 mol of $BiCl_3$ and 0.81 mol of H_2S. Which reactant is in excess and how many extra moles of that reactant are left over after the reaction is complete?

$$0.56 \text{ mol } BiCl_3 \cdot \frac{3 \text{ mol } H_2S}{2 \text{ mol } BiCl_3} = 0.84 \text{ mol } H_2S$$

$$0.81 \text{ mol } H_2S \cdot \frac{2 \text{ mol } BiCl_3}{3 \text{ mol } H_2S} = 0.54 \text{ mol } BiCl_3$$

$$0.56 \text{ mol } BiCl_3 - 0.54 \text{ mol } BiCl_3 = 0.02 \text{ mol } BiCl_3 \text{ excess } BiCl_3$$

6. In a chemical reaction, phosphorus pentachloride and water react to form phosphoric acid and hydrochloric acid. Given initial amounts of 62.47 g of phosphorus pentachloride and 24.32 g of water, determine **a)** which reactant is in excess; **b)** how many grams of that reactant remain after the reaction is complete; **c)** what mass of phosphoric acid *should* be produced; and **d)** what the percent yield is if only 23.0 g of phosphoric acid are produced.

$PCl_5 + 4H_2O$! $H_3PO_4 + 5HCl$

$$62.47 \text{ g } PCl_5 \cdot \frac{1 \text{ mol } PCl_5}{208.22 \text{ g } PCl_5} = 0.3000192 \text{ mol } PCl_5$$

$$24.32 \text{ g } H_2O \cdot \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 1.349612 \text{ mol } H_2O$$

$$0.3000192 \text{ mol } PCl_5 \cdot \frac{4 \text{ mol } H_2O}{1 \text{ mol } PCl_5} = 1.2000768 \text{ mol } H_2O$$ (water in excess)

$1.349612 - 1.2000768 = 0.1495352 \text{ mol } H_2O$

$$0.1495352 \text{ mol } H_2O \cdot \frac{18.02 \text{ g } H_2O}{1 \text{ mol } H_2O} = 2.69462 \text{ g } H_2O = 2.695 \text{ g } H_2O \text{ excess}$$

$$0.3000192 \text{ mol } PCl_5 \cdot \frac{1 \text{ mol } H_3PO_4}{1 \text{ mol } PCl_5} = 0.3000192 \text{ mol } H_3PO_4$$

$$0.3000192 \text{ mol } H_3PO_4 \cdot \frac{98.00 \text{ g } H_3PO_4}{1 \text{ mol } H_3PO_4} = 29.4 \text{ g } H_3PO_4$$

$23.0 \text{ g } H_3PO_4 / 29.4 \text{ g } H_3PO_4 = 78.2\ \%$ yield

7. A 96.144 g sample of a copper sulfate hydrate is heated over a Bunsen burner. After sufficient heating, the sample if found to contain 71.824 g of copper sulfate ($CuSO_4$). What is the correct chemical formula for the copper sulfate hydrate before heating?

$$71.824 \text{ g } CuSO_4 \cdot \frac{1 \text{ mol } CuSO_4}{159.61 \text{ g } CuSO_4} = 0.449997 \text{ mol } CuSO_4$$

$$24.32 \text{ g } H_2O \cdot \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 1.349612 \text{ mol } H_2O$$

$$\frac{1.349612 \text{ mol } H_2O}{0.449997 \text{ mol } CuSO_4} = 3.00$$

Molecular formula of hydrate: $CuSO_4 \cdot 3H_2O$