Problem Set 8: Working With Chemical Equations

1) Balance the following chemical reaction equations.

a) $C_7H_{16} + O_2 \rightarrow CO_2 + H_2O$

b) $H_3AsO_3 \rightarrow As_2O_3 + H_2O$

c) $MgNH_4PO_4 \rightarrow Mg_2P_2O_7 + NH_3 + H_2O$

d) $FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$

e) $Ca_3(PO_4)_2 + SiO_2 + C \rightarrow CaSiO_3 + P_4 + CO$

f) $ZnS + O_2 \rightarrow ZnO + SO_2$

g) $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

h) $CuO + NH_3 \rightarrow Cu + H_2O + N_2$

i) $NH_3 + H_2O \rightarrow NO + H_2O$

j) $CaCl_2 + Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + NaCl$

k) $NH_3 + O_2 \rightarrow NO + H2O$

a) $C_7H_{16} + 11\ O_2 \rightarrow 7\ CO_2 + 8\ H_2O$

b) $2\ H_3AsO_3 \rightarrow As_2O_3 + 3\ H_2O$

c) $2\ MgNH_4PO_4 \rightarrow Mg_2P_2O_7 + 2\ NH_3 + H_2O$

d) $4\ FeS_2 + 11\ O_2 \rightarrow 2\ Fe_2O_3 + 8\ SO_2$

e) $2\ Ca_3(PO_4)_2 + 6\ SiO_2 + 10\ C \rightarrow 6\ CaSiO_3 + P_4 + 10\ CO$

f) $2\ ZnS + 3\ O_2 \rightarrow 2\ ZnO + 2\ SO_2$

g) $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$

h) $3\ CuO + 2\ NH_3 \rightarrow 3\ Cu + 3\ H_2O + N_2$

i) $4\ NH_3 + 5\ H_2O \rightarrow 4\ NO + 6\ H_2O$

j) $3\ CaCl_2 + 2\ Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\ NaCl$

k) $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H2O$

2) Household bleach is an aqueous solution of sodium hypochlorite (NaOCl) that is prepared by the reaction of sodium hydroxide (NaOH) with chlorine. How many grams of sodium hydroxide are required to react with 15.0 g of Cl_2?

$$NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2O$$

Balance the equation: $2\ NaOH + Cl_2 \rightarrow NaOCl + NaCl + H_2O$

$$15.0\ \text{g}\ Cl_2 \times \frac{1\ \text{mol}\ Cl_2}{70.9\ \text{g}\ Cl_2} \times \frac{2\ \text{mol NaOH}}{1\ \text{mol}\ Cl_2} \times \frac{40.00\ \text{g NaOH}}{1\ \text{mol NaOH}} = 16.9\ \text{g NaOH}$$

3) Eggshells are mainly comprised of calcium carbonate ($CaCO_3$), the approximate mass of an average egg shell is 6.3 g. Calcium carbonate dissolves in hydrochloric acid (HCl), what volume of 0.80 M HCl is required to dissolve the shell of an average egg?

$$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Balance the equation: $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2O + CO_2$

$$6.30\ g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.09\ g\ CaCO_3} \times \frac{2\ mol\ HCl}{1\ mol\ CaCO_3} = 0.12589\ mols\ HCl$$

$$0.12589\ \ mols\ HCl \times \frac{1\ L\ HCl}{0.80\ mols\ HCl} = 0.15735\ L = 0.16\ L\ HCl$$

4) Sodium reacts with ethanol to form hydrogen gas and sodium ethoxide.

$$CH_3CH_2OH + Na \rightarrow CH_3CH_2ONa + H_2$$

Calculate the mass of hydrogen gas produced from the reaction of 250.0 mL of ethanol with 10.0 g of sodium. What is the limiting reagent? How many grams of excess reagent are left at the end of the reaction? The density of ethanol is 0.789 g/ml.

Balance the equation: $2\ CH_3CH_2OH + 2\ Na \rightarrow 2\ CH_3CH_2ONa + H_2$

$$250.0\ \text{mL}\ CH_3CH_2OH \times \frac{0.789\ \text{g}}{1\ \text{mL}} = 197.25\ \text{g}\ CH_3CH_2OH$$

$$197.25\ \text{g}\ CH_3CH_2OH \times \frac{1\ \text{mol}\ CH_3CH_2OH}{46.08\ \text{g}\ CH_3CH_2OH} \times \frac{1\ \text{mol}\ H_2}{2\ \text{mol}\ CH_3CH_2OH} \times \frac{2.02\ \text{g}\ H_2}{1\ \text{mol}\ H_2} = 4.323\ \text{g}\ H_2$$

$$10.0\ \text{g Na} \times \frac{1\ \text{mol Na}}{22.99\ \text{g Na}} \times \frac{1\ \text{mol}\ H_2}{2\ \text{mol Na}} \times \frac{2.02\ \text{g}\ H_2}{1\ \text{mol}\ H_2} = 0.4393\ \text{g}\ H_2$$

Limiting reagent is sodium.

$$197.25\ \text{g}\ CH_3CH_2OH \times \frac{1\ \text{mol}\ CH_3CH_2OH}{46.08\ \text{g}\ CH_3CH_2OH} = 4.2805\ \text{initial mols}\ CH_3CH_2OH$$

$$0.4393\text{ g H}_2 \times \frac{1\text{ mol H}_2}{2.02\text{ g H}_2} \times \frac{2\text{ mol CH}_3\text{CH}_2\text{OH}}{1\text{ mol H}_2} = 0.4349\text{ mols CH}_3\text{CH}_2\text{OH used}$$

$$4.2805\text{ initial mols CH}_3\text{CH}_2\text{OH} - 0.4349\text{ mols CH}_3\text{CH}_2\text{OH used}$$
$$= 3.8456\text{ mols CH}_3\text{CH}_2\text{OH remaining}$$

$$3.8456\text{ mols CH}_3\text{CH}_2\text{OH remaining} \times \frac{46.08\text{ g CH}_3\text{CH}_2\text{OH}}{1\text{ mol CH}_3\text{CH}_2\text{OH}} = 177.2\text{ g CH}_3\text{CH}_2\text{OH remaining}$$

5) The decomposition of ammonium nitrate (NH_4NO_3) produces nitrous oxide, laughing gas, and water. To fill a typical cylinder for medicinal use 3.0 kg of laughing gas is required. How much ammonium nitrate must be decomposed to fill a typical cylinder with 3.0 kg of laughing gas? If 2.5 kg of laughing gas was actually produced in the reaction, what is the percent yield?

$$NH_4NO_3 \rightarrow N_2O + H_2O$$

Balance the equation: $NH_4NO_3 \rightarrow N_2O + 2\ H_2O$

$$3.0\text{ kg N}_2\text{O} \times \frac{1000\text{ g}}{1\text{ kg}} \times \frac{1\text{ mol N}_2\text{O}}{44.02\text{ g N}_2\text{O}} \times \frac{1\text{ mol NH}_4\text{NO}_3}{1\text{ mol N}_2\text{O}} \times \frac{80.06\text{ g NH}_4\text{NO}_3}{1\text{ mol NH}_4\text{NO}_3}$$
$$= 5456.15\text{ g NH}_4\text{NO}_3 \times \frac{1\text{ kg}}{1000\text{ g}} = 5.5\text{ kg NH}_4\text{NO}_3$$

$$\frac{2.5\ kg\ N_2O}{3.0\ kg\ N_2O} \times 100 = 83\ \%$$