Name(s)____

Stoichiometry Problems

You may work these problems individually, or with one partner. If you work with a partner, both people will get the same score on the assignment.

1. The reaction of calcium hydride with water can be used to prepare small quantities of hydrogen gas, as is done to fill weather-observation balloons.

$$CaH_2(s) + H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g) \text{ (not balanced)}$$

(a) How many grams of water are consumed in the reaction of 56.2 g CaH_2?

$$CaH_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + 2H_2(g)$$

$$56.2\text{g } CaH_2 \times \frac{1 \text{ mol } CaH_2}{42.10 \text{ g } CaH_2} \times \frac{2 \text{ mol } H_2O}{1 \text{ mol } CaH_2} \times \frac{18.02 \text{ g } H_2O}{1 \text{ mol } H_2O} = \mathbf{48.1 \text{ g } H_2O}$$

(b) What mass of $CaH_2(s)$ must react with an excess of water to produce 8.12×10^{24} molecules of H_2?

$$8.12\times10^{24} \text{ molec. } H_2 \times \frac{1 \text{ mol } H_2}{6.02\times10^{23} \text{ molec.}} \times \frac{1 \text{ mol } CaH_2}{2 \text{ mol } H_2} \times \frac{42.10 \text{ g } CaH_2}{1 \text{ mol } CaH_2} = \mathbf{284 \text{ g } CaH_2}$$

2. The reaction of potassium superoxide, KO_2, is used in life-support systems to replace $CO_2(g)$ in expired air with $O_2(g)$.

$$4\ KO_2(s) + 2\ CO_2(g) \rightarrow 2\ K_2CO_3(S) + 3O_2(g)$$

(a) How many moles of $O_2(g)$ are produced by the reaction of 156 g CO_2 with excess KO_2?

$$156\text{g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } CO_2} = \mathbf{5.32 \text{ mol } O_2}$$

(b) How many grams of KO_2 are consumed per 100.0 g CO_2 removed from expired air?

$$100\text{g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2} \times \frac{4 \text{ mol } KO_2}{2 \text{ mol } CO_2} \times \frac{71.10 \text{ g } KO_2}{1 \text{ mol } KO_2} = \mathbf{323 \text{ g } KO_2}$$

3. Ammonia can be generated by heating together the solids NH_4Cl and $Ca(OH)_2$ with $CaCl_2$ and H_2O also being formed.
   (a) If a mixture containing 33.0 g each of NH_4Cl and $Ca(OH)_2$ is heated, how many grams of NH_3 will form?

$$2\ NH_4Cl + Ca(OH)_2 \rightarrow 2\ NH_3 + 2\ H_2O + CaCl_2$$

Find limiting reactant

$$33.0\text{g } NH_4Cl \times \frac{1 \text{ mol } NH_4Cl}{53.50 \text{ g } NH_4Cl} \times \frac{2 \text{ mol } NH_3}{2 \text{ mol } NH_4Cl} \times \frac{17.04 \text{ g } NH_3}{1 \text{ mol } NH_3} = 10.5 \text{ g } NH_3$$

$$33.0\text{g } Ca(OH)_2 \times \frac{1 \text{ mol } Ca(OH)_2}{74.10 \text{ g } Ca(OH)_2} \times \frac{2 \text{ mol } NH_3}{1 \text{ mol } Ca(OH)_2} \times \frac{17.04 \text{ g } NH_3}{1 \text{ mol } NH_3} = 15.2 \text{ g } NH_3$$

Therefore NH_4Cl is the limiting reactant and 10.5 g NH_3 can be made.

   (b) Which reactant remains in excess, and in what mass?

$$10.5 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.04 \text{ g } NH_3} \times \frac{1 \text{ mol } Ca(OH)_2}{2 \text{ mol } NH_3} \times \frac{74.01 \text{ g } Ca(OH)_2}{1 \text{ mol } Ca(OH)_2} = 22.8 \text{ g } Ca(OH)_2$$

Therefore 22.8 g $Ca(OH)_2$ will be consumed and (33.0 – 22.8)g = 10.2 g $Ca(OH)_2$ will remain.

4. Azobenzene ($(C_6H_5N)_2$), an intermediate in the manufacture of dyes, can be prepared from nitrobenzene ($C_6H_5NO_2$) by reaction with triethylene glycol ($C_6H_{14}O_4$). In one reaction, 120 g of nitrobenzene and 310 mL of triethylene glycol (*d* = 1.12 g/mL) yields 55 g azobenzene.

$$2\ C_6H_5NO_2 + 4\ C_6H_{14}O_4 \rightarrow (C_6H_5N)_2 + 4\ C_6H_{12}O_4 + 4\ H_2O$$

   (a) What is the theoretical yield?

$$120 \text{ g } C_6H_5NO_2 \times \frac{1 \text{ mol } C_6H_5NO_2}{123.1 \text{ g } C_6H_5NO_2} \times \frac{1 \text{ mol } (C_6H_5N)_2}{2 \text{ mol } C_6H_5NO_2} = 0.487 \text{ mol } (C_6H_5N)_2$$

$$300 \text{ mL } C_6H_{14}O_4 \times \frac{1.12 \text{ g } C_6H_{14}O_4}{1 \text{ mL } C_6H_{14}O_4} \times \frac{1 \text{ mol } C_6H_{14}O_4}{150.2 \text{ g } C_6H_{14}O_4} \times \frac{1 \text{ mol } (C_6H_5N)_2}{4 \text{ mol } C_6H_{14}O_4} = 0.559 \text{ mol } (C_6H_5N)_2$$

So, $C_6H_5NO_2$ is our limiting reactant and our theoretical yield is:

$$0.487 \text{ mol } (C_6H_5N)_2 \times \frac{182.26\text{g } (C_6H_5N)_2}{1 \text{ mol } (C_6H_5N)_2} = \mathbf{88.8 \text{ g } (C_6H_5N)_2}$$

   (b) What is the actual yield?

The actual yield is **55 g**

   (c) What is the percent yield of this reaction?

$$\% \text{ yield} = \frac{55 \text{ g}}{89 \text{ g}} \times 100\% = \mathbf{62\ \%\ yield}$$