CHEM 210 Laboratory Discussion • STOICHIOMETRY 1

Key

1. Consider the reaction, $2\ KBr + Cl_2 \rightarrow 2\ KCl + Br_2$. If 4.5 g of KBr is reacted in excess chlorine, what mass of Br_2 could be produced?

(119.0 g/mol KBr; 159.8 g/mol Br_2)

$$4.5\text{ g KBr} \left| \frac{1\text{ mol KBr}}{119.0\text{ g KBr}} \right| \frac{1\text{ mol } Br_2}{2\text{ mol KBr}} \left| \frac{159.8\text{ g } Br_2}{1\text{ mol } Br_2} \right| = 3.0\text{ g } Br_2$$

2. Fermentation is a complex chemical process of wine making in which glucose is converted into ethanol and carbon dioxide:

(180.16 g/mol $C_6H_{12}O_6$)

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

Starting with 500. g of glucose, what is the maximum ~~amount~~ volume of ethanol that can be obtained by this process? (Density of ethanol = 0.789 g/mL.)

$$500\text{ g } C_6H_{12}O_6 \left| \frac{1\text{ mol } C_6H_{12}O_6}{180.16\text{ g } C_6H_{12}O_6} \right| \frac{2\text{ mol } C_2H_5OH}{1\text{ mol } C_6H_{12}O_6} \left| \frac{46.07\text{ g } C_2H_5OH}{1\text{ mol } C_2H_5OH} \right| \frac{1\text{ mL } C_2H_5OH}{0.789\text{ g } C_2H_5OH}$$

$$= 324\text{ mL}$$

3. Calculate the mass in grams of elemental iodine that will react completely with 20.4g of aluminum metal to form aluminum iodide.

$$2\ Al + 3\ I_2 \longrightarrow 2\ AlI_3$$

(26.98 g/mol Al; 253.8 g/mol I_2)

20.4 g Al; g = ?

$$20.4\text{ g Al} \left| \frac{1\text{ mol Al}}{26.98\text{ g Al}} \right| \frac{3\text{ mol } I_2}{2\text{ mol Al}} \left| \frac{253.8\text{ g } I_2}{1\text{ mol } I_2} \right| = \boxed{288\text{ g } I_2}$$

4. Hydrogen fluoride is used in the manufacture of Freons (which destroy ozone in the stratosphere) and in the production of aluminum metal. It is prepared by the reaction

78.08 20.01
$$\mathbf{CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2\ HF}$$

In an industrial process 6.00 kg of CaF_2 are treated with an excess of H_2SO_4 and yield 2.86 kg of HF. Calculate the percent yield of HF.

$$6.00\text{ kg } CaF_2 \left|\frac{1000\text{ g}}{1\text{ kg}}\right| \frac{1\text{ mol } CaF_2}{78.08\text{ g } CaF_2} \left|\frac{2\text{ mol HF}}{1\text{ mol } CaF_2}\right| \frac{20.01\text{ g HF}}{1\text{ mol HF}} \left|\frac{1\text{ kg}}{1000\text{ g}}\right.$$

$$TY = 3.0\overline{7}5\text{ kg}$$

$$\%Y = \frac{2.86\text{ kg}}{3.0\overline{7}5\text{ kg}} \times 100\% = \boxed{93.0\%}$$

5. Industrially, nitric acid is produced by the Ostwald process, with the following balanced equation:

$M_n = 17.03$ g/mol $M_n = 63.02$ g/mol
mass = ? 1.00 ton desired
$$\mathbf{4\ NH_{3(g)} + 7\ O_{2(g)} \rightarrow 2\ HNO_{3(aq)} + 2\ HNO_{2(aq)} + 4\ H_2O_{(l)}}$$

The reaction proceeds by the following steps:

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(l)}$$

$$4\ NO_{(g)} + 2\ O_{2(g)} \rightarrow 4\ NO_{2(g)}$$

$$4\ NO_{2(g)} + 2\ H_2O_{(l)} \rightarrow 2\ HNO_{3(aq)} + 2\ HNO_{2(aq)}$$

What mass of NH_3 (in kg) must be used to produce 1.00 ton of HNO_3 by the above procedure, assuming an 80.0% percent yield in each of the three steps?(1 ton = 2000 lb; 1 lb = 453.6 g.)

Desired actual yield = 1.00 ton

If each step yields only 80% (0.80), then the TY can be calculated by:

$$(TY) \times (0.8) \times (0.8) \times (0.8) = 1.00\text{ tons}$$

$$TY = 1.9\overline{5}3\text{ tons}$$

$$1.9\overline{5}3\text{ tons } HNO_3 \left|\frac{2000\text{ lbs}}{1\text{ ton}}\right| \frac{453.6\text{ g}}{1\text{ lb}} \left|\frac{1\text{ mol } HNO_3}{63.02\text{ g } HNO_3}\right| \frac{4\text{ mol } NH_3}{2\text{ mol } HNO_3} \left|\frac{17.03\text{ g } NH_3}{1\text{ mol } NH_3}\right| \frac{1\text{ kg}}{1000\text{ g}}$$

$$= 958\text{ kg}$$