CHEQ 1094 STOICHIOMETRY: ANSWERS

1. (a) FW of $KClO_3$ = 39.1 + 35.45 + 3(16.0) = 122.6 g/mol

$$\text{mol } KClO_3 = 3.00 \text{ g } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.6 \text{ g } KClO_3} = 0.02447 \text{ mol } KClO_3$$

$$\text{mol } O_2 = 0.02447 \text{ mol } KClO_3 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} = 0.03671 \text{ mol } O_2$$

$$\text{mass } O_2 = 0.03671 \text{ mol } O_2 \times \frac{32.0 \text{ g } O_2}{1 \text{ mol } O_2} = 1.17 \text{ g } O_2$$

(b) FW of KCl = 39.1 + 35.45 = 74.55 g/mol
from the equation, mol KCl = mol $KClO_3$ = 0.02447 mol KCl
mass KCl = 0.02447 mol x 74.55 g/mol = 1.82 g KCl

(c) $$\text{mol } O_2 = 3.00 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} = 0.09375 \text{ mol } O_2$$

$$\text{mol } KClO_3 = 0.09375 \text{ mol } O_2 \times \frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2} = 0.06250 \text{ mol } KClO_3$$

$$\text{mass } KClO_3 = 0.06250 \text{ mol } KClO_3 \times \frac{122.6 \text{ g } KClO_3}{1 \text{ mol } KClO_3} = 7.66 \text{ g } KClO_3$$

(d) theoretical yield (TY) of O_2 from 3.00 g $KClO_3$ = 0.03671 mol O_2
therefore, TY of O_2 from 9.00 g $KClO_3$ = 3 x 0.03671 mol O_2 = 0.1101 mol O_2
TY of O_2 in grams = 0.1101 mol O_2 x 32.0 g/mol = 3.524 g O_2

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theor. yield}} \times 100 = \frac{3.30 \text{ g}}{3.524 \text{ g}} \times 100 = 93.6\%$$

2. FW of NH_4Cl = 14.01 + 4(1.01) + 35.45 = 53.50 g/mol
FW of CaO = 40.1 + 16.0 = 56.1 g/mol
FW of NH_3 = 14.01 + 3(1.01) = 17.04 g/mol

$$\text{mol } NH_4Cl = 23.8 \text{ g } NH_4Cl \times \frac{1 \text{ mol } NH_4Cl}{53.5 \text{ g } NH_4Cl} = 0.4449 \text{ mol } NH_4Cl$$

$$\text{mol CaO} = 0.4449 \text{ mol } NH_4Cl \times \frac{1 \text{ mol CaO}}{2 \text{ mol } NH_4Cl} = 0.22245 \text{ mol CaO}$$

$$\text{mass CaO} = 0.22245 \text{ mol CaO} \times \frac{56.1 \text{ g CaO}}{1 \text{ mol CaO}} = 12.5 \text{ g CaO}$$

mol NH_3 = mol NH_4Cl = 0.4449 mol
mass NH_3 = 0.4449 mol x 17.04 g/mol = 7.58 g NH_3

3. 10.0 g is the **actual yield** of CH_4 needed;

$$\text{therefore, } \frac{10.0 \text{ g}}{\text{theor. yield}} \times 100 = 93.5 \quad \text{and theor. yield} = 10.70 \text{ g}$$

$$\text{mass } Al_4C_3 = 10.70 \text{ g } CH_4 \times \frac{1 \text{ mol } CH_4}{16.0 \text{ g } CH_4} \times \frac{1 \text{ mol } Al_4C_3}{3 \text{ mol } CH_4} \times \frac{144 \text{ g } Al_4C_3}{1 \text{ mol } Al_4C_3}$$

= 32.1 g Al_4C_3

4. let ethyl alcohol = E, glucose = G, and theoretical yield = TY

$$\text{TY of E} = 454 \text{ g G} \times \frac{1 \text{ mol G}}{180 \text{ g G}} \times \frac{2 \text{ mol E}}{1 \text{ mol G}} \times \frac{46.0 \text{ g E}}{1 \text{ mol E}} = 232.0 \text{ g E}$$

actual yield = (232.0 x 0.88) g = 204.2 g
volume of E = 204.2 g x 1 mL/0.789 g = 259 mL

5. (a) mass of Mg_3N_2 = 47.5 g imp. Mg_3N_2 x 0.860 = 40.85 g

$$\text{mass of } NH_3 = 40.85 \text{ g } Mg_3N_2 \times \frac{1 \text{ mol } Mg_3N_2}{100.9 \text{ g } Mg_3N_2} \times \frac{2 \text{ mol } NH_3}{1 \text{ mol } Mg_3N_2} \times \frac{17.0 \text{ g } NH_3}{1 \text{ mol } NH_3}$$

= 13.8 g NH_3

$$\text{(b) mass of } Mg_3N_2 = 62.6 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.0 \text{ g } NH_3} \times \frac{1 \text{ mol } Mg_3N_2}{2 \text{ mol } NH_3} \times \frac{100.9 \text{ g } Mg_3N_2}{1 \text{ mol } Mg_3N_2}$$

= 185.8 g Mg_3N_2

$$\text{mass of 91.0\% } Mg_3N_2 = 185.8 \text{ g } Mg_3N_2 \times \frac{100 \text{ g imp. } Mg_3N_2}{91.0 \text{ g } Mg_3N_2} = 204 \text{ g imp. (91.0\%) } Mg_3N_2$$

$$\text{(c) mass of } Mg_3N_2 = 8.50 \text{ g } NH_3 \times \frac{1 \text{ mol } NH_3}{17.0 \text{ g } NH_3} \times \frac{1 \text{ mol } Mg_3N_2}{2 \text{ mol } NH_3} \times \frac{100.9 \text{ g } Mg_3N_2}{1 \text{ mol } Mg_3N_2}$$

= 25.23 g Mg_3N_2

$$\text{mass of sample of } Mg_3N_2 = 31.0 \text{ g; therefore, \% purity} = \frac{25.23}{31.0} \times 100 = 81.4\%$$

6. FW of $Na_2CO_3 \cdot 10H_2O$ = (2x23.0) + (12.0) + (3x16.0) + (10x18.0) = 286.0
FW of Na_3PO_4 = (3x23.0) + (31.0) + (4x16.0) = 164.0
mass of $Na_2CO_3 \cdot 10H_2O$ =

$$25.0 \text{ g } Na_3PO_4 \text{ x } \frac{1 \text{ mol } Na_3PO_4}{164 \text{ g } Na_3PO_4} \text{ x } \frac{3 \text{ mol } Na_2CO_3 \cdot 10H_2O}{2 \text{ mol } Na_3PO_4} \text{ x } \frac{286 \text{ g } Na_2CO_3 \cdot 10H_2O}{1 \text{ mol } Na_2CO_3 \cdot 10H_2O}$$

= 65.4 g $Na_2CO_3 \cdot 10H_2O$

7. (a) mass Na_2S needed to react with 3.50 g $FeBr_3$

$$= 3.50 \text{ g } FeBr_3 \text{ x } \frac{1 \text{ mol } FeBr_3}{295.6 \text{ g } FeBr_3} \text{ x } \frac{3 \text{ mol } Na_2S}{2 \text{ mol } FeBr_3} \text{ x } \frac{78.1 \text{ g } Na_2S}{1 \text{ mol } Na_2S} = 1.39 \text{ g } Na_2S$$

BUT, 6.40 g of Na_2S are available; hence Na_2S is **in excess** and $FeBr_3$ is the **limiting reactant**.

$$\text{mass } Fe_2S_3 = 3.50 \text{ g } FeBr_3 \text{ x } \frac{1 \text{ mol } FeBr_3}{295.6 \text{ g } FeBr_3} \text{ x } \frac{1 \text{ mol } Fe_2S_3}{2 \text{ mol } FeBr_3} \text{ x } \frac{208 \text{ g } Fe_2S_3}{1 \text{ mol } Fe_2S_3}$$

= 1.23 g Fe_2S_3

(b) mass of Na_2S reacted = 1.39 g; excess Na_2S = (6.40-1.39) g
= 5.01 g

8. mass BF_3 needed to react with 1.30 g $NaBH_4$

$$= 1.30 \text{ g } NaBH_4 \text{ x } \frac{1 \text{ mol } NaBH_4}{37.8 \text{ g } NaBH_4} \text{ x } \frac{4 \text{ mol } BF_3}{3 \text{ mol } NaBH_4} \text{ x } \frac{67.8 \text{ g } BF_3}{1 \text{ mol } BF_3} = 3.11 \text{ g } BF_3$$

BUT, only 2.50 g BF_3 are available; hence BF_3 is the **limiting reactant**.

$$\text{mass } B_2H_6 = 2.50 \text{ g } BF_3 \text{ x } \frac{1 \text{ mol } BF_3}{67.8 \text{ g } BF_3} \text{ x } \frac{2 \text{ mol } B_2H_6}{4 \text{ mol } BF_3} \text{ x } \frac{27.6 \text{ g } B_2H_6}{1 \text{ mol } B_2H_6} = 0.509 \text{ g } B_2H_6$$

$$\text{mass } NaBH_4 \text{ reacted} = 2.50 \text{ g } BF_3 \text{ x } \frac{1 \text{ mol } BF_3}{67.8 \text{ g } BF_3} \text{ x } \frac{3 \text{ mol } NaBH_4}{4 \text{ mol } BF_3} \text{ x } \frac{37.8 \text{ g } NaBH_4}{1 \text{ mol } NaBH_4}$$

= 1.05 g $NaBH_4$
therefore, mass of $NaBH_4$ left = (1.30-1.05) g = 0.25 g

9. mass PH_3 needed to react with 5.50 g O_2

$$= 5.50 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} \times \frac{4 \text{ mol } PH_3}{8 \text{ mol } O_2} \times \frac{34.0 \text{ g } PH_3}{1 \text{ mol } PH_3} = 2.92 \text{ g } PH_3$$

BUT, 3.00 g of PH_3 are available; hence PH_3 is **in excess** and O_2 is the **limiting reactant**.

Since the actual yield of P_4O_{10} (5.60 g) is given, calculation of the theoretical yield (TY) of P_4O_{10} would allow the determination of the percent yield.

$$\text{TY of } P_4O_{10} = 5.50 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} \times \frac{1 \text{ mol } P_4O_{10}}{8 \text{ mol } O_2} \times \frac{284 \text{ g } P_4O_{10}}{1 \text{ mol } P_4O_{10}} = 6.10 \text{ g } P_4O_{10}$$

$$\text{percent yield of } P_4O_{10} = \frac{5.60}{6.10} \times 100 = 91.8\%$$

10. (a) **Exothermic**, because heat is *produced* in the reaction.

(b) $$\text{heat produced} = 222 \text{ g } C_3H_8 \times \frac{1 \text{ mol } C_3H_8}{44.0 \text{ g } C_3H_8} \times \frac{2200 \text{ kJ}}{1 \text{ mol } C_3H_8} = 1.11 \times 10^4 \text{ kJ}$$

(c) $$\text{mass of } CO_2 = 456 \text{ J} \times \frac{3 \text{ mol } CO_2}{2200 \times 10^3 \text{ J}} \times \frac{44.0 \text{ g } CO_2}{1 \text{ mol } CO_2} = 0.0274 \text{ g } CO_2$$

11. (a) **Endothermic**, because heat is *added* in the reaction.

(b) $$\text{heat required} = 454 \text{ g } Ca(OH)_2 \times \frac{1 \text{ mol } Ca(OH)_2}{74.1 \text{ g } Ca(OH)_2} \times \frac{66 \text{ kJ}}{1 \text{ mol } Ca(OH)_2} = 4.0 \times 10^2 \text{ kJ}$$