CHEM 1110 ANSWERS TO STOICHIOMETRY PROBLEM SET

1. moles of SCl_2 = $4.00 \text{ g } SCl_2 \times \frac{1 \text{ mol } SCl_2}{103.1 \text{ g } SCl_2} = 0.03880 \text{ mol } SCl_2$

moles NaF = $2.00 \text{ g NaF} \times \frac{1 \text{ mol NaF}}{42.0 \text{ g NaF}} = 0.04762 \text{ mole NaF}$

moles SCl_2 needed to react with 0.04762 mol NaF

$= 0.04762 \text{ mol NaF} \times \frac{3 \text{ mol } SCl_2}{4 \text{ mol NaF}} = 0.03572 \text{ mol } SCl_2$

BUT, 0.03880 mol SCl_2 is available; hence SCl_2 is in EXCESS and NaF is LIMITING.

moles SF_4 = $0.04762 \text{ mol NaF} \times \frac{1 \text{ mol } SF_4}{4 \text{ mol NaF}} = 0.01191 \text{ mol } SF_4$

mass SF_4 = $0.01191 \text{ mol } SF_4 \times \frac{108.1 \text{ g } SF_4}{1 \text{ mol } SF_4}$ = **1.29 g SF_4**

2. moles BF_3 = $54.0 \text{ g } BF_3 \times \frac{1 \text{ mol } BF_3}{67.8 \text{ g } BF_3} = 0.7965 \text{ mol } BF_3$

mass $NaBH_4$ = $25.0 \text{ g "85.0\% } NaBH_4\text{"} \times \frac{85.0 \text{ g } NaBH_4}{100 \text{ g "85.0\% } NaBH_4\text{"}} = 21.25 \text{ g } NaBH_4$

moles $NaBH_4$ = $21.25 \text{ g } NaBH_4 \times \frac{1 \text{ mol } NaBH_4}{37.8 \text{ g } NaBH_4} = 0.5622 \text{ mol } NaBH_4$

moles $NaBH_4$ needed to react with with 0.7965 mol BF_3

$= 0.7965 \text{ mol } BF_3 \times \frac{3 \text{ mol } NaBH_4}{4 \text{ mol } BF_3} = 0.5974 \text{ mol } NaBH_4$

BUT, only 0.5622 mol $NaBH_4$ is available; hence $NaBH_4$ is the LIMITING REACTANT.

moles B_2H_6 = $0.5622 \text{ mol } NaBH_4 \times \frac{2 \text{ mol } B_2H_6}{3 \text{ mol } NaBH_4} = 0.3748 \text{ mol } B_2H_6$

mass B_2H_6 = $0.3748 \text{ mol } B_2H_6 \times \frac{27.7 \text{ g } B_2H_6}{1 \text{ mol } B_2H_6}$ = **10.4 g B_2H_6**

3. $$\text{moles } O_2 = 0.655 \text{ L } O_2 \times \frac{1 \text{ mol } O_2}{22.4 \text{ L } O_2} = 0.02924 \text{ mol } O_2$$

$$\text{moles } KO_2 = 0.02924 \text{ mol } O_2 \times \frac{4 \text{ mol } KO_2}{3 \text{ mol } O_2} = 0.03899 \text{ mole } KO_2$$

$$\text{mass } KO_2 = 0.03899 \text{ mol } KO_2 \times \frac{71.1 \text{ g } KO_2}{1 \text{ mol } KO_2} = 2.772 \text{ g } KO_2$$

$$\% \text{ purity} = \frac{2.772}{3.30} \times 100 = \mathbf{84.0\ \%}$$

4. MW of $C_{17}H_{21}O_4N$ (cocaine; "coc") = 303.2 g/mole
MW of $C_{12}H_{22}O_{11}$ (sucrose; "suc") = 342.2 g/mole

1 mole of $C_{17}H_{21}O_4N$ produces 17 moles of CO_2 on combustion
1 mole of $C_{12}H_{22}O_{11}$ produces 12 moles of CO_2 on combustion

Let $\boldsymbol{x}$ = mass (mg) of cocaine; 1-$\boldsymbol{x}$ = mass (mg) of sucrose

mass of CO_2 produced from cocaine =

$$\frac{\boldsymbol{x}}{303.2} \text{ mmol coc} \times \frac{17 \text{ mmol } CO_2}{1 \text{ mmol coc}} \times \frac{44.01 \text{ mg } CO_2}{1 \text{ mmol } CO_2} = 2.468\boldsymbol{x} \text{ mg } CO_2$$

mass of CO_2 produced from sucrose =

$$\frac{(1-\boldsymbol{x})}{342.2} \text{ mmol suc} \times \frac{12 \text{ mmol } CO_2}{1 \text{ mmol suc}} \times \frac{44.01 \text{ mg } CO_2}{1 \text{ mmol } CO_2} = 1.543 - 1.543\boldsymbol{x}$$

total mass of $CO_2 = 2.468\boldsymbol{x} + 1.543 - 1.543\boldsymbol{x} = 1.75$
$(2.468 - 1.543)\boldsymbol{x} = 1.75 - 1.543$
$0.928\boldsymbol{x} = 0.207$
$\boldsymbol{x} = 0.22$ mg

$$\% \text{ cocaine} = \frac{0.22 \text{ mg cocaine}}{1.00 \text{ mg mixture}} \times 100 = \mathbf{22\%}$$

5. 86 proof is equivalent to 43 mL of ethanol (EtOH) in 100 mL of solution.
Consider 100 mLof solution ≡ 0.100 L

$$\text{moles EtOH} = 43 \text{ mL EtOH} \times \frac{0.79 \text{ g EtOH}}{1 \text{ mL EtOH}} \times \frac{1 \text{ mol EtOH}}{46.0 \text{ g EtOH}} = 0.738 \text{ mol}$$

$$\text{molarity} = \frac{0.738 \text{ mol EtOH}}{0.100 \text{ L}} = \mathbf{7.4}\ \boldsymbol{M}$$

6. Since I_2 is in excess, SO_3^{2-} is limiting.
No. of moles SO_3^{2-} oxidized = No.of moles $Na_2SO_3 \cdot XH_2O$ originally present

$$= 0.0400 \text{ L NaOH sol.} \times \frac{0.100 \text{ mol NaOH}}{1 \text{ L NaOH sol.}} \times \frac{1 \text{ mol OH}^-}{1 \text{ mol NaOH}} \times \frac{1 \text{ mol H}^+}{1 \text{ mol OH}^-}$$

$$\times \frac{1 \text{ mol SO}_3^{2-}}{2 \text{ mol H}^+} \times \frac{1 \text{ mol SO}_3^{2-}}{1 \text{ mol Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O}} = 2.00 \times 10^{-3} \text{ mol Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O}$$

$$\text{Molar mass of Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O} = \frac{0.4322 \text{ g Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O}}{2.00 \times 10^{-3} \text{ mol Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O}} = 216 \text{ g/mol}$$

$$X = \frac{\text{Molar mass Na}_2\text{SO}_3 \cdot \text{XH}_2\text{O} - \text{Molar mass Na}_2\text{SO}_3}{\text{Molar mass H}_2\text{O}}$$

$= \frac{216 - 126}{18.0} = 5$ Therefore, formula is **$Na_2SO_3 \cdot 5H_2O$**

7. Let X g = mass of Cu in alloy and Y g = mass of Ag in alloy

mass of NO_2 formed from X g Cu =

$$\text{X g Cu} \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \times \frac{2 \text{ mol NO}_2}{1 \text{ mol Cu}} \times \frac{46.01 \text{ g NO}_2}{1 \text{ mol NO}_2} = 1.448 \text{ X}$$

mass of NO_2 formed from Y g Ag =

$$\text{Y g Ag} \times \frac{1 \text{ mol Ag}}{107.9 \text{ g Ag}} \times \frac{1 \text{ mol NO}_2}{1 \text{ mol Ag}} \times \frac{46.01 \text{ g NO}_2}{1 \text{ mol NO}_2} = 0.4264 \text{ Y}$$

total mass of NO_2 formed = 1.448 X + 0.4264 Y = 10.00 g ....(1)
But, X + Y = 10.0 g; therefore, X = 10.0 - Y ....(2)

substitution of Eqn. 2 into Eqn.1 gives:

1.448 (10.0- Y) + 0.4264 Y = 10.00

hence, Y = 4.385 g = mass of Ag

% Ag by mass = $\frac{4.385 \text{ g Ag}}{10.0 \text{ g alloy}} \times 100 =$ **43.85%**