CHEM 105 **ANSWERS TO PROBLEM SET 2**

1. (a) No. of g MnO_2 =

$$32.1 \text{ g } Cl_2 \times \frac{1 \text{ mole } Cl_2}{70.9 \text{ g } Cl_2} \times \frac{1 \text{ mole } MnO_2}{1 \text{ mole } Cl_2} \times \frac{86.9 \text{ g } MnO_2}{1 \text{ mole } MnO_2}$$

$= 39.34$ g MnO_2 % purity = $\frac{39.34}{50.0} \times 100 = 78.7\ \%$

(b) No. of moles MnO_2

$$= 25.0 \text{ g imp. } MnO_2 \times \frac{88.5 \text{ g } MnO_2}{100 \text{ g imp. } MnO_2} \times \frac{1 \text{ mole } MnO_2}{86.9 \text{ g } MnO_2}$$

$= 0.2546$ mole MnO_2

No. of moles HCl = $1.50 \text{ L} \times \frac{0.635 \text{ mole HCl}}{1 \text{ L}} = 0.9525$ mole HCl

For 0.2546 mole MnO_2, moles HCl needed =

$$0.2546 \text{ mole } MnO_2 \times \frac{4 \text{ moles HCl}}{1 \text{ mole } MnO_2} = 1.018 \text{ moles HCl}$$

But, only 0.9525 mole of HCl is available and therefore
HCl is the limiting reactant.

$$\text{No. of g } Cl_2 = 0.9525 \text{ mole HCl} \times \frac{1 \text{ mole } Cl_2}{4 \text{ moles HCl}} \times \frac{70.9 \text{ g } Cl_2}{1 \text{ mole } Cl_2}$$

$= 16.9$ g Cl_2

2. Actual yield = 13.7 g $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = 86.5$

therefore, theoretical yield = $\frac{13.7 \text{ g} \times 100}{86.5} = 15.84$ g

No. of g NH_3 needed =

$$15.84 \text{ g } H_2O \times \frac{1 \text{ mole } H_2O}{18.0 \text{ g } H_2O} \times \frac{4 \text{ mole } NH_3}{6 \text{ mole } H_2O} \times \frac{17.0 \text{ g } NH_3}{1 \text{ mole } NH_3} = 9.97 \text{ g } NH_3$$

3. No. of g H_2SO_4 = 1000 mL H_2SO_4 x $\frac{1.85 \text{ g } H_2SO_4}{1 \text{ mL } H_2SO_4}$ = 1850 g H_2SO_4

No. of moles H_2SO_4 = 1850 g H_2SO_4 x $\frac{1 \text{ mole } H_2SO_4}{98.1 \text{ g } H_2SO_4}$ = 18.86 mole

No. of moles SO_3 = 18.86 mole H_2SO_4 x $\frac{1 \text{ mole } SO_3}{1 \text{ mole } H_2SO_4}$ = 18.86 mole SO_3

No. of moles SO_2 = 18.86 mole SO_3 x $\frac{2 \text{ mole } SO_2}{2 \text{ mole } SO_3}$ = 18.86 mole SO_2

No. of moles FeS_2 = 18.86 mole SO_2 x $\frac{4 \text{ mole } FeS_2}{8 \text{ mole } SO_2}$ = 9.430 mole FeS_2

No. of g FeS_2 = 9.430 mole FeS_2 x $\frac{120.0 \text{ g } FeS_2}{1 \text{ mole } FeS_2}$ = 1.13 x 10^3 g FeS_2

4. No. of moles HCl = 0.066 g H_2 x $\frac{1 \text{ mole } H_2}{2.02 \text{ g } H_2}$ x $\frac{\boldsymbol{x} \text{ mole HCl}}{0.5\boldsymbol{x} \text{ mole } H_2}$

= 0.06533 mole HCl

No. of moles V = 1.11 g V x $\frac{1 \text{ mole V}}{50.94 \text{ g V}}$ = 0.02179 mole V

$\boldsymbol{x} = \frac{\text{moles HCl}}{\text{moles V}} = \frac{0.06533}{0.02179} = 3.00$

5. From 4.00 g SCl_2: No. of g SF_4 =

4.00 g SCl_2 x $\frac{1 \text{ mole } SCl_2}{103.1 \text{ g } SCl_2}$ x $\frac{1 \text{ mole } SF_4}{3 \text{ mole } SCl_2}$ x $\frac{108.1 \text{ g } SF_4}{1 \text{ mole } SF_4}$ = 1.40 g SF_4

From 2.00 g NaF: No. of g SF_4 =

2.00 g NaF x $\frac{1 \text{ mole NaF}}{42.0 \text{ g NaF}}$ x $\frac{1 \text{ mole } SF_4}{4 \text{ mole NaF}}$ x $\frac{108.1 \text{ g } SF_4}{1 \text{ mole } SF_4}$ = 1.29 g SF_4

Therefore, NaF is the **limiting reactant**, SCl_2 is **in excess** and 1.29 g of SF_4 **can be produced**.

No. of g SCl_2 reacted =

$$2.00 \text{ g NaF} \times \frac{1 \text{ mole NaF}}{42.0 \text{ g NaF}} \times \frac{3 \text{ mole } SCl_2}{4 \text{ mole NaF}} \times \frac{103.1 \text{ g } SCl_2}{1 \text{ mole } SCl_2} = 3.68 \text{ g } SCl_2$$

No. of g SCl_2 left over = 4.00 g - 3.68 g = 0.32 g
1(b) can be done by this method and *vice versa*.

6.

		C	:	H	:	Cl
mass ratio		29.95		3.137		66.91
mole ratio		$\frac{29.95}{12.01}$		$\frac{3.137}{1.008}$		$\frac{66.91}{35.45}$
	=	2.494		3.112		1.887
	=	$\frac{2.494}{1.887}$		$\frac{3.112}{1.887}$		$\frac{1.887}{1.887}$
	=	1.32		1.65		1
x 3	=	4		5		3

empirical formula is $C_4H_5Cl_3$

empirical formula weight = (4 x 12) + (5 x 1) + (3 x 35.5) = 159.5 molecular formula =

$n(C_4H_5Cl_3)$ where $n = \frac{MW}{EFW} = \frac{320}{159.5} \approx 2$

molecular formula = $C_8H_{10}Cl_6$

7. no. of moles H_2SO_4 in final solution = final vol (L) x final *M*

$= 0.0440 \text{ L} \times \frac{0.0375 \text{ mole}}{1 \text{ L}} = 0.00165 \text{ mole} =$ H_2SO_4 left over

no. of moles H_2SO_4 reacted with NaOH =

$$24.0 \text{ mL NaOH} \times \frac{0.100 \text{ mole NaOH}}{1000 \text{ mL NaOH}} \times \frac{1 \text{ mole } H_2SO_4}{2 \text{ mole NaOH}} = 0.00120 \text{ mole } H_2SO_4$$

original no. of moles H_2SO_4 = moles reacted + moles left
= 0.00120 + 0.00165 = 0.00285 mole

$$\text{original molarity} = \frac{0.00285 \text{ mole}}{\text{original vol. of } H_2SO_4} = \frac{0.00285 \text{ mole}}{0.0200 \text{ L}} = 0.1425\ M$$

8. Consider 100 g of solution: mass of HNO_3 = 40.0 g

$$\text{moles } HNO_3 = 40.0 \text{ g } HNO_3 \times \frac{1 \text{ mole } HNO_3}{63.0 \text{ g } HNO_3} = 0.6349 \text{ mole}$$

$$V_{solution} = 100 \text{ g} \times \frac{1 \text{ mL}}{1.25 \text{ g}} = 80.0 \text{ mL} = 0.0800 \text{ L}. \quad \text{Molarity} = \frac{0.6349 \text{ mole}}{0.0800 \text{ L}} = 7.94\ M$$

9. Consider 1.00 L (1000 mL) of solution:

$$\text{mass of KBr} = 3.44 \text{ moles KBr} \times \frac{119 \text{ g KBr}}{1 \text{ mole KBr}} = 409.4 \text{ g KBr}$$

$$\text{mass of solution} = 409.4 \text{ g KBr} \times \frac{100 \text{ g solution}}{32.0 \text{ g KBr}} = 1279 \text{ g soln.}$$

$$\text{density of solution} = \frac{1279 \text{ g}}{1000 \text{ mL}} = 1.28 \text{ g/mL}$$

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

$$\text{moles } NaBH_4 = 25.0 \text{ g } 85.0\% \ NaBH_4 \times \frac{85.0 \text{ g } NaBH_4}{100 \text{ g } 85.0\% \ NaBH_4} \times \frac{1 \text{ mole } NaBH_4}{37.8 \text{ g } NaBH_4}$$

= 0.5622 mole $NaBH_4$. Moles of $NaBH_4$ needed to react with 0.7965 mole of BF_3 =

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

BUT only 0.5622 mole of $NaBH_4$ is available. Therefore, $NaBH_4$ is the LIMITING REACTANT
Theoretical yield of B_2H_6 =

$$0.5622 \text{ mole } NaBH_4 \times \frac{2 \text{ mole } B_2H_6}{3 \text{ mole } NaBH_4} \times \frac{27.7 \text{ g } B_2H_6}{1 \text{ mole } B_2H_6} = 10.3 \text{ g } B_2H_6$$

11. $$\text{Mass } KO_2 = 0.655 \text{ L } O_2 \times \frac{1 \text{ mole } O_2}{22.4 \text{ L } O_2} \times \frac{4 \text{ mole } KO_2}{3 \text{ mole } O_2} \times \frac{71.1 \text{ g } KO_2}{1 \text{ mole } KO_2} = 2.772 \text{ g}$$

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