1. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

2.46 g (H_2O)

a)

$$2.46 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 0.137 \text{ mol } H_2O$$

b)

$$2.46 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{2 \text{ mol } C_4H_{10}}{10 \text{ mol } H_2O} = 0.0273 \text{ mol } C_4H_{10}$$

c)

$$2.46 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{2 \text{ mol } C_4H_{10}}{10 \text{ mol } H_2O} \times \frac{58.14 \text{ g } C_4H_{10}}{1 \text{ mol } C_4H_{10}} = 1.59 \text{ g } C_4H_{10}$$

d)

$$2.46 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{13 \text{ mol } O_2}{10 \text{ mol } H_2O} \times \frac{32.00 \text{ g } O_2}{1 \text{ mol } O_2} = 5.68 \text{ g } O_2$$

2. $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$

a)

$$25 \text{ mol } C_2H_6O \times \frac{3 \text{ mol } O_2}{1 \text{ mol } C_2H_6O} = 75 \text{ mol } O_2$$

b)

$$30 \text{ mol } O_2 \times \frac{1 \text{ mol } C_2H_6O}{3 \text{ mol } O_2} = 10 \text{ mol } C_2H_6O$$

$$30 \text{ mol } O_2 \times \frac{2 \text{ mol } CO_2}{3 \text{ mol } O_2} = 20 \text{ mol } CO_2$$

c)

$$23 \text{ mol } CO_2 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } CO_2} = 34.5 \text{ mol } O_2$$

d)

$$41 \text{ mol } H_2O \times \frac{3 \text{ mol } O_2}{3 \text{ mol } H_2O} = 41 \text{ mol } O_2$$

$$41 \text{ mol } H_2O \times \frac{2 \text{ mol } CO_2}{3 \text{ mol } H_2O} = 27.3 \text{ mol } CO_2$$

3. $Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$

a) $$25 \text{ mol } Fe_2O_3 \times \frac{2 \text{ mol } Fe}{1 \text{ mol } Fe_2O_3} = 50 \text{ mol } Fe$$

b) $$30 \text{ mol } Fe \times \frac{3 \text{ mol } H_2}{2 \text{ mol } Fe} = 45 \text{ mol } H_2$$

c) $$120 \text{ mol } H_2O \times \frac{1 \text{ mol } Fe_2O_3}{3 \text{ mol } H_2O} \times \frac{159.7 \text{ g } Fe_2O_3}{1 \text{ mol } Fe_2O_3} = 6388 \text{ g } Fe_2O_3$$

4. $N_2H_4 + 7H_2O_2 \rightarrow 2HNO_3 + 8H_2O$

a) $$2.68 \text{ mol } N_2H_4 \times \frac{7 \text{ mol } H_2O_2}{1 \text{ mol } N_2H_4} = 18.76 \text{ mol } H_2O_2$$

b) $$2.68 \text{ mol } N_2H_4 \times \frac{2 \text{ mol } HNO_3}{1 \text{ mol } N_2H_4} = 5.36 \text{ mol } HNO_3$$

c) $$2.68 \text{ mol } N_2H_4 \times \frac{8 \text{ mol } H_2O}{1 \text{ mol } N_2H_4} = 21.44 \text{ mol } H_2O$$

5. $\underset{250\text{ g}}{WO_3(s)} + \underset{?\text{ g}}{3H_2(g)} \Longrightarrow \underset{?\text{ g}}{W(s)} + 3H_2O(l)$

a) $$250 \text{ g } WO_3 \times \frac{1 \text{ mol } WO_3}{231.84 \text{ g } WO_3} \times \frac{1 \text{ mol } W}{1 \text{ mol } WO_3} \times \frac{183.84 \text{ g } W}{1 \text{ mol } W} = 198 \text{ g } W$$

b) $$250 \text{ g } WO_3 \times \frac{1 \text{ mol } WO_3}{231.84 \text{ g } WO_3} \times \frac{3 \text{ mol } H_2}{1 \text{ mol } WO_3} \times \frac{2.02 \text{ g } H_2}{1 \text{ mol } H_2} = 6.53 \text{ g } H_2$$

STOICHIOMETRIC PROBLEMS 2B – ANSWERS

1.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

C_4H_{10}: ? g; H_2O: 100 g

$$100\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} \times \frac{2\text{ mol } C_4H_{10}}{10\text{ mol } H_2O} \times \frac{58.14\text{ g } C_4H_{10}}{1\text{ mol } C_4H_{10}} = 64.53\text{ g } C_4H_{10}$$

2.

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

$KClO_3$: 2.50 mol; O_2: ? mol

$$2.50\text{ mol } KClO_3 \times \frac{3\text{ mol } O_2}{2\text{ mol } KClO_3} = 3.75\text{ mol } O_2$$

3.

$$3\ Ca(NO_3)_2 + 2\ K_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\ KNO_3$$

$Ca(NO_3)_2$: 80.00 g; K_3PO_4: ? g; $Ca_3(PO_4)_2$: ? g; KNO_3: ? g

$$80.00\text{ g } Ca(NO_3)_2 \times \frac{1\text{ mol } Ca(NO_3)_2}{164.10\text{ g } Ca(NO_3)_2} \times \frac{1\text{ mol } Ca_3(PO_4)_2}{3\text{ mol } Ca(NO_3)_2} \times \frac{310.18\text{ g } Ca_3(PO_4)_2}{1\text{ mol } Ca_3(PO_4)_2} = 50.41\text{ g } Ca_3(PO_4)_2$$

$$80.00\text{ g } Ca(NO_3)_2 \times \frac{1\text{ mol } Ca(NO_3)_2}{164.10\text{ g } Ca(NO_3)_2} \times \frac{2\text{ mol } K_3PO_4}{3\text{ mol } Ca(NO_3)_2} \times \frac{212.27\text{ g } K_3PO_4}{1\text{ mol } K_3PO_4} = 68.99\text{ g } K_3PO_4$$

$$80.00\text{ g } Ca(NO_3)_2 \times \frac{1\text{ mol } Ca(NO_3)_2}{164.10\text{ g } Ca(NO_3)_2} \times \frac{6\text{ mol } KNO_3}{3\text{ mol } Ca(NO_3)_2} \times \frac{101.11\text{ g } KNO_3}{1\text{ mol } KNO_3} = 98.58\text{ g } KNO_3$$

4. mass reactants $= \text{mass } Ca(NO_3)_2 + \text{mass } K_3PO_4$
$= 80.00\text{ g} + 68.99\text{ g}$
$= 148.99\text{ g}$

mass products $= \text{mass } Ca_3(PO_4)_2 + \text{mass } KNO_3$
$= 50.41\text{ g} + 98.58\text{ g}$
$= 148.99\text{ g}$

The mass of reactants and products are the same (or nearly the same). This makes sense, since the law of conservation of mass states that matter cannot be created nor destroyed, therefore mass is conserved.

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5. $$\underset{25.0\text{ g}}{Al_2O_3} + 3\ H_2O \rightarrow \underset{?\text{ g}}{2\ Al(OH)_3}$$

$$25.0\text{ g } Al_2O_3 \times \frac{1\text{ mol } Al_2O_3}{101.96\text{ g } Al_2O_3} \times \frac{2\text{ mol } Al(OH)_3}{1\text{ mol } Al_2O_3} \times \frac{78.01\text{ g } Al(OH)_3}{1\text{ mol } Al(OH)_3} = 38.3\text{ g } Al(OH)_3$$

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6. $$\underset{35.0\text{ g}}{2\ CuO} \rightarrow \underset{?\text{ g}}{Cu_2O} + O_2$$

$$35.0\text{ g } CuO \times \frac{1\text{ mol } CuO}{79.55\text{ g } CuO} \times \frac{1\text{ mol } Cu_2O}{2\text{ mol } CuO} \times \frac{143.10\text{ g } Cu_2O}{1\text{ mol } Cu_2O} = 31.5\text{ g } Cu_2O$$

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7. $$\underset{11.0\text{ mol}}{Ca(ClO_3)_2} \rightarrow \underset{?\text{ g}}{CaCl_2} + \underset{?\text{ mol}}{3\ O_2}$$

$$11.0\text{ mol } Ca(ClO_3)_2 \times \frac{3\text{ mol } O_2}{1\text{ mol } Ca(ClO_3)_2} = 33.0\text{ mol } O_2$$

$$11.0\text{ mol } Ca(ClO_3)_2 \times \frac{1\text{ mol } CaCl_2}{1\text{ mol } Ca(ClO_3)_2} \times \frac{110.98\text{ g } CaCl_2}{1\text{ mol } CaCl_2} = 1220\text{ g } CaCl_2$$

8.

$$\underset{?\ \text{mol}}{Cu} + \underset{1.25\ \text{mol}}{2\ AgNO_3} \rightarrow Cu(NO_3)_2 + 2\ Ag$$

? g (AgNO₃)   132 g (Ag)

$$1.25\ \text{mol}\ AgNO_3 \times \frac{1\ \text{mol}\ Cu}{2\ \text{mol}\ AgNO_3} = 0.625\ \text{mol}\ Cu$$

$$132\ \text{g}\ Ag \times \frac{1\ \text{mol}\ Ag}{107.87\ \text{g}\ Ag} \times \frac{1\ \text{mol}\ AgNO_3}{1\ \text{mol}\ Ag} \times \frac{169.88\ \text{g}\ AgNO_3}{1\ \text{mol}\ AgNO_3} = 208\ \text{g}\ AgNO_3$$

9.

$$\underset{25.0\ \text{kg}}{Fe_2O_3} + 3\ C \rightarrow \underset{?\ \text{kg}}{2\ Fe} + 3\ CO$$

$$25.0\ \text{kg}\ Fe_2O_3 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol}\ Fe_2O_3}{159.70\ \text{g}\ Fe} \times \frac{2\ \text{mol}\ Fe}{1\ \text{mol}\ Fe_2O_3}$$

$$\times \frac{55.85\ \text{g}\ Fe}{1\ \text{mol}\ Fe} \times \frac{1\ \text{kg}}{1000\ \text{g}} = 17.5\ \text{kg}\ Fe$$

10.

$$\underset{120\ \text{g}}{C_6H_{12}O_6} + 6\ O_2 \rightarrow \underset{?\ \text{g}}{6\ CO_2} + 6\ H_2O$$

$$120\ \text{g}\ C_6H_{12}O_6 \times \frac{1\ \text{mol}\ C_6H_{12}O_6}{180.18\ \text{g}\ C_6H_{12}O_6} \times \frac{6\ \text{mol}\ CO_2}{1\ \text{mol}\ C_6H_{12}O_6} \times \frac{44.01\ \text{g}\ CO_2}{1\ \text{mol}\ CO_2} = 176\ \text{g}\ CO_2$$

The mass of oxygen added to carbon in carbon dioxide gives this product more mass when compared to the mass of oxygen (and hydrogen) added to the carbon in glucose.

11. $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

14.0 g ? mol ? g

$$14.0\text{ g } NH_3 \times \frac{1\text{ mol } NH_3}{17.04\text{ g } NH_3} \times \frac{6\text{ mol } H_2O}{4\text{ mol } NH_3} \times \frac{18.02\text{ g } H_2O}{1\text{ mol } H_2O} = 22.2\text{ g } H_2O$$

$$14.0\text{ g } NH_3 \times \frac{1\text{ mol } NH_3}{17.04\text{ g } NH_3} \times \frac{5\text{ mol } O_2}{4\text{ mol } NH_3} = 1.03\text{ mol } O_2$$

Sheet #2

1. $2S + 3O_2 \longrightarrow 2SO_3$

$9 mol\ O_2 \times \frac{2 mol\ S}{3 mol\ O_2} = 6 mol\ S$

2. $4FeS + 7O_2 \longrightarrow 2Fe_2O_3 + 4SO_2$

$7.81 g\ O_2 \times \frac{1 mol\ O_2}{32 g\ O_2} \times \frac{4 mol\ FeS}{7 mol\ O_2} \times \frac{87.92 g\ FeS}{1 mol\ FeS} = 12.3 g\ FeS$

$6.79 mol\ FeS \times \frac{7 mol\ O_2}{4 mol\ FeS} = 11.88 mol\ O_2$

3. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

$6.4 g\ CH_4 \times \frac{1 mol\ CH_4}{16.05 g\ CH_4} \times \frac{2 mol\ O_2}{1 mol\ CH_4} \times \frac{32 g\ O_2}{1 mol\ O_2} = 25.52 g\ O_2$

$6.4 g\ CH_4 \times \frac{1 mol\ CH_4}{16.05 g\ CH_4} \times \frac{1 mol\ CO_2}{1 mol\ CH_4} \times \frac{44.01 g\ CO_2}{1 mol\ CO_2} = 17.55 g\ CO_2$

4. $Na_2CO_3 + 2HCl_{(aq)} \longrightarrow 2NaCl + CO_2 + H_2O$

$286 g\ CO_2 \times \frac{1 mol\ CO_2}{44.01 g\ CO_2} \times \frac{1 mol\ Na_2CO_3}{1 mol\ CO_2} \times \frac{106.01 g\ Na_2CO_3}{1 mol\ Na_2CO_3} = 688.91 g\ Na_2CO_3$

$286 g\ CO_2 \times \frac{1 mol\ CO_2}{44.01 g\ CO_2} \times \frac{2 mol\ HCl}{1 mol\ CO_2} \times \frac{36.46 g\ HCl}{1 mol\ HCl} = 473.87 g\ HCl$

5. $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$

$8.61 mol\ Na_2SO_4 \times \frac{2 mol\ NaOH}{1 mol\ Na_2SO_4} = 17.22 mol\ NaOH$

$4.77 mol\ Na_2SO_4 \times \frac{1 mol\ H_2SO_4}{1 mol\ Na_2SO_4} \times \frac{98.09 g\ H_2SO_4}{1 mol\ H_2SO_4} = 467.9 g\ H_2SO_4$

6. $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

$20 g\ Zn \times \frac{1 mol\ Zn}{65.41 g\ Zn} \times \frac{1 mol\ ZnCl_2}{1 mol\ Zn} \times \frac{136.31 g\ ZnCl_2}{1 mol\ ZnCl_2} = 41.68 g\ ZnCl_2$

$20 g\ Zn \times \frac{1 mol\ Zn}{65.41 g\ Zn} \times \frac{1 mol\ H_2}{1 mol\ Zn} \times \frac{2.02 g\ H_2}{1 mol\ H_2} = 0.618 g\ H_2$

$$20g\ Zn \times \frac{1mol\ Zn}{65.39g\ Zn} \times \frac{2mol\ HCl}{1mol\ Zn} \times \frac{36.46g\ HCl}{1mol\ HCl} = 22.3\ g\ HCl$$

7. $2KClO_3 \longrightarrow 2KCl + 3O_2$

$$5g\ KClO_3 \times \frac{1mol\ KClO_3}{122.55g\ KClO_3} \times \frac{3mol\ O_2}{2mol\ KClO_3} \times \frac{32g\ O_2}{1mol\ O_2} = 1.96g\ O_2$$

8. $Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$

$$4g\ AgNO_3 \times \frac{1mol\ AgNO_3}{169.88g\ AgNO_3} \times \frac{1mol\ Cu}{2mol\ AgNO_3} \times \frac{63.55g\ Cu}{1mol\ Cu} = .748g\ Cu$$

9. $(NH_4)_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + 2NH_3 + 2H_2O$

$$20g\ Ca(OH)_2 \times \frac{1mol\ Ca(OH)_2}{74.1g\ Ca(OH)_2} \times \frac{2mol\ NH_3}{1mol\ Ca(OH)_2} \times \frac{17.04g\ NH_3}{1mol\ NH_3} = 9.2g\ NH_3$$

10. $H_2SO_4 + 2NaCl \longrightarrow 2HCl + Na_2SO_4$

$$30g\ NaCl \times \frac{1mol\ NaCl}{58.45g\ NaCl} \times \frac{2mol\ HCl}{2mol\ NaCl} \times \frac{36.46g\ HCl}{1mol\ HCl} = 18.7g\ HCl$$

Dec 7/12.

Sheet #3: Volume → Amount → Amount → Volume

1. $CaCO_3 \rightarrow CaO + CO_2$

a) $1Kg\,CaCO_3 \times \frac{1000g\,CaCO_3}{1Kg\,CaCO_3} \times \frac{1mol\,CaCO_3}{100.086g\,CaCO_3} \times \frac{1mol\,CaO}{1mol\,CaCO_3} \times \frac{56.077g\,CaO}{1mol\,CaO}$

$= 560.288g\,CaO$

b) $1Kg\,CaCO_3 \times \frac{1000g\,CaCO_3}{1Kg\,CaCO_3} \times \frac{1mol\,CaCO_3}{100.086g\,CaCO_3} \times \frac{1mol\,CO_2}{1mol\,CaCO_3} \times \frac{22.414L\,CO_2}{1mol\,CO_2}$

$= 223.947L\,CO_2$

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

a) $454g\,C_6H_{12}O_6 \times \frac{1mol\,C_6H_{12}O_6}{180.18g\,C_6H_{12}O_6} \times \frac{2mol\,C_2H_5OH}{1mol\,C_6H_{12}O_6} \times \frac{46.08g\,C_2H_5OH}{1mol\,C_2H_5OH}$

$= 232.21g\,C_2H_5OH$

b) $454g\,C_6H_{12}O_6 \times \frac{1mol\,C_6H_{12}O_6}{180.18g\,C_6H_{12}O_6} \times \frac{2mol\,CO_2}{1mol\,C_6H_{12}O_6} = 5.0394mol\,CO_2$

$P = 101.325 Kpa$
$V = ?$
$n = 5.0394 mol$
$R = 8.314 \frac{KPa \cdot L}{mol \cdot K}$
$T = 300.15K$

$\frac{PV}{P} = \frac{nRT}{P}$

$V = \frac{nRT}{P}$

$\rightarrow V = \frac{(5.0394mol\,CO_2)(8.314\frac{KPa \cdot L}{mol \cdot K})(300.15K)}{101.325KPa}$

$V = 124.1L$

3. $4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$

a) $2500g\,NH_3 \times \frac{1mol\,NH_3}{17.03g\,NH_3} \times \frac{5mol\,O_2}{4mol\,NH_3} \times \frac{22.414L\,O_2}{1mol\,O_2} = 4112.96L\,O_2$

b) $2500g\,NH_3 \times \frac{1mol\,NH_3}{17.03g\,NH_3} \times \frac{4mol\,NO}{4mol\,NH_3} \times \frac{30g\,NO}{1mol\,NO} = 4403.99g\,NO$

4. $3Zn + 2MoO_3 \rightarrow Mo_2O_3 + 3ZnO$

$20g\,MoO_3 \times \frac{1mol\,MoO_3}{143.94MoO_3} \times \frac{1mol\,Mo_2O_3}{2mol\,MoO_3} \times \frac{239.88Mo_2O_3}{1mol\,Mo_2O_3} = 16.66g\,Mo_2O_3$

$20g\,MoO_3 \times \frac{1mol\,MoO_3}{143.94MoO_3} \times \frac{3mol\,ZnO}{2mol\,MoO_3} \times \frac{81.409g\,ZnO}{1mol\,ZnO} = 16.967g\,ZnO$

5. $CaCO_3 + 2HCl \rightarrow CO_2 + H_2O + CaCl_2$

$$15g\,HCl \times \frac{1mol\,HCl}{36.463g\,HCl} \times \frac{1mol\,CaCO_3}{2mol\,HCl} \times \frac{100.088g\,CaCO_3}{1mol\,CaCO_3} = 20.587g\,CaCO_3$$

$$15g\,HCl \times \frac{1mol\,HCl}{36.463g\,HCl} \times \frac{1mol\,CO_2}{2mol\,HCl} \times \frac{44.01g\,CO_2}{1mol\,CO_2} = 9.0524g\,CO_2.$$

6. $2KNO_3 + 3C + S \rightarrow N_2 + 3CO_2 + K_2S$

$$50g\,KNO_3 \times \frac{1mol\,KNO_3}{101.105g\,KNO_3} \times \frac{1mol\,N_2}{2mol\,KNO_3} \times \frac{22.414L\,N_2}{1mol\,N_2} = 5.542L\,N_2$$

$$50g\,KNO_3 \times \frac{1mol\,KNO_3}{101.105g\,KNO_3} \times \frac{3mol\,CO_2}{2mol\,KNO_3} \times \frac{22.414L\,CO_2}{1mol\,CO_2} = 16.626L\,CO_2$$

$5.542L\,N_2 + 16.626L\,CO_2 = 22.168L$ gas

7. $2NH_3 + 3Ca \rightarrow 3CaH_2 + N_2$

$$30L\,N_2 \times \frac{1mol\,N_2}{22.414L\,N_2} \times \frac{3mol\,Ca}{1mol\,N_2} \times \frac{40.078g\,Ca}{1mol\,Ca} = 160.927g\,Ca$$

8 $C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2$

$$1L\,C_3H_8 \times \frac{1mol\,C_3H_8}{22.414L\,C_3H_8} \times \frac{5mol\,O_2}{1mol\,C_3H_8} \times \frac{22.414L\,O_2}{1mol\,O_2} = 5L\,O_2$$

$$\frac{100L\,air}{21L\,O_2} = \frac{23.80952L\,air}{5L\,O_2}$$ ∴ the optimum Ratio is 23.8095L of air.

Sheet #4

1\. a) $2Cu_2S + 3O_2 \Rightarrow 2Cu_2O + 2SO_2$

b) $2C_2H_6 + 5F_2 \Rightarrow 2C_2HF_5 + 5H_2$

c) $Bi_2O_3 + 3H_2 \Rightarrow 2Bi + 3H_2O$

d) $Al_4C_3 + 12H_2O \Rightarrow 3CH_4 + 4Al(OH)_3$

2\. $3Fe + 4H_2O \Rightarrow Fe_3O_4 + 4H_2$

$16.8\text{g Fe} \times \frac{1\text{ mol Fe}}{55.845\text{g Fe}} \times \frac{4\text{ mol }H_2}{3\text{ mol Fe}} \times \frac{22.414\text{ L }H_2}{1\text{ mol }H_2} = 8.99\text{ L }H_2$

3\. $2C_4H_{10} + 13O_2 \Rightarrow 8CO_2 + 10H_2O$

a) $11\text{g }C_4H_{10} \times \frac{1\text{ mol }C_4H_{10}}{58.124\text{g }C_4H_{10}} \times \frac{13\text{ mol }O_2}{2\text{ mol }C_4H_{10}} \times \frac{31.998\text{g }O_2}{1\text{ mol }O_2} = 39.36166\text{g }O_2$

b) 〃 $\times \frac{8\text{ mol }CO_2}{2\text{ mol }C_4H_{10}} \times \frac{22.414\text{ L }CO_2}{1\text{ mol }CO_2} = 16.967\text{ L }CO_2$

4\. $2ZnS + 3O_2 \Rightarrow 2ZnO + 2SO_2$

$ZnO + C \Rightarrow Zn + CO$

$150.0\text{g ZnS} \times \frac{1\text{ mol ZnS}}{97.46\text{g ZnS}} \times \frac{2\text{ mol ZnO}}{2\text{ mol ZnS}} = 1.539\text{ mol ZnO}$

$1.539\text{ mol ZnO} \times \frac{1\text{ mol Zn}}{1\text{ mol ZnO}} \times \frac{65.39\text{g Zn}}{1\text{ mol Zn}} = 100.64\text{g Zn}$

5\. $4NH_3 + 5O_2 \Rightarrow 4NO + 6H_2O$

$1\text{ mol }NH_3 \times \frac{5\text{ mol }O_2}{4\text{ mol }NH_3} \times \frac{22.414\text{ L }O_2}{1\text{ mol }O_2} = 28.0175\text{ L }O_2$

$1\text{ mol }NH_3 \times \frac{4\text{ mol NO}}{4\text{ mol }NH_3} \times \frac{22.414\text{ L }O_2}{1\text{ mol }O_2} = 22.414\text{ L NO}$

6\. $2C_6H_6 + 15O_2 \Rightarrow 12CO_2 + 6H_2O$

$25.0\text{ L }O_2 \times \frac{1\text{ mol }O_2}{22.414\text{ L }O_2} \times \frac{2\text{ mol }C_6H_6}{15\text{ mol }O_2} \times \frac{78.114\text{g }C_6H_6}{1\text{ mol }C_6H_6} = 11.6168\text{g }C_6H_6$

7\. $3H_2 + N_2 \Rightarrow 2NH_3$

$5.00\text{ L }NH_3 \times \frac{1\text{ mol }NH_3}{22.414\text{ }NH_3} \times \frac{3\text{ mol }H_2}{2\text{ mol }NH_3} \times \frac{2.016\text{g }H_2}{1\text{ mol }H_2} = 0.6746\text{g }H_2$

8\. $2KClO_3 \Rightarrow 2KCl + 3O_2$

$125\text{g }KClO_3 \times \frac{1\text{ mol }KClO_3}{122.548\text{g }KClO_3} \times \frac{3\text{ mol }O_2}{2\text{ mol }KClO_3} = 1.53\text{ mol }O_2$

$P = 101.325\text{ kPa}$

$V = ?$

$n = 1.53\text{ mol}$

$R = 8.314\ \frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}}$

$T = 100\,°C + 273.15 = 373.15\text{ K}$

$V = \frac{nRT}{P}$

$= \frac{1.53\text{ mol} \times 8.314\ \frac{\text{kPa}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 373.15\text{K}}{101.325\text{ kPa}}$

$= 46.8455\text{ L }O_2$

9\. $3Fe_2O_3 + CO \Rightarrow 2Fe_3O_4 + CO_2$

$14.0\text{g CO} \times \frac{1\text{ mol CO}}{28.01\text{g CO}} \times \frac{3\text{ mol }Fe_2O_3}{1\text{ mol CO}} \times \frac{159.687\text{g }Fe_2O_3}{1\text{ mol }Fe_2O_3} = 239.445\text{g }Fe_2O_3$

Sheet #5

1. $S + O_2 \Rightarrow SO_2$

$SO_2 + CaO \Rightarrow CaSO_3$

$$1200\text{ t coal} \times \frac{2.8\text{ t S}}{100\text{ t coal}} \times \frac{1000000\text{ g S}}{1\text{ t S}} \times \frac{1\text{ mol S}}{32.066\text{ g S}} \times \frac{1\text{ mol }SO_2}{1\text{ mol S}} \times \frac{1\text{ mol }CaSO_3}{1\text{ mol }SO_2} \times \frac{120.141\text{ g }CaSO_3}{1\text{ mol }CaSO_3} \ldots$$

$$\ldots \times \frac{1\text{ t }CaSO_3}{1000000\text{ g }CaSO_3} = 125.8884\text{ t }CaSO_3$$

2. $Cu + 2AgNO_3 \Rightarrow 2Ag + Cu(NO_3)_2$

$$158\text{ g Cu} \times \frac{1\text{ mol Cu}}{63.546\text{ g Cu}} \times \frac{2\text{ mol Ag}}{1\text{ mol Cu}} \times \frac{107.868\text{ g Ag}}{1\text{ mol Ag}} = 536.403\text{ g Ag}$$

3. $2NH_4NO_3 \Rightarrow 4H_2O + 2N_2 + O_2$

$$12.0\text{ g }NH_4NO_3 \times \frac{1\text{ mol }NH_4NO_3}{80.06\text{ g }NH_4NO_3} \times \frac{7\text{ mol }(H_2O+N_2+O_2=\text{gas})}{2\text{ mol }NH_4NO_3} = 0.525\text{ mol gas}$$

$$P = 745\text{ torr} \times \frac{101.325\text{ kPa}}{760\text{ torr}} = 99.325\text{ kPa}$$

$V = ?$

$n = 0.525$ mol gas

$R = 8.314 \frac{kPa \cdot L}{mol \cdot K}$

$T = 527°C + 273.15 = 800.15\text{ K}$

$$V = \frac{nRT}{P} = \frac{0.525\text{ mol gas} \times 8.314 \frac{kPa \cdot L}{mol \cdot K} \times 800.15\text{ K}}{99.325\text{ kPa}} = 35.1\text{ L gas}$$

4. $CaCO_3 \Rightarrow CaO + CO_2$

mass CO_2 = MASS ORIGINAL − MASS RESIDUE = 500g − 300g = 200g CO_2!

$$200\text{ g }CO_2 \times \frac{1\text{ mol }CO_2}{44.009\text{ g }CO_2} \times \frac{1\text{ mol }CaCO_3}{1\text{ mol }CO_2} \times \frac{100.086\text{ g }CaCO_3}{1\text{ mol }CaCO_3} = 454.8433\text{ g }CaCO_3$$

$$\%\text{ of }CaCO_3\text{ in original} = \frac{454.8433\text{ g }CaCO_3}{500\text{ g original}} \times 100\% = 90.97\%$$

5. $Na_2CO_3 + 2HCl \Rightarrow CO_2 + H_2O + 2NaCl$

$$50.0\text{ g }Na_2CO_3 \times \frac{60\%\ Na_2CO_3}{100\%\ Na_2CO_3} \times \frac{1\text{ mol }Na_2CO_3}{105.99\text{ g }Na_2CO_3} \times \frac{1\text{ mol }CO_2}{1\text{ mol }Na_2CO_3} \times \frac{44.01\text{ g }CO_2}{1\text{ mol }CO_2} = 12.5\text{ g }CO_2$$

6. $Fe_2O_3 + 3CO \Rightarrow 2Fe + 3CO_2$

$$1.00\text{ t }Fe_2O_3 \times \frac{1000000\text{ g }Fe_2O_3}{1.00\text{ t }Fe_2O_3} \times \frac{1\text{ mol }Fe_2O_3}{159.69\text{ g }Fe_2O_3} \times \frac{2\text{ mol Fe}}{1\text{ mol }Fe_2O_3} \times \frac{55.85\text{ g Fe}}{1\text{ mol Fe}} \times \frac{1\text{ kg Fe}}{1000\text{ g Fe}} = 699.5\text{ kg Fe}$$

7. $FeSAs \Rightarrow FeS + As$

$$1\text{ kg As} \times \frac{1000\text{ g As}}{1\text{ kg As}} \times \frac{1\text{ mol As}}{74.922\text{ g As}} \times \frac{1\text{ mol FeSAs}}{1\text{ mol As}} \times \frac{162.833\text{ g FeSAs}}{1\text{ mol FeSAs}} \times \frac{1\text{ kg FeSAs}}{1000\text{ g FeSAs}} = 2.173\text{ kg FeSAs}$$

8. $N_2O_4 + 2N_2H_4 \Rightarrow 3H_2 + 4H_2O$

$$25.0\text{ t }N_2O_4 \times \frac{1000000\text{ g }N_2O_4}{1\text{ t }N_2O_4} \times \frac{1\text{ mol }N_2O_4}{92.01\text{ g }N_2O_4} \times \frac{2\text{ mol }N_2H_4}{1\text{ mol }N_2O_4} \times \frac{32.046\text{ g }N_2H_4}{1\text{ mol }N_2H_4} \times \frac{1\text{ t }N_2H_4}{1000000\text{ g }N_2H_4} = 17.4144\text{ t }N_2H_4$$

SHEET 6 ANSWERS

1. 16.0 g of Ca_2C reacts with 42.0 g of H_2O according to the following reaction:

$$CaC_2(s) + 2\,H_2O(l) \longrightarrow C_2H_2(g) + Ca(OH)_2(s)$$

a) Determine which reactant in the limiting reagent.
b) What mass of $C_2H_2(g)$ and $Ca(OH)_2(s)$ is produced.
c) Calculate the excess mass of the excess reagent

$$\underset{16.0\text{ g}}{CaC_2(s)} + \underset{42.0\text{ g}}{2\,H_2O(l)} \longrightarrow \underset{?\text{ g}}{C_2H_2(g)} + \underset{?\text{ g}}{Ca(OH)_2(s)}$$

a) This question is usually not asked directly. If there is information given about two or more reactants, this step MUST BE TAKEN.

Consider CaC_2 :

$$16.0\text{ g }CaC_2 \text{ x } \frac{1\text{ mol }CaC_2}{64.10\text{ g }CaC_2} = 0.250\text{ mol }CaC_2\text{ available}$$

$$0.250\text{ mol }CaC_2 \text{ x } \frac{2\text{ mol }H_2O}{1\text{ mol }CaC_2} = 0.499\text{ mol }H_2O\text{ required}$$

Consider H_2O :

$$42.0\text{ g }H_2O \text{ x } \frac{1\text{ mol }H_2O}{18.02\text{ g }H_2O} = 2.33\text{ mol }H_2O\text{ available}$$

$$2.23\text{ mol }H_2O \text{ x } \frac{1\text{ mol }CaC_2}{2\text{ mol }H_2O} = 1.17\text{ mol }CaC_2\text{ required}$$

therefore the limiting reagent is CaC_2

b) These are examples of typical final questions.

$$0.250\text{ mol }CaC_2 \text{ x } \frac{1\text{ mol }C_2H_2}{1\text{ mol }CaC_2} \text{ x } \frac{26.04\text{ g }C_2H_2}{1\text{ mol }C_2H_2} = 6.50\text{ g }C_2H_2\text{ produced}$$

$$0.250\text{ mol }CaC_2 \text{ x } \frac{1\text{ mol }Ca(OH)_2}{1\text{ mol }CaC_2} \text{ x } \frac{74.10\text{ g }Ca(OH)_2}{1\text{ mol }Ca(OH)_2} = 18.5\text{ g }Ca(OH)_2\text{ produced}$$

c) This is not a typical question but it helps to point out that there will be left overs for the excess reagent.

$$0.250\text{ mol }CaC_2 \text{ x } \frac{2\text{ mol }H_2O}{1\text{ mol }CaC_2} \text{ x } \frac{18.02\text{ g }H_2O}{1\text{ mol }H_2O} = 9.00\text{ g }H_2O\text{ consumed}$$

$$\begin{aligned}\text{mass }H_2O\text{ excess} &= (\text{mass }H_2O\text{ available}) - (\text{mass }H_2O\text{ consumed})\\ &= (42.0\text{ g }H_2O) - (9.00\text{ g }H_2O)\\ &= 33.0\text{ g }H_2O\text{ remains after reaction}\end{aligned}$$

2. Consider the following reaction at S.T.P. If 35 g of tungsten trioxide reacts with 15 L of H_2 at S.T.P., what mass of tungsten is produced?

$$\underset{35.0\text{ g}}{WO_3(s)} + \underset{15.0\text{ L}}{3\,H_2(g)} \longrightarrow \underset{?\text{ g}}{W(s)} + 3\,H_2O(aq)$$

Consider WO_3 :

$$35.0 \text{ g } WO_3 \text{ x } \frac{1 \text{ mol } WO_3}{231.84 \text{ g } WO_3} = 0.151 \text{ mol } WO_3 \text{ available}$$

$$0.151 \text{ mol } WO_3 \text{ x } \frac{3 \text{ mol } H_2}{1 \text{ mol } WO_3} = 0.453 \text{ mol } H_2 \text{ required}$$

Consider H_2 :

$$15.0 \text{ L } H_2 \text{ x } \frac{1 \text{ mol } H_2}{22.414 \text{ L } H_2} = 0.669 \text{ mol } H_2 \text{ available}$$

$$0.669 \text{ mol } H_2 \text{ x } \frac{1 \text{ mol } WO_3}{3 \text{ mol } H_2} = 0.223 \text{ mol } WO_3 \text{ required}$$

therefore the limiting reagent is WO_3

$$0.151 \text{ mol } WO_3 \text{ x } \frac{1 \text{ mol W}}{1 \text{ mol } WO_3} \text{ x } \frac{183.84 \text{ g W}}{1 \text{ mol W}} = 27.8 \text{ g W}$$

3. What mass of H_2SO_4 can be produced from 50.0 g of SO_2 , 15.0 g O_2 and an unlimited amount of H_2O ? The equation is:

$$\underset{50.0\text{ g}}{2\,SO_2(g)} + \underset{15.0\text{ g}}{O_2(g)} + 2\,H_2O(l) \longrightarrow \underset{?\text{ g}}{2\,H_2SO_4(aq)}$$

Consider SO_2 :

$$50.0\text{ g } SO_2 \text{ x } \frac{1\text{ mol } SO_2}{64.07\text{ g } SO_2} = 0.780\text{ mol } SO_2 \text{ available}$$

$$0.780\text{ mol } SO_2 \text{ x } \frac{1\text{ mol } O_2}{2\text{ mol } SO_2} = 0.390\text{ mol } O_2 \text{ required}$$

Consider O_2 :

$$15.0\text{ g } O_2 \text{ x } \frac{1\text{ mol } O_2}{32.00\text{ g } O_2} = 0.469\text{ mol } O_2 \text{ available}$$

$$0.469\text{ mol } O_2 \text{ x } \frac{2\text{ mol } SO_2}{1\text{ mol } O_2} = 0.938\text{ mol } SO_2 \text{ required}$$

therefore the limiting reagent is SO_2

$$0.780\text{ mol } SO_2 \text{ x } \frac{2\text{ mol } H_2SO_4}{2\text{ mol } SO_2} \text{ x } \frac{98.09\text{ g } H_2SO_4}{1\text{ mol } H_2SO_4} = 76.5\text{ g } H_2SO_4$$

4. 40.0 L of O_2 react with 19.6 L of methane (CH_4) at S.T.P. according to the reaction shown below. What volume of water and carbon dioxide are produced at S.T.P.

$$\underset{19.6\text{ L}}{CH_4(g)} + \underset{40.0\text{ L}}{2\,O_2(g)} \longrightarrow \underset{?\text{ L @ S.T.P.}}{CO_2(g)} + \underset{?\text{ L @ S.T.P.}}{2\,H_2O(g)}$$

Consider CH_4 :

$$19.6\text{ L }CH_4 \text{ x } \frac{1\text{ mol }CH_4}{22.414\text{ L }CH_4} = 0.874\text{ mol }CH_4\text{ available}$$

$$0.874\text{ mol }CH_4 \text{ x } \frac{2\text{ mol }O_2}{1\text{ mol }CH_4} = 1.75\text{ mol }O_2\text{ required}$$

Consider O_2 :

$$40.0\text{ L }O_2 \text{ x } \frac{1\text{ mol }O_2}{22.414\text{ L }O_2} = 1.78\text{ mol }O_2\text{ available}$$

$$1.78\text{ mol }O_2 \text{ x } \frac{1\text{ mol }CH_4}{2\text{ mol }O_2} = 0.892\text{ mol }CH_4\text{ required}$$

therefore the limiting reagent is CH_4

$$0.874\text{ mol }CH_4 \text{ x } \frac{2\text{ mol }H_2O}{1\text{ mol }CH_4} \text{ x } \frac{22.414\text{ L }H_2O}{1\text{ mol }H_2O} = 39.2\text{ L }H_2O$$

$$0.874\text{ mol }CH_4 \text{ x } \frac{1\text{ mol }CO_2}{1\text{ mol }CH_4} \text{ x } \frac{22.414\text{ L }CO_2}{1\text{ mol }CO_2} = 19.6\text{ L }CO_2$$

5. What is the maximum mass of carbon dioxide that can be produced by the reaction between 15.0 g of propane (C_3H_8) with 60.0 g of oxygen gas?

$$\underset{15.0\text{ g}}{C_3H_8(g)} + \underset{60.0\text{ g}}{5\,O_2(g)} \longrightarrow \underset{?\text{ g}}{3\,CO_2(g)}\ 3\,CO_2(g) + 4\,H_2O(g)$$

Consider C_3H_8 :

$$15.0\text{ g } C_3H_8 \text{ x } \frac{1\text{ mol } C_3H_8}{44.11\text{ g } C_3H_8} = 0.340\text{ mol } C_3H_8 \text{ available}$$

$$0.340\text{ mol } C_3H_8 \text{ x } \frac{5\text{ mol } O_2}{1\text{ mol } C_3H_8} = 1.70\text{ mol } O_2 \text{ required}$$

Consider O_2 :

$$60.0\text{ g } O_2 \text{ x } \frac{1\text{ mol } O_2}{32.00\text{ g } O_2} = 1.88\text{ mol } O_2 \text{ available}$$

$$1.88\text{ mol } O_2 \text{ x } \frac{1\text{ mol } C_3H_8}{5\text{ mol } O_2} = 0.375\text{ mol } C_3H_8 \text{ required}$$

therefore the limiting reagent is C_3H_8

$$0.340\text{ mol } C_3H_8 \text{ x } \frac{3\text{ mol } CO_2}{1\text{ mol } C_3H_8} \text{ x } \frac{44.01\text{ g } CO_2}{1\text{ mol } CO_2} = 44.9\text{ g } CO_2$$

6. What mass of iron(III) oxide is produced when 20.9 g of iron(II) sulphide reacts with 10.0 L of oxygen gas at 105.5 kPa and a temperature of 42 °C? What volume of sulphur dioxide is produced at S.T.P.?

$$\underset{20.9\text{ g}}{4\,\text{FeS(s)}} + \underset{\substack{10.0\text{ L}\\105.5\text{ kPa}\\42\ ^\circ\text{C}}}{7\,\text{O}_2\text{(g)}} \longrightarrow \underset{?\text{ g}}{2\,\text{Fe}_2\text{O}_3\text{(s)}} + \underset{?\text{ L @ S.T.P.}}{4\,\text{SO}_2\text{(g)}}$$

Consider O_2 :

$$\begin{aligned} P &= 105.5\text{ kPa} \\ V &= 10.0\text{ L} \\ n &= ? \\ R &= 8.314\frac{\text{kPa}\cdot\text{L}}{\text{K}\cdot\text{mol}} \\ T &= 42\ ^\circ\text{C} \rightarrow 315.15\text{ K} \end{aligned}$$

$$n = \frac{PV}{RT}$$

$$n = \frac{105.5\text{ kPa} \times 10.0\text{ L}}{8.314\frac{\text{kPa}\cdot\text{L}}{\text{K}\cdot\text{mol}} \times 315.15\text{ K}}$$

$$n = 0.403\text{ mol O}_2\text{ available}$$

$$0.403\text{ mol O}_2 \text{ x } \frac{4\text{ mol FeS}}{7\text{ mol O}_2} = 0.230\text{ mol FeS required}$$

Consider FeS :

$$20.9\text{ g FeS x } \frac{1\text{ mol FeS}}{87.92\text{ g FeS}} = 0.238\text{ mol FeS available}$$

$$0.238\text{ mol FeS x } \frac{7\text{ mol O}_2}{4\text{ mol FeS}} = 0.416\text{ mol O}_2\text{ required}$$

---

therefore the limiting reagent is O_2

$$0.403\text{ mol O}_2 \text{ x } \frac{2\text{ mol Fe}_2\text{O}_3}{7\text{ mol O}_2} \text{ x } \frac{159.70\text{ g Fe}_2\text{O}_3}{1\text{ mol Fe}_2\text{O}_3} = 18.4\text{ g Fe}_2\text{O}_3$$

$$0.403\text{ mol O}_2 \text{ x } \frac{4\text{ mol SO}_2}{7\text{ mol O}_2} \text{ x } \frac{22.414\text{ L SO}_2}{1\text{ mol SO}_2} = 5.16\text{ L SO}_2$$

---

7. Nickel metal can be highly purified using the Mond Process:

$$Ni(s) + 4\,CO(g) \longrightarrow Ni(CO)_4(g)$$

In the first step of this process nickel metal is reacted with carbon monoxide under high pressure and heat to produce a gas product known as nickel carbonyl ($Ni(CO)_4$). If 40.0 g of nickel metal is reacted with 5.00 L of carbon monoxide at 60.75 atm. pressure and a temperature of 875 K, calculate the resulting total pressure of all gases at 25 ^{o}C and total volume 5.00 L. Hints: nickel is the limiting reagent, Dalton's Law of Partial Pressures could be used to solve this problem

---

Calculate the amount of CO(g) available:

$$P = 60.75 \text{ atm kPa x } \frac{101.325 \text{ kPa}}{1 \text{ atm}} = 6155 \text{ kPa}$$

$$V = 5.00 \text{ L}$$

$$n = ?$$

$$R = 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}}$$

$$T = 875 \text{ K}$$

$$n = \frac{PV}{RT}$$

$$n = \frac{6155 \text{ kPa} \times 5.00 \text{ L}}{8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 875 \text{ K}}$$

$$n = 4.231 \text{ mol CO available}$$

Calculate amount of CO(g) consumed in the reaction:

$$40.0 \text{ g Ni x } \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} \text{ x } \frac{4 \text{ mol CO}}{1 \text{ mol Ni}} = 2.726 \text{ mol CO consumed}$$

Calculate the amount of CO remaining (unreacted):

$$\begin{aligned} \text{amount CO remaining} &= (\text{amount CO available}) - (\text{amount CO consumed}) \\ &= (4.231 \text{ mol CO}) - (2.726 \text{ mol CO}) \\ &= 1.505 \text{ mol CO remains after reaction} \end{aligned}$$

Calculate the amount of $Ni(CO)_4$ formed:

$$40.0 \text{ g Ni x } \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} \text{ x } \frac{1 \text{ mol Ni(CO)}_4}{1 \text{ mol Ni}} = 0.6815 \text{ mol Ni(CO)}_4 \text{ formed}$$

Calculate the total amount of gases after reaction:

$$\begin{aligned} \text{total amount of gases} &= (\text{amount CO remaining}) - (\text{amount Ni(CO)}_4 \text{ formed}) \\ &= (1.505 \text{ mol CO}) + (0.6815 \text{ mol Ni(CO)}_4) \\ &= 2.186 \text{ mol of gas remains after reaction} \end{aligned}$$

Calculate the pressure of remaining gas:

$$P = ?$$
$$V = 5.00\ \text{L}$$
$$n = 2.186\ \text{mol gas}$$
$$R = 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}}$$
$$T = 25\ ^{\circ}\text{C} \rightarrow 298.15\ \text{K}$$

$$P = \frac{nRT}{V}$$

$$P = \frac{2.186\ \text{mol} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 298.15\ \text{K}}{5.00\ \text{L}}$$

$$P = 1084\ \text{kPa}$$

$$1084\ \text{kPa} \times \frac{1\ \text{atm}}{101.325\ \text{kPa}} = 10.696\ \text{atm}$$

Sheet #7

1. $CaCO_3 \Rightarrow CaO + CO_2$

b) $225g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.086g\ CaCO_3} \times \frac{1\ mol\ CO_2}{1\ mol\ CaCO_3} \times \frac{22.414L\ CO_2}{1\ mol\ CO_2} = 50.388\ L\ CO_2$

c) $\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100\%$

$= \frac{28.2\ L\ CO_2}{50.388L} \times 100\%$

$= 55.97\%$

2. $\overset{50g}{Fe} + \overset{150g}{CuSO_4} \Rightarrow FeSO_4 + Cu$

consider Fe:

$50g\ Fe \times \frac{1\ mol\ Fe}{55.845g\ Fe} = 0.8953\ mol\ Fe$ (available)

$0.8953\ mol\ Fe \times \frac{1\ mol\ CuSO_4}{1\ mol\ Fe} = 0.8953\ mol\ CuSO_4$ (required)

consider $CuSO_4$:

$150g\ CuSO_4 \times \frac{1\ mol\ CuSO_4}{159.608g\ CuSO_4} = 0.9398\ mol\ CuSO_4$ (available)

$0.9398\ mol\ CuSO_4 \times \frac{1\ mol\ Fe}{1\ mol\ CuSO_4} = 0.9398\ mol\ Fe$ (required)

∴ Fe is the limiting reagent.

b) $0.8953\ mol\ Fe \times \frac{1\ mol\ Cu}{1\ mol\ Fe} \times \frac{63.546g\ Cu}{1\ mol\ Cu} = 56.893g\ Cu$

c) $\%\ yield = \frac{43g\ Cu}{56.893g\ Cu} \times 100\%$

$= 75.58\%$

3. $2C_2H_6 + 7O_2 \Rightarrow 6H_2O + 4CO_2$

$40g\ C_2H_6 \times \frac{1\ mol\ C_2H_6}{30.070g\ C_2H_6} \times \frac{6\ mol\ H_2O}{2\ mol\ C_2H_6} \times \frac{18.015g\ H_2O}{1\ mol\ H_2O} = 71.892g\ H_2O$

$\%\ yield = \frac{60g\ H_2O}{71.892g\ H_2O} \times 100\%$

$= 83.46\%$

4. $Mg_3N_2 + 6H_2O \Rightarrow 2NH_3 + 3Mg(OH)_2$

consider Mg_3N_2:

$50.0g\ Mg_3N_2 \times \frac{1\ mol\ Mg_3N_2}{100.929g\ Mg_3N_2} = 0.4954\ mol\ Mg_3N_2$ (available)

$0.4954\ mol\ Mg_3N_2 \times \frac{6\ mol\ H_2O}{1\ mol\ Mg_3N_2} = 2.9724\ mol\ H_2O$ (required)

consider H_2O:

$30.0g\ H_2O \times \frac{1\ mol\ H_2O}{18.015g\ H_2O} = 1.6653\ mol\ H_2O$ (available)

$1.6653\ mol\ H_2O \times \frac{1\ mol\ Mg_3N_2}{6\ mol\ H_2O} = 0.2776\ mol\ Mg_3N_2$ (required)

∴ H_2O is the limiting reagent.

$1.6653\ mol\ H_2O \times \frac{3\ mol\ Mg(OH)_2}{6\ mol\ H_2O} \times \frac{58.319g\ Mg(OH)_2}{1\ mol\ Mg(OH)_2} = 48.559\ g\ Mg(OH)_2$

$\%\ yield = \frac{40g\ Mg(OH)_2}{48.559g\ Mg(OH)_2} \times 100\%$

$= 82.37\%$

(continued on next page)

$P = 98\ kPa$

$V = ?\ L$

$n = 1.6653\ mol\ H_2O \times \frac{2\ mol\ NH_3}{6\ mol\ H_2O} = 0.5551\ mol\ NH_3$

$R = 8.314\ \frac{kPa \cdot L}{mol \cdot K}$

$T = 25°C + 273.15 = 298.15\ K$

$V = \frac{nRT}{P}$

$= \frac{0.5551\ mol \times 8.314\ \frac{kPa \cdot L}{mol \cdot K} \times 298.15\ K}{98\ kPa}$

$= 14.04\ L$
(of NH_3)

if % yield was the same,

$14.04\ L\ NH_3 \times 82.37\%$

$= 11.563\ L\ NH_3$

5. $N_2 + 3H_2 \Rightarrow 2NH_3$

consider N_2:

$10\ L\ N_2 \times \frac{1\ mol\ N_2}{22.414\ L\ N_2} = 0.4461\ mol\ N_2$ (available)

$0.4461\ mol\ N_2 \times \frac{3\ mol\ H_2}{1\ mol\ N_2} = 1.3383\ mol\ H_2$ (required)

consider H_2:

$25\ L\ H_2 \times \frac{1\ mol\ H_2}{22.414\ L\ H_2} = 1.1154\ mol\ H_2$ (available)

$1.1154\ mol\ H_2 \times \frac{1\ mol\ N_2}{3\ mol\ H_2} = 0.3718\ mol\ N_2$ (required)

∴ H_2 is the limiting reagent

$1.1154\ mol\ H_2 \times \frac{2\ mol\ NH_3}{3\ mol\ H_2} \times \frac{22.414\ L\ NH_3}{1\ mol\ NH_3} = 16.667\ L\ NH_3$

% yield $= \frac{15\ L\ NH_3}{16.667\ L\ NH_3} \times 100\%$

$= 89.998\%$

6. $3O_2 + 4Al \Rightarrow 2Al_2O_3$

Consider O_2:

$5\ L\ O_2 \times \frac{1\ mol\ O_2}{22.414\ L\ O_2} = 0.2231\ mol\ O_2$ (available)

$0.2231\ mol\ O_2 \times \frac{4\ mol\ Al}{3\ mol\ O_2} = 0.2975\ mol\ Al$ (required)

Consider Al

$2\ g\ Al \times \frac{1\ mol\ Al}{26.982\ g\ Al} = 0.0741\ mol\ Al$ (available)

$0.0741\ mol\ Al \times \frac{3\ mol\ O_2}{4\ mol\ Al} = 0.0556\ mol\ O_2$ (required)

∴ Al is the limiting reagent

$0.0741\ mol\ Al \times \frac{2\ mol\ Al_2O_3}{4\ mol\ Al} \times \frac{101.961\ g\ Al_2O_3}{1\ mol\ Al_2O_3} = 3.778\ g\ Al_2O_3$

% yield $= \frac{2.95\ g\ Al_2O_3}{3.778\ g\ Al_2O_3} \times 100\%$

$= 78.08\%$

7. a) $2Hg_2O \Rightarrow 4Hg + O_2$

$P = 1\ atm. \times \frac{101.325\ kPa}{1\ atm.} = 101.325\ kPa$

$V = ?\ L$

$n = 500g\ Hg_2O \times \frac{1\ mol\ Hg_2O}{417.179g\ Hg_2O} \times \frac{1\ mol\ O_2}{2\ mol\ Hg_2O} = 0.5993\ mol\ O_2$

$R = 8.314\ \frac{kPa \cdot L}{mol \cdot K}$

$T = 185°C + 273.15 = 458.15\ K$

$V = \frac{0.5993\ mol\ O_2 \times 8.314 \frac{kPa \cdot L}{mol \cdot K} \times 458.15K}{101.325 kPa}$

$= 22.529\ L\ O_2$

$\%\ yield = \frac{6.95\ L\ O_2}{22.529\ L\ O_2} \times 100\%$

$= 30.849\ \%$

b) $500g\ Hg_2O \times \frac{1\ mol\ Hg_2O}{417.179g\ Hg_2O} \times \frac{4\ mol\ Hg}{2\ mol\ Hg_2O} \times \frac{200.59g\ Hg}{1\ mol\ Hg} = 480.825g\ Hg$

c) if % yield was the same,

$480.825g\ Hg \times 30.849\%$

$= 148.3297g\ Hg$

d) The mass in b) would be closer to the experimental observations because gas is harder to recover than liquids or solids in a reaction.

8. $2Fe_2O_3 \Rightarrow 4Fe + 3O_2$

$12200t\ iron\ ore \times \frac{56.1t\ Fe_2O_3}{100t\ iron\ ore} \times \frac{85.5t\ Fe_2O_3}{100t\ Fe_2O_3} \times \frac{1000000g\ Fe_2O_3}{1t\ Fe_2O_3} \times \frac{1\ mol\ Fe_2O_3}{159.687g\ Fe_2O_3} \times \frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3} \times \frac{55.845g\ Fe}{1\ mol\ Fe}$

$\times \frac{1t\ Fe}{1000000g\ Fe} = 4092.923t\ Fe$