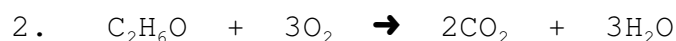


$$a) \quad 2.46 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 0.137 \text{ mol H}_2\text{O}$$

$$b) \quad 2.46 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol C}_4\text{H}_{10}}{10 \text{ mol H}_2\text{O}} = 0.0273 \text{ mol C}_4\text{H}_{10}$$

$$c) \quad 2.46 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol C}_4\text{H}_{10}}{10 \text{ mol H}_2\text{O}} \times \frac{58.14 \text{ g C}_4\text{H}_{10}}{1 \text{ mol C}_4\text{H}_{10}} = 1.59 \text{ g C}_4\text{H}_{10}$$

$$d) \quad 2.46 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{13 \text{ mol O}_2}{10 \text{ mol H}_2\text{O}} \times \frac{32.00 \text{ g O}_2}{1 \text{ mol O}_2} = 5.68 \text{ g O}_2$$



$$a) \quad 25 \text{ mol C}_2\text{H}_6\text{O} \times \frac{3 \text{ mol O}_2}{1 \text{ mol C}_2\text{H}_6\text{O}} = 75 \text{ mol O}_2$$

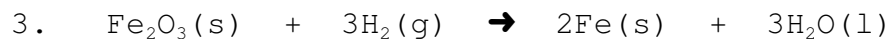
$$b) \quad 30 \text{ mol O}_2 \times \frac{1 \text{ mol C}_2\text{H}_6\text{O}}{3 \text{ mol O}_2} = 10 \text{ mol C}_2\text{H}_6\text{O}$$

$$30 \text{ mol O}_2 \times \frac{2 \text{ mol CO}_2}{3 \text{ mol O}_2} = 20 \text{ mol CO}_2$$

$$c) \quad 23 \text{ mol CO}_2 \times \frac{3 \text{ mol O}_2}{2 \text{ mol CO}_2} = 34.5 \text{ mol O}_2$$

$$d) \quad 41 \text{ mol H}_2\text{O} \times \frac{3 \text{ mol O}_2}{3 \text{ mol H}_2\text{O}} = 41 \text{ mol O}_2$$

$$41 \text{ mol H}_2\text{O} \times \frac{2 \text{ mol CO}_2}{3 \text{ mol H}_2\text{O}} = 27.3 \text{ mol CO}_2$$



$$\text{a)} \quad 25 \text{ mol Fe}_2\text{O}_3 \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} = 50 \text{ mol Fe}$$

$$\text{b)} \quad 30 \text{ mol Fe} \times \frac{3 \text{ mol H}_2}{2 \text{ mol Fe}} = 45 \text{ mol H}_2$$

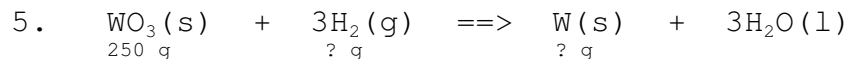
$$\text{c)} \quad 120 \text{ mol H}_2\text{O} \times \frac{1 \text{ mol Fe}_2\text{O}_3}{3 \text{ mol H}_2\text{O}} \times \frac{159.7 \text{ g Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} = 6388 \text{ g Fe}_2\text{O}_3$$



$$\text{a)} \quad 2.68 \text{ mol N}_2\text{H}_4 \times \frac{7 \text{ mol H}_2\text{O}_2}{1 \text{ mol N}_2\text{H}_4} = 18.76 \text{ mol H}_2\text{O}_2$$

$$\text{b)} \quad 2.68 \text{ mol N}_2\text{H}_4 \times \frac{2 \text{ mol HNO}_3}{1 \text{ mol N}_2\text{H}_4} = 5.36 \text{ mol HNO}_3$$

$$\text{c)} \quad 2.68 \text{ mol N}_2\text{H}_4 \times \frac{8 \text{ mol H}_2\text{O}}{1 \text{ mol N}_2\text{H}_4} = 21.44 \text{ mol H}_2\text{O}$$



$$\text{a)} \quad 250 \text{ g WO}_3 \times \frac{1 \text{ mol WO}_3}{231.84 \text{ g WO}_3} \times \frac{1 \text{ mol W}}{1 \text{ mol WO}_3} \times \frac{183.84 \text{ g W}}{1 \text{ mol W}} = 198 \text{ g W}$$

$$\text{b)} \quad 250 \text{ g WO}_3 \times \frac{1 \text{ mol WO}_3}{231.84 \text{ g WO}_3} \times \frac{3 \text{ mol H}_2}{1 \text{ mol WO}_3} \times \frac{2.02 \text{ g H}_2}{1 \text{ mol H}_2} = 6.53 \text{ g H}_2$$

$$\begin{aligned}
4. \quad \text{mass reactants} &= \text{mass Ca(NO}_3)_2 + \text{mass K}_3\text{PO}_4 \\
&= 80.00 \text{ g} + 68.99 \text{ g} \\
&= 148.99 \text{ g}
\end{aligned}$$

$$\begin{aligned}
\text{mass products} &= \text{mass Ca}_3(\text{PO}_4)_2 + \text{mass KNO}_3 \\
&= 50.41 \text{ g} + 98.58 \text{ g} \\
&= 148.99 \text{ g}
\end{aligned}$$

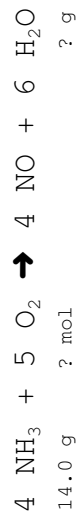
The mass of reactants and products are the same (or nearly the same). This makes sense, since the law of conservation of mass states that matter cannot be created nor destroyed, therefore mass is conserved.

$$\begin{aligned}
5. \quad &\text{Al}_2\text{O}_3 + 3 \text{H}_2\text{O} \rightarrow 2 \text{Al(OH)}_3 \\
&25.0 \text{ g} \qquad \qquad \qquad ? \text{ g} \\
25.0 \text{ g Al}_2\text{O}_3 &\times \frac{1 \text{ mol Al}_2\text{O}_3}{101.96 \text{ g Al}_2\text{O}_3} \times \frac{2 \text{ mol Al(OH)}_3}{1 \text{ mol Al}_2\text{O}_3} \times \frac{78.01 \text{ g Al(OH)}_3}{1 \text{ mol Al(OH)}_3} = 38.3 \text{ g Al(OH)}_3
\end{aligned}$$

$$\begin{aligned}
6. \quad &2 \text{CuO} \rightarrow \text{Cu}_2\text{O} + \text{O}_2 \\
&35.0 \text{ g} \qquad \qquad \qquad ? \text{ g} \\
35.0 \text{ g CuO} &\times \frac{1 \text{ mol CuO}}{79.55 \text{ g CuO}} \times \frac{1 \text{ mol Cu}_2\text{O}}{2 \text{ mol CuO}} \times \frac{143.10 \text{ g Cu}_2\text{O}}{1 \text{ mol Cu}_2\text{O}} = 31.5 \text{ g Cu}_2\text{O}
\end{aligned}$$

$$\begin{aligned}
7. \quad &\text{Ca(ClO}_3)_2 \rightarrow \text{CaCl}_2 + 3 \text{O}_2 \\
&11.0 \text{ mol} \qquad \qquad \qquad ? \text{ g} \qquad \qquad \qquad ? \text{ mol} \\
11.0 \text{ mol Ca(ClO}_3)_2 &\times \frac{3 \text{ mol O}_2}{1 \text{ mol Ca(ClO}_3)_2} = 33.0 \text{ mol O}_2 \\
11.0 \text{ mol Ca(ClO}_3)_2 &\times \frac{1 \text{ mol CaCl}_2}{1 \text{ mol Ca(ClO}_3)_2} \times \frac{110.98 \text{ g CaCl}_2}{1 \text{ mol CaCl}_2} = 1220 \text{ g CaCl}_2
\end{aligned}$$

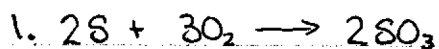
11.



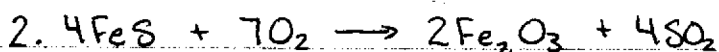
$$14.0 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.04 \text{ g NH}_3} \times \frac{6 \text{ mol H}_2\text{O}}{4 \text{ mol NH}_3} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 22.2 \text{ g H}_2\text{O}$$

$$14.0 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.04 \text{ g NH}_3} \times \frac{5 \text{ mol O}_2}{4 \text{ mol NH}_3} = 1.03 \text{ mol O}_2$$

Sheet #2



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



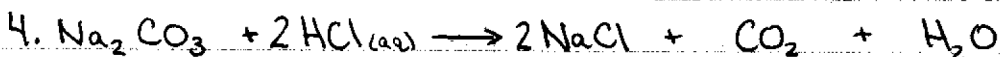
$$7.81 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32 \text{ g } O_2} \times \frac{4 \text{ mol } FeS}{7 \text{ mol } O_2} \times \frac{87.92 \text{ g } FeS}{1 \text{ mol } FeS} = 12.3 \text{ g } FeS$$

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



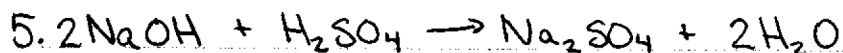
$$6.4 \text{ g } CH_4 \times \frac{1 \text{ mol } CH_4}{16.05 \text{ g } CH_4} \times \frac{2 \text{ mol } O_2}{1 \text{ mol } CH_4} \times \frac{32 \text{ g } O_2}{1 \text{ mol } O_2} = 25.52 \text{ g } O_2$$

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



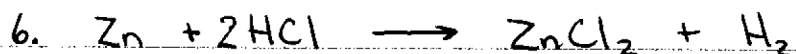
$$286 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2} \times \frac{1 \text{ mol } Na_2CO_3}{1 \text{ mol } CO_2} \times \frac{106.01 \text{ g } Na_2CO_3}{1 \text{ mol } Na_2CO_3} = 688.91 \text{ g } Na_2CO_3$$

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



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

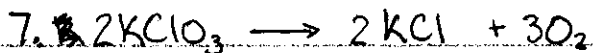
$$4.77 \text{ mol } Na_2SO_4 \times \frac{1 \text{ mol } H_2SO_4}{1 \text{ mol } Na_2SO_4} \times \frac{98.09 \text{ g } H_2SO_4}{1 \text{ mol } H_2SO_4} = 467.9 \text{ g } H_2SO_4$$



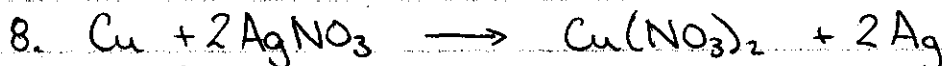
$$20 \text{ g } Zn \times \frac{1 \text{ mol } Zn}{65.41 \text{ g } Zn} \times \frac{1 \text{ mol } ZnCl_2}{1 \text{ mol } Zn} \times \frac{136.31 \text{ g } ZnCl_2}{1 \text{ mol } ZnCl_2} = 41.68 \text{ g } ZnCl_2$$

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

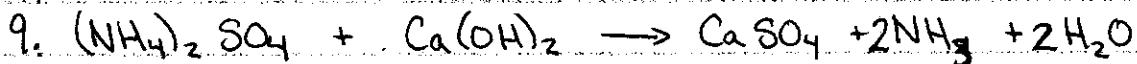
$$20\text{g Zn} \times \frac{1\text{mol Zn}}{65.39\text{g Zn}} \times \frac{2\text{mol HCl}}{1\text{mol Zn}} \times \frac{36.46\text{g HCl}}{1\text{mol HCl}} = 22.3\text{g HCl}$$



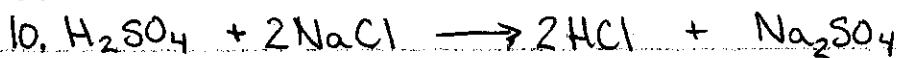
$$5\text{g KClO}_3 \times \frac{1\text{mol KClO}_3}{122.55\text{g KClO}_3} \times \frac{3\text{mol O}_2}{2\text{mol KClO}_3} \times \frac{32\text{g O}_2}{1\text{mol O}_2} = 1.96\text{g O}_2$$



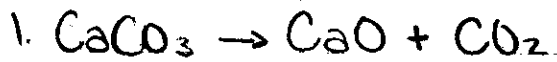
$$4\text{g AgNO}_3 \times \frac{1\text{mol AgNO}_3}{169.88\text{g AgNO}_3} \times \frac{1\text{mol Cu}}{2\text{mol AgNO}_3} \times \frac{63.55\text{g Cu}}{1\text{mol Cu}} = .748\text{g Cu}$$



$$20\text{g Ca}(\text{OH})_2 \times \frac{1\text{mol Ca}(\text{OH})_2}{74.1\text{g Ca}(\text{OH})_2} \times \frac{2\text{mol NH}_3}{1\text{mol Ca}(\text{OH})_2} \times \frac{17.04\text{g NH}_3}{1\text{mol NH}_3} = 9.2\text{g NH}_3$$



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

Sheet #3: Volume \rightarrow Amount \rightarrow Amount \rightarrow Volume

$$\text{a) } 1 \text{ Kg CaCO}_3 \times \frac{1000 \text{ g CaCO}_3}{1 \text{ Kg CaCO}_3} \times \frac{1 \text{ mol CaCO}_3}{100.086 \text{ g CaCO}_3} \times \frac{1 \text{ mol CaO}}{1 \text{ mol CaCO}_3} \times \frac{56.077 \text{ g CaO}}{1 \text{ mol CaO}} = 560.288 \text{ g CaO}$$

$$\text{b) } 1 \text{ Kg CaCO}_3 \times \frac{1000 \text{ g CaCO}_3}{1 \text{ Kg CaCO}_3} \times \frac{1 \text{ mol CaCO}_3}{100.086 \text{ g CaCO}_3} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CaCO}_3} \times \frac{22.414 \text{ L CO}_2}{1 \text{ mol CO}_2} = 223.947 \text{ L CO}_2$$



$$\text{a) } 454 \text{ g C}_6\text{H}_{12}\text{O}_6 \times \frac{1 \text{ mol C}_6\text{H}_{12}\text{O}_6}{180.18 \text{ g C}_6\text{H}_{12}\text{O}_6} \times \frac{2 \text{ mol C}_2\text{H}_5\text{OH}}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} \times \frac{46.08 \text{ g C}_2\text{H}_5\text{OH}}{1 \text{ mol C}_2\text{H}_5\text{OH}} = 232.21 \text{ g C}_2\text{H}_5\text{OH}$$

$$\text{b) } 454 \text{ g C}_6\text{H}_{12}\text{O}_6 \times \frac{1 \text{ mol C}_6\text{H}_{12}\text{O}_6}{180.18 \text{ g C}_6\text{H}_{12}\text{O}_6} \times \frac{2 \text{ mol CO}_2}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} = 5.0394 \text{ mol CO}_2$$

$P = 101.325 \text{ kPa}$

$V = ?$

$n = 5.0394 \text{ mol}$

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

$T = 300.15 \text{ K}$

$PV = nRT$

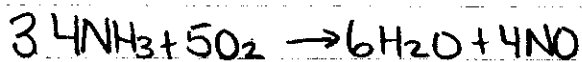
$\frac{P}{P} = \frac{nRT}{P}$

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

P

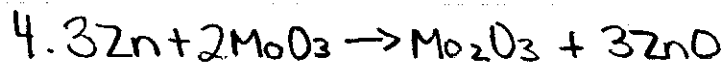
$$\rightarrow V = \frac{(5.0394 \text{ mol CO}_2)(8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}})(300.15 \text{ K})}{101.325 \text{ kPa}}$$

$V = 124.1 \text{ L}$



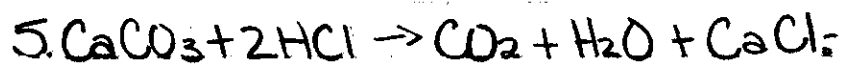
$$\text{a) } 2500 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.03 \text{ g NH}_3} \times \frac{5 \text{ mol O}_2}{4 \text{ mol NH}_3} \times \frac{22.414 \text{ L O}_2}{1 \text{ mol O}_2} = 4112.96 \text{ L O}_2$$

$$\text{b) } 2500 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.03 \text{ g NH}_3} \times \frac{4 \text{ mol NO}}{4 \text{ mol NH}_3} \times \frac{30 \text{ g NO}}{1 \text{ mol NO}} = 4403.99 \text{ g NO}$$



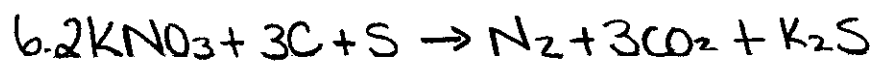
$$20 \text{ g MoO}_3 \times \frac{1 \text{ mol MoO}_3}{143.94 \text{ g MoO}_3} \times \frac{1 \text{ mol Mo}_2\text{O}_3}{2 \text{ mol MoO}_3} \times \frac{239.88 \text{ g Mo}_2\text{O}_3}{1 \text{ mol Mo}_2\text{O}_3} = 16.66 \text{ g Mo}_2\text{O}_3$$

$$20 \text{ g MoO}_3 \times \frac{1 \text{ mol MoO}_3}{143.94 \text{ g MoO}_3} \times \frac{3 \text{ mol ZnO}}{2 \text{ mol MoO}_3} \times \frac{81.409 \text{ g ZnO}}{1 \text{ mol ZnO}} = 16.967 \text{ g ZnO}$$



$$15\text{g HCl} \times \frac{1\text{mol HCl}}{36.463\text{g HCl}} \times \frac{1\text{mol CaCO}_3}{2\text{mol HCl}} \times \frac{100.088\text{g CaCO}_3}{1\text{mol CaCO}_3} = 20.587\text{g CaCO}_3$$

$$15\text{g HCl} \times \frac{1\text{mol HCl}}{36.463\text{g HCl}} \times \frac{1\text{mol CO}_2}{2\text{mol HCl}} \times \frac{44.01\text{g CO}_2}{1\text{mol CO}_2} = 9.0524\text{g CO}_2$$



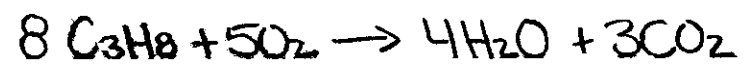
$$50\text{g KNO}_3 \times \frac{1\text{mol KNO}_3}{101.105\text{g KNO}_3} \times \frac{1\text{mol N}_2}{2\text{mol KNO}_3} \times \frac{22.414\text{L N}_2}{1\text{mol N}_2} = 5.542\text{L N}_2$$

$$50\text{g KNO}_3 \times \frac{1\text{mol KNO}_3}{101.105\text{g KNO}_3} \times \frac{3\text{mol CO}_2}{2\text{mol KNO}_3} \times \frac{22.414\text{L CO}_2}{1\text{mol CO}_2} = 16.626\text{L CO}_2$$

$$5.542\text{L N}_2 + 16.626\text{L CO}_2 = 22.168\text{L gas}$$



$$30\text{L N}_2 \times \frac{1\text{mol N}_2}{22.414\text{L N}_2} \times \frac{3\text{mol Ca}}{1\text{mol N}_2} \times \frac{40.078\text{g Ca}}{1\text{mol Ca}} = 160.927\text{g Ca}$$

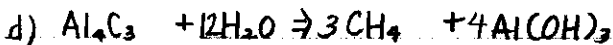
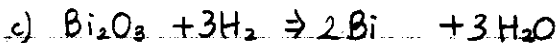
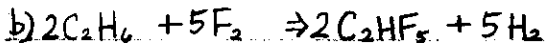
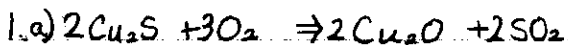


$$1\text{L C}_3\text{H}_8 \times \frac{1\text{mol C}_3\text{H}_8}{22.414\text{L C}_3\text{H}_8} \times \frac{5\text{mol O}_2}{1\text{mol C}_3\text{H}_8} \times \frac{22.414\text{L O}_2}{1\text{mol O}_2} = 5\text{L O}_2$$

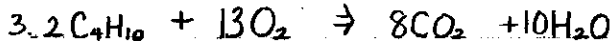
$$\frac{100\text{L air}}{21\text{L O}_2} = \frac{23.80952\text{L air}}{5\text{L O}_2}$$

∴ the optimum ratio is 23.8095 L of air.

Sheet #4

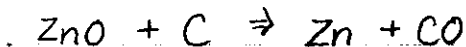
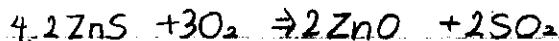


$$16.8\text{g Fe} \times \frac{1\text{ mol Fe}}{55.845\text{g Fe}} \times \frac{4\text{ mol H}_2}{3\text{ mol Fe}} \times \frac{22.414\text{ L H}_2}{1\text{ mol H}_2} = 8.99\text{ L H}_2$$



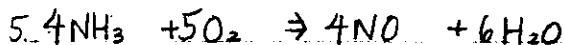
a) $1\text{g C}_4\text{H}_{10} \times \frac{1\text{ mol C}_4\text{H}_{10}}{58.124\text{g C}_4\text{H}_{10}} \times \frac{13\text{ mol O}_2}{2\text{ mol C}_4\text{H}_{10}} \times \frac{31.998\text{g O}_2}{1\text{ mol O}_2} = 39.36166\text{g O}_2$

b) $1\text{g C}_4\text{H}_{10} \times \frac{1\text{ mol C}_4\text{H}_{10}}{58.124\text{g C}_4\text{H}_{10}} \times \frac{8\text{ mol CO}_2}{2\text{ mol C}_4\text{H}_{10}} \times \frac{22.414\text{ L CO}_2}{1\text{ mol CO}_2} = 16.967\text{ L CO}_2$



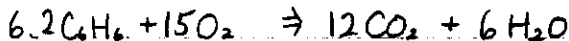
$$150.0\text{g ZnS} \times \frac{1\text{ mol ZnS}}{97.46\text{g ZnS}} \times \frac{2\text{ mol ZnO}}{2\text{ mol ZnS}} = 1.539\text{ mol ZnO}$$

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

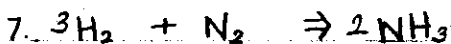


$$1\text{ mol NH}_3 \times \frac{5\text{ mol O}_2}{4\text{ mol NH}_3} \times \frac{22.414\text{ L O}_2}{1\text{ mol O}_2} = 28.0175\text{ L O}_2$$

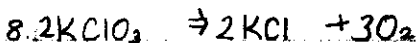
$$1\text{ mol NH}_3 \times \frac{4\text{ mol NO}}{4\text{ mol NH}_3} \times \frac{22.414\text{ L NO}}{1\text{ mol NO}} = 22.414\text{ L NO}$$



$$25.0\text{ L O}_2 \times \frac{1\text{ mol O}_2}{22.414\text{ L O}_2} \times \frac{2\text{ mol C}_6\text{H}_6}{15\text{ mol O}_2} \times \frac{78.114\text{g C}_6\text{H}_6}{1\text{ mol C}_6\text{H}_6} = 11.6168\text{g C}_6\text{H}_6$$



$$5.00\text{ L NH}_3 \times \frac{1\text{ mol NH}_3}{22.414\text{ L NH}_3} \times \frac{3\text{ mol H}_2}{2\text{ mol NH}_3} \times \frac{2.016\text{g H}_2}{1\text{ mol H}_2} = 0.6746\text{g H}_2$$



$$125\text{g KClO}_3 \times \frac{1\text{ mol KClO}_3}{122.548\text{g KClO}_3} \times \frac{3\text{ mol O}_2}{2\text{ mol KClO}_3} = 1.53\text{ mol O}_2$$

$$P = 101.325\text{ kPa}$$

$$V = ?$$

$$n = 1.53\text{ mol}$$

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

$$T = 100^\circ\text{C} + 273.15 = 373.15\text{ K}$$

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

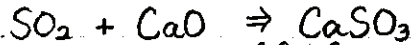
$$= \frac{1.53\text{ mol} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 373.15\text{ K}}{101.325\text{ kPa}}$$

$$= 46.8455\text{ L O}_2$$

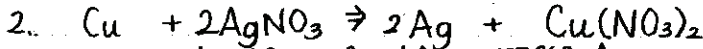


$$14.0\text{g CO} \times \frac{1\text{ mol CO}}{28.01\text{g CO}} \times \frac{3\text{ mol Fe}_2\text{O}_3}{1\text{ mol CO}} \times \frac{159.6873\text{g Fe}_2\text{O}_3}{1\text{ mol Fe}_2\text{O}_3} = 239.445\text{g Fe}_2\text{O}_3$$

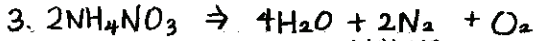
Sheet #5



$$1200 \text{ t coal} \times \frac{2.8 \text{ t S}}{100 \text{ t coal}} \times \frac{1000000 \text{ g S}}{1 \text{ t S}} \times \frac{1 \text{ mol S}}{32.066 \text{ g S}} \times \frac{1 \text{ mol SO}_2}{1 \text{ mol S}} \times \frac{1 \text{ mol CaSO}_3}{1 \text{ mol SO}_2} \times \frac{120.141 \text{ g CaSO}_3}{1 \text{ mol CaSO}_3} \times \frac{1 \text{ t CaSO}_3}{1000000 \text{ g CaSO}_3} = 125.8884 \text{ t CaSO}_3$$



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



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

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

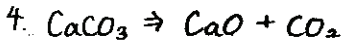
$V = ?$

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

$n = 0.525 \text{ mol gas}$

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

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



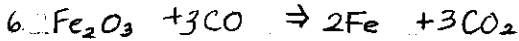
$$200 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.009 \text{ g } CO_2} \times \frac{1 \text{ mol } CaCO_3}{1 \text{ mol } CO_2} \times \frac{100.086 \text{ g } CaCO_3}{1 \text{ mol } CaCO_3} = 454.8433 \text{ g } CaCO_3$$

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

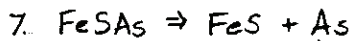
mass $CO_2 = \text{mass original} - \text{mass residue}$
 $= 500 \text{ g} - 300 \text{ g}$
 $= 200 \text{ g } CO_2!$



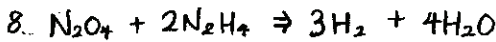
$$50.0 \text{ g } Na_2CO_3 \times \frac{60\% \text{ } Na_2CO_3}{100\% \text{ } Na_2CO_3} \times \frac{1 \text{ mol } Na_2CO_3}{105.99 \text{ g } Na_2CO_3} \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } Na_2CO_3} \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 12.5 \text{ g } CO_2$$



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



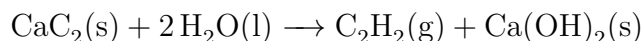
$$1 \text{ kg } As \times \frac{1000 \text{ g } As}{1 \text{ kg } As} \times \frac{1 \text{ mol } As}{74.922 \text{ g } As} \times \frac{1 \text{ mol } FeSAs}{1 \text{ mol } As} \times \frac{162.833 \text{ g } FeSAs}{1 \text{ mol } FeSAs} \times \frac{1 \text{ kg } FeSAs}{1000 \text{ g } FeSAs} = 2.173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



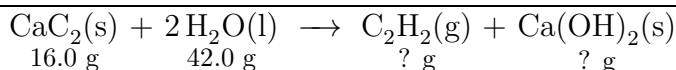
$$25.0 \text{ t } N_2O_4 \times \frac{1000000 \text{ g } N_2O_4}{1 \text{ t } N_2O_4} \times \frac{1 \text{ mol } N_2O_4}{92.01 \text{ g } N_2O_4} \times \frac{2 \text{ mol } N_2H_4}{1 \text{ mol } N_2O_4} \times \frac{32.046 \text{ g } N_2H_4}{1 \text{ mol } N_2H_4} \times \frac{1 \text{ t } N_2H_4}{1000000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

SHEET 6 ANSWERS

1. 16.0 g of CaC_2 reacts with 42.0 g of H_2O according to the following reaction:



- Determine which reactant is the limiting reagent.
- What mass of $\text{C}_2\text{H}_2(\text{g})$ and $\text{Ca}(\text{OH})_2(\text{s})$ is produced.
- Calculate the excess mass of the excess reagent



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 :

$$16.0 \text{ g CaC}_2 \times \frac{1 \text{ mol CaC}_2}{64.10 \text{ g CaC}_2} = 0.250 \text{ mol CaC}_2 \text{ available}$$

$$0.250 \text{ mol CaC}_2 \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol CaC}_2} = 0.499 \text{ mol H}_2\text{O required}$$

Consider H_2O :

$$42.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 2.33 \text{ mol H}_2\text{O available}$$

$$2.23 \text{ mol H}_2\text{O} \times \frac{1 \text{ mol CaC}_2}{2 \text{ mol H}_2\text{O}} = 1.17 \text{ mol CaC}_2 \text{ required}$$

therefore the limiting reagent is CaC_2

b) These are examples of typical final questions.

$$0.250 \text{ mol CaC}_2 \times \frac{1 \text{ mol C}_2\text{H}_2}{1 \text{ mol CaC}_2} \times \frac{26.04 \text{ g C}_2\text{H}_2}{1 \text{ mol C}_2\text{H}_2} = 6.50 \text{ g C}_2\text{H}_2 \text{ produced}$$

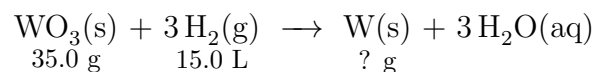
$$0.250 \text{ mol CaC}_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{1 \text{ mol CaC}_2} \times \frac{74.10 \text{ g Ca}(\text{OH})_2}{1 \text{ mol Ca}(\text{OH})_2} = 18.5 \text{ g Ca}(\text{OH})_2 \text{ produced}$$

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

$$0.250 \text{ mol CaC}_2 \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol CaC}_2} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 9.00 \text{ g H}_2\text{O consumed}$$

$$\begin{aligned} \text{mass H}_2\text{O excess} &= (\text{mass H}_2\text{O available}) - (\text{mass H}_2\text{O consumed}) \\ &= (42.0 \text{ g H}_2\text{O}) - (9.00 \text{ g H}_2\text{O}) \\ &= 33.0 \text{ g H}_2\text{O remains after reaction} \end{aligned}$$

2. Consider the following reaction at S.T.P. If 35 g of tungsten trioxide reacts with 15 L of H₂ at S.T.P., what mass of tungsten is produced?



Consider WO₃ :

$$35.0 \text{ g WO}_3 \times \frac{1 \text{ mol WO}_3}{231.84 \text{ g WO}_3} = 0.151 \text{ mol WO}_3 \text{ available}$$

$$0.151 \text{ mol WO}_3 \times \frac{3 \text{ mol H}_2}{1 \text{ mol WO}_3} = 0.453 \text{ mol H}_2 \text{ required}$$

Consider H₂ :

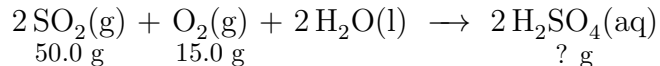
$$15.0 \text{ L H}_2 \times \frac{1 \text{ mol H}_2}{22.414 \text{ L H}_2} = 0.669 \text{ mol H}_2 \text{ available}$$

$$0.669 \text{ mol H}_2 \times \frac{1 \text{ mol WO}_3}{3 \text{ mol H}_2} = 0.223 \text{ mol WO}_3 \text{ required}$$

therefore the limiting reagent is WO₃

$$0.151 \text{ mol WO}_3 \times \frac{1 \text{ mol W}}{1 \text{ mol WO}_3} \times \frac{183.84 \text{ g W}}{1 \text{ mol W}} = 27.8 \text{ g W}$$

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:



Consider SO_2 :

$$50.0 \text{ g SO}_2 \times \frac{1 \text{ mol SO}_2}{64.07 \text{ g SO}_2} = 0.780 \text{ mol SO}_2 \text{ available}$$

$$0.780 \text{ mol SO}_2 \times \frac{1 \text{ mol O}_2}{2 \text{ mol SO}_2} = 0.390 \text{ mol O}_2 \text{ required}$$

Consider O_2 :

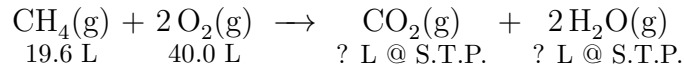
$$15.0 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32.00 \text{ g O}_2} = 0.469 \text{ mol O}_2 \text{ available}$$

$$0.469 \text{ mol O}_2 \times \frac{2 \text{ mol SO}_2}{1 \text{ mol O}_2} = 0.938 \text{ mol SO}_2 \text{ required}$$

therefore the limiting reagent is SO_2

$$0.780 \text{ mol SO}_2 \times \frac{2 \text{ mol H}_2\text{SO}_4}{2 \text{ mol SO}_2} \times \frac{98.09 \text{ g H}_2\text{SO}_4}{1 \text{ mol H}_2\text{SO}_4} = 76.5 \text{ g H}_2\text{SO}_4$$

4. 40.0 L of O₂ react with 19.6 L of methane (CH₄) at S.T.P. according to the reaction shown below. What volume of water and carbon dioxide are produced at S.T.P.



Consider CH₄ :

$$19.6 \text{ L CH}_4 \times \frac{1 \text{ mol CH}_4}{22.414 \text{ L CH}_4} = 0.874 \text{ mol CH}_4 \text{ available}$$

$$0.874 \text{ mol CH}_4 \times \frac{2 \text{ mol O}_2}{1 \text{ mol CH}_4} = 1.75 \text{ mol O}_2 \text{ required}$$

Consider O₂ :

$$40.0 \text{ L O}_2 \times \frac{1 \text{ mol O}_2}{22.414 \text{ L O}_2} = 1.78 \text{ mol O}_2 \text{ available}$$

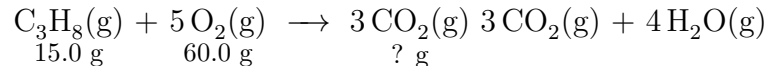
$$1.78 \text{ mol O}_2 \times \frac{1 \text{ mol CH}_4}{2 \text{ mol O}_2} = 0.892 \text{ mol CH}_4 \text{ required}$$

therefore the limiting reagent is CH₄

$$0.874 \text{ mol CH}_4 \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol CH}_4} \times \frac{22.414 \text{ L H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 39.2 \text{ L H}_2\text{O}$$

$$0.874 \text{ mol CH}_4 \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CH}_4} \times \frac{22.414 \text{ L CO}_2}{1 \text{ mol CO}_2} = 19.6 \text{ L CO}_2$$

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?



Consider C_3H_8 :

$$15.0 \text{ g C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{44.11 \text{ g C}_3\text{H}_8} = 0.340 \text{ mol C}_3\text{H}_8 \text{ available}$$

$$0.340 \text{ mol C}_3\text{H}_8 \times \frac{5 \text{ mol O}_2}{1 \text{ mol C}_3\text{H}_8} = 1.70 \text{ mol O}_2 \text{ required}$$

Consider O_2 :

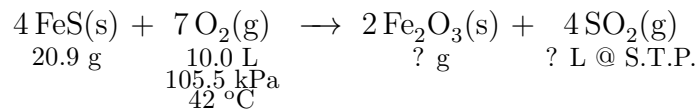
$$60.0 \text{ g O}_2 \times \frac{1 \text{ mol O}_2}{32.00 \text{ g O}_2} = 1.88 \text{ mol O}_2 \text{ available}$$

$$1.88 \text{ mol O}_2 \times \frac{1 \text{ mol C}_3\text{H}_8}{5 \text{ mol O}_2} = 0.375 \text{ mol C}_3\text{H}_8 \text{ required}$$

therefore the limiting reagent is C_3H_8

$$0.340 \text{ mol C}_3\text{H}_8 \times \frac{3 \text{ mol CO}_2}{1 \text{ mol C}_3\text{H}_8} \times \frac{44.01 \text{ g CO}_2}{1 \text{ mol CO}_2} = 44.9 \text{ g CO}_2$$

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.?



Consider O₂ :

$$\begin{array}{l}
 P = 105.5 \text{ kPa} \\
 V = 10.0 \text{ L} \\
 n = ? \\
 R = 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \\
 T = 42 \text{ }^\circ\text{C} \rightarrow 315.15 \text{ K}
 \end{array}
 \qquad
 \begin{array}{l}
 n = \frac{PV}{RT} \\
 n = \frac{105.5 \text{ kPa} \times 10.0 \text{ L}}{8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 315.15 \text{ K}} \\
 n = 0.403 \text{ mol O}_2 \text{ available}
 \end{array}$$

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

Consider FeS :

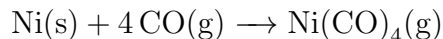
$$\begin{array}{l}
 20.9 \text{ g FeS} \times \frac{1 \text{ mol FeS}}{87.92 \text{ g FeS}} = 0.238 \text{ mol FeS available} \\
 0.238 \text{ mol FeS} \times \frac{7 \text{ mol O}_2}{4 \text{ mol FeS}} = 0.416 \text{ mol O}_2 \text{ required}
 \end{array}$$

therefore the limiting reagent is O₂

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

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

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



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 °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:

$$\begin{aligned} P &= 60.75 \text{ atm kPa} \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} = 6155 \text{ kPa} & n &= \frac{PV}{RT} \\ V &= 5.00 \text{ L} & n &= \frac{6155 \text{ kPa} \times 5.00 \text{ L}}{8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 875 \text{ K}} \\ n &= ? \\ R &= 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \\ T &= 875 \text{ K} & n &= 4.231 \text{ mol CO available} \end{aligned}$$

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

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

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:

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

Calculate the total amount of gases after reaction:

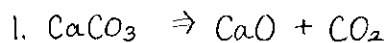
$$\begin{aligned} \text{total amount of gases} &= (\text{amount CO remaining}) - (\text{amount Ni(CO)}_4 \text{ formed}) \\ &= (1.505 \text{ mol CO}) + (0.6815 \text{ mol Ni(CO)}_4) \\ &= 2.186 \text{ mol of gas remains after reaction} \end{aligned}$$

Calculate the pressure of remaining gas:

$$\begin{aligned} P &= ? & P &= \frac{nRT}{V} \\ V &= 5.00 \text{ L} \\ n &= 2.186 \text{ mol gas} \\ R &= 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \\ T &= 25 \text{ }^\circ\text{C} \rightarrow 298.15 \text{ K} \end{aligned}$$
$$P = \frac{2.186 \text{ mol} \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 298.15 \text{ K}}{5.00 \text{ L}}$$
$$P = 1084 \text{ kPa}$$

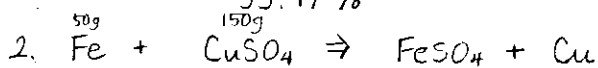
$$1084 \text{ kPa} \times \frac{1 \text{ atm}}{101.325 \text{ kPa}} = 10.696 \text{ atm}$$

Sheet #7



b) $225 \text{ g CaCO}_3 \times \frac{1 \text{ mol CaCO}_3}{100.086 \text{ g CaCO}_3} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CaCO}_3} \times \frac{22.414 \text{ L CO}_2}{1 \text{ mol CO}_2} = 50.388 \text{ L CO}_2$

c) $\% \text{ yield} = \frac{\text{theoretical yield}}{\text{actual yield}} \times 100\%$
 $= \frac{50.388 \text{ L}}{28.2 \text{ L}} \times 100\%$
 $= 55.97\%$



consider Fe:

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

$0.8953 \text{ mol Fe} \times \frac{1 \text{ mol CuSO}_4}{1 \text{ mol Fe}} = 0.8953 \text{ mol CuSO}_4 \text{ (required)}$

consider CuSO_4 :

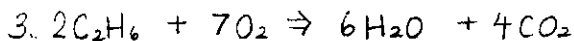
$150 \text{ g CuSO}_4 \times \frac{1 \text{ mol CuSO}_4}{159.608 \text{ g CuSO}_4} = 0.9398 \text{ mol CuSO}_4 \text{ (available)}$

$0.9398 \text{ mol CuSO}_4 \times \frac{1 \text{ mol Fe}}{1 \text{ mol CuSO}_4} = 0.9398 \text{ mol Fe (required)}$

\therefore Fe is the limiting reagent.

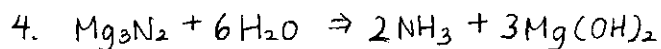
a) $0.8953 \text{ mol Fe} \times \frac{1 \text{ mol Cu}}{1 \text{ mol Fe}} \times \frac{63.546 \text{ g Cu}}{1 \text{ mol Cu}} = 56.893 \text{ g Cu}$

c) $\% \text{ yield} = \frac{43 \text{ g Cu}}{56.893 \text{ g Cu}} \times 100\%$
 $= 75.58\%$



$40 \text{ g C}_2\text{H}_6 \times \frac{1 \text{ mol C}_2\text{H}_6}{30.070 \text{ g C}_2\text{H}_6} \times \frac{6 \text{ mol H}_2\text{O}}{2 \text{ mol C}_2\text{H}_6} \times \frac{18.015 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 71.892 \text{ g H}_2\text{O}$

$\% \text{ yield} = \frac{60 \text{ g H}_2\text{O}}{71.892 \text{ g H}_2\text{O}} \times 100\%$
 $= 83.46\%$



consider Mg_3N_2 :

$50.0 \text{ g Mg}_3\text{N}_2 \times \frac{1 \text{ mol Mg}_3\text{N}_2}{100.929 \text{ g Mg}_3\text{N}_2} = 0.4954 \text{ mol Mg}_3\text{N}_2 \text{ (available)}$

$0.4954 \text{ mol Mg}_3\text{N}_2 \times \frac{6 \text{ mol H}_2\text{O}}{1 \text{ mol Mg}_3\text{N}_2} = 2.9724 \text{ mol H}_2\text{O (required)}$

consider H_2O :

$30.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18.015 \text{ g H}_2\text{O}} = 1.6653 \text{ mol H}_2\text{O (available)}$

$1.6653 \text{ mol H}_2\text{O} \times \frac{1 \text{ mol Mg}_3\text{N}_2}{6 \text{ mol H}_2\text{O}} = 0.2776 \text{ mol Mg}_3\text{N}_2 \text{ (required)}$

\therefore H_2O is the limiting reagent.

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

$\% \text{ yield} = \frac{40 \text{ g Mg(OH)}_2}{48.559 \text{ g Mg(OH)}_2} \times 100\%$
 $= 82.37\%$

(continued on next page)

$$P = 98 \text{ kPa}$$

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

$$n = 1.6653 \text{ mol H}_2\text{O} \times \frac{2 \text{ mol NH}_3}{6 \text{ mol H}_2\text{O}} = 0.5551 \text{ mol NH}_3$$

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

$$T = 25^\circ\text{C} + 273.15 = 298.15 \text{ K}$$

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

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

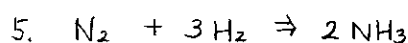
$$= 14.04 \text{ L}$$

(of NH_3)

if % yield was the same,

$$14.04 \text{ L NH}_3 \times 82.37\%$$

$$= 11.563 \text{ L NH}_3$$



consider N_2 :

$$10 \text{ L N}_2 \times \frac{1 \text{ mol N}_2}{22.414 \text{ L N}_2} = 0.4461 \text{ mol N}_2 \text{ (available)}$$

$$0.4461 \text{ mol N}_2 \times \frac{3 \text{ mol H}_2}{1 \text{ mol N}_2} = 1.3383 \text{ mol H}_2 \text{ (required)}$$

consider H_2 :

$$25 \text{ L H}_2 \times \frac{1 \text{ mol H}_2}{22.414 \text{ L H}_2} = 1.1154 \text{ mol H}_2 \text{ (available)}$$

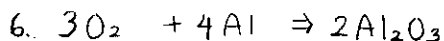
$$1.1154 \text{ mol H}_2 \times \frac{1 \text{ mol N}_2}{3 \text{ mol H}_2} = 0.3718 \text{ mol N}_2 \text{ (required)}$$

$\therefore \text{H}_2$ is the limiting reagent.

$$1.1154 \text{ mol H}_2 \times \frac{2 \text{ mol NH}_3}{3 \text{ mol H}_2} \times \frac{22.414 \text{ L NH}_3}{1 \text{ mol NH}_3} = 16.667 \text{ L NH}_3$$

$$\% \text{ yield} = \frac{15 \text{ L NH}_3}{16.667 \text{ L NH}_3} \times 100\%$$

$$= 89.998\%$$



consider O_2 :

$$5 \text{ L O}_2 \times \frac{1 \text{ mol O}_2}{22.414 \text{ L O}_2} = 0.2231 \text{ mol O}_2 \text{ (available)}$$

$$0.2231 \text{ mol O}_2 \times \frac{4 \text{ mol Al}}{3 \text{ mol O}_2} = 0.2975 \text{ mol Al} \text{ (required)}$$

consider Al

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

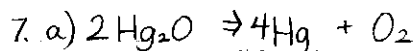
$$0.0741 \text{ mol Al} \times \frac{3 \text{ mol O}_2}{4 \text{ mol Al}} = 0.0556 \text{ mol O}_2 \text{ (required)}$$

$\therefore \text{Al}$ is the limiting reagent

$$0.0741 \text{ mol Al} \times \frac{2 \text{ mol Al}_2\text{O}_3}{4 \text{ mol Al}} \times \frac{101.961 \text{ g Al}_2\text{O}_3}{1 \text{ mol Al}_2\text{O}_3} = 3.778 \text{ g Al}_2\text{O}_3$$

$$\% \text{ yield} = \frac{2.95 \text{ g Al}_2\text{O}_3}{3.778 \text{ g Al}_2\text{O}_3} \times 100\%$$

$$= 78.08\%$$



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

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

$$n = 500 \text{ g Hg}_2\text{O} \times \frac{1 \text{ mol Hg}_2\text{O}}{417.179 \text{ g Hg}_2\text{O}} \times \frac{1 \text{ mol O}_2}{2 \text{ mol Hg}_2\text{O}} = 0.5993 \text{ mol O}_2$$

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

$$T = 185^\circ\text{C} + 273.15 = 458.15 \text{ K}$$

$$V = \frac{0.5993 \text{ mol O}_2 \times 8.314 \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 458.15 \text{ K}}{101.325 \text{ kPa}}$$

$$= 22.529 \text{ L O}_2$$

$$\% \text{ yield} = \frac{6.95 \text{ L O}_2}{22.529 \text{ L O}_2} \times 100\%$$

$$= 30.849 \%$$

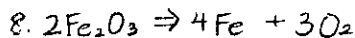
$$\text{b) } 500 \text{ g Hg}_2\text{O} \times \frac{1 \text{ mol Hg}_2\text{O}}{417.179 \text{ g Hg}_2\text{O}} \times \frac{4 \text{ mol Hg}}{2 \text{ mol Hg}_2\text{O}} \times \frac{200.59 \text{ g Hg}}{1 \text{ mol Hg}} = 480.825 \text{ g Hg}$$

c) if % yield was the same,

$$480.825 \text{ g Hg} \times 30.849 \%$$

$$= 148.3297 \text{ g Hg}$$

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.



$$12200 \text{ t iron ore} \times \frac{56.1 \text{ t Fe}_2\text{O}_3}{100 \text{ t iron ore}} \times \frac{85.5 \text{ t Fe}_2\text{O}_3}{100 \text{ t Fe}_2\text{O}_3} \times \frac{1000000 \text{ g Fe}_2\text{O}_3}{1 \text{ t Fe}_2\text{O}_3} \times \frac{1 \text{ mol Fe}_2\text{O}_3}{159.687 \text{ g Fe}_2\text{O}_3} \times \frac{4 \text{ mol Fe}}{2 \text{ mol Fe}_2\text{O}_3} \times \frac{55.845 \text{ g Fe}}{1 \text{ mol Fe}} \times \frac{1 \text{ t Fe}}{1000000 \text{ g Fe}} = 4092.923 \text{ t Fe}$$