Objective 3

2. ΔH is negative and obtained by taking the enthalpy of the products minus the enthalpy of the reactants. For ΔH to be negative, the enthalpy of the reactants (2 Cl) must be greater than that of the product.

3. a. exothermic

b. $\frac{2.4 g\ Mg}{1} \times \frac{1 \cancel{mol\ Mg}}{24.31 g} \times \frac{-1204 kJ}{2 \cancel{mol\ Mg}} = \boxed{-59.4\ kJ}$

c. $\frac{-96.0 kJ}{1} \times \frac{2 mol\ MgO}{-1204 kJ} \times \frac{40.31 g}{1 mol\ MgO} = \boxed{6.43 g}$

4. $q = m \cdot C \cdot \Delta T = 60.0 g \cdot 4.184 \frac{J}{g \cdot °C} (16.9°C - 22.0°C)$

$= -1280 J$ lost by water

$+1280 J$ endothermic or $1.28 kJ$

need to find mol

$\frac{4.25 g\ NH_4NO_3}{1} \times \frac{1 mol}{80 g} = .0531 mol$

$\frac{1.28 kJ}{.0531 mol} = \boxed{24.1 \frac{kJ}{mol}}$

5.a $A \rightarrow C$

$A \rightarrow \cancel{B}$ $\Delta H = +30 kJ$

$\cancel{B} \rightarrow C$ $\Delta H = +60 kJ$

$A \rightarrow C$ $\boxed{\Delta H = +90 kJ}$

b. Don't worry about enthalpy diagram
Hess's law is a law of summations
Partial paths add to the desired path

6.a $P_4O_6 + 2O_2 \rightarrow P_4O_{10}$

$P_4O_6 (s) \rightarrow \cancel{P_4(s)} + \cancel{3O_2}(g)$ $\Delta H = +1640 kJ$

$\cancel{P_4(s)} + \cancel{5O_2}\ 2O_2 \rightarrow P_4O_{10} (s)$ $\Delta H = -2940 kJ$

$P_4O_6 + 2O_2 \rightarrow P_4O_{10}$ $\boxed{\Delta H = -1300 kJ}$

7. a. $1 CH_4 (g) + 2 O_2 (g) \rightarrow 1 CO_2 (g) + 2 H_2O (l)$

$-74.86 \frac{kJ}{mol}$ $0 \frac{kJ}{mol}$ $-393.5 \frac{kJ}{mol}$ $-285.8 \frac{kJ}{mol}$

$\Delta H = \Delta H \text{(products)} - \Delta H \text{(reactants)}$

$= \left(\left(1 \cancel{mol} \cdot -393.5 \frac{kJ}{\cancel{mol}}\right) + \left(2 \cancel{mol} \cdot -285.8 \frac{kJ}{\cancel{mol}}\right) \right) - \left(\left(1 \cancel{mol} \cdot -74.86 \frac{kJ}{\cancel{mol}}\right) + \left(2 mol \cdot 0\right) \right)$

$= -965.1 - -74.86 = \boxed{-890.24 kJ}$

b. $3 NO (g) + 1 O_3 (g) \rightarrow 3 NO_2 (g)$

$90.37 \frac{kJ}{mol}$ $142.0 \frac{kJ}{mol}$ $33.85 \frac{kJ}{mol}$

$\Delta H = \Delta H \text{(products)} - \Delta H \text{(reactants)}$

$= \left(3 \cancel{mol} \cdot 33.85 \frac{kJ}{\cancel{mol}}\right) - \left(\left(3 \cancel{mol} \cdot 90.37 \frac{kJ}{\cancel{mol}}\right) + \left(1 \cancel{mol} \cdot 142.0 \frac{kJ}{\cancel{mol}}\right) \right)$

$= 101.55 kJ - 413.11 kJ = \boxed{-311.56 kJ}$

7. c. $2Al(s) + 1\,Fe_2O_3(s) \rightarrow 2\,Fe(s) + 1\,Al_2O_3(s)$

$0.0 \quad -822.1\frac{kJ}{mol} \quad 0.0 \quad -1676.0\frac{kJ}{mol}$

$\Delta H = \Delta H(\text{products}) - \Delta H(\text{reactants})$

$= ((1\cancel{mol} \cdot -1676.0\frac{kJ}{\cancel{mol}}) + (2mol \cdot 0)) - ((2mol \cdot 0) + (1\cancel{mol} \cdot -822.1\frac{kJ}{\cancel{mol}}))$

$= -1676.0kJ + + 822.1\,kJ = \boxed{-853.9kJ}$

d. $1\,CaO(s) + 1\,CO_2(g) \rightarrow 1\,CaCO_3(s)$

$-635.1\frac{kJ}{mol} \quad -393.5\frac{kJ}{mol} \quad -1207.0\frac{kJ}{mol}$

$\Delta H = \Delta H(\text{products}) - \Delta H(\text{reactants})$

$= (1\cancel{mol} \cdot -1207.0\frac{kJ}{\cancel{mol}}) - ((1\cancel{mol} \cdot -635.1\frac{kJ}{\cancel{mol}}) + (1\cancel{mol} \cdot -393.5\frac{kJ}{\cancel{mol}})$

$= -1207.0\frac{kJ}{\cancel{mol}} + + 1028.6\,kJ = \boxed{-178.4\,kJ}$

Objective 4

2. a. $+$ decreases
   b. $+$ increases
   c. $-$ decreases
   d. $-$ decreases

3. a. $2\,H_2S(g) + SO_2(g) \rightarrow 3S(s, \text{rhombic}) + 2H_2O(g)$

$\Delta S = ((3\cancel{mol} \cdot 31.92\frac{J}{\cancel{mol}\cdot K}) + (2 \cdot 188.72)) - ((2 \cdot 205.78) + (1 \cdot 248.11))$

$473.2\frac{J}{\cancel{mol}K} - 659.67\frac{J}{\cancel{mol}K} = \boxed{-186.47\frac{J}{\cancel{mol}K}}$

$\Delta G = ((3mol \cdot 0) + (2mol \cdot -228.59)) - (2mol \cdot -33.05) + (1 \cdot -300.$

$= -457.18\,kJ - - 366.29\,kJ$

$= \boxed{-90.89\,kJ}$

3. b. $2SO_3(g) \rightarrow 2SO_2(g) + O_2(g)$

$\Delta S = ((2mol \cdot 248.11 \frac{J}{mol \cdot K}) + (1mol \cdot 205.03)) - (2mol \cdot 256.65))$

$\Delta S = 701.25 - 513.3 = \boxed{187.95 \frac{J}{K}}$

$\Delta G = ((2mol \cdot -300.19 \frac{kJ}{mol}) + (1mol \cdot 0)) - (2mol \cdot -371.08)$

$= -600.38 KJ + +742.16 = \boxed{+141.78 KJ}$

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

$\Delta S = ((2mol \cdot 27.28 \frac{J}{mol \cdot K}) + (3 \cdot 188.72)) - ((1 \cdot 87.40) + (3 \cdot 130.59))$

$620.72 \frac{J}{K} - 479.17 \frac{J}{K} = \boxed{141.55 \frac{J}{K}}$

$\Delta G = ((2mol \cdot 0) + (3 \cdot -228.59) - ((1 \cdot -742.24) + (3 \cdot 0)))$

$-685.77 KJ + +742.24 KJ$

$= \boxed{56.47 KJ}$

d. $2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$

$\Delta S = ((2mol \cdot 213.67 \frac{J}{mol \cdot K}) + (4 \cdot 188.72)) - ((2 \cdot 239.70) + (3 \cdot 205.03))$

$= 1182.22 - 1094.49 = \boxed{87.73 \frac{J}{K}}$

$\Delta G = ((2mol \cdot -394.38 \frac{kJ}{mol}) + (4 \cdot -228.59)) - ((2 \cdot -162.42) + (3 \cdot 0))$

$-1703.4 KJ + +324.84 KJ$

$= \boxed{-1378.6 KJ}$

4. a. $\Delta G = \Delta H - T\Delta S$

$= -58.03kJ - (298\cancel{K} \cdot -.1766 \frac{kJ}{\cancel{K}})$

$= -58.03kJ + +52.63kJ$

$\boxed{= -5.4kJ}$

b. $0 = -58.03kJ - (T \cdot -.1766 \frac{kJ}{K})$

$58.03kJ = + + .1766 \frac{kJ}{K} \cdot T$

$T = 328.5K$

c. Below this temperature the reaction is spontaneous

5. $\Delta G = \Delta H - T\Delta S$

$-254.3kJ = \Delta H - (298\cancel{K} \cdot .658 \frac{kJ}{\cancel{K}})$

$-254.3kJ = \Delta H - 196kJ$

$\boxed{\Delta H = -58.3kJ}$