

37 a) ΔS -

c) ΔS -

b) ΔS +

d) ΔS +

38 a) a) (diamond more ordered than graphite)

b) $C_2H_5OH(g)$ is more disordered than liquid

c) $CO_2(g)$ is more disordered than $CO_2(s)$

4) a) $2H_2S(g) + SO_2(g) \rightarrow 3S_{\text{rhombic}} + 2H_2O(g)$
 ΔS - (less moles of gas on product)

$$\Delta S_{\text{rxn}} = \sum n S_{\text{prod}}^{\circ} - \sum n S_{\text{react}}^{\circ}$$

$$= [2 \text{ mol} \left(32 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) + 2 \text{ mol} \left(189 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right)] -$$

$$[2 \text{ mol} \left(206 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) + 1 \text{ mol} \left(248 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right)]$$

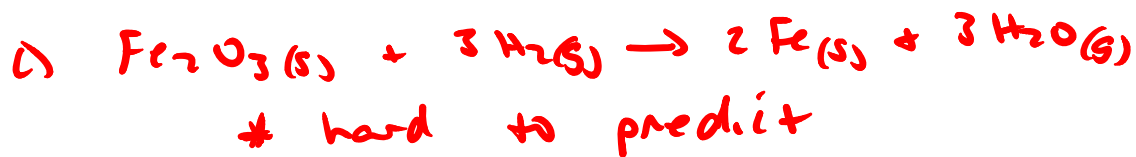
$$= 474 \frac{\text{J}}{\text{K}} - 660 \frac{\text{J}}{\text{K}} = -186 \frac{\text{J}}{\text{K}}$$

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

ΔS (+)

$$\Delta S^{\circ} = [2 \text{ mol} \left(248 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) + 1 \text{ mol} \left(205 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right)] - [2 \text{ mol} \left(257 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right)]$$

$$\Delta S^{\circ} = 187 \frac{\text{J}}{\text{K}}$$



$$\Delta S^\circ = \left[2\text{mol} \left(27 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) + 3\text{mol} \left(189 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) \right] - \left[1\text{mol} \left(90 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) + 3\text{mol} \left(141 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) \right]$$

$$\Delta S = 138 \frac{\text{J}}{\text{K}}$$



$$\Delta S^\circ = \left[2(S^\circ_{\text{CF}_4}) + 1(S^\circ_{\text{H}_2}) \right] - \left[1(S^\circ_{\text{H}_2}) + 4(S^\circ_{\text{F}_2}) \right]$$

$$-358 \frac{\text{J}}{\text{K}} = \left[2\text{mol}(x) + 1\text{mol} \left(131 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) \right] -$$

$$\left[1\text{mol} \left(201 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) + 4\text{mol} \left(203 \frac{\text{J}}{\text{mol}\cdot\text{K}} \right) \right]$$

$$S^\circ_{\text{CF}_4} = 262 \frac{\text{J}}{\text{mol}\cdot\text{K}}$$

47) a) when a bond is formed, energy is released
 exothermic ΔH -
 more reactant moles of gas than product
 moles of gas
 ΔS -

b) $\Delta G = \Delta H - T\Delta S$

$\ominus \quad - \quad \downarrow \quad -$

must be low temperature



$$\Delta H_{rxn}^\circ = \sum n \Delta H_f^\circ \text{prod} - \sum n \Delta H_f^\circ \text{react}$$

$$= [2 \text{mol}(-242 \frac{\text{kJ}}{\text{mol}}) + 1 \text{mol}(-393.5 \frac{\text{kJ}}{\text{mol}})] -$$

$$[1 \text{mol}(-75 \frac{\text{kJ}}{\text{mol}})] = \boxed{-803 \text{ kJ}}$$

$$\Delta S_{rxn}^\circ = \sum n S^\circ \text{prod} - \sum n S^\circ \text{react}$$

$$= [2 \text{mol}(189 \frac{\text{J}}{\text{mol}\cdot\text{K}}) + 1 \text{mol}(214 \frac{\text{J}}{\text{mol}\cdot\text{K}})] -$$

$$[1 \text{mol}(186 \frac{\text{J}}{\text{mol}\cdot\text{K}}) + 2 \text{mol}(205 \frac{\text{J}}{\text{mol}\cdot\text{K}})] = \boxed{-4 \frac{\text{J}}{\text{K}}}$$

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

$$= (-803,000 \text{ J}) - (298 \text{ K})(-4 \frac{\text{J}}{\text{K}}) = -802 \times 10^3 \text{ J or } -802 \text{ kJ}$$



$$\Delta H^\circ = [-1275] - [6(-286) + 6(-393.5)] = 2802 \text{ kJ}$$

$$\Delta S^\circ = [6(205) + 212] - [6(214) + 6(70)] = -262 \frac{\text{J}}{\text{K}}$$

$$\Delta G = 2802 \text{ kJ} - (298 \text{ K})(-0.262 \frac{\text{kJ}}{\text{K}}) = 2880 \text{ kJ}$$



$$\Delta H^\circ = [4 \text{mol}(-1279 \frac{\text{kJ}}{\text{mol}})] - [1 \text{mol}(-2984 \frac{\text{kJ}}{\text{mol}}) + 6 \text{mol}(-286 \frac{\text{kJ}}{\text{mol}})]$$

$$= -416 \text{ kJ}$$

$$\Delta S^\circ = [4 \text{mol}(110. \frac{\text{J}}{\text{mol}\cdot\text{K}})] - [1 \text{mol}(229 \frac{\text{J}}{\text{mol}\cdot\text{K}}) + 6 \text{mol}(70 \frac{\text{J}}{\text{mol}\cdot\text{K}})]$$

$$= -209 \frac{\text{J}}{\text{K}}$$



$$\Delta H^\circ = (314) - (-92 - 46) = -176 \text{ kJ}$$

$$\Delta S^\circ = 96 - (187 + 193) = -284 \frac{\text{J}}{\text{K}}$$

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

$$= -176 \text{ kJ} - (298 \text{ K}) \left(-0.284 \frac{\text{kJ}}{\text{K}} \right) = -91 \text{ kJ}$$

$$51) \quad \Delta G^\circ = \Delta H - T \Delta S$$

$$= -58.04 \text{ kJ} - (298 \text{ K}) \left(-0.1766 \frac{\text{kJ}}{\text{K}} \right)$$

$$= -5.40 \text{ kJ}$$

$$\Delta G^\circ = 0 = \Delta H - T \Delta S$$

$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{-58.03 \text{ kJ}}{-0.1766 \frac{\text{kJ}}{\text{K}}} = 328.6 \text{ K}$$

ΔG° is negative below 328.6 K



$$\begin{aligned}
 55) \quad \Delta G^\circ &= \sum n \Delta G_{F, \text{prod}}^\circ - \sum n \Delta G_{F, \text{react}}^\circ \\
 &= -374 \text{ kJ} = -1105 \text{ kJ} - \Delta G_{F, \text{SF}_4}^\circ \\
 \Delta G_{F, \text{SF}_4}^\circ &= -731 \frac{\text{kJ}}{\text{mol}}
 \end{aligned}$$

$$\begin{aligned}
 57) \quad \Delta G^\circ &= [2 \text{ mol}(0) + 3 \text{ mol}(-229 \frac{\text{kJ}}{\text{mol}})] - \\
 & \quad [1 \text{ mol}(-740 \frac{\text{kJ}}{\text{mol}}) + 3 \text{ mol}(0)] = 53 \text{ kJ}
 \end{aligned}$$

b) ΔG° is +
 * not spontaneous @ standard conditions

$$c) \quad \Delta G^\circ = \Delta H^\circ - T \Delta S$$

$$\Delta S = \frac{\Delta G^\circ - \Delta H^\circ}{T} = \frac{100. \text{ kJ} - 53 \text{ kJ}}{298 \text{ K}} = 0.16 \frac{\text{kJ}}{\text{K}}$$

solve for temp when $\Delta G^\circ = 0$

$$\Delta G^\circ = \Delta H^\circ - T \Delta S$$

$$T = \frac{\Delta H^\circ}{\Delta S} = \frac{100. \text{ kJ}}{0.16 \frac{\text{kJ}}{\text{K}}} = 630 \text{ K}$$

that reaction will be spontaneous

$\Delta G^\circ < 0$ when $T > 630 \text{ K}$