CHAPTER 17

33. a) $H_2O_{(l)} \rightarrow H_2O_{(g)}$ endothermic

ΔH_{sys} increases, thus ΔS_{surr} decreases

$\therefore \Delta S_{surr}$ is negative

b) $I_{2(g)} \rightarrow I_{2(s)}$ exothermic

ΔH_{sys} decreases, thus ΔS_{surr} increases

$\therefore \Delta S_{surr}$ is positive

41. a) volume decreased, thus decrease in distribution of E. $\therefore$ entropy decreases and $\Delta S°$ is negative.

c) 3 mol gas $\rightarrow$ 1 mol liquid (0 mol gas)

liquid has less entropy than gas

$\therefore$ entropy decreases and $\Delta S°$ is negative

out of order

d) 11 mol liquid $\rightarrow$ 4 mol gas

4 mol gas have much more entropy than 11 mol liquid

$\therefore$ entropy increases and $\Delta S°$ is positive

b) liquid $\rightarrow$ solid

solids have less entropy than liquids

$\therefore$ entropy decreases and $\Delta S°$ is negative

43. a) $C_{graphite\ (s)}$, it is less ordered in structure than diamond.

b) $C_2H_5OH_{(g)}$, gases have more disorder than liquids

c) $CO_{2(g)}$, gases have more disorder than solids

CHAPTER 17

45. a) $2H_2S(g) + SO_2(g) \rightarrow 3S_{rhombic}(s) + 2H_2O(g)$

3 mol gas → 2 mol gas $\Delta S°$ is negative

$\Delta S° = [(3)(32\ J/mol \cdot K) + (2)(189\ J/mol \cdot K)]$
$- [(2)(206\ J/mol \cdot K) + (1)(248\ J/mol \cdot K)]$

$\Delta S° = [474\ J/mol \cdot K] - [660\ J/mol \cdot K] = \boxed{-186\ J/mol \cdot K}$

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

2 mol gas → 3 mol gas $\Delta S°$ is positive

$\Delta S° = [(2)(248\ J/mol \cdot K) + (1)(205\ J/mol \cdot K)]$
$- [(2)(257\ J/mol \cdot K)]$

$\Delta S° = 701\ J/mol \cdot K - 514\ J/mol \cdot K = \boxed{187\ J/mol \cdot K}$

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

3 mol gas → 3 mol gas $\Delta S° = ?$

Too hard to predict

$\Delta S° = [(2)(27\ J/mol \cdot K) + (3)(189\ J/mol \cdot K)]$
$- [(1)(90.\ J/mol \cdot K) + (3)(131\ J/mol \cdot K)]$

$\Delta S° = [621\ J/mol \cdot K] - [483\ J/mol \cdot K] = \boxed{138\ J/mol \cdot K}$

CHAPTER 17

47. $C_2H_2(g) + 4F_2(g) \rightarrow 2CF_4(g) + H_2(g)$ $\Delta S^\circ = -358\ J/K$

$-358\ J/mol \cdot K = [(2)\ S^\circ_{CF_4} + (1)(131\ J/mol \cdot K)]$
$- [(1)(201\ J/mol \cdot K) + (4)(203\ J/mol \cdot K)]$

$655\ J/mol \cdot K = (2)\ S^\circ_{CF_4} + 131\ J/mol \cdot K$

$\boxed{S^\circ_{CF_4} = 262\ J/mol \cdot K}$

57. $CH_4(g) \rightarrow \cancel{2H_2(g)} + \cancel{C(s)}$ $\Delta G^\circ = +51\ kJ$

$\cancel{2H_2(g)} + O_2(g) \rightarrow 2H_2O(l)$ $\Delta G^\circ = -474\ kJ$

$\cancel{C(s)} + O_2(g) \rightarrow CO_2(g)$ $\Delta G^\circ = -394\ kJ$

$CH_4(g) + 2O_2(g) \rightarrow 2H_2O(l) + CO_2(g)$

$\Delta G^\circ = 51\ kJ - 474\ kJ - 394\ kJ = \boxed{-817\ kJ}$

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

a) $\Delta G^\circ = [(2)(0\ kJ/mol) + (3)(-229\ kJ/mol)]$
$- [(1)(-740\ kJ/mol) + (3)(0)]$

$\boxed{\Delta G^\circ = 53\ kJ/mol}$

b) Since ΔG° is positive, the rxn is not spontaneous (not thermodynamically favorable) at 298 K.

CHAPTER 17

69. $NO(g) + O_3(g) \rightleftharpoons NO_2(g) + O_2(g)$

$\Delta G^\circ = [(1)(52\ kJ/mol) + (1)(0)] - [(1)(87\ kJ/mol\cdot K) + (1)(163\ kJ/mol\cdot K)]$

$\boxed{\Delta G^\circ = -198\ kJ/mol}$

$\Delta G^\circ = -RT\ln K$

$-198000\ J = -8.31\ \frac{J}{mol\cdot K}(298\ K)\ln K$

$\ln K = 79.955$

$K = e^{79.955} = \boxed{5.30 \times 10^{34}}$

71. $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H^\circ = -58.03\ kJ/mol$

$\Delta S^\circ = -176.6\ J/mol\cdot K$

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

At 25°C $\Delta G = -58.03\ kJ/mol - 298\ K(-0.1766\ kJ/mol\cdot K)$

$\Delta G = -5.4032\ kJ/mol$

$\Delta G = -RT\ln K$

$-5403.2\ J/mol = -8.31\ J/mol\cdot K(298\ K)\ln K$

$\ln K = 2.18189$

$K = e^{2.18189} = \boxed{8.86}$

At 100.0°C $\Delta G = -58.03\ kJ/mol - 373K(-0.1766\ kJ/mol\cdot K) = 7.84\ kJ/mol$

$\Delta G = -RT\ln K$

$7841.8\ J/mol = -8.31\ J/mol\cdot K(373\ K)\ln K \therefore K = e^{-2.5299} = \boxed{0.0797}$

CHAPTER 17

75. $ATP_{(aq)} + H_2O_{(l)} \rightarrow ADP_{(aq)} + H_2PO_4^-{}_{(aq)}$

a) $\Delta G = -RT \ln K$

$-30500\ J = -8.31\ J/mol \cdot K\ (298\ K) \ln K$

$\ln K = 12.316$

$K = e^{12.316} = \boxed{2.23 \times 10^5}$

b) $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$

$\Delta G^\circ = [(6)(-394\ kJ/mol) + (6)(-237\ kJ/mol)]$
$- [(1)(-911\ kJ/mol) + (6)(0)]$

$\Delta G^\circ = -2875\ kJ/mol$

$1\ mol\ C_6H_{12}O_{6(s)} = 2875\ kJ$

$\therefore \frac{2875\ kJ}{} \left| \frac{1\ mol\ ATP}{30.5\ kJ} \right. = 94.3\ mol\ ATP$

$\boxed{\therefore 1\ molecule\ of\ C_6H_{12}O_{6(s)} = 94.3\ molecules\ ATP}$