Homework Chapter 20

Wednesday, January 10, 2007
12:11 AM

Problems 14, 15, 18, 19, 20, 21, 33, 43, 46, 47, 50, 51, 55, 57, 58, 59, 63, 67, 68, 74, 78, 82, 96, 105

14 a $\Delta S > 0$
b $\Delta S > 0$
c $\Delta S > 0$

15 a $\Delta S < 0$
b $\Delta S < 0$
c $\Delta S < 0$

18 a $\Delta S^\circ > 0$
b $\Delta S^\circ < 0$
c $\Delta S^\circ > 0$

19 a $\Delta S^\circ < 0$
b $\Delta S^\circ > 0$
c $\Delta S^\circ < 0$

20 a $\Delta S^\circ > 0$
b $\Delta S^\circ < 0$
c $\Delta S^\circ > 0$

21 a $\Delta S^\circ < 0$
b $\Delta S^\circ > 0$
c $\Delta S^\circ < 0$

33 a $\Delta S^\circ < 0$

$3NO_{(g)} \rightarrow N_2O_{(g)} + NO_{2(g)}$

ΔS | 210.65   219.7   239.9   J/mol·K

$219.7 + 239.9 - 3 \times 210.65$

-172.35 J/K

b $\Delta S^\circ > 0$

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

130.6   87.400   27.3   188.72

$(2 \times 27.3 + 3 \times 188.72) - (3 \times 130.6 + 87.400)$

$620.76 - 479.2$

141.56 J/K

c $\Delta S^\circ < 0$

$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$

41.1   205.0   229

$\Delta S^\circ = 229 - (41.1 + 5 \times 205.0)$

$= -837.1$ J/K

(43) $SO_2(g) + Ca(OH)_2(s) \rightarrow CaSO_3(s) + H_2O(l)$

248.1 84.4 101.4 69.940

$(101.4 + 69.940) - (248.1 + 84.4)$

$= -161.16$

(48) ΔH and ΔS are positive.

$2N_2O(g) + O_2(g) \rightarrow 4NO(g)$ $\Delta H = 197.1$ kJ

$\Delta S = 198.2$ J/K

(46) as the spontaneity or entropy increases the free energy decreases

(47) higher temperature

(50) ⓐ $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

0 0 -569.0

$\Delta G° = 2 \times -569.0 - 0$

$= -1138.0$ kJ

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

-161.9 0 -394.4 -228.60

$(4 \times -228.6\ 2 \times -394.4) - (2 \times -161.9)$

$\Delta G = -1379.4$ kJ

ⓒ $BaO(s) + CO_2(g) \rightarrow BaCO_3(s)$

-520.4 -394.4 -1139

$-1139 + 520.4 + 394.4$

$\Delta G = -224.2$

(51) ⓐ $H_2(g) + I_2(s) \rightarrow 2HI(g)$

0 0 1.3

$\Delta G° = 1.3 \times 2 = 2.6$ kJ

ⓑ $MnO_2(s) + 2CO(g) \rightarrow Mn(s) + 2CO_2(g)$

-446.1 -137.2 0 -394.4

$(-394 \times 2) - (-446.1 + -137.2 \times 2)$

$\Delta G° = -67.5$ kJ

ⓒ $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

-203.0 -16 -95.3

$\Delta G° = (-95.3 - 16) - (-203.0)$

$= 91.7$ kJ

(55) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$

ⓐ $\Delta H° < 0$ $\Delta S° > 0$

ⓑ $(5 \times -228.60 + 4 \times -394.4) - (-16.7 + \frac{13}{2} \times 0)$

$\Delta G° = -2703.9$

(57) $CO(g) + Cl_2(g) \rightarrow COCl_2$

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

$$\Delta S° = \frac{\Delta H° - \Delta G°}{T}$$

$$\Delta S° = \frac{(-220.\ kJ/mol) - (-206\ kJ/mol)}{298}$$

$= -0.0470\ kJ/K$

ⓑ $\Delta G = -220.\ kJ/mol - (450.\ K)(-0.0470\ kJ/K)$

$= -217.9\ kJ/mol$

(58) $CH_3OH(g) \rightleftharpoons CO(g) + 2H_2(g)$

ⓐ $\Delta H° = (2 \times 0 + -110.5) - (-201.2)$

$= 90.7\ kJ$

$\Delta S° = (2 \times 130.6 + 197.5) - (238)$

$= 220.7\ J/K$

ⓑ $\frac{220.7\ J}{K} \times \frac{1\ kJ}{1000\ J} = .2207\ kJ/K$

$\Delta G° = 90.7\ kJ - (311\ K)(.2207\ kJ/K)$

$= 22.1\ kJ$ at 38°C

$\Delta G° = 90.7\ kJ - (411\ K)(.2207\ kJ/K)$

$= -.0077\ kJ$ at 138°C

$\Delta G° = 90.7\ kJ - (511\ K)(.2207\ kJ/K)$

$= -22.1\ kJ$ at 238°C

ⓒ not spontaneous at 38°C, at equilibrium at 138°C and spontaneous at 238°C

(59) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

ⓐ $\Delta H° = (2 \times 90.29) - (0 + 0)$

$= 180.58\ kJ$

$\Delta S° = (2 \times 210.65) - (191.5 + 205.0)$

$= 24.8\ J/K$

ⓑ $\frac{24.8\ J}{K} \times \frac{1\ kJ}{1000\ J} = .0248\ kJ/K$

$\Delta G° = 180.58\ kJ - (373\ K)(.0248\ kJ/K)$

$= 171.3\ kJ$ at 100°C

$\Delta G° = 180.58\ kJ - (2833\ K)(.0248\ kJ/K)$

$= 110.3$ at 2560°C

$\Delta G° = 180.58\ kJ - (3813)(.0248\ kJ/K)$

$= 86.0\ kJ$ at 3540°C

ⓒ the reaction is not spontaneous as temperature increases.

(63) $C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$

$\Delta H° = (2 \times -393.5 + 2 \times -277.63) - (-1273.3)$

$= -68.96\ kJ$

$\Delta S° = (2 \times 213.7 + 2 \times 161) - (212.1)$

$= \frac{537.3\ J}{K} \times \frac{1\ kJ}{1000\ J} = .5373\ kJ/K$

$\Delta G° = -68.96\ kJ - (298)(.5373)$

$= -229.1\ kJ$

it is spontaneous at all temp. because $\Delta H° < 0$ and $\Delta S > 0$

(67) $\Delta G°$ is when all components of the system are in their standard states.

ΔG does not need all components to be in their standard states so temperature, concentration, and pressure can deviate fro m STP .

(68) ⓐ $NO(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO_2(g)$

$K = e^{-\Delta G/RT}$

$\Delta G° = (51) - (86.60 + 0)$

$= -35.6\ kJ \times \frac{1000\ J}{1\ kJ} = -35600\ J$

$K = e^{35600/(8.314)(298)}$

$K = 1.74 \times 10^6$

ⓑ $2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$

$\Delta G° = 0 - (-95.30 \times 2)$

$= 190.6\ kJ = 190600\ J$

$K = e^{-190600/(8.314)(298)}$

$K = 3.89 \times 10^{-34}$

ⓒ $2C(graphite) + O_2(g) \rightleftharpoons 2CO(g)$

$\Delta G° = 2 \times -137.2 = -274.4\ kJ = -274400\ J$

$K = e^{274400/(8.314)(298)}$

$K = 1.26 \times 10^{48}$

(69) ⓐ $MgCO_3(s) \rightleftharpoons Mg^{2+}(aq) + CO_3^{2-}(aq)$

$\Delta G° = (-528.10) - (-1028)$

$= 499.9\ kJ = 499900\ J$

$K = e^{-499900/8.314 \times 298}$

$K = 2.36 \times 10^{-88}$

ⓑ $2HCl(g) + Br(l) \rightleftharpoons 2HBr(g) + Cl_2(g)$

$\Delta G° = (2 \times -53.5) - (2 \times -95.30)$

$= -297.6\ kJ = -297600\ J$

$K = e^{297600/8.314 \times 298}$

$= 1.47 \times 10^{52}$

ⓒ $H_2(g) + O_2(g) \rightleftharpoons H_2O_2(l)$

$\Delta G° = -120.4\ kJ = -120400\ J$

$K = e^{120400/8.314 \times 298}$

$K = 1.27 \times 10^{21}$

(74) $I_2(g) + Cl_2(g) \rightleftharpoons 2ICl(g)$

$\Delta G° = (-6.075 \times 2) - (19.38)$

$= -31.53 kJ = -31530 J$

$K = e^{31530/RT}$

$= 3.36 \times 10^5$

(78) $2Fe^{3+}(aq) + Hg_2^{2+}(aq) \rightleftharpoons 2Fe^{2+}(aq) + 2Hg^{2+}(aq)$

$K_c = 9.1 \times 10^{-6}$ at 298 K

(a) $\Delta G° = -RT \ln K$

$= 28758 J/mol$

(b) $2Fe^{3+} + Hg_2^{2+} \rightleftharpoons 2Fe^{2+} + 2Hg^{2+}$

I: 1M 1M 1M 1M

F: 2-x 1-x 2+x 2+x

$9.1 \times 10^{-6} = \frac{(2+x)^2(2+x)^2}{(2-x)^2(1-x)}$

$= \frac{(4+2x+x^2)(4+2x+x^2)}{(4-2x+x^2)(1-x)} = \frac{16+8x+4x^2+8x+4x^2+2x^3+4x^2+2x^3+x^4}{4-2x+x^2-4x+2x^2-x^3}$

$= \frac{x^4+4x^3+12x^2+16x+16}{-x^3+3x^2-6x+4}$

or neglect some Xs

$\frac{16+8x+4x^2}{4} = 9.1 \times 10^{-6}$

$16+8x+4x^2 = 3.64 \times 10^{-5}$

$4x^2+8x+15.9999636$

$\frac{-8 \pm \sqrt{64-255.99}}{8}$ negative $\sqrt{\ }$

(82) $C_{diamond} \rightarrow C_{graphite}$

(a) $\Delta H° = -1.896$ kJ/mol

$\Delta G° = -2.866$ kJ/mol

$\Delta S° = 5.686 - 2.439 = 3.247$ J/mol·K

(b) $K = e^{2866/RT}$

$= 3.456$

diamonds are not forever, perhaps many lifetimes, but not forever.

(c) 1.896 kJ/mol would be required at 298K

(d) it is not spontaneous for the reverse reaction $\Delta H > 0$ $\Delta S < 0$

(96) $2HX(g) \rightleftharpoons H_2(g) + X_2(g)$ using HF

(a) $\Delta H° = 2 \times -273 = -546$ kJ/mol

$\Delta S° = (130.6 + 202.7) - (2 \times 173.67) = -14.04$ J/mol·K

$\Delta G° = 2 \times -275 = -550$ kJ/mol

(b) reaction is spontaneous at low temp because $\Delta H° < 0$ $\Delta S° < 0$

(c) no

(d) when $\Delta G = 0$

(105) $Sb_2S_{3(s)} + 3Fe_{(s)} \rightarrow 2Sb_{(s)} + 3FeS$ $\Delta H^\circ_{rxn} = -125\ kJ$

$\Delta G^\circ_{f\ FeS} = -100\ kJ/mol$ $\Delta H^\circ_{f\ FeS} = -100\ kJ/mol$ $S^\circ_{f\ FeS} = .0603\ kJ/mol$

$\Delta G^\circ_{f\ Sb_2S_3} = -174\ kJ$ $S_{f\ Sb_2S_3} = .182\ kJ$

ⓐ $\Delta H^\circ_{rxn} = \sum \Delta H^\circ_f\ prod - \sum \Delta H^\circ_f\ reactants$

$-125 = [2(\Delta H^\circ_{f\ Sb(s)}) + 3(\Delta H^\circ_{f\ FeS})] - [\Delta H^\circ_{f\ Sb_2S_3} + 3\Delta H^\circ_{f\ Fe}]$

$-125 = 0 + 3(-100\ kJ/mol) - x - 3(0)$ $x = \Delta H^\circ_{f\ Sb_2S_3}$

$x = 425\ kJ = \Delta H^\circ_{f\ Sb_2S_3}$

ⓑ $\Delta G^\circ_{RXN} = (3 \times -100 + 2 \times 0) - (3 \times 0 - 174)$

$= -126\ kJ/mol$

ⓒ S° for Sb(s)

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

$-126\ kJ/mol = -125\ kJ/mol - (298)(\Delta S)$

$-1\ kJ/mol = -298\Delta S$

$\Delta S^\circ = 3.356 \times 10^{-3}$

$3.356 \times 10^{-3} = (.0603 \times 3 + 2x) - (.0273 \times 3 + .182)$

$3.356 \times 10^{-3} = 2x - .083$

$x = .0398\ kJ = \Delta S_{Sb(s)}$