Key

CHEM 1474
Homework #12 (Key)
Spring 2007
Buckley

Show your work on numerical problems to receive any credit. This homework is due on Wednesday, April 11, 2007. Show your work on numerical problems on the back page. Attach extra sheets if you wish.

Multiple choice questions. 2 points each.

1. Which of the following would you expect to have the largest entropy?
   a. Ice at -10 °C
   b. Steam at 150 °C
   c. Ice at 0 °C
   d. Liquid water at 150 °C (this can happen at a higher pressure)
   e. Steam at 100 °C

2. Which of the following is a true statement?
   a. In a spontaneous process, the entropy of a system increases more than the entropy of the surroundings decreases.
   b. In a spontaneous process, the entropy of both the system and the surroundings increases.
   c. In a spontaneous process, the entropy change of the system is in the opposite direction of the entropy change of the surroundings.
   d. In a spontaneous process, the entropy change of the system plus the surroundings is positive.
   e. In a process, the system entropy change determines whether or not the process is spontaneous.

3. Which of the following is mostly directly related to the equilibrium constant for a reaction?
   a. $\Delta H^\circ$
   b. $\Delta S^\circ$
   c. $\Delta G^\circ$
   d. $\Delta T$
   e. $\Delta P$
4. Using the information in the back of your textbook, find $\Delta H^\circ$, $\Delta S^\circ$, and $\Delta G^\circ$ for each of the following reactions. Further indicate whether the reaction would be spontaneous as written or spontaneous in the reverse direction.

$$4 \text{ Fe (s)} + 3 \text{ O}_2 (g) \rightarrow 2 \text{ Fe}_2\text{O}_3 (s)$$

$$\Delta H^\circ = 2(-822.16 \text{ kJ/mol}) - 4(0 \text{ kJ/mol}) - 3(0 \text{ kJ/mol}) = -1644.32 \text{ kJ} = \Delta H$$

$$\Delta S^\circ = 2(89.96 \text{ J/K mol}) - 4(27.15 \text{ J/K mol}) - 3(205.0 \text{ J/K mol}) = -543.68 \text{ J/K} = \Delta S$$

$$\Delta G^\circ = 2(-740.98 \text{ kJ/mol}) - 4(0 \text{ kJ/mol}) - 3(0 \text{ kJ/mol}) = -1481.96 \text{ kJ} = \Delta G$$

$$\text{SO}_3 \text{ (g)} + \text{ H}_2\text{O (l)} \rightarrow \text{ H}_2\text{SO}_4 \text{ (aq)}$$

$$\Delta H^\circ = 1(-909.3 \text{ kJ/mol}) - 1(-395.2 \text{ kJ/mol}) - 1(-285.83 \text{ kJ/mol}) = -228.27 \text{ kJ} = \Delta H$$

$$\Delta S^\circ = 1(20.1 \text{ J/K mol}) - 1(256.2 \text{ J/K mol}) - 1(69.91 \text{ J/K mol}) = -306.01 \text{ J/K} = \Delta S$$

$$\Delta G^\circ = 1(-744.5 \text{ kJ/mol}) - 1(-370.4 \text{ kJ/mol}) - 1(-237.13 \text{ kJ/mol}) = -136.79 \text{ kJ} = \Delta G$$

$$\text{NO}_2 \text{ (g)} + \text{ N}_2\text{O (g)} \rightarrow 3 \text{ NO (g)}$$

$$\Delta H^\circ = 3(90.37 \text{ kJ/mol}) - 1(33.84 \text{ kJ/mol}) - 1(81.6 \text{ kJ/mol}) = 155.67 \text{ kJ} = \Delta H$$

$$\Delta S^\circ = 3(210.62 \text{ J/K mol}) - 1(240.45 \text{ J/K mol}) - 1(220.0 \text{ J/K mol}) = 171.41 \text{ J/K} = \Delta S$$

$$\Delta G^\circ = 3(86.71 \text{ kJ/mol}) - 1(51.84 \text{ kJ/mol}) - 1(103.59 \text{ kJ/mol}) = 104.7 \text{ kJ} = \Delta G$$
5. For each of the reactions in question 4, indicate the temperature range over which the reaction would be spontaneous as written. (i.e., above some temperature or below some temperature – and indicate what temperature.)

First reaction:  Negative \( \Delta H^\circ \) negative \( \Delta S^\circ \) favored at temperatures below
\[
\begin{align*}
\Delta H^\circ &= -1644.32kJ \\
\Delta S^\circ &= -.54368kJ / K = 3024K
\end{align*}
\]

Second reaction:  Negative \( \Delta H^\circ \) negative \( \Delta S^\circ \) favored at temperatures below
\[
\begin{align*}
\Delta H^\circ &= -228.27kJ \\
\Delta S^\circ &= -.30601kJ / K = 746K
\end{align*}
\]

Third reaction:  Positive \( \Delta H^\circ \) Positive \( \Delta S^\circ \) favored at temperatures above
\[
\begin{align*}
\Delta H^\circ &= 155.67kJ \\
\Delta S^\circ &= .17141kJ / K = 908K
\end{align*}
\]