Chapter 19 Thermodynamics

1. Which of the following processes will lead to a decrease in the entropy of the system?
    a. Sugar crystals are dissolving in water.
    b. Air escaping from a balloon.
    c. Iron and oxygen form rust.
    d. Ice melting into water

2. Determine which of the species will have the greatest standard molar entropy S°?
    a. NH_3 (g)
    b. H_2O (s)
    c. Ne (g)
    d. NaCl (s)

3. Identify which one of the reactions would result in a positive ΔSsys.
    a. H_2O (g) + CO_2 (g) ⇌ H_2CO_3 (aq)
    b. H_2 (g) + I_2 (g) ⇌ 2Hl (g)
    c. $C_2H_2O_2$ (g) ⇌ 2CO (g) + H_2 (g)
    d. H_2O (g) ⇌ H_2O (l)

4. Determine $\Delta S°$ for the reaction: $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$

$N_2\,(g) = 191.5$ J/mol·K

$H_2\,(g) = 130.6$ J/mol·K

$NH_3\,(g) = 192.8$ J/mol·K

5. 5.0 g of Mg (s) reacts with excess oxygen to form magnesium oxide (MgO) under standard conditions. Determine the entropy change for this reaction

$$2Mg\,(s) + O_2\,(g) \rightleftharpoons 2MgO\,(s)$$

Mg (s) = 32.7 J/mol·K

$O_2\;(g) = 205.0$ J/mol·K

MgO (s) = 26.9 J/mol·K

6. In a spontaneous process, which of the following always increases?
    a. Entropy of the system
    b. Entropy of the surroundings
    c. Entropy of the universe
    d. Entropy of the system and universe

7. What is the standard entropy change when 10.0 g of methane reacts with 10.0 g of oxygen?

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

CH_4 (g) = 186.2 J/mol·K
O_2 (g) = 205.0 J/mol·K
CO_2 (g) = 213.6 J/mol·K
H_2O (l) = 70.0 J/mol·K

8. A reaction is at equilibrium at a given temperature and constant pressure when _____
    a. $\Delta S_{rxn} = 0$
    b. $\Delta G = 0$
    c. $\Delta H_{rxn} = 0$
    d. $\Delta G_{rxn} = 0$

9. Fill out the table below regarding Gibbs ' free energy

ΔH	ΔS	Temp	ΔG	Spontaneity
-	+	Any	-	
+	-	Any		
+	+			Spontaneous
-		Low	-	Spontaneous

10. A chemical reaction is spontaneous, with ΔSsys < 0. Which of the following statements must be true?
    a. The amount of entropy gained by the surroundings outweighs the loss of entropy by the system.
    b. The amount of entropy lost by the surroundings is greater than the amount of entropy lost by the system.
    c. The amount of entropy gained by the surroundings is less than the loss of entropy by the system.
    d. The chemical reaction cannot be valid because ΔSsys must be > 0 for a spontaneous reaction to occur.

11. Consider the following reaction & data: $C_3H_8(g) + 5O_2(g) \rightleftharpoons 3CO_2(g) + 4H_2O(g)$

$C_3H_8(g) = -23.5$ kJ/mol

$CO_2(g) = -394.4$ kJ/mol

$H_2O(g) = -228.6$ kJ/mol

a. What is the $\Delta G°$ for oxygen in the reaction?
b. What is the ΔG_{rxn} for the reaction?

12. According to the reaction $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$ Determine $\Delta G°$ at 32 °C

$\Delta H° = -565.98$ kJ/mol

$\Delta S° = -173$ J/mol·K