Spontaneity and Free Energy
Assignment

1. For each of the following pairs, circle the situation which favors a spontaneous reaction:

a)	endothermic reaction	or	exothermic reaction
b)	negative value of $\Delta H°$	or	positive value of $\Delta H°$
c)	negative value of $\Delta S°$	or	positive value of $\Delta S°$
d)	increasing entropy	or	decreasing entropy
e)	positive value of $\Delta G°$	or	negative value of $\Delta G°$

2. Describe the circumstances where:

a) $\Delta H_f° = 0$ _____

b) $S = 0$ _____

c) $\Delta G_f° = 0$ _____

d) $\Delta G = 0$ _____

3. Which one of the following shows and increase in entropy:

a) dissolving sugar in a cup of hot tea.
b) arranging a pack of playing cards into suits.
c) building a sand castle on the beach.

4. Using values of $\Delta G_f°$ from the table calculate $\Delta G°$ for the following reaction **and** tell whether or not the reaction will occur spontaneously. Show your work clearly. Use the formula $\Delta G = \Sigma \Delta G_{products} - \Sigma \Delta G_{reactants}$

   $C_2H_{6(g)} + 2Cl_{2(g)} \rightarrow C_2H_4Cl_{2\ (g)} + 2\ HCl_{(g)}$

Substance	**$\Delta G_f°$ (kJ/mol)**
$C_2H_{6(g)}$	-32.9
$Cl_{2(g)}$	0.0
$C_2H_4Cl_{2(g)}$	-80.3
$HCl_{(g)}$	-95.2

   Is the reaction spontaneous?

5. Calculate $\Delta G°$ using the formula $\Delta G = \Delta H - T\Delta S$

   Also, for each question, tell whether or not the reaction will be spontaneous.

   Values for ΔH and ΔS are given. All reactions take place at 25°C (298 K). Remember to convert ΔS values to kJ.

   a) $CH_3OH_{(l)} + 1½\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$

   $\Delta H = -638.4$ kJ $\Delta S = 156.9$ J / K

b) $2\ NO_{2(g)} \rightarrow N_2O_{4(g)}$

$\Delta H = -\ 57.2$ kJ $\qquad\qquad$ $\Delta S = -175.9$ J / K

6. Calculate $\Delta G°$ for the following reaction using values of $\Delta G_f°$ obtained from the Table of Thermochemical Data. Will the reaction be spontaneous?

   Use the formula $\Delta G = \Sigma \Delta G_{products} - \Sigma \Delta G_{reactants}$

   $3\ Fe_2O_{3(s)} \rightarrow 2\ Fe_3O_{4(s)} + ½\ O_{2(g)}$

7. For a certain spontaneous reaction, the change in enthalpy ($\Delta H°$) is -92.0 kJ and $\Delta G° = -50.2$ kJ at 25ºC. Calculate ΔS.

8. Calculate the entropy change ΔS per mole for the following reaction: Combustion of hydrogen in a fuel cell at 298 K
   $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)}$ ΔH = -241.6 kJ, ΔG = -228.4kJ (Ans $\Delta S = -44.3\ JK^{-1}$)

9. Calculate the free energy change for the reaction:
   $N2(g) + 3H_2\ (g) \rightarrow 2NH_3(g)$ at 298 K
   ΔH = -92.4kJ, ΔS = -197.6 JK-1 (Ans ΔG = -33.5kJ)

10. For the reaction $Ag_2O(s) \rightarrow 2Ag(s) + ½\ O_2(g)$ ΔH = 30.56kJ, ΔS = +66JK-1 at 1 atm pressure. Calculate the temperature at which the free energy change is equal to zero. Predict the nature of the reaction at this temperature and below this temperature.
    (Ans:463K)