Entropy and Gibbs Free Energy

1. Consider the following energy levels, each capable of holding two objects:

E= 2kj ___

E=1 kj ___

E= 0 XX

Draw all the possible arrangements of the two identical particles (represented by X) in the three energy levels. What total energy is most likely, that is, occurs the greatest number of times? Assume that the particles are indistinguishable from each other.

2. Calculate ΔS_{sur} for the following reactions at 25°C and 1 atm.

a. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^o = -2221$ kJ

b. $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$ $\Delta H^o = 112$kJ

3. At what temperatures will the following processes be spontaneous?

a. $\Delta H = -18$KJ and $\Delta S = -60$.J/K

b. $\Delta H = +18$KJ and $\Delta S = +60$.J/K

c. $\Delta H = +18$KJ and $\Delta S = -60$.J/K

d. $\Delta H = -18$KJ and $\Delta S = +60$.J/K

4. For ammonia (NH_3), the enthalpy of fusion is 5.65 kJ/mol and the entropy of fusion is 28.9 J/K . mol.

a. Will $NH_3(s)$ spontaneously melt at 200.K?

b. What is the approximate melting point of ammonia?

5. Predict the sign of ΔS^o for each of the following changes.

a. $Ag(CI(s) \rightarrow Ag^+(aq) + CI^-(aq)$

b. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

c. $H_2O(l) \rightarrow H_2O(g)$

6.Predict the sign of ΔS^o and then calculate ΔS^o for each of the following reactions.

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

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

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

7. Given the following data:

$2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ $\quad \Delta G^o = -6399kJ$

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta G^o = -394kJ$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$ $\quad \Delta G^o = -237kJ$

Calculate ΔG^o for the reaction

$6C(s) + 3H_2(g) \rightarrow C_6H_6(l)$

8.Using data from Appendix 4, Calculate ΔG for the reaction

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

For the following conditions at 25°C:

$P_{H2S} = 1.0 \times 10^{-4}$ atm, $P_{SO2} = 1.0 \times 10^{-2}$ atm, and $P_{H2O} = 3.0 \times 10^{-2}$ atm

9.Consider the reaction

$H_2(g) + CI_2(g) \rightarrow 2HCI(g)$

a. Calculate ΔH^o, ΔS^o, ΔG^o, and K (at 298 K).
b. If $H_2(g)$, $CI_2(g)$, and HCI(g) are placed in a flask such that the pressure of each gas is 1 atm, in which direction will the system shift to reach equilibrium at 25°C?