Thermochemistry: Entropy Worksheet

1. Are the following processes are spontaneous?

   _____ (a) the melting of ice cubes at $-5^{\circ}C$ and 1 atm of pressure

   _____ (b) dissolving of sugar in a cup of hot coffee

   _____ (c) formation of CH_4 and O_2 molecules from CO_2 and H_2O at 298 K and 1 atm

2. How does the entropy of the system change (increase or decrease) when each of the following occurs?

   _____ (a) a liquid vaporizes

   _____ (b) a solid melts

   _____ (c) a gas liquefies

   _____ (d) a solid dissolves in water

3. Which process (melting or vaporization) shown below would be expected to show the larger increase in entropy? Explain.

   $M(s) \rightarrow M(l)$ $\qquad$ $M(l) \rightarrow M(g)$

4. What do you expect for the sign of ΔS if two moles of gaseous reactants are converted into three moles of gaseous products?

5. In a certain chemical reaction, two gases combine to form a solid product. What is the sign of ΔS?

6. **Without** using a reference sheet of thermochemical values, predict the sign of the entropy change of the system for each of the following reactions.

   (a) $CO(g) + 2\,H_2(g) \rightarrow CH_4O(l)$ $\qquad$ **$\Delta S < 0$** $\qquad$ **$\Delta S > 0$**

   (b) $Zn(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ $\qquad$ **$\Delta S < 0$** $\qquad$ **$\Delta S > 0$**

   (c) $FeCl_2(s) + H_2(g) \rightarrow Fe(s) + 2\,HCl(g)$ $\qquad$ **$\Delta S < 0$** $\qquad$ **$\Delta S > 0$**

Key Formula: $\Delta S^{\circ}_{rxn} = \Sigma S^{\circ}$ (Products) - ΣS° (Reactants)

7. Use the chart of S° values to calculate ΔS° values for the following reactions.

(a) $C_2H_4\,(g) + H_2\,(g) \rightarrow C_2H_6\,(g)$

ΔS^{o} =

Does the sign make sense? Why?

(b) $N_2O_4\,(g) \rightarrow 2\,NO_2\,(g)$

ΔS^{o} =

Does the sign make sense? Why?

(c) $Be(OH)_2\,(s) \rightarrow BeO\,(s) + H_2O\,(g)$

ΔS^{o} =

Does the sign make sense? Why?

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

ΔS^{o} =

Does the sign makes sense? Why?

(e) $2\,Al\,(s) + 3\,Cl_2\,(g) \rightarrow 2\,AlCl_3\,(s)$

ΔS^{o} =

Does the sign makes sense? Why?

S values	Joules/Kelvin-mole
Al (s)	28.32
$AlCl_3$ (s)	109.29
$Be(OH)_2$ (s)	47
C_2H_4 (g)	185
C_2H_6 (g)	229.5
CH_3OH (g)	240
CO_2 (g)	214
Cl_2 (g)	222.957
H_2 (g)	131
H_2O (g)	189
N_2O_4 (g)	304
NO_2 (g)	240
O_2 (g)	205