Thermodynamics Key

1. Predict the sign of ΔS_{rxn} (positive or negative) for the following reactions:
   a. $2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)$ ΔS__-__
   b. $C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$ ΔS__+__
   c. $2NH_3(g) + CO_2(g) \rightarrow H_2O(l) + NH_2CONH_2(aq)$ ΔS___-__
   d. $Cu(s)\ (100^oC) \rightarrow Cu(s)\ (25^oC)$ ΔS__-_

2. Which two variables can indicate if a reaction is spontaneous or not? **____ΔG and ΔS_{tot}__**

3. The second law of thermodynamics tells us that:
   a. Energy is conserved.
   b. The entropy of a pure solid crystal at 0 Kelvin is zero.
   c. The total enthalpy of the universe is increasing.
   d. The total entropy of a spontaneous process is increasing.
   e. The free energy of a spontaneous process is increasing.

4. Which combination of ΔH and ΔS for a reaction is not spontaneous at low temperatures and becomes spontaneous at higher temperatures? Answer: ΔH _**positive**_ and ΔS _**positive**

5. The process of a liquid boiling has a:
   a. **Positive enthalpy change and a positive entropy change.**
   b. Positive enthalpy change and a negative entropy change.
   c. Negative enthalpy change and a positive entropy change.
   d. Negative enthalpy change and a negative entropy change.
   e. Not enough information is given.

6. Calculate the temperature at which this reaction changes from being spontaneous to non spontaneous: $Mg(s) + O_2(g) \leftrightarrows MgO(s)$. Is the reaction spontaneous above or **below** this temperature? *(Hint – balance the rxn and use data from Appendix B)*

   ΔH^o_{rxn} = [2(-601.7)] – [0] = -1203 kJ
   ΔS^o_{rxn} = [2(26.9)] – [1(32.7) + 1(205.0)] = -216.6 J/K

   0 = (-1203 kJ) – T (-0.2166 kJ/K)
   T = -1203 kJ / -0.2166 kJ/K
   T = 5550 Kelvin or 5280^{o}C spont below this temp

7. Calculate ΔG^o_{rxn} for this reaction: $2\ CH_3OH\ (l) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 4\ H_2O\ (l)$
   Given: $\Delta H_f^o\ CH_3OH\ (l) = -238.6$ kJ/mol
   $S^o\ CH_3OH\ (l) = 126.8$ J/molK
   $S^o\ O_2\ (g) = 205.0$ J/molK
   $S^o\ H_2O\ (l) = 69.91$ J/molK
   $\Delta H_f^o\ H_2O\ (l) = -285.83$ kJ/mol
   $\Delta H_f^o\ CO_2\ (g) = -393.5$ kJ/mol
   $S^o\ CO_2\ (g) = 213.6$ J/molK
   (only use this given data for your solution)

   ΔH^o_{rxn} = [2(-393.5) + 4(-285.83)] - [2(-238.6) + 0] = -1453.12 kJ
   ΔS^o_{rxn} = [2(213.6) + 4(69.91)] - [2(126.8) + 3(205)] = -161.76 J/K = -0.16176 kJ/K
   ΔG^o_{rxn} = -1453.12 kJ/mol - (298 K)-0.16176 kJ/molK = -1405 kJ