Chemistry 223 Oregon State University
Worksheet 6

1. Write a balanced chemical equation (use your notes or text as a source of reactions) for:
   (A) an exothermic process in which entropy increases.
   (B) an exothermic process in which entropy decreases.
   (C) an endothermic process in which entropy increases.
   (D) an endothermic process in which entropy decreases.

2. Identify (if possible) ΔH, ΔS, and ΔG as being (-), (+), or (?) for:
   (A) $CO_2\ (g) \rightarrow CO_2\ (s)$
   (B) $2\ NO_2\ (g) \rightarrow 2\ NO\ (g) + O_2\ (g)$
   (C) The combustion of methanol (liquid CH_3OH) to produce CO_2 (g) and steam.

3. Consider the "Cold Pack" reaction, $NH_4NO_3\ (s) \rightarrow NH_4NO_3\ (aq)$. Do you expect ΔH to be positive or negative? Do you expect ΔS to be positive or negative? Do you expect ΔG to be positive or negative?

4. Consider the complete combustion of methane gas in oxygen to produce carbon dioxide and liquid water. Determine $\Delta G^o_{reaction}$.

5. Which of the following produces a DECREASE in entropy of the system? The system is shown in bold.
   Dissolving **sugar** in a cup of coffee.
   Condensation of **water** on the surface of a glass of iced tea on a hot summer day.
   Boiling **water** in a pot on the stove to make macaroni and cheese.
   Allowing the liquid **propane** in a gas grill to escape from the tank.
   Producing **CO_2 gas from baking soda ($NaHCO_3$)** when baking a cake.

6. What is the Second Law of Thermodynamics?

7. What is the Third Law of Thermodynamics?

8. Calculate the value (in kJ) of ΔG^o at 25°C for $2H_2O_2(aq) <==> 2H_2O(l) + O_2(g)$ given:

substance	ΔH_f^o, kJ mol^{-1}	S^o, J mol^{-1} K^{-1}
$H_2O_2(aq)$	-191.17	143.9
$H_2O(l)$	-285.83	69.91
$O_2(g)$	0	205.14

9. Which of the following reactions is unfavorable at low temperatures but becomes favorable as the temperature increases? At what temperature does the process become favored?

   (A) $2\ CO(g) + O_2(g) \text{ --> } CO_2(g);\ \Delta H^o = -566\ kJ;\ \Delta S^o = -173\ J/K$

   (B) $2\ H_2O(g) \text{ --> } 2\ H_2(g) + O_2(g);\ \Delta H^o = 484\ kJ;\ \Delta S^o = 90.0\ J/K$

   (C) $2\ N_2O(g) \text{ --> } 2\ N_2(g) + O_2(g);\ \Delta H^o = -164\ kJ;\ \Delta S^o = 149\ J/K$

   (D) $PbCl_2(s) \text{ --> } Pb^{2+}(aq) + O_2(g);\ \Delta H^o = 23.4\ kJ;\ \Delta S^o = -12.5\ J/K$