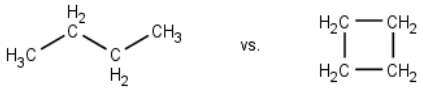
Thermodynamics. These problems are mostly from your textbook. More can be found in chapter 14 and 23.

1. Define the First and Second Laws of Thermodynamics in words and with an equation. Discuss how they are related to our understanding on ΔH, ΔS, and ΔG.

2. Standard molar entropy (S^0) can be used to calculate reaction entropies (ΔS^0_{rxn}). These values are always positive ($S^0 > 0$). Why?

3. (23-6) Predict which molecule will have a higher molar entropy

CO vs. CO_2 H_2O (s) vs. H_2O (l)  vs.

4. Predict whether the following reactions will be spontaneous, non-spontaneous, or temperature dependent.
   a. H_2O_2 (l) ⇌ H_2O_2 (s)
   b. C (s) 2 H_2 (g) ⇌ CH_4 (g)

5. (23.23) Using the information below, calculate the ΔG_{rxn} when [ATP] = 5.0 mM, [ADP] = 0.50 mM, and $[HPO_4^{2-}]$ = 5.0 mM. Is the reaction spontaneous under these conditions?

   ATP (aq) + H_2O (l) ⇌ ADP (aq) + HPO_4^{2-} $\Delta G^o_{rxn} = -30.5\ kJ\ mol^{-1}$

6. (14.19) Calculate ΔH^o_{rxn} and for CH_3CH_2OH (l) ⇌ CH_3OCH_3 (l) noting that:

   CH_3CH_2OH (l) + 3 O_2 (g) ⇌ 2 CO_2 (g) + 3 H_2O (g) $\Delta H^o_{rxn} = -1234.8\ kJ\ mol^{-1}$

   CH_3OCH_3 (l) + 3 O_2 (g) ⇌ 2 CO_2 (g) + 3 H_2O (g) $\Delta H^o_{rxn} = -1309.1\ kJ\ mol^{-1}$

7. (23-67) From the following data, calculate ΔS_{fus} for each metal.

Metal	T_m (K)	$\Delta H_{fus}\ (kJ\ mol^{-1})$
Li	454	2.99
Na	371	2.60

8. (23.72) From the data below, calculate ΔG^0_{rxn} and K for the following reactions at 25°C.

   Ag^+ (aq) + Cl^-(aq) ⇌ AgCl (s)

   Pb^{2+} (aq) + 2 Cl^-(aq) ⇌ $PbCl_2$ (s)

	Pb^{2+} (aq)	Ag^+ (aq)	Cl^- (aq)	$PbCl_2$(s)	AgCl (s)
ΔG^0_f (kJ mol^{-1})	-24.4	77.1	-131.2	-314.1	-109.8
S^0 (J mol^{-1}K^{-1})	10.5	72.7	56.5	136.0	96.3

9. For the reactions in problem 8, determine $\Delta S^0_{rxn}\ and \Delta H^0_{rxn}$.

10. Using your answers from problem 8, determine ΔG^0_{rxn}, $\Delta S^0_{rxn}, \Delta H^0_{rxn}$, and K for the following reactions.

    3 Ag^+ (aq) + 3 Cl^-(aq) ⇌ 3 AgCl (s)

    2 $PbCl_2$ (s) ⇌ 2 Pb^{2+} (aq) + 4 Cl^-(aq)

11. (23-43) Use the following data to calculate ΔH^0_{rxn} the reaction N_2 (g) + O_2 (g) ⇌ 2 NO (g)

Kp = 4.08 x 10^{-4} at 2000 K Kp = 11.0 x 10^{-4} at 2200 K.

12. For the vaporization of water, $\Delta H^0_{vap} = 44.03\ kJ\ mol^{-1}$ and $\Delta S^0_{vap} = 118.89\ J\ mol^{-1}K^{-1}$.
    a. Calculate ΔG^0_{vap} and K at 25 °C.
    b. What is the vapor pressure of water at 25 °C? This is the pressure of H_2O (g) at this temperature.
    c. What is K at 100 °C?
    d. What is the vapor pressure of water at 100°C?

Thermodynamics Equation Sheet

$\Delta G = \Delta H - T\Delta S$

$\Delta G^0 = -RTlnK$

$\Delta G = \Delta G^o + RTlnQ$

$\Delta U = q + w$

$w = -p\Delta V$

$\Delta H = q_p$

$\Delta G = -T\Delta S_{universe}$

$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surrounding}$

$\Delta S_{universe} > 0$

$\Delta S = \frac{\Delta H}{T}$

$C_P = \frac{\Delta H}{\Delta T}$

$ln\frac{K_2}{K_1} = \frac{\Delta H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$