Chem 531: Problem Set #1

<u>Due in class: Tues, Sept. 5th</u> (please indicate your source for all thermochemical data)

(1)

(a) Calculate q, w, ΔU, and ΔH for the reversible isothermal expansion at 300 K of 5.00 mol of an ideal gas from 500 to 1500 cm^3.

(b) What would ΔU and w be if the expansion connects the same initial and final states as in (a) but is done by having the ideal gas expand into vacuum?

(c) Likewise, if the gas expands against a constant pressure of 10 bar, how much work is done by the gas?

(2) A nearly flat bicycle tire becomes noticeably warmer after it has been pumped up. Approximate this process as a reversible adiabatic compression. Assume the initial pressure and temperature of the air before it is put into the tire to be $P_i = 1.00$ bar and $T_i = 298$ K. The final volume of the air in the tire is $V_f = 1.00$ L and the final pressure is $P_f = 5.00$ bar. Calculate the final temperature of the air in the tire. Assume that $\bar{C}_v = 5R/2$.

(3) For a certain ideal gas, $\bar{C}_v = 2.5R$ at all temperatures. Calculate q, w, ΔU, and ΔH when 2.00 mol of this gas undergoes each of the following processes:

(a) a reversible isobaric expansion from (1.00 atm, 20.0 L) to (1.00 atm, 40.0 L)

(b) a reversible isochoric change of state from (1.00 atm, 40.0 L) to (0.500 atm, 40.0 L)

(c) a reversible isothermal compression from (0.500 atm, 40.0 L) to (1.00 atm, 20.0 L).

Also calculate q, w, ΔU, and ΔH for the cycle that consists of steps (a), (b), and (c).

(4)

(a) Starting with the total differential of P as a function of V and T, obtain an expression for ΔP in terms of α (thermal expansion coefficient) and κ (isothermal compressibility) for the situation where both the temperature and volume change in a general process. Show all work.

(b) A rigid container is filled completely with liquid water and sealed at 25.0ºC and a pressure of 1.00 bar. What is the final pressure if the temperature of the system is raised to 60.0ºC ? Under these conditions $\alpha_{water} = 2.04 \times 10^{-4}\ K^{-1}$ and $\kappa_{water} = 4.59 \times 10^{-5}\ bar^{-1}$ are constants. (Note: α is not really a constant - it rises to $5.16 \times 10^{-4}\ K^{-1}$ at 60ºC but don't worry about that for this problem)

(5) Calculate the molar heat of vaporization of water at 25ºC. The heat of vaporization of water at 100ºC is 40.68 kJ/mol.