Chem 531: Problem Set #2

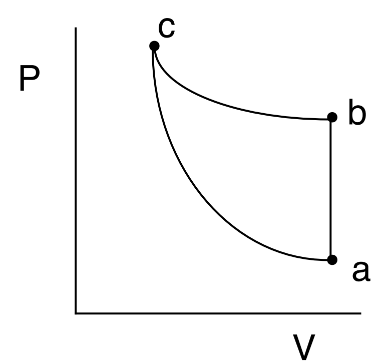
Due in class: Thurs, Sept. 14th

(1) The heat capacities of a gas are often represented by expressions such as:

$$\bar{C}_P = \alpha + \beta T + \gamma T^2 + \delta T^3$$

For N_2, $\alpha = 28.883$ J K^{-1} mol^{-1}, $\beta = -1.57 \times 10^{-3}$ J K^{-2} mol^{-1}, $\gamma = 0.808 \times 10^{-5}$ J K^{-3} mol^{-1}, and $\delta = -2.871 \times 10^{-9}$ J K^{-4} mol^{-1}. How much heat is required to heat a mole of N_2 from 200 to 1000 K at a constant pressure of 1 bar?

(2) Compressing the system represented in the figure along the adiabatic path a → c requires 1000 J of work. Compressing the system along the isothermal line b → c requires 1500 J of work but 600 J of heat flows out of the system. Fill in the table below, paying close attention to signs.



Process	**w**	**q**	**ΔU**
a → b			
b → c			
c → a			
cycle abca			

(3)

(a) Show that

$$\left(\frac{\partial C_v}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V \quad \text{noting that} \quad \left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

(b) Evaluate this for an ideal gas.

(4) The standard enthalpy of dissociation ΔH^o_{diss} for hypobromous acid, i.e., ΔH^o_r, for the reaction HOBr(g) → OH(g) + Br(g), has been measured to be 206.8 kJ/mol at 25ºC.

(a) Determine the standard internal energy change ΔU^o_r for this reaction at 25ºC.

(b) Determine the standard enthalpy of formation, ΔH^o_f, of HOBr at 25ºC [Note: you'll need to look up appropriate thermodynamic data for OH(g) and Br(g). See: https://atct.anl.gov]

(5) The standard enthalpy of combustion for liquid benzene at 25ºC is -3268 kJ/mol. Determine the enthalpy of combustion of gaseous benzene at 110ºC. Please note your sources for the required thermodynamic data.

(6) Two moles of superheated steam at 200ºC is injected into 50 moles of 25ºC water at a constant pressure of 1.0 bar under adiabatic conditions. Calculate the final temperature (T_f) of the system. The constant pressure molar heat capacities of H_2O(g) and H_2O(l) are 33.6 and 75.3 J K^{-1} mol^{-1}, respectively, and can be assumed to be independent of temperature. The enthalpy of vaporization at 100ºC and 1 bar for H_2O is 40.66 kJ mol^{-1}.