CHEM 331
Physical Chemistry
Fall 2010

Problem Set 6

1. Suppose a gas has the following behavior:

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

$$P\,(V - b) = RT$$

Calculate the following two quantities:

$$\left(\frac{\partial H}{\partial V}\right)_T$$

$$C_p - C_v$$

2. For Air, $\gamma = 1.40$. Which is the best model for an Air "molecule":

An elastic sphere.
A rigid dumbbell.
A non-rigid dumbbell which vibrates and rotates.

3. Compare the Specific Heat of Ice with that calculated from the Law of Dulong-Petit. Explain any difference.

4. Read the article of Dulong and Petit and answer the following questions:

a) What is the principle of Irvine and Crawford? Is their proposal supported experimentally?
b) What do Dulong and Petit identify as a major cause of error in heat capacity measurements?
c) How did Dulong and Petit overcome deal with this source of error in their heat capacity measurments?
d) Do the measurements of heat capacity for Oxygen and Azote by Laroche and Berard deviate from the Law of Dulong and Petit? Explain.

4. The compression ratio in a diesel engin is 16:1; that is, the gas in th episton is compressed to 1/16 its original volume. Take C_p of Air to be 27 J/K mol independent of temperature. Assuming the compression stroke of a diesel engine to be reversible and adiabatic, calculate the temperature increase of Air in the cylinder during a compression stroke. (Assume the operating temperature is 350K.)
[Ans. 1202K]

5. One mole of an Ideal Gas is compressed Adiabatically from 0.100 MPa to 1.00 MPa. Initially the gas is at 27°C. The gas is diatomic with $C_v = 5/2\ R$.

   a) Assume the compression is done in a single stage with a constant opposing pressure of 1.0 MPa.
   b) Assume the compression is done reversibly.

   For each case, compute the final temperature and Q, W, ΔU and ΔH.
   [Ans. (a) 1072K, 0, 16.0 kJ/mol, 16.0 kJ/mol, 22.5 kJ/mol (b) 579K, 0, 5.80 kJ/mol, 5.80kJ/mol, 8.12 kJ/mol]

6. Suppose that a piece of metal with a volume of 100 cm^3 is compressed adiabatically by a shock wave of 10^5 atm to a volume of 90 cm^3. Assume the compression occurs at a constant pressure of 10^5 atm. Calculate ΔU and ΔH for the metal.

7. In an Ideal Gas undergoes a reversible polytropic expansion, the relation $PV^n = C$ holds throughout the process; where C and *n* are constants with $n > 1$. Calculate W for such an expansion if one mole of the gas expands from V_1, where $T_1 = 300$ K, to V_2, where $T_2 = 200$ K. Assume $n = 2$. If $C_v = (5/2)R$ for the gas, calculate ΔU, Q and ΔH for this change in state.
   [Ans. 830 kJ/mol, -2080 kJ/mol, -1250 kJ/mol, -2910 kJ/mol]