Chemistry 342

Problem Set 2

1. Three moles of an ideal gas at 27°C expand isothermally and reversibly from 20.0 liters to 60.0 liters. Compute W, q, ΔU, ΔH.

2. One mole of a van der Waals gas at 27°C expands isothermally and reversibly from 10.0 liters to 30.0 liters. Compute the work W. (The van der Waals parameters are a = 5.49 liters^2 atm moles^{-2}, b = 0.064 liter mole^{-1}.)

3. One mole of an ideal gas is compressed adiabatically in a single stage with a constant opposing pressure equal to 10.0 atm. Initially the gas is at 27°C and 1.0 atm pressure; the final pressure is 10.0 atm. Calculate the final temperature of the gas, W, q, ΔU, ΔH. Do this for two cases: Case I. Monatomic gas, $C_V = (3/2)R$. Case II. Diatomic gas, $C_V = (5/2)R$. How would the various quantities be affected if n moles were used instead of one mole?

4. One mole of an ideal gas at 27°C and 1.0 atm is compressed adiabatically and reversibly to a final pressure of 10.0 atm. Compute the final temperature of the gas, W, q, ΔU, ΔH for the same two cases as in the above problem.

5. One mole of an ideal gas at 27°C and 10 atm is expanded adiabatically to a final pressure of 1.0 atm against a constant opposing pressure of 1.0 atm. Calculate the final temperature of the gas, q, W, ΔU, ΔH for the two cases $C_V = (3/2)R$ and $C_V = (5/2)R$.

6. Repeat Problem 5 assuming that the expansion is reversible.

7. A house of constant volume V, is warmed, the air pressure being kept constant at 1.0 atm. (During the heating process some of the air must be expelled through keyholes, around doorjambs, etc.)

(a) Assuming that C_V and C_p are constant for air, <u>derive</u> an expression for the amount of heat that must be supplied to warm the air in the house from T_1 to T_2, taking into account the continuous ejection of air.

Answer is $q = (pVC_p/R)\ln(T_2/T_1)$ Why C_p and not C_V?

(b) If the molar heat capacity at constant volume is $(5/2)R$, and if V = 2000 m^3, t_1 = 15°C, and t_2 = 20°C, what is q?

8. Suppose that the house of Problem 7 were cooled from temperature T_1 to temperature T_2 with the temperature of the outside air at T_0.

(a) How much heat must be extracted from the air within the house if you take into account the entry of additional air upon cooling? Why is the absolute value of this quantity of heat not equal to that of Problem 7?

(b) If you assume that $t_1 = 30°C$, $t_2 = 25°C$, and $t_0 = 35°C$, how much heat must be extracted for the house described in Problem 7?

9. One mole of an ideal gas is contained in a cylinder provided with a tightly fitting piston that is not free of friction. To cause this piston to move, one must apply a constant extra force in the direction of its movement. If this friction force is divided by the area of the piston, it reduces to a pressure equivalent of friction p_f.

(a) Derive expressions for the work and heat attending the isothermal expansion of the ideal gas from gas pressure p_1 to p_2 by means of the apparatus described above. If the gas is now compressed from p_2 to p_1, what are q and W ?

(b) Calculate the values of q and W for 1 mole of the ideal gas expanded irreversibly according to the same mechanism from 1 atm to 0.5 atm if $p_f = 0.1$ atm and $t = 25°C$.

10. One mole of an ideal monatomic gas (for which $C_V = (3/2)R$) is subjected to the following sequence of steps:

(A) The gas is heated reversibly at a constant pressure of 1 atm from 25°C to 100°C.

(B) Next, the gas is expanded reversibly and isothermally to double its volume.

(C) Finally the gas is cooled reversibly and adiabatically to 35°C.

Calculate ΔU, ΔH , q, W, for for the over-all process A + B + C.