Course: CHM202

Energetics and dynamics of chemical reactions

Assignment – II

Q.1 The internal energy change when 1.0 mol $CaCO_3$ in the form of calcite converts to aragonite is +0.21 kJ. What is the difference between the enthalpy change and the change in internal energy when the pressure is 1.0 bar [Given: Densities of the solids are 2.71 g cm^{-3} and 2.93 g cm^{-3}, respectively.

Q.2 A chemical reaction takes place in a container of cross-sectional area 50.0 cm^2. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121 kPa. Evaluate the work done by the system.

Q.3 A sample of argon of mass 6.56 g occupies 18.5 dm^3 at 305 K. (a) Calculate the work done when the gas expands isothermally against a constant external pressure of 7.7 kPa until its volume has increased by 2.5 dm^3. (b) What would be the work done if the same expansion occurred reversibly?

Q.4 The isothermal compressibility of lead at 20 ºC is 2.21×10^{-6} atm^{-1}. Evaluate the pressure that must be applied in order to increase its density by 0.08%.

Q.5 A sample consisting of 2.0 mol CO_2 occupies a fixed volume of 15.0 dm^3 at 300 K. When it is supplied with 2.35 kJ of energy as heat its temperature increases to 341 K. Assume that CO_2 is described by the van der Waals equation of state, then calculate w, ΔU, and ΔH.

Q.6 The value of ΔH at 25 ºC and one bar for the reaction described by

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

is -572 kJ. Calculate ΔU for this reaction as written.

Q.7. Three moles of an ideal gas at 1 atm and 20 ºC are heated at constant pressure until the final temperature is 80 ºC. For the gas $C_V = 7.50 + 3.2 \times 10^{-3}$ T Cal $mole^{-1}$ K^{-1}. Calculate w, ΔU, ΔH and Q.

Q.8 The coefficient of thermal expansion (α) and compressibility coefficient (β) for metallic Cu at 25 ºC are 49.2×10^{-6} K^{-1} and 7.747×10^{-6} $Pascal^{-1}$ respectively. The density of Cu at 25 ºC is 8.93 gm/cc. Calculate C_P-C_V per mole of Cu. [Mol. Wt. of Cu = 63.5]

Q.9 For a certain gas, the van der Waals constants are a = 6.69 atm litre^2 mole^{-2} and b = 0.057 litre mole^{-1}. What will be the maximum work performed in the expansion of 2 moles of the gas from 4 to 40 litres at 300 K?

Q.10 A cylinder is fitted with a frictionless piston and is kept in a thermostat. It contains 2 moles of an ideal gas at 27 ºC and 2 atm pressure. Following (i), (ii) and (iii) are three separate experiments carried out independently with the above.

(i) The piston is all of a sudden withdrawn to a position where the pressure is reduced to 1 atm and equilibrium restored.

(ii) The pressure is reduced at a single step from 2 to 1 atm.

(iii) The pressure is reduced slowly to 1 atm in such a way that the position of the piston remains unaltered if left to itself any moment during the operation.

Calculate in each case ΔU, w, ΔH and Q.

Q.11 N_2 gas is expanded reversibly and adiabatically from a volume of one litre at 0 ºC and 1 atm to a volume of 2 litres. The C_V and C_P values are 20.8 and 29.1 Joule mole^{-1} K^{-1}. Assuming ideal behavior calculate the final temperature and pressure. What are Q, w, ΔU, and ΔH?

Q.12 A gas obeys van der Waals equation with a = 6.69 atm litre^2 mole^{-2} and b = 0.057 litre mole^{-1}. For the gas C_V = 7.00 Cal mole^{-1} K^{-1}. What will be ΔU for a process involving the compression of 5 moles of the gas from a volume of 100 litres at 300 K to a volume of 10 litres at 400 K.

Q.13 At 300℃ and at a pressure of 0.60 atm the Joule-Thomson coefficient for N_2 is given by $\mu = 0.0142 - 2.60 \times 10^{-4}\ P$. Assuming the equation to be independent of temperature near 300 ºC. Find the temperature drop which may be expected on Joule-Thomson expansion from 60 atm to 20 atm.

Q.14 One mole of an ideal monoatomic gas at 25 ºC and 5 atm pressure is expanded to a final pressure of 1 atm (a) isothermally against a constant pressure of 1 atm (b) adiabatically reversibly. Calculate in each case (i) the final temperature (ii) the heat absorbed (iii) the change in internal energy and (iv) the change in enthalpy of the gas.

Q.15 0.1 mole of a mono-atomic perfect gas with C_V independent of temperature is made to undergo a reversible cyclic process consisting of the following steps:

State 1 (1 litre, 1 atm) → State 2 (1 litre, 3 atm)

State 2 → State 3 (2 litres, 3 atm)

State 2 → State 4 (2 litres, 1 atm)

State 4 → State 1

Calculate *w*, *Q*, and ΔU for each step and for the complete cycle. Comment on the thermodynamic nature of these functions on the basis of the evaluated values.