KMM 2621 Physical Chemistry for Engineers

Homework 2- The First Law

P1. 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 dm3. (b) Calculate the work that would be done if the same expansion occurred reversibly.

P2. A sample of 2.00 mol $CH_3OH(g)$ is condensed isothermally and reversibly to liquid at 64°C. The standard enthalpy of vaporization of methanol at 64°C is 35.3 kJ mol^{-1}. Find *w*, *q*, ΔU, and ΔH for this process.

P3. The constant-pressure heat capacity of a sample of a perfect gas was found to vary with temperature according to the expression Cp /(J K^{-1}) = 20.17 + 0.4001(T/K). Calculate *q*, *w*, ΔU, and ΔH when the temperature is raised from 0°C to 100°C (a) at constant pressure, (b) at constant volume.

P4. A sample of 5.0 mol $CO_2(g)$ is originally confined in 15 dm^3 at 280 K and then undergoes adiabatic expansion against a constant pressure of 78.5 kPa until the volume has increased by a factor of 4.0. Calculate *q*, *w*, ΔT, ΔU, and ΔH.

P5. From the following data, determine $\Delta_f H^0$ for diborane, $B_2H_6(g)$, at 298 K:

(1) $B_2H_6(g) + 3\ O_2(g) \rightarrow B_2O_3(s) + 3\ H_2O(g)$ $\qquad \Delta_r H^0 = -2036$ kJ mol^{-1}

(2) $2\ B(s) + 3/2\ O_2(g) \rightarrow B_2O_3(s)$ $\qquad \Delta_r H^0 = -1274$ kJ mol^{-1}

(3) $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(g)$ $\qquad \Delta_r H^0 = -241.8$ kJ mol^{-1}

P6. For the reaction $2\ C_6H_5COOH(s) + 13\ O_2(g) \rightarrow 12\ CO_2(g) + 6\ H_2O(g)$, $\Delta_r U^0 = -772.7$ kJ mol^{-1} at 298 K, calculate $\Delta_r H^0$.

P7. A vapour at 22 atm and 5°C was allowed to expand adiabatically to a final pressure of 1.00 atm; the temperature fell by 10 K. Calculate the Joule–Thomson coefficient, μ, at 5°C, assuming it remains constant over this temperature range.

P8. The isothermal compressibility of lead at 293 K is 2.21×10^{-6} atm^{-1}. Calculate the pressure that must be applied in order to increase its density by 0.08 per cent.