

## KMM 2621 Physical Chemistry for Engineers

### Homework 2- The First Law

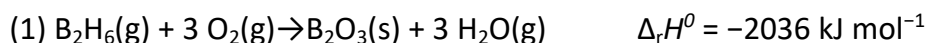
**P1.** A sample of argon of mass 6.56 g occupies 18.5 dm<sup>3</sup> at 305 K. (a) Calculate the work done when the gas expands isothermally against a constant external pressure of 7.7 kPa until its volume has increased by 2.5 dm<sup>3</sup>. (b) Calculate the work that would be done if the same expansion occurred reversibly.

**P2.** A sample of 2.00 mol CH<sub>3</sub>OH(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<sup>-1</sup>. Find  $w$ ,  $q$ ,  $\Delta U$ , and  $\Delta H$  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  $C_p / (\text{J K}^{-1}) = 20.17 + 0.4001(T/\text{K})$ . Calculate  $q$ ,  $w$ ,  $\Delta U$ , and  $\Delta H$  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<sub>2</sub>(g) is originally confined in 15 dm<sup>3</sup> 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  $q$ ,  $w$ ,  $\Delta T$ ,  $\Delta U$ , and  $\Delta H$ .

**P5.** From the following data, determine  $\Delta_f H^\circ$  for diborane, B<sub>2</sub>H<sub>6</sub>(g), at 298 K:



**P6.** For the reaction  $2 \text{C}_6\text{H}_5\text{COOH}(\text{s}) + 13 \text{O}_2(\text{g}) \rightarrow 12 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$ ,  $\Delta_r U^\circ = -772.7 \text{ kJ mol}^{-1}$  at 298 K, calculate  $\Delta_r H^\circ$ .

**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,  $\mu$ , at 5°C, assuming it remains constant over this temperature range.

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