Homework 4

1. The internal energy of a perfect monoatomic gas relative to its value at T = 0 is (3/2)nRT. Calculate $(\partial U/\partial V)_T$, $(\partial H/\partial V)_T$, $(\partial U/\partial p)_T$, and $(\partial H/\partial p)_T$ for the gas.

2. Given that $\mu = 1.11$ K atm⁻¹ for carbon dioxide, calculate the value of its isothermal Joule-Thompson coefficient. Calculate the energy that must be supplied as heat to maintain constant temperature when 12.0 mol CO₂ flows through a throttle in an isothermal Joule-Thompson experiment and the pressure drop is 55 atm.

3. The constant-volume heat capacity of a gas can be measured by observing the decrease in temperature when it expands adiabatically and reversibly. If a decrease in pressure is also measured, we can use it to infer the value of γ (the ratio of heat capacities, C_p/C_V) and hence, by combining the two values, deduce the constant pressure heat capacity. A fluorocarbon gas was allowed to expand reversibly and adiabatically to twice its volume; as a result, the temperature fell from 298.15 K to 248.44 K and its pressure fell from 1522.2 Torr to 613.85 Torr. Evaluate C_p .

4. Suppose you put a cube of ice of mass 100 g into a glass of water at just above 0°C. When the ice melts, about 33 kJ of energy is absorbed from the surroundings as heat. What is the change in entropy of (a) the sample (the ice), (b) the surroundings (the glass of water)?

5. A sample of aluminum of mass 1.25 kg is cooled at constant pressure from 300 K to 260 K. Calculate the energy that must be removed as heat and the change in entropy of the sample. The molar heat capacity of aluminum is $24.35 \text{ J K}^{-1} \text{ mol}^{-1}$.

6. Calculate the change in molar entropy when carbon dioxide expands isothermally from 1.5 L to 4.5 L.

7. Octane is typical of the components of gasoline. Estimate (a) the entropy of vaporization, (b) the enthalpy of vaporization of octane, which boils at 126°C.

8. Calculate the standard reaction entropy at 298 K of

(a) $2 \text{ CH}_3\text{CHO}(g) + O_2(g) \rightarrow 2\text{CH}_3\text{COOH}(l)$ (b) $2 \text{ AgCl}(s) + \text{Br}_2(l) \rightarrow 2 \text{ AgBr}(s) + \text{Cl}_2(g)$ (c) $\text{Hg}(l) + \text{Cl}_2(g) \rightarrow \text{HgCl}_2(s)$ (d) $2n(s) + \text{Cu}^{2+}(aq) \rightarrow 2n^{2+}(aq) + \text{Cu}(s)$ (e) $\text{C}_{12}\text{H}_{22}\text{O}_{11}(s) + 12 \text{ O}_2(g) \rightarrow 12 \text{ CO}_2(g) + 11 \text{ H}_2\text{O}(l)$

Use data from Tables 2.6 and 2.8 in the Data Section.

9. The heat capacity of chloroform (trichloromethane, CHCl₃) in the range 240 K to 330 K is given by $C_{p,m}$ (in J K⁻¹ mol⁻¹) = 91.47 + 7.5×10⁻² T (in K). In a particular experiment, 1.00 mol of CHCl₃ is heated from 273 K to 300 K. Calculate the change in molar entropy of the sample.