Chemistry 230 -- Quiz 4

September 26, 2001 — Tellinghuisen

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Note: If you want your paper returned folded (*i.e.*, score concealed), please print your name on the back.

1. (11) The molar heat capacity of many gases can be taken to be a linear function of T over not-too-large ranges of T: $C_{P,m} = a + b\,T$. n mol of $N_2(g)$ is initially at 300K and 1.00 atm and may be treated as a perfect gas.

   (a) Obtain expressions for q, w, ΔU, and ΔH for reversible heating of the gas to 400 K at constant P.

$$q = q_P = \Delta H = \int_{T_1}^{T_2} C_P\,dT = n\int_{300}^{400}(a+bT)\,dT = n\left[100a + \tfrac{b}{2}(400^2 - 300^2)\right]$$

$$\Delta U = \int_{T_1}^{T_2} C_V\,dT = \int_{T_1}^{T_2}(C_P - nR)\,dT = \Delta H - 100\text{K}\,nR$$

$$W = \Delta U - q$$

   (b) How do your results change if the heating is carried out at constant V.

ΔU & ΔH same. $q = q_V = \Delta U$; $W = 0$.

2. (8) (a) Consider $CF_4(g)$. Give the total degrees of freedom and the numbers of translational, rotational, and vibratational degrees of freedom.

3 N = 15 total. 3 transl, 3 rot., 9 vib.

   (b) If only translation and rotation contribute to the heat capacity of $CF_4(g)$, estimate $C_{V,m}$ and $C_{P,m}$(units R), and γ for it.

$$C_{V,m} = \tfrac{3}{2}R + \tfrac{3}{2}R = 3R;\quad C_{P,m} = 4R;\quad \gamma = \frac{C_P}{C_V} = \frac{4}{3}$$

   (c) How much does vibration contribute to the heat capacity $C_{V,m}$ for $CF_4(g)$: (i) in the low-T limit? (ii) in the high-T limit? (i) 0 (ii) 9R

   (d) Consider $CF_4(g)$ and $CBr_4(g)$ at 300K. Which should have the larger heat capacity.

CBr_4

3. (7) 1.00 mol of a gas which obeys the equation $PV = nRT$ and has heat capacity $C_{P,m} = a + b\,T$ (independent of P), is taken from the initial state (P, V) = (10.00 atm, 3.00 L) to the final state (3.00 atm, 10.00 L). Calculate as many of the following as possible, and for others, indicate why they cannot be determined: ΔP, ΔV, ΔT, ΔU, ΔH, q, w.

$P_1V_1 = P_2V_2$, so $T_2 = T_1$

$\Delta P = -7.00$ atm; $\Delta V = 7.00$ L; $\Delta T = 0$

Hence $\Delta U = \Delta H = 0$. q & w are indeterminate, because the path is not specified.