MIDTERM 2022

Q1] NH_3 has $3N = 12$ motions of atoms

→ 3 translations — 3 dof [1]

→ 3 rotations — 3 dof [1]

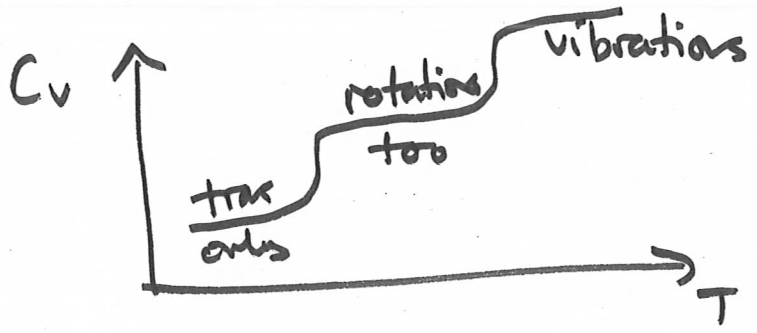
→ 6 vibrations — 12 dof [1]

(KE+PE)

Each gets $\frac{1}{2}kT$ so

$$U_{mole} = N_A \frac{18}{2} kT \quad [1]$$

$$\Rightarrow C_V = \frac{dU_{mole}}{dT} = 9R. \quad [1]$$



[2]

Q2] $$\frac{dQ}{dt} = -KA\frac{dT}{dx} \quad [2]$$

$K \approx 0.24$, $A = 4\pi(6.37\times10^6)^2$, $\frac{dT}{dx} = 1/30$ [1]

$$= 1.3\times10^{13}\,J \quad [1]$$

Q3 Adiabatics $\Rightarrow$ no energy in

$\Rightarrow PV^{\gamma} = \text{const}$ [1]

$$W_{\substack{\text{on}\\\text{gas}}} = -\int_{V_i}^{V_s} P\,dV$$ [1]

$$= -\int_{V_i}^{V_s} P_i V_i^{\gamma} \frac{dV}{V^{\gamma}}$$ [1]

$$= \frac{-1}{(1-\gamma)} P_i V_i^{\gamma} \left[V^{1-\gamma}\right]_{V_i}^{V_s}$$

$$= -\frac{P_i V_i^{\gamma}}{(1-\gamma)} \left(V_s^{1-\gamma} - V_i^{1-\gamma}\right)$$ [1]

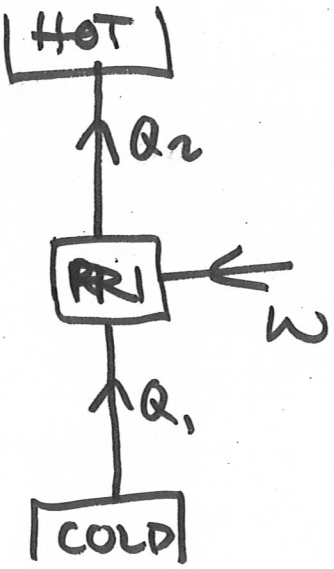
$P_i = 1.01\times10^5$ Pa ; $V_i = 1\,m^3$; $\gamma = C_p/C_v = \frac{7/2R}{5R/2} = 7/5$ [1]

$V_s = 0.2\,m^3$

$$W = \frac{1.01\times10^5}{\frac{2}{5}} \left(0.2^{-2/5} - 1\right)$$

$$= 2.3\times10^5\ J$$ [1]

Q4



[2]

$\eta = \frac{Q_1}{W}$ [1]