Unit 8

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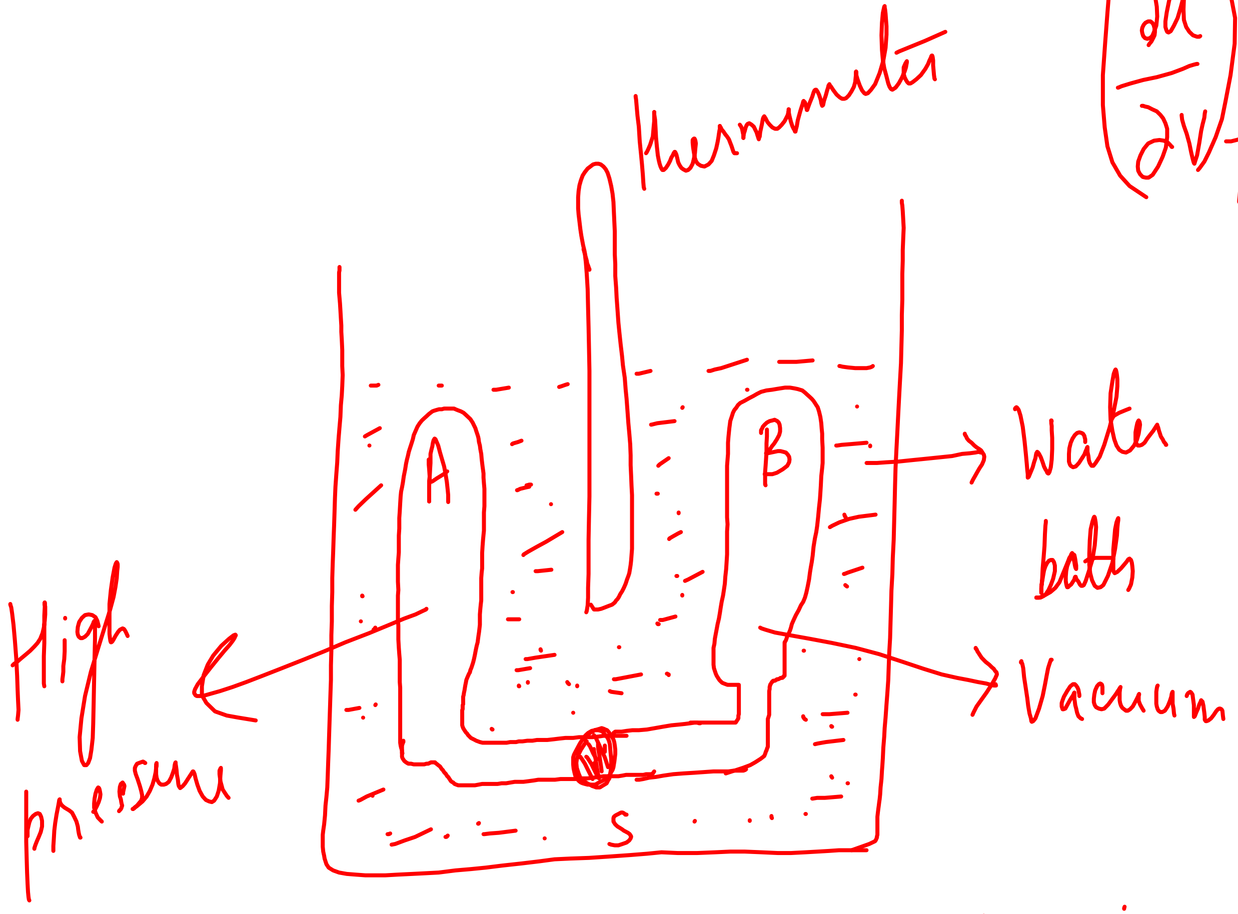
Physics

Shivaji College

Joule's Experiment

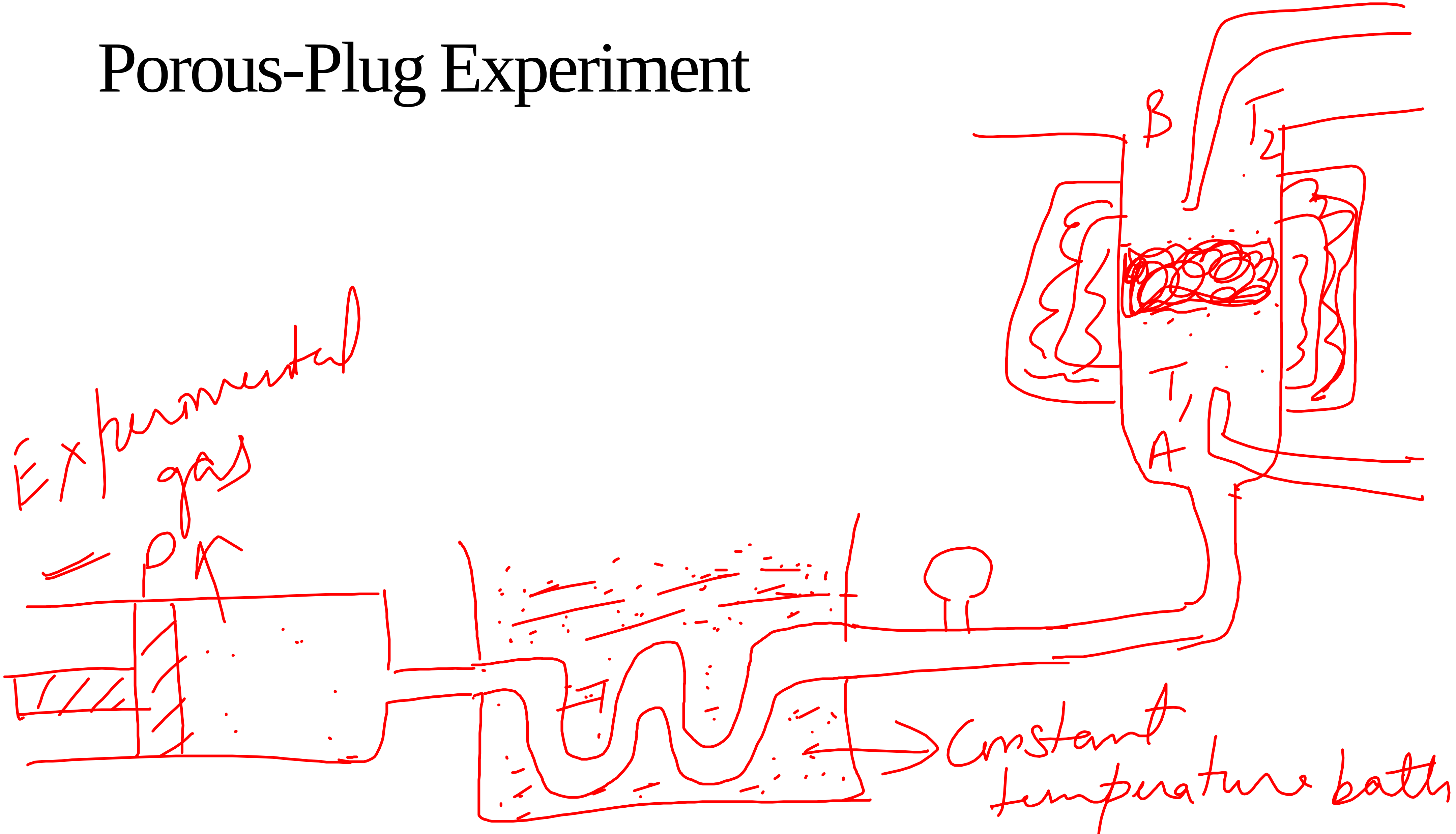


$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

$$\left(\frac{\partial U}{\partial P}\right)_T = 0$$

For free expansion

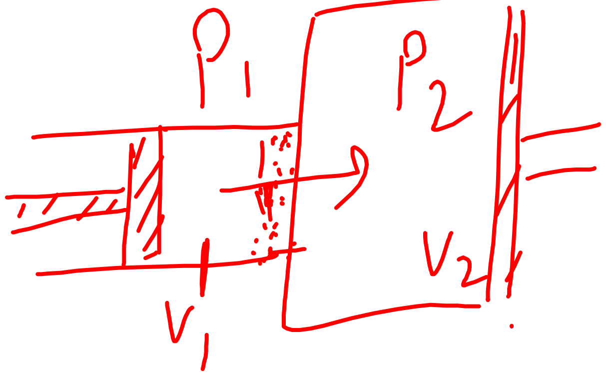
Porous-Plug Experiment



Estimation of Joule-Thomson cooling: Temperature of inversion

$$p = \frac{a}{V^2}$$

$$w = \int_{V_1}^{V_2} p \cdot dV = \int_{V_1}^{V_2} \frac{a}{V^2} dV = -\frac{a}{V_2} + \frac{a}{V_1} \quad \text{---}(1)$$



External work done by gas in expansion $= P_2V_2 - P_1V_1$

$$W = (P_2V_2 - P_1V_1) + w$$

$$W = P_2V_2 - P_1V_1 - \frac{a}{V_2} + \frac{a}{V_1}$$

$$= P_2V_2 - P_1V_1 + \frac{a}{V_1} - \frac{a}{V_2} \quad \text{--- (2)}$$

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

$$\Rightarrow PV + \frac{a}{V} - bP - \frac{ab}{V^2} = RT$$

$$\Rightarrow PV = RT - \frac{a}{V} + bP$$

$$W = \left[RT + bP_2 - \frac{a}{V_2}\right] - \left[RT + bP_1 - \frac{a}{V_1}\right] - \frac{a}{V_2} + \frac{a}{V_1}$$

$$= b(P_2 - P_1) + 2a\left(\frac{1}{V_1} - \frac{1}{V_2}\right) \quad \text{--- (3)}$$

$$V \rightarrow \frac{RT}{P}$$

$$V_1 = \frac{RT}{P_1} \qquad V_2 = \frac{RT}{P_2}$$

$$W = b(P_2 - P_1) + 2a\left(\frac{P_1}{RT} - \frac{P_2}{RT}\right)$$

$$= -b(P_1 - P_2) + \frac{2a}{RT}(P_1 - P_2)$$

$$W = (P_1 - P_2)\left(\frac{2a}{RT} - b\right) \quad \text{— (4)}$$

$$\Rightarrow H = M C_p \Delta T$$

$$C_p \Delta T = (P_1 - P_2)\left(\frac{2a}{RT} - b\right)$$

$$C_p \Delta T = \left(\frac{2a}{RT} - b\right)\Delta P$$

$$\boxed{\Delta T = \frac{\Delta P}{C_p}\left(\frac{2a}{RT} - b\right)} \quad - (5)$$

Joule Thomson coefficient

$$\mu = \frac{\Delta T}{\Delta P} = \frac{1}{C_p}\left(\frac{2a}{RT} - b\right) \quad - (6)$$

$$\Delta T = \frac{\Delta P}{C_p}\left(\frac{2a}{RT} - b\right)$$

(1) $\Delta P = +ve$

$$\left(\frac{2a}{RT} - b\right) = +ve$$

$\Delta T = +ve$

cooling

$$\frac{2a}{RT} > b$$

$$\Rightarrow T < \frac{2a}{Rb} \quad \text{— (7)}$$

(ii) $\frac{2a}{RT} - b = 0$

$\Delta T = 0$

$\Rightarrow T = \frac{2a}{Rb}$

$\boxed{T_i = \frac{2a}{Rb}}$ — (8)

	He	H_2	N_2	A	O_2
T_i	23.6	195	621	723	893

CO_2	Air
1500	603

(iii) $\left(\frac{2a}{RT} - b\right)$ — ve

$\Rightarrow b > \frac{2a}{RT}$

$\Rightarrow \boxed{T > \frac{2a}{Rb}}$ $\Rightarrow \boxed{T > T_i}$

Heating

✓ $T_B =$

✓ $T_i =$

✓ $T_c =$

$$\frac{T_i}{T_c} = 6.75$$

$$\boxed{T_i = 6.75\, T_c}$$

Thankyou