Describe a method for finding the magnetic susceptibility a small specimen (liquid) of a paramagnetic substance by uink's method.

Measurement of magnetic susceptibility by ~~Quin~~ Quink's Method:→

when a paramagnetic substance is placed n a non-uniform magnetic field, it tends to move ~~upwards~~ owards the region of greater field intensity. It is subjected o a net force. A measurement of this force enables us to etermine the susceptibility of the substance.

Let F Newton be the force acting on the ubstance which moves through a distance δx, then work one by the force $= F \cdot \delta x$ - - - - - - - - - (1) nd is equal to the change in P.E resulting from the displacement

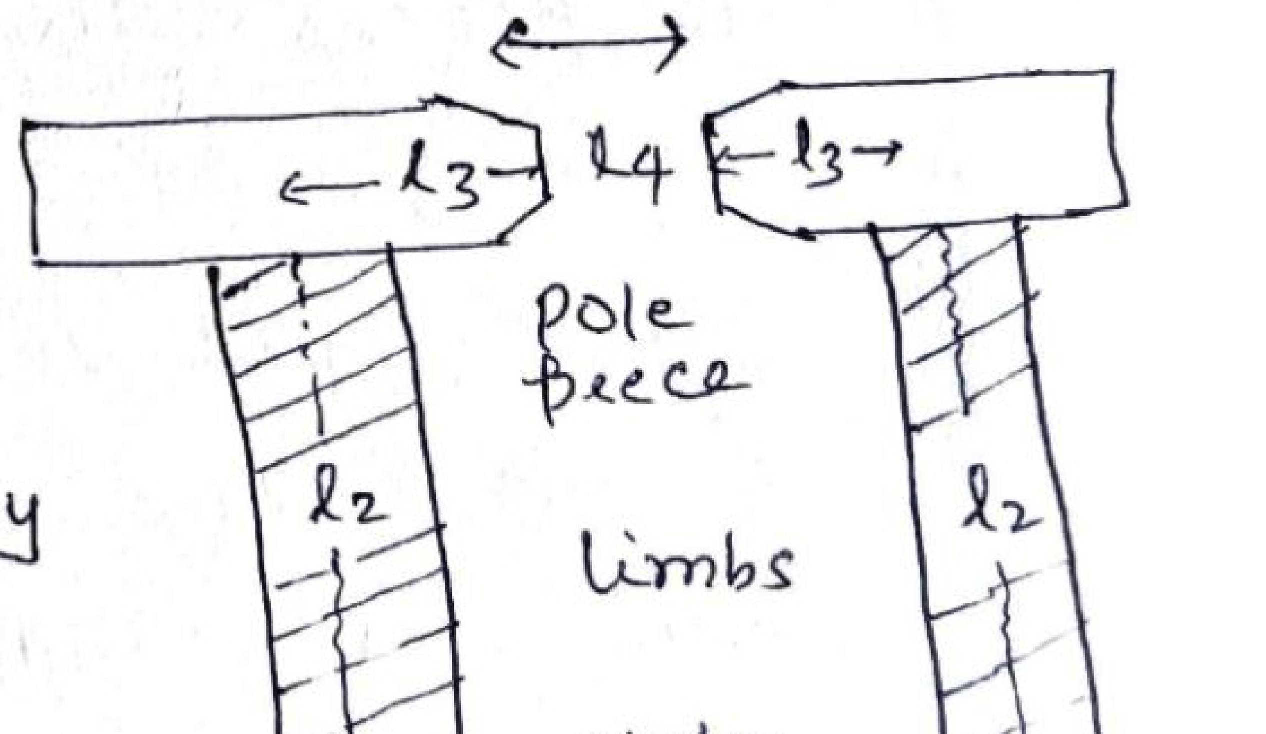
Suppose, that the substance is first outside e field. Let a point where the field intensity is H. μ_0 the permeability constant, then the energy per unit Volume the medium $= \frac{1}{2}\mu_0 H^2$

Energy density $U = B^2/2\mu_0$ $\because B = \mu_0 H$

$\therefore U = \frac{1}{2}\mu_0 H^2$

Magnetic circuit of an Electromagnet:→

The electromagnet consists of a yoke, the limbs, the pole pieces and the air gap as shown in figure



Let 'l_1' be the effective length and A_1 the area of cross-section of the Yoke, and μ_1 be the permeability of its material.

The ~~resultant~~ reluctance of the yoke is given by $= l_1/\mu_1 A_1$

Similarly the reluctance of each limb, it is given as $l_2/\mu_2 A_2$. That is each pole-pieces is given by $l_3/\mu_3 A_3$ and that of air gap is given by $l_4/\mu_0 A_4$

The total reluctance of the magnetic circuit

$$= \frac{l_1}{\mu_1 A_1} + \frac{l_2}{\mu_2 A_2} + \frac{l_3}{\mu_3 A_3} + \frac{l_4}{\mu_0 A_4}$$

We know that, the volume v, into which the substance is to be placed contains an amount of energy $= \frac{1}{2}\mu_0 H^2 V$ Joule but when the substance is in position, the energy $= \frac{1}{2}\mu H^2 V$ joule, Here μ = permeability of substance

$\therefore$ The energy resulting from the introduction of the substance into the field $= \frac{1}{2}(\mu - \mu_0) H^2 V$ joule

When the substance moves through a distance δx to a place where the value of $H^2 = \left(H^2 + \frac{dH^2}{dx}\delta x\right)$, the energy $\frac{1}{2}(\mu - \mu_0)\left(H^2 + \frac{dH^2}{dx}\delta x\right) V$ joule.

Hence change in Energy $= \frac{1}{2}(\mu - \mu_0)\left(\frac{dH^2}{dx}\delta x\right) V$ joule ------ (I)

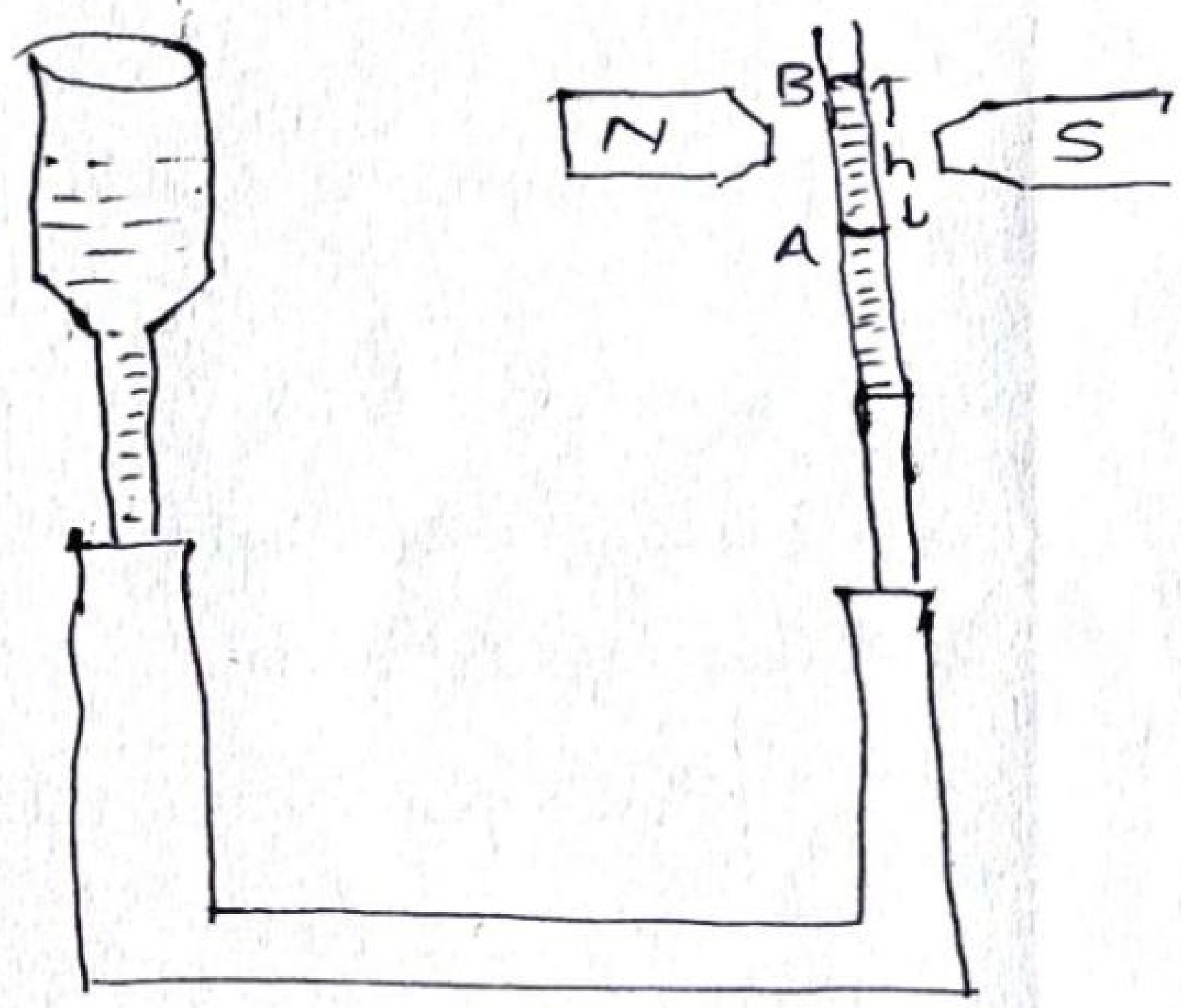
But $\mu = \mu_0 + \mu_0 X_m$

In terms of susceptibility, Change in energy

$= \frac{1}{2}\mu_0 X_m \left(\frac{dH^2}{dx}\delta x\right) V$ joule ------ (2)

Equating eq^n (I) & (II) we get

$F = \frac{1}{2}\mu_0 X_m \frac{dH^2}{dx} V$ newton ---- (III)



Method:-

The experimental arrangement is shown in figure. The given specimen paramagnetic solution is placed in a U-tube consisting of a wide and a narrow limb. The wide limb is placed outside the field, and the narrow limb ~~is~~ inside of magnetic field provided by an electromagnet with wedge shaped pole pieces. The field varies rapidly along the vertical direction due to the wedging of the pole pieces. The force on the specimen is vertical.

Let A be position of liquid level before the magnetic field is generated. The position is noted by a micrometer microscope. The electron magnet is now switched on. The level of paramagnetic liquid in the narrow limbs rises to B. The new position of the level is also noted by the micrometer microscope. Thus the height AB = h is obtained. This is the height of the liquid column supported by the forces arising from the magnetic field.

Let 'a' be the area of cross section of the narrow limb, ρ be the density of the liquid and 'g' be the accl^n due to gravity. Then $h\rho a g$ is the vertical force on the liquid arising from the magnetic field.

Now O (let) be the section where the field is negligible and x be the vertical co-ordinate of O. The force of an element of dx on the liquid at O by the eqn (III) will be

$$dF = \frac{1}{2}\mu_0 \chi_m \frac{dH^2}{dx} V = \frac{1}{2}\mu_0 \chi_m \frac{dH^2}{dx}(a \cdot dx)$$

Therefore, the force on the entire liquid above O is given

$$F = \frac{1}{2}\mu_0 \chi_m a \int_0^{H_1} \frac{dH^2}{dx} \cdot dx$$

where H_1 is the field intensity at the upper level of the liquid, i.e at B. Thus

$$F = \frac{1}{2}\mu_0 \chi_m a H_1^2$$

The force F on the liquid due to the magnetic field has been shown above and is equal to $h\rho g a$

$$\therefore \quad \frac{1}{2}\mu_0 \chi_m a H_1^2 = h\rho g a$$

$$\therefore \quad \chi_m = \frac{2h\rho g}{\mu_0 H_1^2}$$

Here 'h' has already determined. H_1 is measured by the fluxmeter, hence knowing the density ρ of the given liquid, the susceptibility χ_m can be ~~a~~ evaluated.