TDC Part III
Paper VI
Inorganic Chemistry

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TOPIC:-UNIT II, Magnetic properties ,

Method of determining magnetic susceptibility, **Quinckes method**

Quinckes method

The Quincke's method is used to caluculate magnetic susceptibility of diamagnetic or paramagnetic substances in a liquid form. When an object is placed in a magnetic field, a magnetic moment is induced in it. Magnetic susceptibility of a magnetic substance is the ratio of the magnetization I (magnetic moment per unit volume) to the applied magnetizing field intensity H. The magnetic moment can be measured either by force methods or induction methods. The Quincke's method like the Gouy's method belongs to force method. The force f on the sample is negative of the gradient of the change in energy density when the sample is placed in magnetic field.

$$f = \frac{d}{dx}\left[\frac{1}{2}\mu_0(\mu_r - \mu_{ra})H^2\right] = \frac{1}{2}\mu_0(\chi - \chi_a)\frac{d}{dx}H^2 \;\ldots\ldots\ldots \quad (1)$$

Here, μ_0 is permeability of the free space and μ_r, χ and μ_{ra}, χ_a are relative permeability and susceptibility of the sample and the air respectively which the sample displaces. The force acting on an element of area A and length dx of the liquid column is fAdx. Therefore, the total force F on the liquid is

$$F = A\int f dx = \frac{A\mu_0}{2}(\chi - \chi_a)(H^2 - H_o{}^2)\ldots\ldots\ldots\ldots \; (2)$$

H is equal to the field at the liquid surface between the poles of the magnet and 0. The liquid of density r moves under the influence of this force until it is balanced by the pressure exerted over the area A due to a height difference of h between the liquid surfaces in the two arms of the U-tube. Therefore, the force will be

$$F = Ah(\int - \int a)g$$

Or

$$\chi = \chi_a + \frac{2}{\mu_o} g(\int - \int a)\frac{h}{(H^2 - H_0{}^2)}\ldots\ldots\ldots\ldots \; (3)$$

In actual practice χ_a, density of air ρ_a and H_0 are negligible and can be ignored and the above expression simplifies to

$$x = 2\int \frac{gh}{\mu_o H^2} \text{ .... (4)}$$

This equation shows that by plotting h as a function of H^2, the susceptibilityc χ (called the volume susceptibility) can be determined directly from the slope of the straight line graph.

It is a dimensionless quantity. This expression is in S.I. units in which ρ, g, h and H are measured in kg/m^3, m/s^2, m and amp. turn/m respectively.

In C.G.S. units, equation (3) and (4) are

$$x = x_a + 2g(\rho - \rho_a)\frac{h}{(H^2 - Ho^2)} \text{ .... (5)}$$

$$x = \frac{2\rho g h}{H^2} \text{ .... (6)}$$

Where ρ, g, h and H are measured in g/cm^3, cm/s^2, cm and gauss respectively. The volume susceptibilities in the two systems of units are related as χ (SI units) = 4 χ (CGS units).
