Lab Manual

B.Sc. Sem V & VI

Expt. I

Aim: To measure Dielectric constant of given material

Apparatus: Capacitance measuring device, samples, screw gauge, Aluminum foil

Theory: Dielectric constant is measured using relation

$K = C_m/C_0$……………………………………………………………(1)

Where C_m is Capacitance of parallel plate capacitor with dielectric medium between electrodes and C_0 is Capacitance of parallel plate capacitor with same dimensions and without dielectric medium

$C_o = \varepsilon_o A/d$…………………………………………… (2)

$C_m = K\ \varepsilon_o A/d$……………………………………… ..(3)

Procedure:

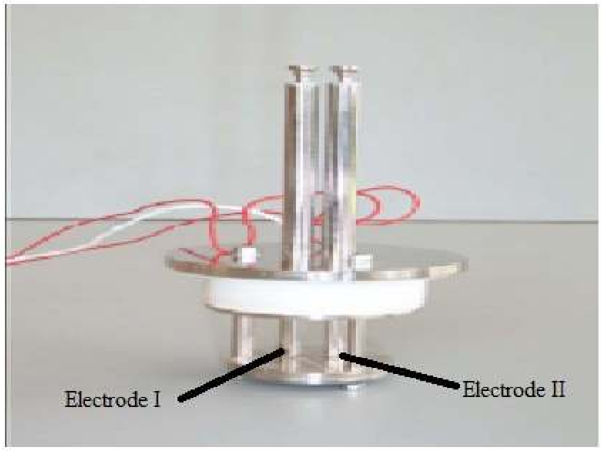
1. Place the sample in holder with Aluminum foil below and above the sample.
2. Put in terminals of holder into probe terminals of main apparatus.
3. Main unit will directly give capacitor reading. This reading will give C_m.
4. Measure the dimensions of sample using screw gauge.
5. Calculate C_o using formula (2)
6. Now calculate K using (1)

Observations:

Sample No.	Area	C_o	C_m	K
1.				
2.				

Precautions/Sources of error:

1. Aluminum foil should be placed below and above samples properly making good contact.
2. Foil size above the sample should be of exactly same size as that of sample itself.
3. Foil size below the sample should run across sample lower surface and electrode II.


Electrode I
Electrode II


STUDY OF DIELECTRIC CONSTANT
CAPACITANCE
OVEN
ON
OFF
TEMPERATURE
PROBE
TERMINALS
SET TEMP
RTD
OVEN
SCIENTIFIC EQUIPMENT
ROORKEE

Expt. II

TO MEASURE THE SUSCEPTIBILTY OF PARAMAGNETIC SOLUTION BY QUINCKE'S TUBE METHOD

APPARATUS: **Quincke's tube with stand, Sample ; FeCl_3 , Electromagnet, Constant Current Power Supply , Digital Gaussmeter , Travelling Microscope.**

THEORY: It was established by Faraday in 1845 that magnetism is universal property of every substance. He classified all magnetic substances into two classes, viz., Paramagnetic and Diamagnetic. Weber, later on, tried to explain para and diamagnetic properties on the basis of molecular currents. The molecular current give rise to intrinsic magnetic moment to the molecule, and such substances are attracted in a magnetic field, and called paramagnetic. The repulsion of diamagnetic substance is assigned to the induced molecular current and its respective reverse magnetic moment. The force acting on a substance whether attractive or repulsive can be measured using accurate balance in case of solids or with measurement of rise in level in narrow capillary in case of liquids. The force depends on the susceptibility $\mathcal{X}$, of the material, i.e. *on the ratio of magnetisation to magnetising field (M/H).* Evidently it refers to the extent to which a body gets magnetised in relation to the applied Magnetising field. Quantitatively it refers to the extent of induced magnetisation in unit field. If the force on the substance and field are measured, the value of susceptibility can be calculated.

The volume susceptibility is defined by the relations,

$$\mu_r = 1 + \mathcal{X}$$

Where the magnetic intensity H is related to B through B=$\mu_0\ \mu_r$ H.

Since the relative permeability, $\mu_r \approx 1$, the magnetisation is given by,

$$M = \mathcal{X} B/\mu_0 = (\mu_r - 1)\ B/\mu_0$$

When the sample is placed in field, it will experience a force which is equal to the negative gradient of change of energy density of sample;

$$f = \frac{1}{2}\mu_0\ (\chi - \chi_0)\frac{d}{dx}H^2 \qquad 1$$

with χ *as susceptibility of substance and* χ_0 *as that of air* that the sample displaces.

The force acting on an element of area A and length dx of the liquid column is fAdx, so the total force F on the liquid is;

$$F = A\int f dx = \frac{A}{2}\mu_0\ (\chi - \chi_0)\ (H^2 - H_0^2) \qquad 2$$

where the integral is taken over the whole liquid. This means that H is equal to the field at the liquid surface between the poles of the magnet and H_o is the field at the other surface away from the magnet. The liquid (density ρ) moves under the action of this force until it is balanced by the pressure exerted over the area A due to a height difference h between the liquid surfaces in the two arms of the U-tube. It follows that

$F = Ah(\rho - \sigma)g$ 3

Comparing equation 2 and 3 we get the of susceptibility $\mathcal{X}$ of liquid aqueous solution of a paramagnetic substance in air is given by a well known expression :

$$\mathcal{X} = \frac{2(\rho - \sigma)gh}{H^2}$$

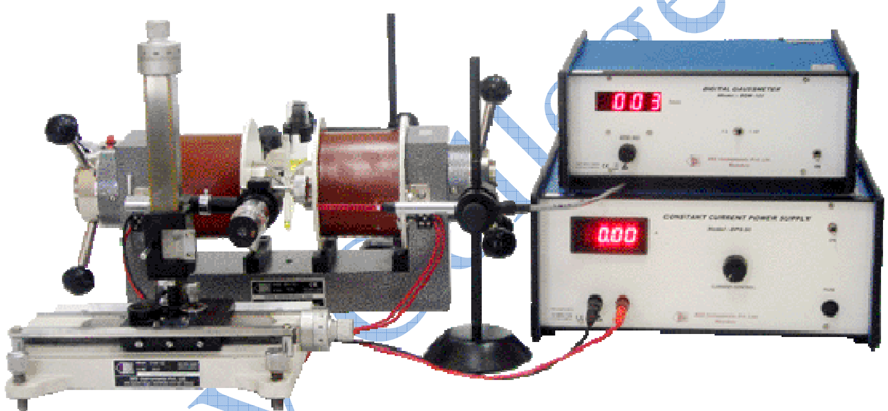
Where, ρ is the density of liquid or solution.

σ is the density of air.

g is acceleration due to gravity.

h is the height through which the column rises on switching on the field.

H is the magnetic field at the centre of pole pieces of magnet.



Apparatus for susceptibility measurement

Quincke's Tube

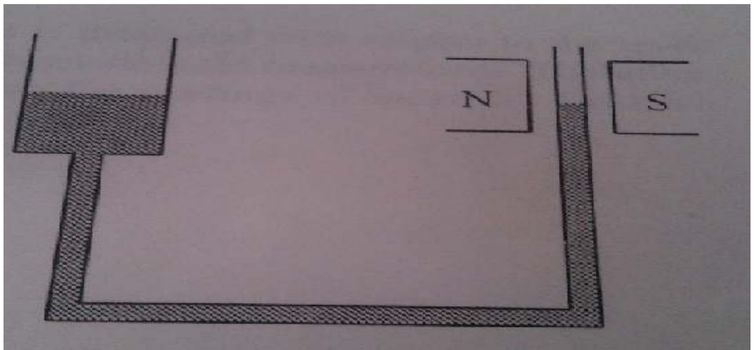


Fig.: Quinck's tube mechanism

PROCEDURE:

1. Adjust the suitable air-gap (about 10 mm) between the pole pieces of the electromagnet.

2. Put the hall Probe off Gaussmeter at the centre of air gap between pole pieces and make sure that flat face of the probe is parallel to the pole pieces.

3. Take out the Hall Probe with (Without disturbing the alignment of hall probe) and switch on the Gaussmeter and let it stabilised for about 5 minute, adjust it to 0000. Put the Hall Probe at the centre of pole pieces again. Gaussmeter would give some reading (about 100G) even when the magnetising current is off. This is residual magnetic field.

4. Plot a graph: Magnetising Current vs. Magnetising Field.

5. Prepare a FeCl_3 solution in water, determine its density (gm/cc) by R.D. bottle and fill it in Quincke's tube.

6. Put the narrow limb of the Quincke's tube between the pole pieces such that the FeCl_3 solution level is at the centre of the pole pieces or slightly lower.

7. Read the height of the level of the solution with the travelling microscope, switch on the power supply of the electromagnet and read the height of the raised level for different value of current.

8. Obtain the value of magnetic field corresponding to magnetising current from graph plotted earlier.

9. Plot a graph: Magnetic field H^2 vs. h (height through which the liquid column rises). It would be a straight line.

OBSERVATION TABLES:

Table-1:Magnetising Current vs. Magnetic Field

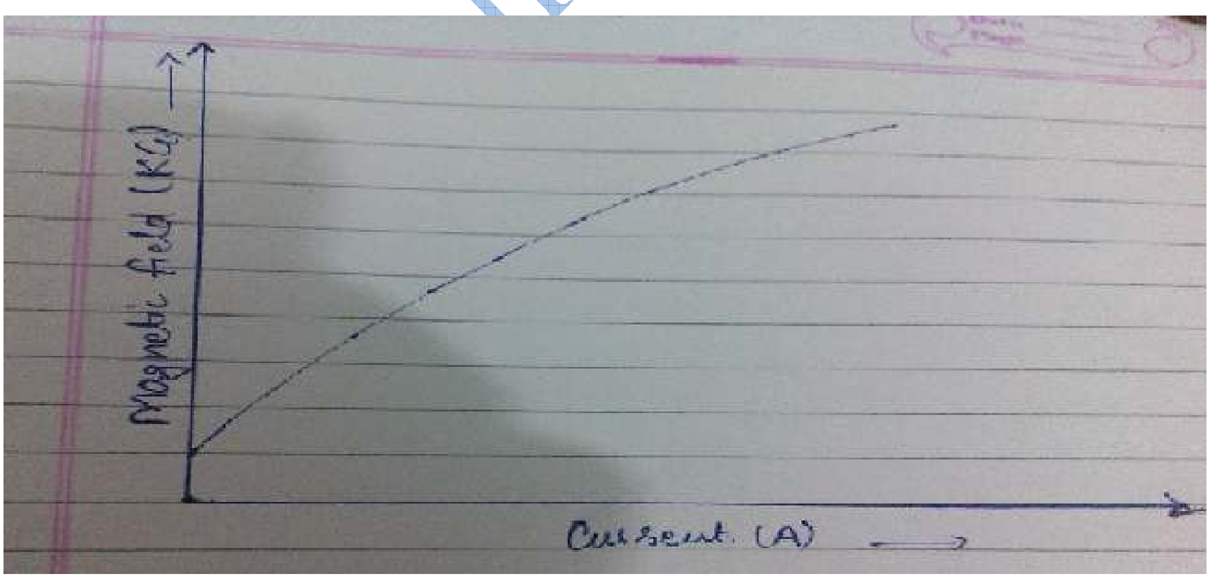
Sr. No.	Current(A)	Magnetic Field(KG)
1		
2		
3		
4		
5		
6		

Table-2: Rise of solution level (h) as a function of magnetic field (H):-

Sr.No.	Current(A)	H(KG)	H^2 $(KG)^2$	Height of liquid level(mm)	Rise of solution(mm)
1					
2					
3					
4					
5					

Graphs :

1. Magnetising Current vs. Magnetic Field:-



2. Rise of solution level (h) as a function of magnetic field (H):-

CALCULATIONS:-

1. Determination of density ρ :

Mass of specific gravity bottle = W_1

Mass of specific gravity bottle + water = W_3

Mass of specific gravity bottle + solution = W_2

$\rho = (W_2 - W_1)/(W_3 - W_1)$

2. From graph of h vs. H^2 :

Slope of graph = $\frac{h}{H^2}$

3. $\chi = \frac{2\rho g h}{H^2}$

PRECAUTION:

Note the height through which the liquid rises is measured with respect to the level of residual magnetic field but it is added in the magnetic field measurement. Therefore residual magnetic field should be subtracted from the readings of magnetic field for plotting the graph : H^2 vs h.