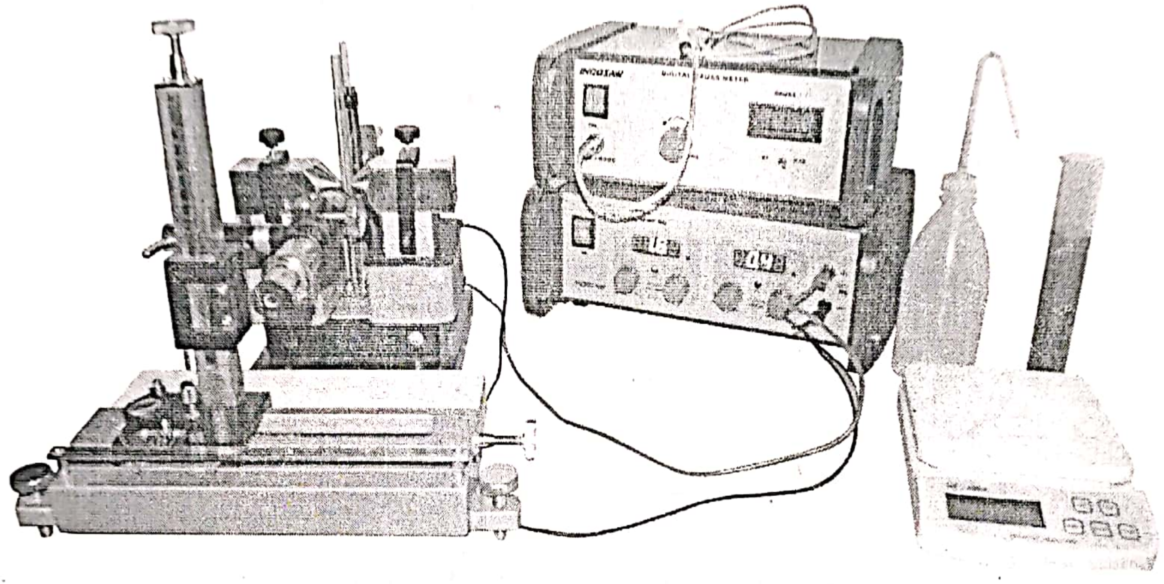
INSTRUCTION MANUAL FOR

QUINCK'S TUBE METHOD



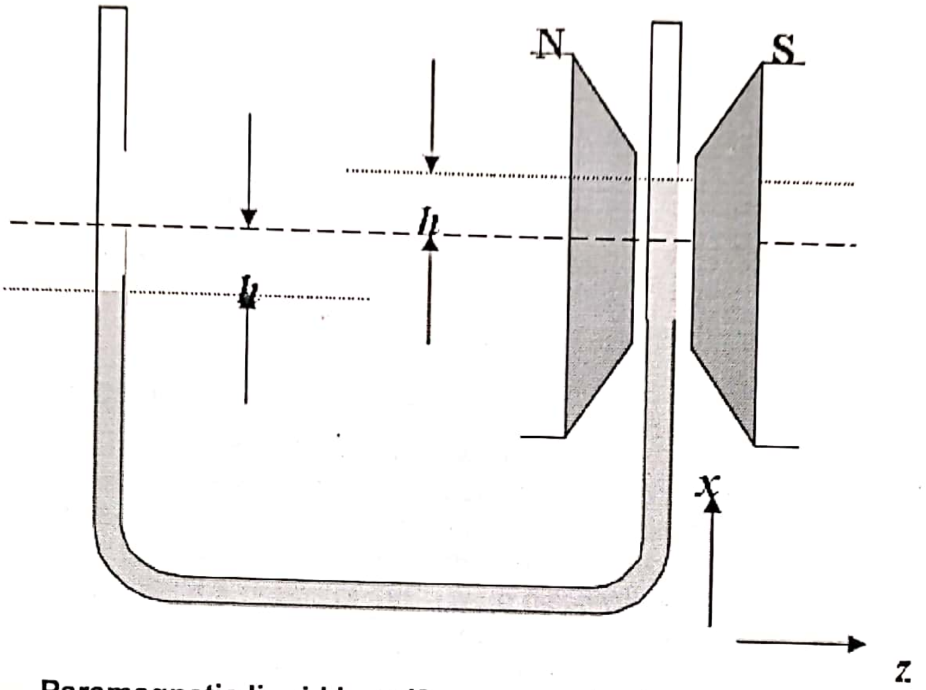
EXPERIMENT:

To measure the magnetic susceptibility of a solution of paramagnetic sample (Ferric Chloride $FeCl3$) and to determine the magnetic dipole moment of a Fe ion in units of the Bohr magneton, μB.

INTRODUCTION:

Quincke's method is based on the force experienced by a magnetised material in a non-uniform magnetic field and is a version of Gouy's method, which is specially adapted for liquids.

On the basis of Susceptibility, a substance can be classified as diamagnetic, paramagnetic and ferromagnetic substance, which is an important observation in material science.



Paramagnetic liquid in uniform magnetic field

The liquid moves under the action of the total force F until it is balanced by the pressure exerted over the area A due to a height difference 2h between the liquid surfaces in the two arms of the U-tube. Allowing for the susceptibility χ_a and density ρ_a of the air which the liquid displaces, it follows that,

where g is the acceleration due to gravity,   density of liquid, so that

by plotting h as a function of , the susceptibility can be determined directly from the slope of the graph.

In practice, the corrections due to air are negligible. There will also be a small but significant diamagnetic (i.e. negative) contribution to the susceptibility mainly due to the water. The total susceptibility of the solution is then given by $X = X_{Fe} + X_{Water}$. This assumes that the number of water molecules per unit volume is not very different in the solution from that in pure water. In the present work you will correct X to yield the true value of X_{Fe} due to the presence of the Ferric Chloride.

SCOPE OF SUPPLY:

S.No.	Item Name	Qty.

1	Electromagnet	1
2	Power Supply for Electromagnet	1
3	U Tube with Stand	1
4	Traveling Microscope	1
5	Digital Gauss Meter	1
6	Connecting Lead (Red & Black)	1
7	Connecting Lead Yellow	1
8	Electronic Balance	1
9	Ferric Chloride (FeCl3) 500gm	1
10	Measuring Cylinder 100ml	1
11	Pipette 10ml	1
12	Funnel	1
13	Dropper	1

EXPERIMENTAL PROCEDURE

1. Prepare the Fecl3 of known mass in 100ml water.
2. Calculate the number of moles of Fe ions per unit volume of the solution. 1 mole of a substance has a weight in grams equal to its molecular weight, W_m. The molecular weight is found by adding up the atomic weights of the constituent atoms of the molecule. If X grams of $FeCl_3$ were dissolved in V m^3 of the solution, the number of moles is X/W_m. Each mole contains NA (Avagadro's number) of molecules. Thus the number of molecules in V m3 is NAX/W_m.
3. Measure the density ρ of your solution using a specific gravity bottle. The method here is to (a) weigh the bottle + stopper when it is dry and empty, (b) fill it with distilled water and weigh it again, (c) dry it with compressed air and fill it with your solution and weigh it again. The density ρ may be found, knowing the density of water ρ_{water}.
4. Calibrate the magnetic field against magnet current using the digital Hall probe. The magnet will run continuously with a current of 5A; for short periods at 10A. Position the probe so that it gives positive values of B and use the stand provided so that it remains in the same position throughout your calibration.
5. Plot the calibration data of magnetic field versus current and try fitting the initial linear region with a straight line in Excel. Does the slope depend on whether you constrain the line to pass through the origin or not. The full calibration curve including the saturation region can be fitted with a second or third order polynomial.
6. Finally before the actual experiment, use the Hall probe to test if there is any variation of B across the region of the magnet pole pieces.

WARNING: Scrupulous cleanliness of the U-tube is essential. Thoroughly clean the tube and rinse it well with distilled water before starting and dry it with compressed air. Make several sets of measurements to ensure consistency; false readings can arise from liquid running down the tube or sticking to the sides. Carefully swab down the inside of the U- tube with a cotton bud, to ensure that there are no droplets of liquid which might interfere with the plastic spacers on the rod which measures the height of the meniscus. Do not use the U-tube for longer than one laboratory period without recleaning. After cleaning ask the laboratory technician to dry the tube for you with compressed air.

1 7.

Transfer some of your solution to the U-tube so that the meniscus is in the centre of the pole pieces. Take care to ensure that the surface of the liquid between the poles of the magnet is in the region where the field is greatest and reasonably uniform. Make sure that it is in the same starting position for all your experiments. The measuring rod should just touch the meniscus and if you wish you may set the micrometer scale to zero at this point.

8.

Measure the displacement h of the column of liquid as a function of applied field B. Note that if you record your data now with the same small increments of current as your calibration data then you can access the B field values directly.

9.

Dispose of all solutions when finished in the waste flask provided.

10.

There is a stronger (3 times) solution of manganese sulphate in a labelled bottle. Repeat the measurements with some of this stronger solution and use equation (9) to determine whether the data obtained are commensurate with this new concentration.

11.

Determine the susceptibility χ using equation (8). Compare χ with the value given in Kaye and Laby, which you should note is the mass susceptibility of the parent crystalline material (units m3 kg-1 at 20 oC). You can easily change this to a volume

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susceptibility by multiplying by the density of the salt (ρMnSO4.4H20=2.95x103 kg m-3). The value you obtain will be different from the susceptibility of your solution since the number density of ions in the salt is larger than the number density of ions in your solution by a factor of about 10.

12.

Make estimates of χa, ρa and B0 in equation 8 and show that their effects are negligible.

13.

From your measured susceptibility χ obtain χMn by correcting for χwater (remember water is diamagnetic). [Diamagnetic volume susceptibility of water χwater=51090] .0−×−

14.

Use equation (11):

kTNpB3022Mnμμχ= (11)

and your value of N to determine the effective number p of Bohr magnetons of a Mn2+ ion and compare your value with those given in Appendix A.