

## DEPARTMENT OF PHYSICS

### Lab Manual

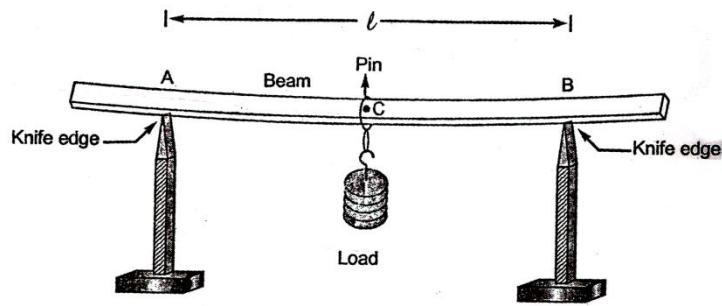
#### PHYSICAL SCIENCES LAB: PART A- REAL AND VIRTUAL LAB IN PHYSICS

##### LIST OF EXPERIMENTS

1. Young's Modulus of a bar – Non uniform bending.
2. Torsional Pendulum – Determination of Rigidity modulus of the wire.
3. Determination of Viscosity of a liquid – Poiseuille's Method.
4. Ultrasonic Interferometer – Determination of velocity of sound and compressibility of the liquid.
5. Diode Laser – Determination of Particle size.
6. Spectrometer – Determination of Wavelength of the mercury Spectrum.
7. Air-wedge – Determination of thickness of the material.
8. Determination of thermal conductivity of bad conductor – Lee's Disc Apparatus.
9. Band Gap Apparatus – Determination of Band gap of a thermistor.



**HOD – H & S**



Young's Modulus – Non Uniform Bending

**OBSERVATION**

**Tabulation – 1**

Distance between the two knife edges  $l = \dots\dots\dots \times 10^{-2} \text{ m}$

To find the depression "S" for "M" Kg load

L.C =  $0.001 \times 10^{-2} \text{ m}$

TR = MSR + (VSC x LC)

S. NO	Load	Microscope reading						mean	Depressions S(For =50x $10^{-3} \text{ Kg}$ )
		Loading			Unloading				
		MSR	VSC	TR	MSR	VSC	TR		
	$(10^{-3} \text{ Kg})$	$\times 10^{-2} \text{ m}$	Div	$\times 10^{-2} \text{ m}$	$\times 10^{-2} \text{ m}$	Div	$\times 10^{-2} \text{ m}$	$\times 10^{-2} \text{ m}$	
	W								
	W+50								
	W+100								
	W+150								
	W+200								
	W+250								

Mean S =  $\dots\dots \times 10^{-2} \text{ m}$

# 1. YOUNG'S MODULUS - NON-UNIFORM BENDING

## AIM:

To determine the Young's modulus of the material of the given beam by non-uniform bending

## APPARATUS REQUIRED:

Travelling microscope, knife edges, slotted weights, pin, meter scale, screw gauge and vernier calipers.

## FORMULA:

$$\text{Young's modulus } Y = \frac{Mgl^3}{4sbd^3} \text{ Nm}^{-2}$$

## EXPLANATION OF SYMBOLS:

M - Load (Kg)

S - Mean depression for a load M (m)

g – Acceleration due to gravity ( $\text{ms}^{-2}$ )

l – Distance between two knife edges (m)

b – Breadth of the beam (m)

d – Thickness of the beam (m)

## PROCEDURE:

- The given beam (meter scale) is placed on the knife edges at equal distances from both the ends of the beam.
- A pin is fixed at the middle of the beam and a weight hanger is suspended. Let its weight be W.
- Adjust the microscope, focus the tip of the pin and made to coincide with the horizontal cross wire, and note the reading.
- The above procedure is repeated by adding slotted weights one by one (50gm) and the corresponding readings are noted (loading).

**Tabulation- 2**

**To find thickness of beam (d) using Screw gauge:**

**L.C** =  $0.01 \times 10^{-3}$  m

**ZE** =  $\pm \dots\dots\dots$  Div

**ZC** =  $\pm \dots\dots\dots \times 10^{-3}$  m

S.NO	Pitch Scale Reading (PSR)	Head Scale Coincidence (HSC)	Observed Reading OR= PSR+ (HSCxLC)	Correct Reading CR = OR $\pm$ ZC
Unit	$\times 10^{-3}$ m	Div	$\times 10^{-3}$ m	$\times 10^{-3}$ m

**Mean d** =  $\dots\dots\dots \times 10^{-3}$  m

**Tabulation- 3**

**To find breadth of beam (b) using Vernier caliper**

**L.C** =  $0.01 \times 10^{-2}$  m

**ZE** =  $\pm \dots\dots\dots$  Div

**ZC** =  $\pm \dots\dots\dots \times 10^{-2}$  m

S.NO	Main Scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Observed Reading OR= MSR+ (VSC x LC)	Correct Reading CR = OR $\pm$ ZC
	$\times 10^{-2}$ m	Div	$\times 10^{-2}$ m	$\times 10^{-2}$ m

**Mean b** =  $\dots\dots\dots \times 10^{-2}$  m

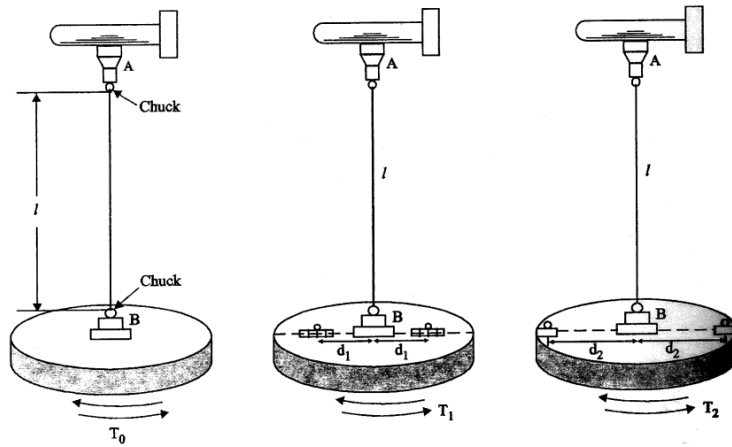
- The same procedure is repeated by removing slotted weights one by one (50 gm) and the corresponding readings are noted (unloading).
- Using above values, the mean depression “s” is calculated.
- Thickness and breadth of the beam are measured using screw gauge and vernier caliper respectively.
- Hence the Young’s modulus of the beam is calculated the using given formula.

**CALCULATION:**

Young's modulus of the material of the beam  $Y = \frac{Mgl^3}{4sbd^3} \text{ Nm}^{-2}$

**RESULT:**

Young's modulus of the material of the given beam by calculation  $Y =$        $\text{Nm}^{-2}$



Torsional Pendulum  
**OBSERVATION**

Tabulation – 1: To determine the values of  $T_0$ ,  $T_1$  &  $T_2$

Length of the wire  $l = \dots\dots\dots \times 10^{-2}$  m

S.NO	Distance between the masses	Time for 10 oscillation				Time period (T)
		Trial-1	Trial-2	Trial-3	mean	
Unit	$\times 10^{-2}$ m	sec	sec	sec	sec	sec
1.	<b>Without masses</b>					<b>(<math>T_0</math>)</b>
2.	<b>With masses at a Distance <math>d_1 = \dots\dots\dots \times 10^{-2}</math> m</b>					<b>(<math>T_1</math>)</b>
3.	<b>With masses at a Distance <math>d_2 = \dots\dots\dots \times 10^{-2}</math> m</b>					<b>(<math>T_2</math>)</b>



## 2. TORSIONAL PENDULUM

### AIM:

To determine the moment of inertia of the disc and the rigidity modulus of the material of wire by Torsional oscillations

### APPARATUS REQUIRED:

Uniform circular disc, wire, two symmetrical masses, stop clock, screw gauge, and meter scale.

### FORMULA:

$$\text{Moment of inertia of the disc } I = \frac{2m(d_2^2 - d_1^2)T_o^2}{T_2^2 - T_1^2} \text{ Kg.m}^2$$

$$\text{Rigidity Modulus } \eta = \frac{8\pi I \times l}{T_o^2 r^4} \text{ Nm}^{-2}$$

### EXPLANATION OF SYMBOLS:

m - Mass of one of the symmetrical masses (kg)

d<sub>1</sub> – Closest distance between the axis of the pendulum and the centre of the mass (m)

d<sub>2</sub> – Farthest distance between the axis of the pendulum and the centre of the mass(m)

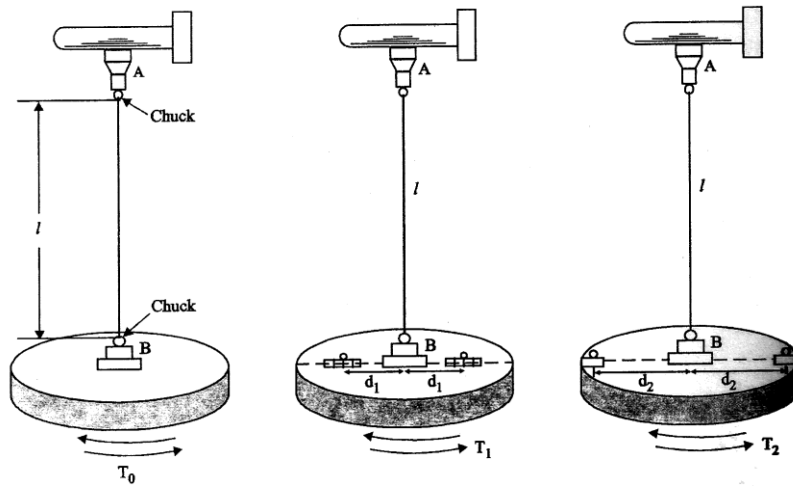
T<sub>o</sub> – Time period of oscillation without mass (sec)

T<sub>1</sub> – Time period of oscillation with mass at a distance d<sub>1</sub> (sec)

T<sub>2</sub> – Time period of oscillation with mass at a distance d<sub>2</sub> (sec)

l - Length of the suspension wire (m)

r – Radius of the wire (m)



**Tabulation- 2: To find thickness of wire (d) using Screw gauge**

**L.C** =  $0.01 \times 10^{-3}$  m

**ZE** =  $\pm \dots\dots\dots$  Div

**ZC** =  $\pm \dots\dots\dots \times 10^{-3}$  m

S.NO	Pitch Scale Reading (PSR)	Head Scale coincidence (HSC)	Observed Reading OR= PSR+ (HSCxLC)	Correct Reading CR = OR $\pm$ ZC
	$\times 10^{-3}$ m	<b>Div</b>	$\times 10^{-3}$ m	$\times 10^{-3}$ m

**Mean** =  $\dots\dots\dots \times 10^{-3}$  m

**PROCEDURE:**

- A thin wire, whose rigidity modulus is to be measured, is fixed between a wall bracket and the disc.
- Set up the Torsional oscillations by means of couple of forces.
- Period of oscillations for without mass, with mass at the closest distance  $d_1$  and with mass at the farthest distance  $d_2$  are measured.
- Hence the moment of inertia and rigidity modulus of the wire are calculated using the given formula.

**CALCULATIONS:**

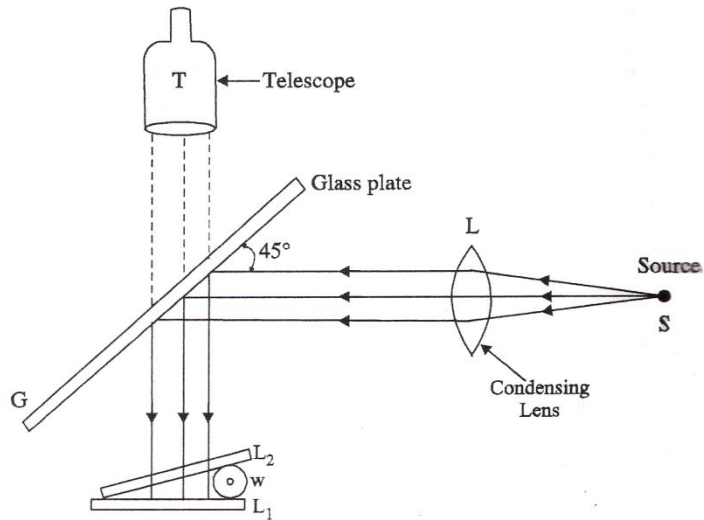
$$\text{Moment of inertia of the disc } I = \frac{2m(d_2^2 - d_1^2)T_o^2}{T_2^2 - T_1^2} \quad \text{Kg.m}^2$$

$$\text{Rigidity Modulus of the wire } \eta = \frac{8\pi l \times l}{T_o^2 r^4} \quad \text{Nm}^{-2}$$

**RESULT:**

Moment of inertia of the disc                       $I =$                        $\text{Kg.m}^2$

Rigidity modulus of the material of wire                       $\eta =$                        $\text{Nm}^{-2}$



$L_1, L_2$  - Transparent plane glass plates       $w$  - Specimen (wire)

Air - wedge arrangement

### OBSERVATION

**Tabulation – 1: To find the band width ( $\beta$ )**

$LC = 0.001 \times 10^{-2} \text{ m}$

$TR = MSR + (VSC \times LC) \times 10^{-2} \text{ m}$

Order of the band	Microscope reading			Width of 5 bands ( $5\beta$ )	Width of one band ( $\beta$ )
	Main Scale Reading (MSR)	Vernier Scale Coincidence (VSC)	TR = MSR + (VSC x LC)		
Unit	$\times 10^{-2} \text{ m}$	div	$\times 10^{-2} \text{ m}$	$\times 10^{-2} \text{ m}$	$\times 10^{-2} \text{ m}$
n					
n+5					
n+10					
n+15					
n+20					
n+25					
n+30					
n+35					
n+40					
n+45					

Mean =  $\quad \times 10^{-2} \text{ m}$

### 3. AIR WEDGE

**AIM:**

To find the thickness of the thin wire using Air-wedge experiment

**APPARATUS REQUIRED:**

Travelling microscope, Na vapour lamp, optical glass plates, reading lens and thin wire.

**FORMULA:** Thickness of thin wire  $t = \frac{\lambda l}{2\beta}$  m

**EXPLANATION OF SYMBOLS:**

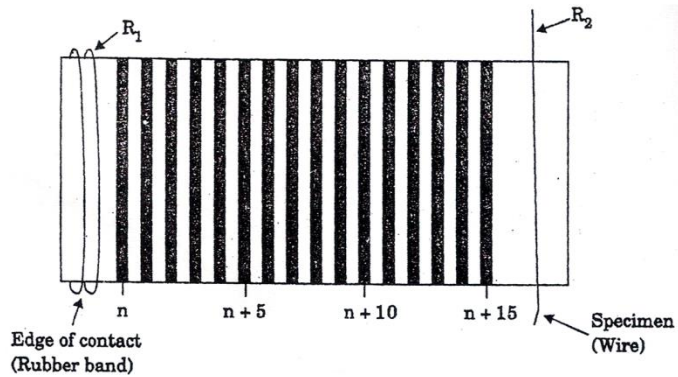
$\lambda$  – Wavelength of Na vapour lamp ( $5893 \times 10^{-10}$  m) (m)

l- Distance between the wire and the edge of the contact (m)

$\beta$  –Band width (m)

**PROCEDURE:**

- Air wedge set up consists of two plane optical glass plates, one end tied with rubber band and in another end a thin wire is inserted whose thickness is to be measured, experimental set up are arranged as shown in fig.
- Light from the source is made passing parallel on it.
- The parallel beam is incident on glass plate at  $45^\circ$  and gets reflected towards air-wedge set up
- By adjusting Air wedge set up, focusing of travelling microscope, the interference fringes are viewed through traveling microscope.
- The vertical cross wire of the microscope is adjusted using horizontal fine adjustment screw to coincide with any one of the dark fringes, taken as n, the reading is noted from the horizontal scale.
- The microscope is moved either left or right using fine- adjustment screw of horizontal scale and made to coincide with every successive 5<sup>th</sup> fringe. The readings are noted. The distance l, between the wire and one edge of contact is measured with the help of travelling microscope.
- From the observed readings, the thickness of the given wire can be calculated by using the given formula.



Interference - fringe pattern

To determine the distance between edge of contact and specimen wire:-

LC = 0.001 cm

Position	MSR  x 10 <sup>-2</sup> m	VSC  Div	TR = MSR + (VSC x LC)  x 10 <sup>-2</sup> m
Rubber band			R <sub>1</sub>
Specimen wire			R <sub>2</sub>

$$l = R_1 - R_2 = \dots\dots\dots \text{X } 10^{-2} \text{ m}$$

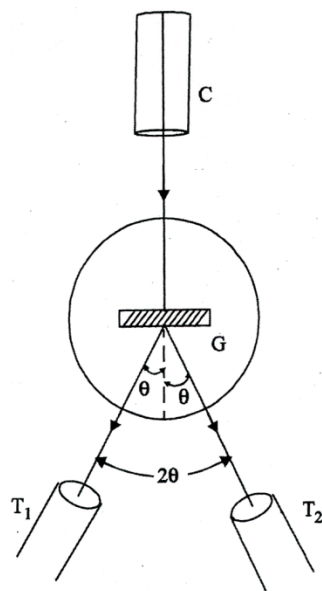
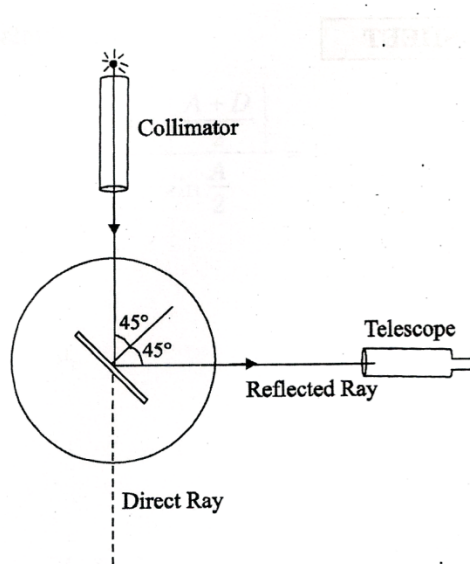


**CALCULATION:**

Thickness of thin wire  $t = \frac{\lambda}{2\beta}$  m

**RESULT:**

The thickness of the given wire  $t = \dots\dots\dots$ m



### OBSERVATION

Tabulation – 1: To determine the angle of diffraction ( $\theta$ ) and wavelength of the spectral lines.

Least count= $1'$

$$VSR = VSC \times LC$$

Spectral Lines (colour)	Reading for the diffracted ray												Difference Between the Readings ( $2\theta$ ) (deg)		M e a n	Angle Of Diffraction $\theta$ (deg)	$\lambda = \sin\theta/mn$  (m)
	Left side (deg)						Right side (deg)										
	Vernier A1			Vernier B1			Vernier A2			Vernier B2			A1~A2	B1~B2	2 $\theta$ deg		
	M	V		M	V		M	V		M	V						
	S	S	T	S	S	T	S	S	T	S	S	T					
	R	C	R	R	C	R	R	C	R	R	C	R					

## 4. SPECTROMETER-GRATING

### AIM:

To determine the wavelength of the predominant spectral lines of Mercury source

### APPARATUS REQUIRED:

Spectrometer, Mercury Source, Spirit level, grating

### FORMULA:

Wavelength of the spectral lines in Hg spectrum

$$\lambda = \frac{\sin\theta}{mn} m$$

$\lambda$  – Wavelength of the spectral lines (m)

N- Number of lines in grating (lines/m)

m- Order of spectral lines

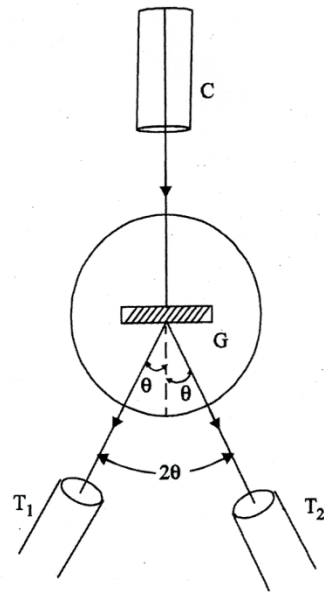
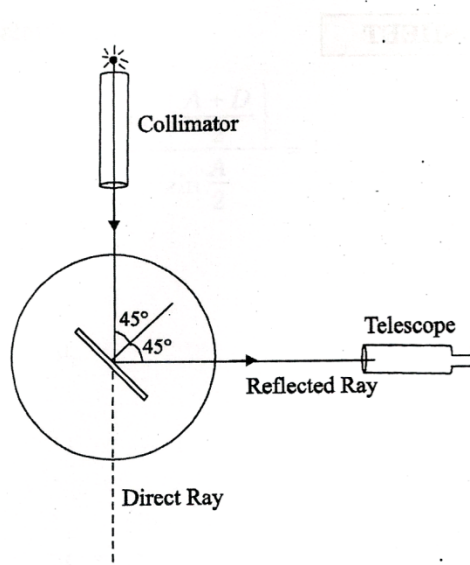
### PROCEDURE:

#### INITIAL ADJUSTMENT OF SPECTROMETER

- The initial adjustment of the spectrometer are made
- The grating is placed on the grating table
- The slit is illuminated by source of light
- The telescope is brought in line with the collimator and the direct ray is made coincide with vertical cross wire and the reading is fixed as  $0^\circ$  and  $180^\circ$  by adjusting vernier scale on either side.

#### ADJUSTMENT OF THE GRATING FOR NORMAL COINCIDENCE

- The telescope is rotated by an angle  $90^\circ$  (either left or right) and fixed.
- The grating table is rotated until the reflected image of slit is coincided with vertical cross wire. The vernier table is released and rotated by an angle  $45^\circ$  towards the collimator.
- Now light coming out from the collimator will be incident normally on the grating.



**CALCULATION:**

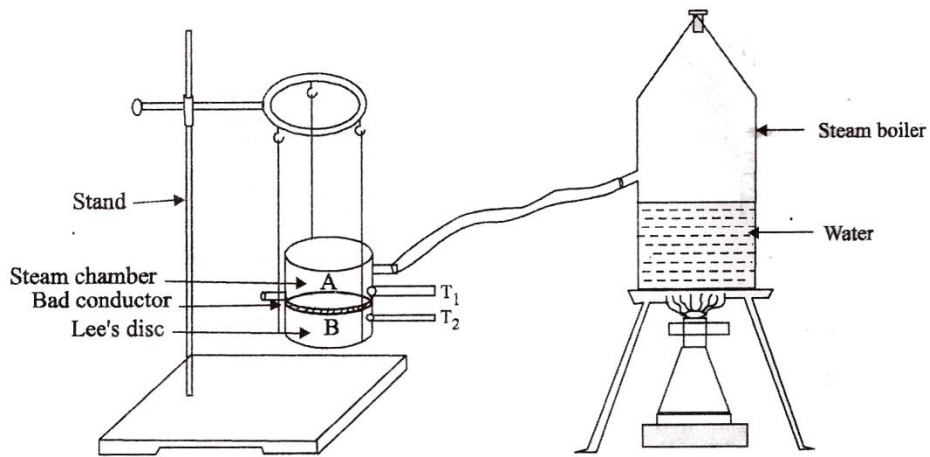
$$\lambda = \sin\theta / mn \quad (\text{m})$$

- Hg vapour lamp is used for normal incidence adjustment.
- The central direct ray is viewed.
- The telescope is moved on either side of the direct image, the diffraction patterns of the spectra of 1<sup>st</sup> and 2<sup>nd</sup> order are seen
- The readings are taken (Vernier A and Vernier B ) by coinciding each colour with vertical cross wire and are tabulated
- The angles of diffraction for different colours are determined and the wavelengths are calculated using the given formula.

**RESULT:**

Wavelengths of the spectral lines of mercury spectrum are calculated and tabulated.

The wavelengths are:



Lee's Disc arrangement

**OBSERVATION: Tabulation 1**

Steady state temperature of the steam chamber ( $\theta_1$ ) = ..... ( $^{\circ}\text{C}$ )

Steady state temperature of the metallic disc ( $\theta_2$ ) = ..... ( $^{\circ}\text{C}$ )

To determine the rate of cooling in the metallic disc  $\left(\frac{d\theta}{dt}\right)_{\theta_2}$

S. NO	Temperature	Time
Unit	( $\theta^{\circ}\text{C}$ )	Sec

## 5. THERMAL CONDUCTIVITY OF BAD CONDUCTOR- LEE'S DISC METHOD

**AIM:**

To determine the thermal conductivity of bad conductor using Lee's disc apparatus

**APPARATUS REQUIRED:**

Lee's disc apparatus, bad conductor (mica/glass/cardboard), thermometers, stop clock, steam boiler, screw gauge, vernier caliper, rubber tubes, and beakers

**FORMULA:**

Thermal Conductivity of the bad conductor

$$K = \frac{Msd(r + 2h)}{\pi r^2 (2r + 2h)(\theta_1 - \theta_2)} \left( \frac{d\theta}{dt} \right)_{\theta_2} \text{ W m}^{-1} \text{ K}^{-1}$$

**EXPLANATION OF SYMBOLS:**

M – Mass of the metallic disc (kg)

S – Specific heat capacity of the material of the disc J/kg/K

$\left( \frac{d\theta}{dt} \right)_{\theta_2}$  - Rate of cooling at steady state temperature  $\theta_2$  ( $^{\circ}$  C)

$\theta_1$  - Steady state temperature of steam chamber ( $^{\circ}$  C)

$\theta_2$  - Steady state temperature of metallic disc ( $^{\circ}$  C)

r – Radius of the metallic disc (m)

h – Thickness of the metallic disc (m)

d – Thickness of the bad conductor (m)

**Tabulation 2: To find thickness of the bad conductor (d) using screw gauge**

$L.C = 0.01 \times 10^{-3} \text{ m}$

$ZE = \pm \dots\dots\dots \text{ Div}$

$ZC = \pm \dots\dots\dots \times 10^{-3} \text{ m}$

S.NO	Pitch scale Reading (PSR)	Head scale coincidence (HSC)	Observed reading OR= PSR+ (HSCxLC)	Correct reading CR = OR $\pm$ ZC
Unit	$\times 10^{-3} \text{ m}$	<b>Div</b>	$\times 10^{-3} \text{ m}$	$\times 10^{-3} \text{ m}$

**Mean (d) =**.....  $\times 10^{-3} \text{ m}$

**Tabulation 3: To find thickness of the metallic disc (h) using screw gauge**

$L.C = 0.01 \times 10^{-3} \text{ m}$

$ZE = \pm \dots\dots\dots \text{ Div}$

$ZC = \pm \dots\dots\dots \times 10^{-3} \text{ m}$

S.NO	Pitch scale Reading (PSR)	Head scale coincidence (HSC)	Observed reading OR= PSR+ (HSCxLC)	Correct reading CR = OR $\pm$ ZC
Unit	$\times 10^{-3} \text{ m}$	<b>Div</b>	$\times 10^{-3} \text{ m}$	$\times 10^{-3} \text{ m}$

**Mean (h) =**.....  $\times 10^{-3} \text{ m}$



## PROCEDURE:

- Set up the Lee's disc arrangement as shown in fig.
- Bad conductor (mica/glass/cardboard), whose thermal conductivity is to be measured, is placed between the steam chamber and the metallic disc.
- Thermometers are inserted in to the holes provided in the chamber and the disc.
- Steam boiler is heated and steam passed through the chamber until the steady state temperatures are reached in the chamber and disc.
- The steady state temperature of the chamber ( $\theta_1$ ) and the steady state temperature of the metallic disc ( $\theta_2$ ) are noted. From the thermometer.
- Now the bad conductor is removed so that temperature increases quickly because of direct contact. When the temperature raises  $10^\circ\text{C}$  above  $\theta_2$  value, the chamber is removed and the metallic disc is allowed to cool.
- Start the stop clock when the temperature reaches  $(\theta_2 + 5)^\circ\text{C}$  and the time is noted for every  $1^\circ\text{C}$  fall of temperature until the disc attains  $(\theta_2 - 5)^\circ\text{C}$ .
- A graph is drawn between the temperature along X-axis and time along Y- axis; rate of cooling at  $\theta_2$  is calculated from the slope of the graph.
- Thickness, radius of the metallic disc are measured and tabulated.
- Thickness of the cardboard is measured and tabulated and hence thermal conductivity of the bad conductor can be calculated.

**To find radius of the metallic disc (r) using vernier calliper**

**L.C** = 0.01cm

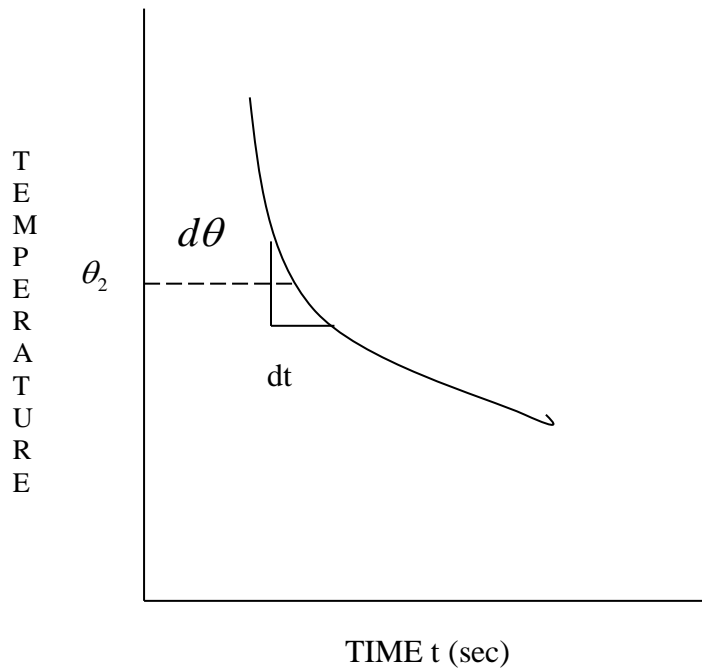
$$ZE = \pm \dots\dots\dots \text{Div}$$

$$ZE = \pm \dots\dots\dots \times 10^{-3}\text{m}$$

S.NO	Main scale Reading (MSR)	Vernier scale coincidence (VSC)	Observed reading OR= MSR + (VSC x LC)	Correct reading CR = OR $\pm$ ZC
Unit	$\times 10^{-2}\text{m}$	<b>Div</b>	$\times 10^{-2}\text{m}$	$\times 10^{-2}\text{m}$

**Mean** =.....  $\times 10^{-2}\text{m}$

**Graph:**

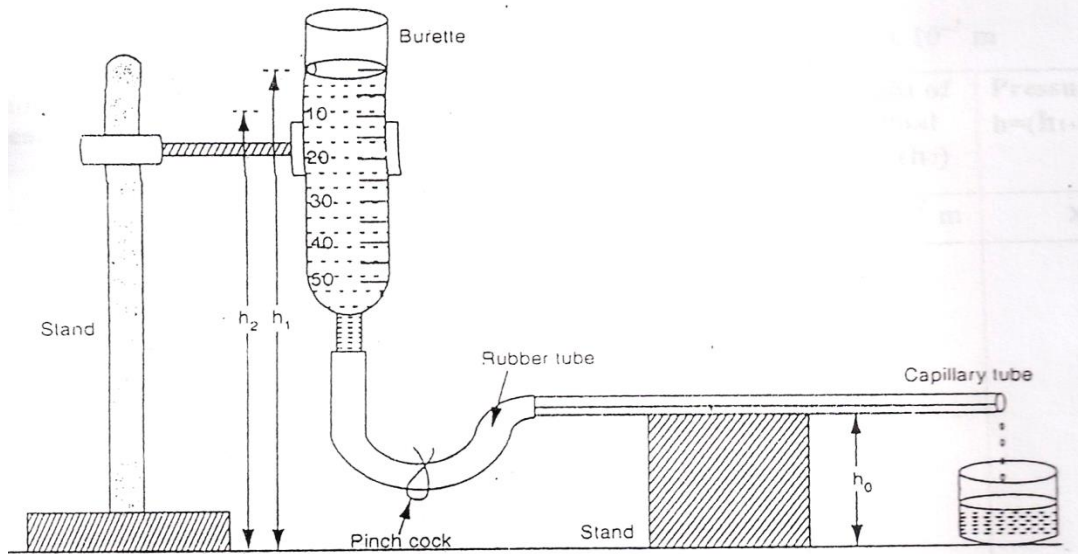


**CALCULATION:**

$$K = \frac{Msd(r + 2h)}{\pi r^2 (2r + 2h)(\theta_1 - \theta_2)} \left( \frac{d\theta}{dt} \right)_{\theta_2} \text{ W m}^{-1} \text{ K}^{-1}$$

**RESULT:**

The Thermal conductivity of the bad conductor is  $K = \text{-----Wm}^{-1} \text{ K}^{-1}$



Coefficient of Viscosity—Poiseuille's Method

### OBSERVATION

Table – 1: to find the time taken for liquid flow and evaluate  $ht$

Height from the table to midpoint of capillary tube  $h_0 = \dots \times 10^{-2}$  m

Length of the capillary tube  $l = \dots \times 10^{-2}$  m

S.NO	Burette Reading	Time taken	Range	Time of flow For 5 cc (t)	Height of the initial level ( $h_1$ )	Height of the final level ( $h_2$ )	Pressure head $h = \frac{h_1 + h_2}{2} - h_0$	$ht$
Unit	Cc	Sec	Cc	Sec	$\times 10^{-2}$ m	$\times 10^{-2}$ m	$\times 10^{-2}$ m	m-sec

Mean  $ht = \dots \times 10^{-2}$  m-sec

## 6. COEFFICIENT OF VISCOSITY OF THE LIQUID- POISEULLE'S METHOD

### AIM:

To determine the co-efficient of viscosity of the given liquid by Poiseulle's method.

### APPARATUS REQUIRED:

Graduated burette, capillary tube, stop clock, travelling microscope and meter scale.

### FORMULA:

$$\text{Coefficient of viscosity } \eta = \frac{\pi \rho g r^4 h t}{8 l V} \quad \text{Nsm}^{-2}$$

$$\text{Pressure head } h = \frac{h_1 + h_2}{2} - h_0 \quad \text{m}$$

### EXPLANATION OF SYMBOLS:

$\rho$ - Density of liquid ( $\text{kg/m}^3$ )

$g$  – Acceleration due to gravity ( $\text{m/s}^2$ )

$r$  – Radius of the capillary tube (m)

$l$  – Length of the capillary tube (m)

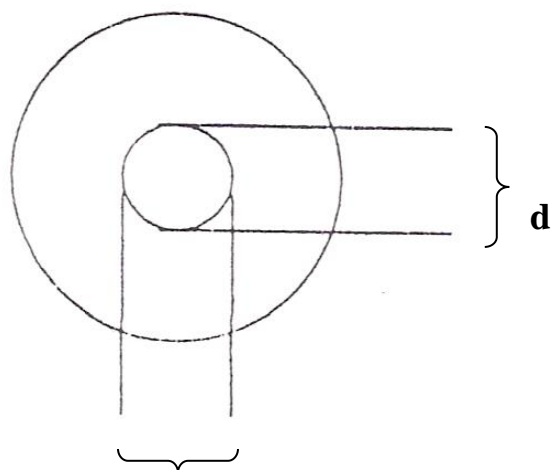
$h_1$  – Height of the initial level of the liquid from table (m)

$h_2$  – Height of the final level of the liquid from table (m)

$h_0$  – Height from table to axis of the capillary tube (m)

$t$  – Time taken for the flow of 5 cc liquid (m)

$V$  – Volume of the liquid ( $\text{m}^3$ )



**Table – 2**

**To find the radius of the capillary tube (r)**

**LC= 0.001X 10<sup>-2</sup> m**

Position	Microscope reading			Mean
	MSR	VSC	TR=MSR+(VSCxLC)	
Unit	x 10 <sup>-2</sup> m	Div	x 10 <sup>-2</sup> m	x 10 <sup>-2</sup> m
Left				(V)
Right				
Top				(H)
Bottom				

**PROCEDURE:**

- A clean and dry graduated burette is clamped vertically and connected to the capillary tube (which is kept horizontally) by means of a rubber tube.
- The burette is then filled with water above 0 Cc level without any air bubble sticking to its sides.
- The burette knob is opened so that the liquid flows through the horizontal capillary tube in stream lined motion.
- When the level of the liquid in the burette comes to 0cc, a stop-clock is started and when the level of the liquid reaches 5, 10,15,
- 20.....45cc, note the time without stopping the stop-clock.
- $h_1, h_2, h_o$  are measured.
- Hence the pressure head is calculated using given formula.
- The radius of the bore of the capillary tube is measured using travelling microscope.

**CALCULATION:**

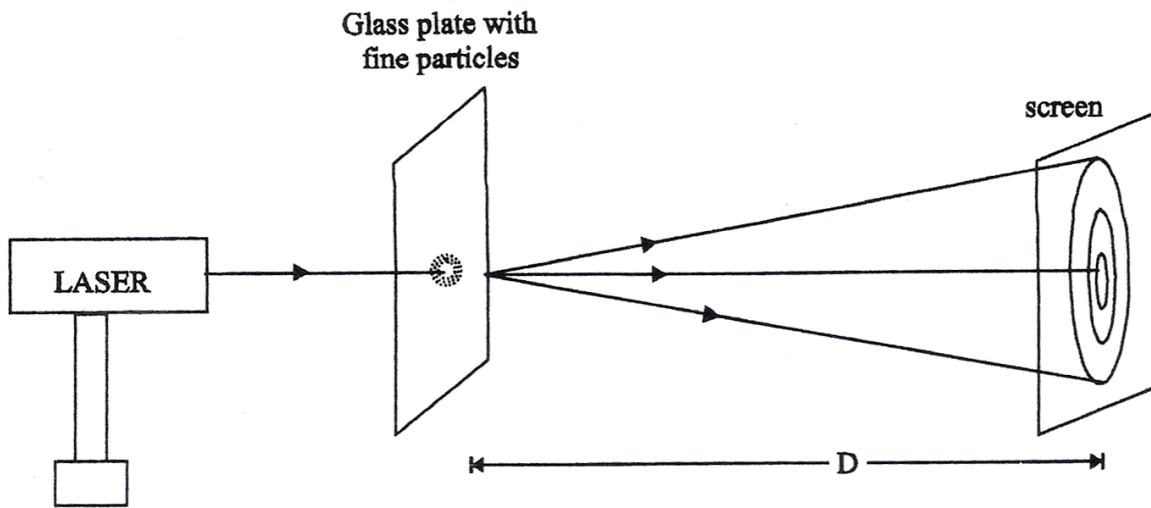
$$\text{Coefficient of viscosity } \eta = \frac{\pi \rho g r^4 h t}{8 l V} \quad \text{Nsm}^{-2}$$

$$\text{Pressure head } h = \frac{h_1 + h_2}{2} - h_0 \quad \text{m}$$

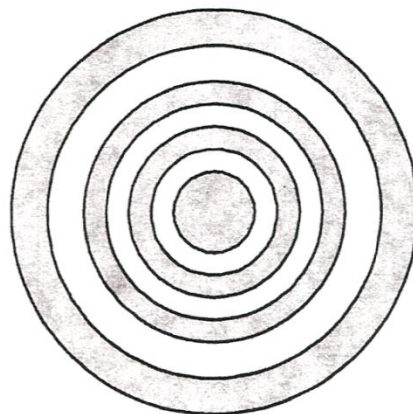


**RESULT:**

The coefficient of viscosity of the given liquid is  $\eta = \text{-----Nsm}^{-2}$



**Particle size determination by LASER**



**order of spectrum**

## **7. PARTICLE SIZE DETERMINATION - LASER DIFFRACTION METHOD**

**AIM:**

To determine the size of the lycopodium particle using laser source

**APPARATUS REQUIRED:**

A laser source, Screen, Scale, Glass plate containing lycopodium powder

**FORMULA:**

$$\text{The size of the particle } d = \frac{\lambda m \sqrt{X_m^2 + D^2}}{X_m} \quad \text{m}$$

**EXPLANATION OF SYMBOLS:**

$\lambda$  - Wavelength of laser source ( $6700 \times 10^{-10}$  m)

m – Order of the fringes

$X_m$  – Radius of the circular fringes (m)

D – Distance between the particle slit and screen. (m)

**PROCEDURE:**

- Insert the Lycopodium sprinkled glass plate in between the screen and the source.
- The laser beam is allowed to fall on the glass plate.
- Then, glass plate is moved back and forth until the clear image of the spectrum is seen.
- The distance between the screen and the glass plate is noted
- Due to diffraction, the circular fringes are obtained. The radii of fringes are noted.
- The values  $X_1$ ,  $X_2$ ,  $X_3$  are belonging to first order, second order, third order respectively.
- The above procedure is repeated thrice

## OBSERVATION

**Table—1**

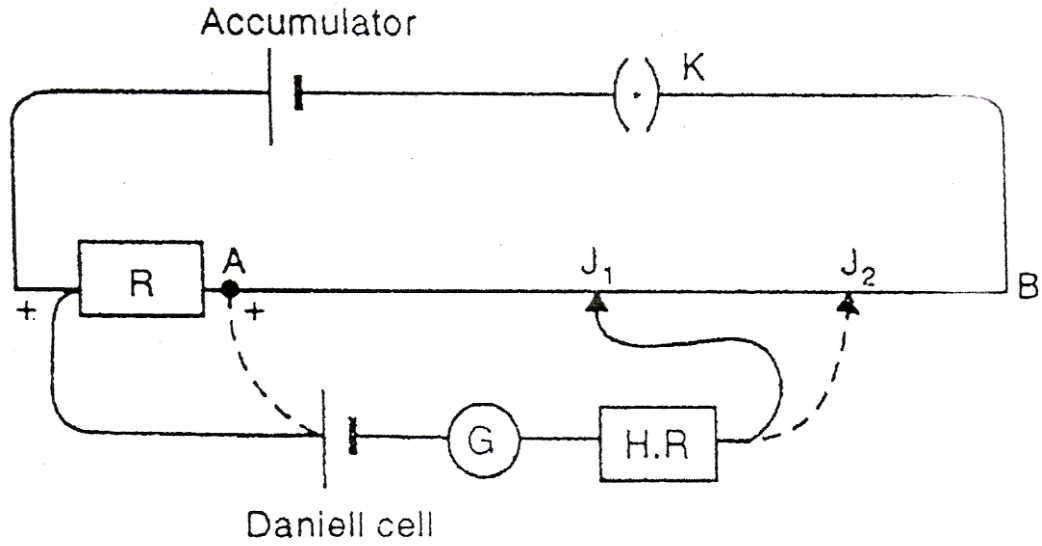
**To find the wavelength of the laser source**

S.NO	Distance between screen and particle (D)	Order of the diffraction (m)	Distance from central Maximum to diffracted Image (Xm)	$\sqrt{(Xm^2 + D^2)}$	$d = \frac{\lambda * m \sqrt{(Xm^2 + D^2)}}{Xm}$
	$x 10^{-2} \text{ m}$	$x 10^{-2} \text{ m}$	$x 10^{-2} \text{ m}$	$x 10^{-2} \text{ m}$	$x 10^{-6} \text{ m}$

**CALCULATION:**

$$d = \frac{\lambda * m \sqrt{(Xm^2 + D^2)}}{Xm} \quad X10^{-6}m$$





### OBSERVATION

**Table-1: Determination of resistance of the potentiometer ( $R_P$ )**

S.NO	Resistance in the decade box (R) ohm	Balancing length $\times 10^{-2}m$		Resistance of the potentiometer wire $R_P = R \cdot 10 / (l_2 - l_1)$ ohm
		Secondary circuit including R	Secondary circuit excluding R	

Mean ( $R_P$ ) = \_\_\_\_\_ ohm

## 8. POTENTIOMETER

### AIM:

To find the resistance of the potentiometer wire

### APPARATUS REQUIRED:

A ten meter Potentiometer wire, Resistance box, Accumulator, Daniel cell, Key, Galvanometer, High resistance, Jockey, Connecting Wires

### FORMULA:

$$\text{The resistance of potentiometer wire (R}_p\text{)} = \frac{R \times 10}{l_1 - l_2} \text{ ohm}$$

### EXPLANATION OF SYMBOLS:

R – Resistance in the resistance box (ohm)

$l_1$  – Balancing length including resistance (m)

$l_2$  – Balancing length excluding resistance (m)

### PROCEDURE:

- Primary circuit is made by connecting “A” end of the potentiometer with resistance, positive end of the Accumulator and key to “B” end as shown in fig.
- Secondary circuit is made by connecting the resistance to Daniel cell’s positive end, Galvanometer, High resistance to Jockey. This is including resistance Circuit
- By sweeping Jockey on the potentiometer wire, the galvanometer shows null value at one point. This balancing length ( $l_1$ ) is measured for the values of resistance ie., 1, 2,.....10 ohms
- Now the secondary circuit is modified by excluding resistance, by means of connecting directly Daniel cell to “A” end as shown in fig.

**CALCULATION:**

The resistance of potentiometer wire ( $R_p$ ) =  $\frac{R \times 10}{l_1 - l_2}$  ohm



- By sweeping Jockey on the potentiometer wire, the galvanometer shows null value at one point. This balancing length ( $l_2$ ) is measured for the values of resistance ie., 1, 2,.....10 ohms
- The resistance of the potentiometer wire is calculated.

**RESULT:**

The resistance of the potentiometer wire =                      ohm

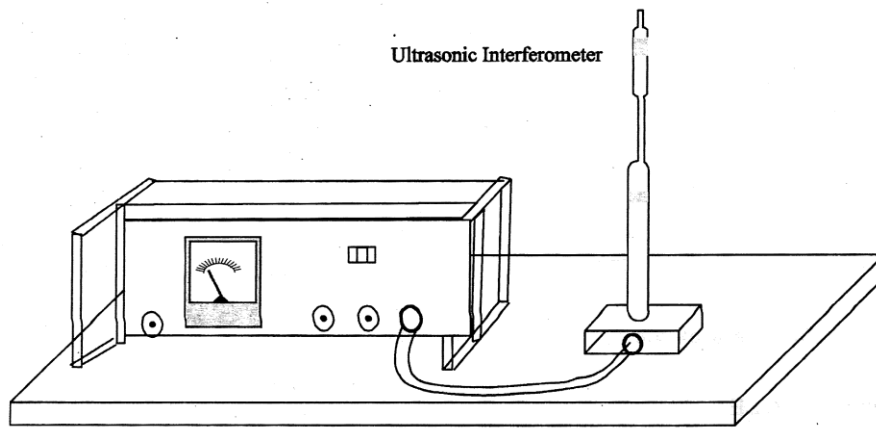


FIG 5.1 Ultrasonic Interferometer - Experimental Setup

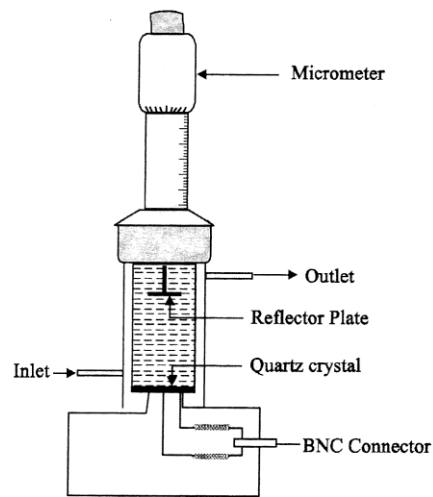


FIG 5.3 Measuring Cell

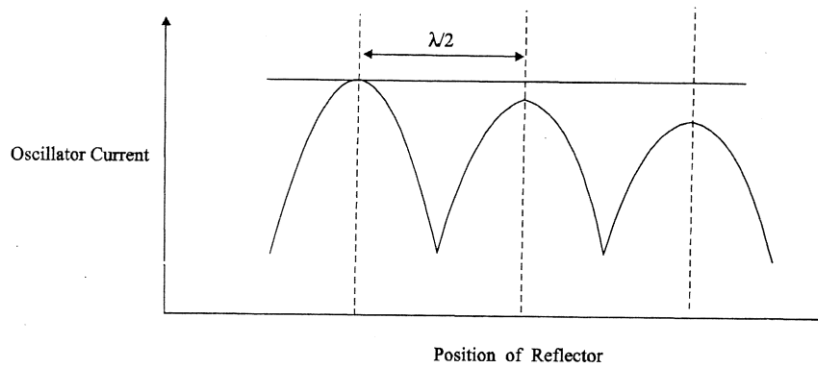


FIG 5.4 Distance moved by the reflector Vs Oscillator current

## 9. ULTRASONIC INTERFEROMETER

### AIM:

To determine the Ultrasonic velocity and compressibility of the given liquid

### APPARATUS REQUIRED:

Ultrasonic interferometer, given liquid, beaker

### FORMULA:

Ultrasonic wavelength  $\lambda = 2d/N$  (m)

Ultrasonic velocity  $V = \lambda \times f$  ( $\text{ms}^{-1}$ )

Adiabatic compressibility  $\beta = \frac{1}{V^2 \rho}$  ( $\text{m}^2\text{N}^{-1}$ )

### EXPLANATION OF SYMBOLS:

$d$  = Distance between maxima (m)

$N=1$

$\rho$  = Density of liquid ( $\text{kgm}^{-3}$ )

$f$  = frequency of the Ultrasonic generator (Hz)

### PROCEDURE:

- Principle is Acoustic grating
- Given liquid is filled in the ultrasonic liquid cell.
- High frequency generator is used to produce ultrasound.
- Quartz crystal which is in basement of the instrument produces stationary standing wave pattern because of superposition of incident and reflected waves from the reflector.
- Readings are noted down using micrometer screw, fixed at the top of the liquid cell.
- For every node, the deflections at the frequency generator are observed.
- For consecutive three deflection cycle( each cycle consists of one maximum and minimum), the readings are noted

## OBSERVATION

**Table-1**

**Determination of ultrasonic velocity:**

$$LC = 0.01 \times 10^{-3} \text{m}$$

Maxima (or)Minima	Interferometer reading $\times 10^{-3} \text{m}$			3d $\times 10^{-3} \text{m}$	d $\times 10^{-3} \text{m}$
	PSR $\times 10^{-3} \text{m}$	HSC div	TR=PSR+ (HSC x LC) $\times 10^{-3} \text{m}$		
N					
N + 3					
N + 6					
N + 9					
N + 12					
N + 15					
N + 18					
N + 21					

$$\text{Mean (d)} = \text{_____} \times 10^{-3} \text{m}$$

### CALCULATION:

Ultrasonic wavelength  $\lambda = 2d/N$  (m)

Ultrasonic velocity  $V = \lambda \times f$  ( $\text{ms}^{-1}$ )

Adiabatic compressibility  $\beta = \frac{1}{V^2 \rho}$  ( $\text{m}^2 \text{N}^{-1}$ )

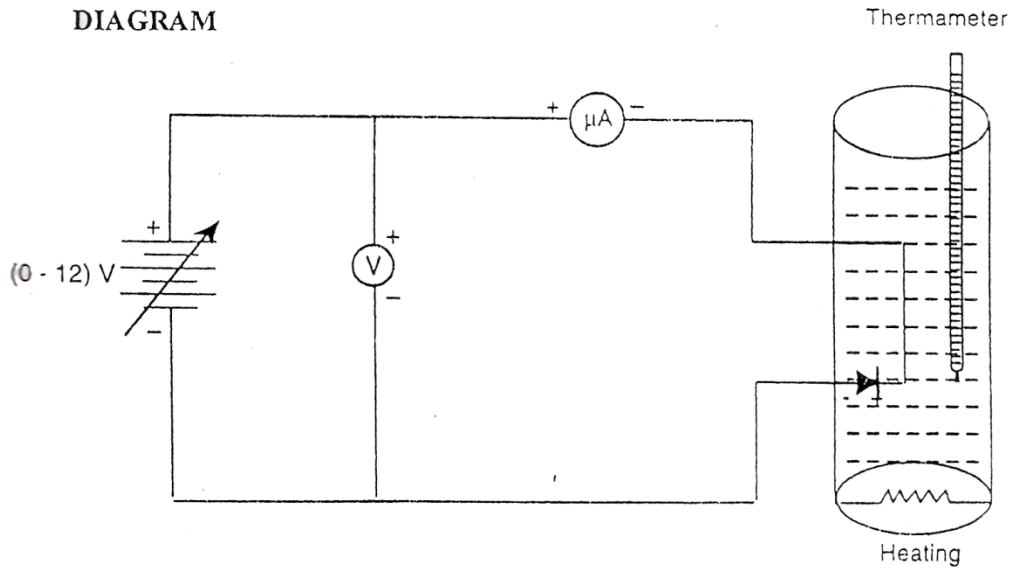
**RESULT:**

Ultrasonic Velocity in the given liquid  $V =$   $\text{ms}^{-1}$

Adiabatic compressibility of the liquid  $\beta =$   $\text{m}^2\text{N}^{-1}$

## Determination of Band-gap in a Semiconductor

DIAGRAM



## OBSERVATION

**Table-1**

**Determination of energy gap of semiconductor:**

S.NO	Current ( $I_0$ ) $\mu\text{A}$	Temperature (K)	1000/ T	Log $I_0$

## 10. BAND GAP ENERGY OF SEMICONDUCTOR

### AIM:

To determine the width of the forbidden energy gap in a semiconductor material taken in the form of p-n junction diode.

### APPARATUS REQUIRED:

0-15V dc power supply, heating arrangement to heat the diode, thermometer, 0-50  $\mu$ A micro ammeter, germanium/silicon diode

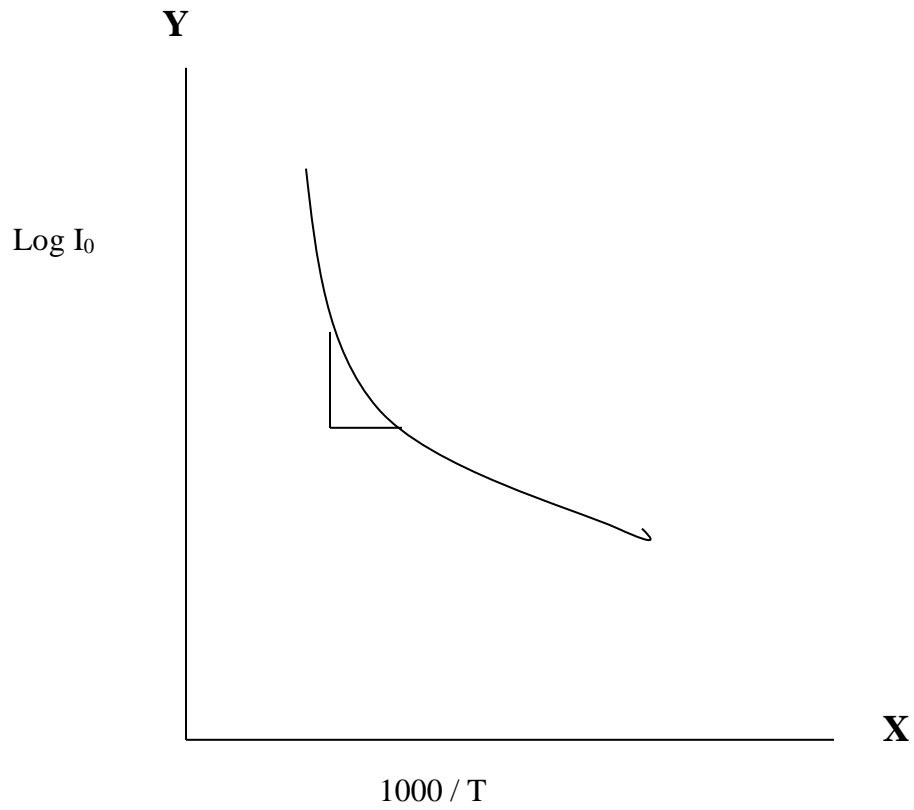
### FORMULA:

Band gap energy  $E_g = 0.198 \times \text{Slope}$  (eV)

### PROCEDURE:

- Sufficiently long wires are soldered to the diode terminals and the diode is connected to the circuit as shown in figure. The diode is immersed in an oil bath that in turn kept in a heating mantle. A thermometer is also kept in the oil bath such that its mercury bulb is just at the height of the diode.
- The power supply is switched on and the voltage is adjusted to say 5 volts. The current through the diode and the room temperature are noted.
- The power supply is switched off. The heating mantle is switched on and the oil bath is heated and stirred so that temperature of oil bath is stabilized say at 75°C.
- The power supply is again switched on and the voltage is kept at 5V. The temperature says 75°C and the corresponding current through the diode are noted.

**Graph:**



**CALCULATION:**

Band gap energy  $E_g = 0.198 \times \text{Slope (eV)}$



- The oil bath is allowed to cool slowly. As its temperature falls, in steps of 2 °C or any other convenient interval corresponding current value in mA is noted down.
- A graph is plotted taking 1000/T on X- axis and log I<sub>0</sub> on Y- axis, which is a straight line.
- The slope of the straight line is determined and using it in the following equation, the energy band of the semiconductor can be determined.

**RESULT:**

The width of the forbidden energy gap in the given semiconductor diode

$$E_g = \text{_____} \text{ eV}$$

## APPENDIX 1

### TABLE 1

S.No	Physical quantity	Unit	Abbreviation
1	Length	metre	m
2	Mass	kilogram	kg
3	Time	second	s
4	Electric current	ampere	A
5	Luminous intensity	candela	cd
6	Temperature	kelvin	K
7	Amount of substance	mole	mol
8	Plane angle	radian	rad
9	Solid angle	steradian	sr

### TABLE 2 -Abbreviation for Multiples and Sub-multiples

Symbol	Prefix	Multiplier
T	tera	$10^{12}$
G	giga	$10^9$
M	mega	$10^6$
k	kilo	$10^3$
h	hecto	$10^2$
da	deca	$10^1$
d	deci	$10^{-1}$
c	centi	$10^{-2}$
m	milli	$10^{-3}$
U	micro	$10^{-6}$
n	nano	$10^{-9}$
p	pico	$10^{-12}$

### TABLE 3 -Elastic constants

Substance	Young's modulus $10^{10}\text{Nm}^{-2}$	Rigidity modulus $10^{10}\text{Nm}^{-2}$	Bulk modulus $10^{10}\text{Nm}^{-2}$	Poisson's Ratio
Aluminium	7.2 – 7.5	2.5 – 3.4	7.46	0.84
Brass	9.7 – 10.1	3.5	10.6	0.34 – 0.40
Copper	10.5 – 12.5	3.5 – 4.5	14.3	0.26
Glass	5.1 – 7.1	3.1	3.75	0.13 – 0.32
Iron (cast)	10 – 13	3.5 – 5.3	9.6	0.23 – 0.31
Lead	1.6	5.6	5	-
Rubber	.00015 – 0.0005	.00005	-	0.46 – 0.40
Silver	7.1	2.5	10.9	-
Steel	20.9	8.12	16.4	0.29

**TABLE 4 – Refractive indices**

Substance	$\mu$
Ethyl alcohol	1.36
Methyl alcohol	1.33
Acetone	1.36
Air	1.0003
Aniline	1.59
Diamond	2.42
Glass (crown)	1.5
Glycerin	1.47
Ice	1.31
Petrol	1.5
Quartz	1.54
Sugar	1.56
Water	1.33

**TABLE 5 –Density**

Substance	Density ( $\text{kg m}^{-3}$ )
Aluminium	2700
Brass	8600
Copper	8900
Steel	7800
Iron (cast)	7500
Iron (wrought)	7900
Castor oil	970
Kerosene	830
Water	1000
Coconut oil	910

**TABLE 6 -Specific heat capacity**

Substance	Specific heat capacity ( $\text{J Kg}^{-1} \text{K}^{-1}$ )
Aluminium	913
Brass	370
Copper	385
Iron (cast)	500
Iron (wrought)	480
Water	4190
Kerosene	2100
Coconut oil	2000
Castor oil	2130

**TABLE 7 -Thermal conductivity**

Substance	Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> )
Card-board	0.04
Glass	1.00
Mica	0.7

**TABLE 8 -Wavelength of mercury line spectrum**

Colour	Wavelength (nm)
Violet-1	404.4
Violet-2	407.8
Blue	435.8
Bluish green	491.6
Green	546.1
Yellow-1	576.9
Yellow-2	579.1
Red	620.4

**TABLE 9- Specific Resistance**

Substance	Resistance (ohm.m)
Aluminium	2.7x10 <sup>-8</sup>
Brass	6.3x10 <sup>-8</sup>
Constantan	4.7x10 <sup>-7</sup>
Copper	1.68x10 <sup>-8</sup>
Gold	2.2x10 <sup>-8</sup>
Iron	9.9x10 <sup>-8</sup>
Lead	2.07x10 <sup>-7</sup>
Manganin	3.9x10 <sup>-7</sup>
Mercury	9.54x10 <sup>-7</sup>



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## DEPARTMENT OF CHEMISTRY

### Lab Manual

#### Physical Sciences – Part – B - Engineering Chemistry Lab

S.NO.	EXPERIMENT
1	Determination of total hardness, temporary hardness and permanent hardness of water by EDTA method.
2	Determination of DO content by winkler's method
3	Estimation of copper in the given ore.
4	Determination of strength of hydrochloric acid by pH metric method.
5	Conductometric titration between strong acid and strong base.
6	Determination of strength of iron by potentiometric method using dichromate.
7	Estimation of iron (thiocyanate method) by spectrometric method.
8	Determination of sodium ions in water sample by flame photometric method.

**HOD – H & S**

## LABORATORY INSTRUCTIONS

1. While entering the Laboratory, the students should wear shoes and lab uniform. Female students should tie their hair back.
2. The students should their observation note book, practical manual, record note book, calculator and necessary stationary items for the all lab classes with out which the students will not be allowed for doing the practical.
3. The student should not perform unauthorized experiments. The chemicals should never be smelt or tasted. Transferring of liquids should be done through funnel only.
4. All the equipments and glassware should be handled with utmost care. Any breakage/ damage will be charged
5. If any chemical comes in to contact with the skin, the area should be washed with sufficient quantity of water and reported to the instructor immediately.
6. When pipetting out solution, if happened to inhale swallowed any vapor any solution, plenty of water should be drunk and reported immediately to the instructor. Buffer solution should not be pipetted out and only dropper / measuring flask should used
7. In order to avoid contamination of chemicals and reagents replace the stoppers and droppers in the respective bottles or boxes
8. At the end of practical class the apparatus should be washed with soap solution
9. The titrations should be repeated for concordancey and should be attested by the lab in charge or instructor in the observation note book
10. Each experiment after completion should be written in the observation note book and should be corrected by the lab incharge on the same day of the practical class
11. Each experiment should be written in the record note book only after getting signature from the lab incharge in the observation note book.
12. Record note book should be submitted in the following after completion of experiment
13. 100% attendance should be maintained for the practical classes

## OBSERVATIONS AND CALCULATIONS

### Procedure:

#### TITRATION : 1

##### Standardisation of EDTA

Burette solution : EDTA solution

Pipette Solution : 20 ml standard hard water  
5 ml Buffer solution (  $\text{NH}_4\text{Cl}$ -  $\text{NH}_4\text{OH}$  )

Indicator : Eriochrome Black- T

End point : Colour change form wine red to steel blue.

S.No	Volume of Standard hard water (ml)	Burette Reading		Volume of EDTA consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

1ml of standard hard water = 1mg of  $\text{CaCO}_3$  equivalent hardness

20ml of standard hard water = 20 mg of  $\text{CaCO}_3$  equivalent hardness

20 ml of standard hard water consumed =  $V_1$  ml of EDTA Solution

$V_1$  ml of EDTA = 20 mg of  $\text{CaCO}_3$  equivalent hardness.

Therefore 1ml of EDTA =  $20/V_1$  mg of  $\text{CaCO}_3$  equivalent hardness

#### TITRATION : 2

##### ESTIMATION OF TOTAL HARDNESS

Burette solution : Standard EDTA solution

Pipette Solution : 20 ml sample hard water  
5 ml Buffer solution (  $\text{NH}_4\text{Cl}$ -  $\text{NH}_4\text{OH}$  )

Indicator : Eriochrome Black- T

End point : Colour change form wine red to steel blue.

S.No	Volume of Sample hard water (ml)	Burette Reading		Volume of EDTA consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

20ml of sample hard water consumed =  $V_2$  ml of EDTA solution

$V_2$  ml of EDTA solution =  $V_2 \times 20 / V_1$  mg of  $\text{CaCO}_3$  equivalent hardness

1000ml of sample hard water contains =  $\frac{20 \times V_2 \times 1000}{V_1 \times 20}$

## **DETERMINATION OF TOTAL, TEMPORARY AND PERMANENT HARDNESS OF THE GIVEN SAMPLE WATER BY EDTA METHOD.**

**EXP. NO: 1**

**Date :**

### **AIM**

To estimate the amount of total, permanent and temporary hardness of the given water sample by EDTA method.

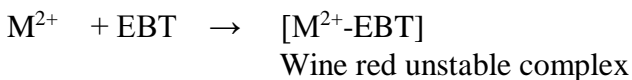
### **CHEMICALS REQUIRED**

Disodium salt of EDTA , Sample hard water, Standard hard water,  $\text{NH}_4\text{Cl} - \text{NH}_4\text{OH}$  Buffer, and Eriochrome black-T indicator.

### **PRINCIPLE**

Hardness of water is caused mainly by the presence of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions and can be conveniently determined by titrating against a standard solution of EDTA using EBT indicator. The principle involves the following steps.

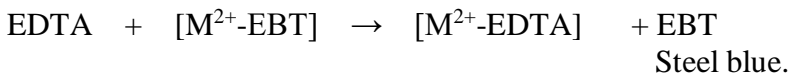
Metal ions  $\text{M}^{2+}$  (where  $\text{M}=\text{Ca}/\text{Mg}$ ) in water forms an unstable wine red complex with EBT indicator.



The unreacted metal ions form a colourless stable complex with EDTA.



The excess EDTA remaining after the colourless complex formation displaces free EBT from the unstable complex.



$\text{NH}_4\text{Cl} - \text{NH}_4\text{OH}$  buffer solution is added to maintain the pH between 8.5 to 10 only at which metal-EDTA complex is stable and indicator EBT functions well.



### TITRATION : 3

#### ESTIMATION OF PERMANENT HARDNESS

Burette solution : Standard EDTA solution

Pipette Solution : 20 ml Boiled hard water sample

5 ml Buffer solution (  $\text{NH}_4\text{Cl}$ -  $\text{NH}_4\text{OH}$ )

Indicator : Eriochrome Black- T

End point : Colour change form wine red to steel blue.

S.No	Volume of Boiled hard water Sample (ml)	Burette Reading		Volume of EDTA consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

20 ml of boiled sample hard water consumed =  $V_3$  ml of EDTA solution.

$V_3$  ml of EDTA solution =  $V_3 \times 20/V_1$  mg of  $\text{CaCO}_3$  equivalent hardness.

1000 ml of sample hard water contains =  $\frac{20 \times V_3 \times 1000}{V_1 \times 20}$

Permanent hardness of the given hard water sample = ----- ppm.

From the total and permanent hardness, temporary hardness can be calculated

#### ESTIMATION OF TEMPORARY HARDNESS

Temporary hardness = Total hardness – Permanent hardness.

## **PROCEDURE**

### **STANDARDISATION OF EDTA**

EDTA solution is filled in the burette. 20ml of standard hard water is pipetted out into a clean conical flask. To this is added 5 ml of  $\text{NH}_4\text{Cl-NH}_4\text{OH}$  buffer and a pinch of Eriochrome Black T indicator and titrated with EDTA. The end point is the colour change from wine red to steel blue. The titrations are repeated for concordancy.

### **ESTIMATION OF TOTAL HARDNESS**

The standard EDTA solution is filled in the burette. 20 ml of the sample hard water is pipetted out into a conical flask. To this is added 5 ml of  $\text{NH}_4\text{Cl-NH}_4\text{OH}$  buffer and a pinch of EBT and titrated with EDTA. The end point is the colour change from wine red to steel blue. The titration is repeated for concordancy.

### **ESTIMATION OF PERMANENT HARDNESS**

100 ml of sample hard water is boiled for 20 minutes and the precipitate formed is removed by filtration using a filter paper placed on a funnel. The resultant solution after removing the precipitate is transferred to a 100ml standard flask. Distilled water is then added to make the solution upto the mark in the 100ml standard flask. The contents are shaken well and from this 20 ml solution is transferred to a conical flask. 5 ml of  $\text{NH}_4\text{Cl-NH}_4\text{OH}$  buffer and a pinch of EBT indicator are added and titrated against EDTA from the burette. End point is the colour change from wine red to steel blue. The titration is repeated for concordancy.

## **RESULT.**

1. The total hardness of the given water sample = ----- ppm.
2. The temporary hardness of the given water sample = -----ppm.
3. The permanent hardness of the given water sample = -----ppm.

**TITRATION :1****STANDARDISATION OF SODIUM THIOSULPHATE**

Burette solution : Standard Sodium thiosulphate

Pipette Solution : 20 ml  $K_2Cr_2O_7$  + 10ml of dil.  $H_2SO_4$  + 10ml KI

Indicator : Starch

End point : Disappearance of blue colour and appearance of pale green colour.

S.No	Volume of $K_2Cr_2O_7$ (ml)	Burette Reading		Volume of Sodium thiosulphate consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

**Calculation**Volume of  $K_2Cr_2O_7$   $V_1 = 20$  mlNormality of  $K_2Cr_2O_7$   $N_1 = 0.1N$ Volume of sodium thiosulphate  $V_2 = \underline{\hspace{2cm}}$  mlNormality of sodium thiosulphate  $N_2 = \frac{V_1 N_1}{V_2} = \underline{\hspace{2cm}}$  N**TITRATION :2****ESTIMATION OF DISSOLVED OXYGEN**

Burette solution : Standard Sodium thiosulphate

Pipette Solution : 100ml of given water sample + 5 ml of NaOH +  
5 ml of manganous sulphate + 10 ml of 5% KI +  
10 drops of conc. Sulphuric acid.

Indicator : Starch

End point : Disappearance of blue colour.

S.No	Volume of water Sample (ml)	Burette Reading		Volume of Sodium thiosulphate consumed (ml)	Concordant Value
		Initial	Final		
1.	100				
2.	100				
3.	100				

**Calculation**Volume of sodium thiosulphate  $V_1 = \underline{\hspace{2cm}}$  mlNormality of sodium thiosulphate  $N_1 = \underline{\hspace{2cm}}$  mlNormality of water sample  $V_2 = 100$ mlNormality of water sample  $N_2 = \frac{V_1 N_1}{V_2} = \underline{\hspace{2cm}}$  NAmount of dissolved oxygen in water sample = Normality of water sample x  
Eq. wt of oxygen X 1000Amount of dissolved oxygen in water sample = Normality of water sample x 8 x 1000  
=  $\underline{\hspace{2cm}}$  mg/lit.

## ESTIMATION OF DISSOLVED OXYGEN IN WATER SAMPLE BY WINKLERS METHOD

**EXP: NO : 2**

**Date :**

### AIM

To estimate the amount of dissolved oxygen (DO) in the given water sample by winkler's method.

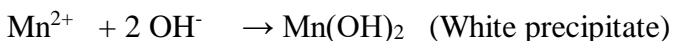
### CHEMICALS REQUIRED

Sodium thiosulphate, potassium dichromate, sulphuric acid, potassium iodide, starch, sodium hydroxide, manganous sulphate.

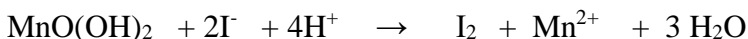
### PRINCIPLE

The dissolved oxygen content in water sample should be 8mg/lit at 25°C, but this amount may decrease due to aerobic oxidation of organic impurities. Thus dissolved oxygen content in water gives an idea about the level of organic impurities in it.

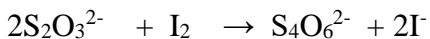
The dissolved oxygen content is determined by winkler's method. When manganous sulphate solution is added in the presence of alkaline iodide to sample water in an iodine flask, the following reactions occur.



When conc.  $\text{H}_2\text{SO}_4$  is added the following reaction occurs

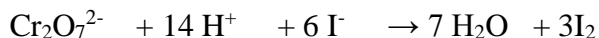


When the solution is titrated with sodium thiosulphate, the following reaction occurs:



one eq.wt of  $\text{I}_2 \equiv$  one eq.wt of  $\text{O}_2 \equiv$  one mol. Wt of  $\text{Na}_2\text{S}_2\text{O}_3$

Sodium thiosulphate is standardised using  $K_2Cr_2O_7$ .  $K_2Cr_2O_7$  liberates  $I_2$  in acidic medium.



Liberated  $I_2$  is titrated with sodium thiosulphate. Starch is added near end point. End point is the disappearance of blue colour leaving behind pale green colour due to chromium sulphate which is already existing.

## **PROCEDURE**

### **1.STANDARDISATION OF SODIUM THIOSULPHATE**

The burette is filled with sodium thiosulphate. 20 ml of standard potassium dichromate is pipetted out into a clean iodine flask. To this is added 20ml of dil. Sulphuric acid and 10 ml of 5% KI. The liberated  $I_2$  is titrated against sodium thiosulphate. When solution turns yellow, 1ml of freshly prepared starch solution is added as the indicator and the titration is continued. The end point is the disappearance of blue colour leaving behind a pale green colour. The titration is repeated for concordancy.

### **2.ESTIMATION OF DISSOLVED OXYGEN IN THE GIVEN WATER SAMPLE.**

The burette is filled with standardized sodium thiosulphate solution. 100 ml of the given water sample is pipetted out into a clean iodine flask. To this is added 10ml of alkali iodide mixture (or 5ml NaOH + 5ml KI) and 5 ml of  $MnSO_4$  solution. Iodine flask is stoppered, shaken well and kept undisturbed for 10 minutes for settling of the precipitate. Then 10 drops of conc.  $H_2SO_4$  is added along the sides of the iodine flask to get a clear yellow solution. This solution is treated with standard sodium thiosulphate from the burette. Near the end point starch indicator is added and titration is continued till the blue colour disappears. Titration is repeated for concordancy.

## **RESULT**

The dissolved oxygen content present in the given water sample = \_\_\_\_\_ mg/lit.

**TITRATION :1**  
**STANDARDISATION OF SODIUM THIOSULPHATE**

Burette solution : Standard Sodium thiosulphate  
 Pipette Solution : 20 ml  $K_2Cr_2O_7$  + 10ml of dil.  $H_2SO_4$  + 10ml 10% KI  
 Indicator : Starch  
 End point : Disappearance of blue colour and appearance of pale green colour.

S.No	Volume of $K_2Cr_2O_7$ (ml)	Burette Reading		Volume of Sodium - thiosulphate consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

Calculation :

Volume of  $K_2Cr_2O_7$   $V_1 = 20$  ml

Normality of  $K_2Cr_2O_7$   $N_1 = 0.1N$

Volume of sodium thiosulphate  $V_2 = \text{-----ml}$

Normality of sodium thiosulphate  $N_2 = \frac{V_1 N_1}{V_2} = \text{-----} N$

**TITRATION :2 ESTIMATION OF COPPER IN THE GIVEN COPPER ORE SOLUTION**

Burette solution : Standard Sodium thiosulphate  
 Pipette Solution : 20 ml given copper ore solution + 1 drop of ammonia solution + 2 drops of acetic acid + 10 ml of 10% KI  
 Indicator : Starch  
 End point : Disappearance of blue colour and appearance of turbid white colour.

S.No	Volume of Given copper ore solution (ml)	Burette Reading		Volume of Sodium thiosulphate consumed (ml)	Concordant Value
		Initial	Final		
1.	20				
2.	20				
3.	20				

Calculation :

Volume of Sodium thiosulphate  $V_1 = 20$  ml

Strength of Sodium thiosulphate  $N_1 = 0.1N$

Volume of given copper ore solution  $V_2 = \text{-----ml}$

Strength of given copper ore  $N_2 = \frac{V_1 N_1}{V_2} = \text{-----} N$

## ESTIMATION OF PERCENTAGE OF COPPER IN THE GIVEN ORE

**EXP. NO : 3**

**AIM**

To estimate the percentage of copper present in the given copper ore solution.

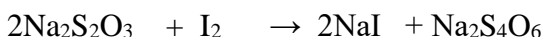
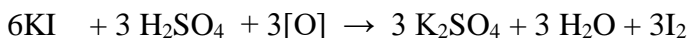
**CHEMICALS REQUIRED**

Given copper ore solution, sodium thiosulphate, potassium dichromate, sulphuric acid, potassium iodide, ammonia solution, acetic acid, starch.

**PRINCIPLE**

This experiment is based on iodometry titration. In this titration, potassium dichromate (strong oxidizing agent) is treated with acid solution of iodide ions during which the dichromate is reduced quantitatively. In such cases an equivalent amount of iodine is liberated which is titrated with a reducing agent like sodium thiosulphate using starch as indicator. Starch gives intense blue colour with iodine due to the formation of an adsorption complex and the end point is the disappearance of blue colour.

When potassium dichromate is treated with dilute sulphuric acid and excess potassium iodide, iodine is liberated which is titrated against sodium thiosulphate during which the blue colour of the indicator starch disappears.



on adding KI to a copper solution iodine is liberated



This iodine, which is liberated is titrated against sodium thiosulphate using starch as indicator. The end point is the disappearance of blue colour.

The amount of copper present in one litre of copper ore solution } = strength(Normality) x Eq. wt (of cu)

The amount of copper present in whole of the given solution } = Strength(Normality) x Eq. wt x 100/1000

The percentage of copper present In the given ore } = Strength (Normality) x 63.54 x  $\frac{100 \times 100}{1000 \times 0.5}$   
= ----- %



## **PROCEDURE**

### **TITRATION : 1 STANDARDISATION OF SODIUM THIOSULPHATE**

The burette solution is filled with sodium thiosulphate solution. 20 ml of potassium dichromate solution is pipetted out into a clean conical flask and added 20 ml dil. Sulphuric acid. 10 ml of 10% KI is added and the liberated iodine is titrated against sodium thiosulphate from the burette. Just before the end point 1ml starch is added and the titration is continued. The end point is the disappearance of the blue colour and appearance of pale green colour. The titration is repeated for concordancy.

### **TITRATION : 2 ESTIMATION OF COPPER IN THE GIVEN COPPER ORE SOLUTION**

The given copper ore solution is made up in a 100 ml standard flask upto the mark, 20ml of this solution is pipetted out into a clean conical flask. To this is added 1 drop of ammonia and 2 drops of acetic acid. 10 ml of 10% KI is added and the liberated iodine is titrated against sodium thiosulphate from the burette. Just before the end point 1 ml of starch is added and the titration is continued. The end point is the disappearance of the blue colour and appearance of turbid white colour. The titration is repeated for concordancy.

## **RESULT**

The percentage of copper present in the given copper ore solution = ----- %

## OBSERVATIONS AND CALCULATIONS

The pH of the given HCl solution = \_\_\_\_\_

$$\text{pH} = -\log \text{H}^+$$

$$\text{H}^+ = \text{-----N ( Normality of Hcl)}$$

$$\left. \begin{array}{l} \text{The amount of HCl present in} \\ \text{Whole of the given solution} \end{array} \right\} = \frac{\text{Normality} \times \text{Eq. Wt} \times 100}{1000} = \text{----- g}$$

## DETERMINATION OF STRENGTH OF HCl USING pH METER

**EXP.NO : 4**

**Date :**

**AIM**

To determine the strength of given hydrochloric acid using pH meter.

### **CHEMICALS REQUIRED**

The given HCl solution, potassium hydrogen phthalate buffer (pH=4) and sodium tetra borate buffer (pH=9.2)

### **PRINCIPLE**

The pH meter is actually an electronic digital voltmeter which is scaled to read the pH directly. It consists of a glass electrode which is coupled with a reference electrode(calomel electrode) from which the emf obtained is converted directly to pH.

$$\text{pH} = -\log\text{H}^+$$

Hence from the pH value which is obtained from the pH meter, the concentration of H<sup>+</sup> ions can be determined. From this concentration the amount of HCl can be calculated.

### **PROCEDURE**

The pH meter is first calibrated using potassium hydrogen phthalate buffer (pH =4) and sodium tetra borate buffer (pH =9.2). The glass electrode of the pH meter is handled with utmost care since it is highly fragile. The given HCl solution is made up in a 100 ml standard flask from which 20 ml of the solution is pipetted out to a clean 100 ml beaker. The glass electrode is immersed in the solution and the pH can be directly obtained for the display of the pH meter. From this pH, the amount of HCl can be calculated.

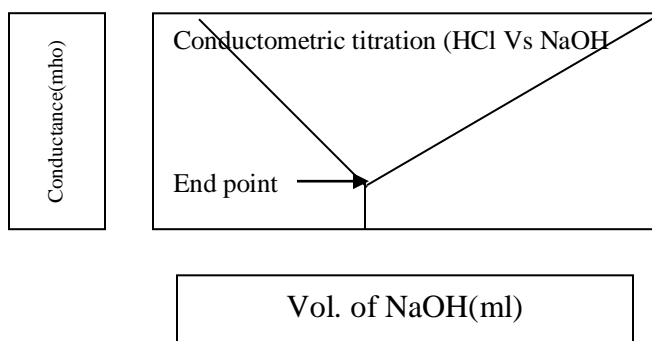
### **RESULT**

The amount of the HCl present in whole of the given solution = -----g

## CONDUCTOMETRIC TITRATION BETWEEN HCl AND NaOH

S.NO	Vol. of Sodium Hydroxide (ml)	Conductance (mho)
1.	0	
2.	1	
3.	2	
4.	3	
5.	4	
6.	5	
7.	6	
8.	7	
9.	8	
10.	9	
11.	10	
12.	11	
13.	12	
14.	13	
15.	14	
16.	15	
17.	16	
18.	17	
19.	18	
20.	19	
21.	20	
22.	21	
23.	22	
24.	23	
25.	24	
26.	25	
27.	26	
28.	27	
29.	28	
30.	29	

### GRAPH



## **CONDUCTOMETRIC TITRATION BETWEEN STRONG ACID AND STRONG BASE**

**EXP. NO: 5**

**Date:**

**AIM**

To determine the amount of strong acid (HCl) in the given solution by titration with a strong base (NaOH) using conductometric method.

### **CHEMICALS REQUIRED**

Hydrochloric acid and sodium hydroxide.

### **PRINCIPLE**

Solution of electrolytes conduct electricity due to the presence of ions. The conductance of a solution is directly proportional to the number of ions present in the solution. The reaction between HCl and NaOH can be represented as follows.



Initially the solution contains only HCl, which is the strong electrolyte, hence dissociation is faster. Therefore the conductance is high when only HCl is present. On titration with NaOH the  $\text{H}^+$  ions with high mobility are replaced by  $\text{Na}^+$  ions with low mobility hence conductance decreases. Near the end point when all the HCl is neutralized by NaOH, the excess NaOH that is added produces more  $\text{OH}^-$  ions increasing steadily; therefore conductance also increases gradually after the end point a graph drawn is between volume of NaOH and conductance. The exact end point is the intersection of two lines.

### **PROCEDURE**

The burette is filled with standard sodium hydroxide solution. The given HCl solution is transferred to a 100 ml standard flask with utmost care. Distilled water is added to make up the solution up to the mark in the 100ml standard flask. The contents are shaken well for uniform concentration from which 20 ml is pipetted out into a clean 100ml beaker. The conductivity cell is then dipped in the solution after connecting it to the terminals of the digital conductivity meter in the digital conductivity meter, which is noted. Now 1 ml of sodium hydroxide is added from the burette to the beaker and the contents are shaken well using a glass rod.

## CALCULATION

$$\begin{array}{ll} \text{Volume of NaOH solution} & V_1 = \text{_____ ml} \\ \text{Normality of NaOH} & N_1 = 0.1\text{N} \\ \text{Volume of HCl solution} & V_2 = 20 \text{ ml} \\ \text{Normality of HCl} & N_2 = \frac{V_1 N_1}{V_2} = \text{----- N} \end{array}$$

$$\text{Eq. wt. of HCl} = 36.5$$

$$\left. \begin{array}{l} \text{Amount of HCl present in} \\ \text{Whole of the given solution} \end{array} \right\} = \frac{\text{Normality of HCl} \times \text{Eq. wt.} \times 100}{1000}$$
$$= \text{_____ g}$$

The conductance is noted and addition of 1 ml of sodium hydroxide is continued. After each addition the contents of beaker are shaken well and conductance values are noted. The process is continued until atleast 15 readings are taken beyond the end point. A graph is plotted between volume of NaOH and conductance values.

**RESULT :** The amount of given hydrochloric acid in the given solution = \_\_\_\_\_ g.

**TITRATION – I PRELIMINARY TITRATION**  
**K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> Vs Ferrous iron solution**

S.No	Volume of K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	EMF (Volts)
1.	1	
2.	2	
3.	4	
4.	6	
5.	8	
6.	10	
7.	12	
8.	14	
9.	16	
10.	18	
11.	20	

**TITRATION – II ACTUAL TITRATION**  
**K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> Vs Ferrous ion solution**

S.No	Vol. of K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	EMF (Volts)	ΔE (Volts)	ΔV(ml)	ΔE/ΔV(Volts/ml)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					



## ESTIMATION OF FERROUS IRON BY POTENTIOMETRIC TITRATION

EXP.NO : 6

Date :

### AIM

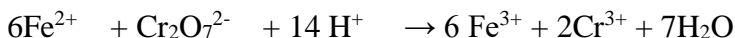
To estimate the amount of Ferrous iron ( $\text{Fe}^{2+}$ ) in the given solution by titrating with potassium dichromate, potentiometrically.

### CHEMICALS REQUIRED

Given ferrous iron solution, potassium dichromate, sulphuric acid.

### PRINCIPLE

Potentiometric titration depend upon the difference in the potential between reference electrode(Calomel) and working electrode (Platinum electrode dipped in the test solution) when a solution containing  $\text{Fe}^{2+}$  ions is titrated with  $\text{K}_2\text{Cr}_2\text{O}_7$  the following redox reaction occurs:

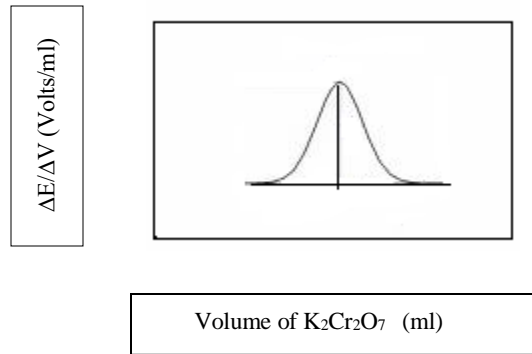


During this titration  $\text{Fe}^{2+}$  is converted to  $\text{Fe}^{3+}$  ; hence there is a drastic change in the potential value due to the sudden removal of  $\text{Fe}^{2+}$  ions form the test solution. A graph is plotted between volume of  $\text{K}_2\text{Cr}_2\text{O}_7$  and  $\Delta E/\Delta V$ .

### PROCEDURE

The given ferrous iron solution is made upto the mark in a 100ml standard flask. 20 ml of this solution is pipetted out into a clean 100 ml beaker. To this is added 10 ml dilute  $\text{H}_2\text{SO}_4$  and the contents are stirred well. A platinum electrode is dipped in this solution which is coupled with a saturated calomel electrode and the cell is introduced into the potentiometric circuit. The emf is noted form the digital potentiometer.

## GRAPH



## CALCULATION

Volume of $K_2Cr_2O_7$	$V_1 = \underline{\hspace{2cm}}$ ml
Normality of $K_2Cr_2O_7$	$N_1 = 0.1N$
Volume of Ferrous iron solution	$V_2 = 20$ ml
Strength of Ferrous iron solution	$N_2 = \frac{V_1 N_1}{V_2} = \underline{\hspace{2cm}}$ N

Eq. wt. of ferrous iron = 55.85

Amount of Ferrous iron present in the given solution	} = $\frac{N_2 \times 55.85 \times 100}{1000}$

### **TITRATION : 1**

First a preliminary titration is carried out by adding standard  $K_2Cr_2O_7$  solution in portions of 2 ml and the emf is noted after every addition. This process is continued even after the end point (drastic increase in emf) and the range at which end point lies is found out.

### **TITRATION : 2**

The actual titration is carried out by adding standard  $K_2Cr_2O_7$  solution in portions of 0.5 ml and the emf is noted after every addition. This process is continued even after the end point. The accurate end point is determined by plotting a graph between volume of  $K_2Cr_2O_7$  and  $\Delta E/\Delta V$ . From the end point, the strength of ferrous iron solution and hence the amount can be calculated.

### **RESULT**

The amount of ferrous iron present in the given solution is \_\_\_\_\_ g.

## ESTIMATION OF IRON BY SPECTROPHOTOMETRY

**EXP.NO: 7**

**Date :**

**AIM :**

To estimate the amount of iron present in the given unknown solution by spectrophotometric method

### CHEMICALS REQUIRED

Ferrous ammonium sulphate, Nitric acid, Ammonium thiocyanate.

### PRINCIPLE

Spectrophotometer is an instrument used to measure the intensity of light absorbed by a substance. It works based on Beer- Lambert's Law

$$\log \frac{I_0}{I} = A = \epsilon Cx$$

Where,  $I_0$  = Intensity of incident light

$I$  = Intensity of transmitted light

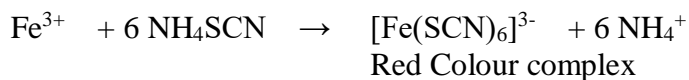
$A$  = Absorbance

$\epsilon$  = Molar extinction coefficient

$C$  = Concentration of the solution

$x$  = Thickness of cuvette in which the sample solution is taken.

In the determination of iron, ferrous iron solution is acidified with  $\text{HNO}_3$  during which  $\text{Fe}^{2+}$  is converted to  $\text{Fe}^{3+}$  which gives red colour with  $\text{NH}_4\text{SCN}$



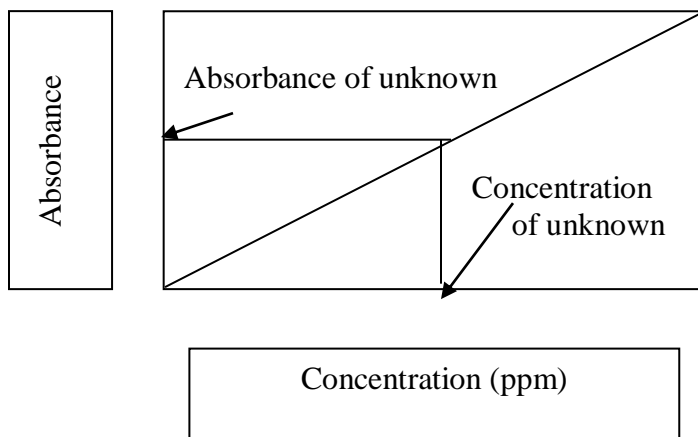
This red colour complex has maximum absorption in the region  $\lambda = 480\text{nm}$   
Since absorption is directly proportional to molar concentration of the solution, a calibration graph can be drawn by measuring absorbance of unknown iron solution.

## PREPARATION OF SOLUTION AND MEASUREMENT OF ABSORBANCE

S.No	Volume of stock solution (ml)	Volume of 4N HNO <sub>3</sub> (ml)	Volume of 10% NH <sub>4</sub> SCN(ml)	Concentration of iron solution (ppm)	Absorbance
1	1	3	5	1	
2	2	3	5	2	
3	3	3	5	3	
4	4	3	5	4	
5	5	3	5	5	
6	6	3	5	6	
7	-	3	5	unknown	

### GRAPH

Calibration curve (Absorbance Vs Concentration )



## PROCEDURE

The spectrophotometer is switched on and warmed up for 10 minutes. The wavelength is adjusted to 480 nm. The blank solution ( distilled water) is kept in the cuvette and the absorbance is measured for which the absorbance is zero and transmittance is 100. Different concentration of iron solution are prepared (1,2,3,4,5,&6ppm) from the stock solution(prepared by dissolving 0.0838 g of FAS with 1ml Con. HNO<sub>3</sub> in 1 litre distilled water) and added 3ml of 4N HNO<sub>3</sub> and 5ml of 10% NH<sub>4</sub>SCN. The absorbance of all these solutions and unknown solution are measured and calibration graph is drawn between the concentration and absorbance from which the concentration of unknown solution can be measured.

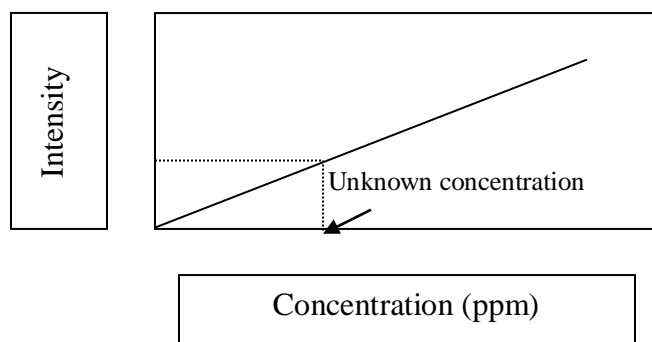
## RESULT

The amount of iron present in the given solution = \_\_\_\_\_ ppm.

## DETERMINATION OF Na<sup>+</sup> IN SAMPLE WATER

S.No	Vol. of NaCl stock solution (ml)	Volume of distilled water (ml)	Concentration of NaCl (ppm)	Intensity of emitted light
1	10	90	1	
2	20	80	2	
3	40	60	4	
4	60	40	6	
5	80	20	8	
6	Unknown water sample	-	-	

### GRAPH : Intensity Vs Concentration



## **DETERMINATION OF SODIUM IN WATER SAMPLE BY FLAME PHOTOMETRY**

**EXP NO : 8**

**Date :**

### **AIM**

To determine the concentration of sodium ions present in the given water sample using flame photometer.

### **CHEMICALS REQUIRED**

Sodium chloride

### **PRINCIPLE**

Flame photometry is based on the principle of emission of radiation in the visible region by a metal atom. The water sample to be analyzed is sprayed into the flame during which water evaporates leaving behind the salt. When heated to 1700°C the salt decomposes to atoms in vapour state. This vapour is excited by the flame to a higher energy level. Radiations are emitted when the electrons fall down from excited to ground state which is measured and recorded. Sodium produces a characteristic yellow emission at 589nm. Different standard solutions are prepared and graph is plotted between concentration (ppm) Vs intensity of emitted light.

### **PROCEDURE**

A stock solution of Na<sup>+</sup> is prepared by dissolving 2.54g of NaCl in one litre of distilled water (1ml of stock solution = 1ppm of Na<sup>+</sup>). From the stock solution, various concentrations are prepared (1,2,4,6 and 8 ppm)

The flame photometer is switched on. Air supply and gas supply are regulated. The ignition is started by initially sending distilled water. After the instrument is warmed up for 10 minutes the instrument is adjusted for zero reading in the display.

NaCl solution of 8 ppm concentration is sent and the reading is adjusted for 100 to calibrate the instrument. The solution of other concentrations of NaCl is sent one by one and the intensity of emitted light is noted. A graph is plotted between concentrations and intensity of emitted light. Then the unknown water sample is sent and the intensity of emitted light is noted. The concentration of the sodium in the water sample is determined from the graph.

### **RESULT**

The concentration of the sodium present in the water sample = \_\_\_\_\_ ppm.