**Techno India NJR Institute of Technology**



**Course File**

**Session:2022-23**

**Engineering Physics Lab (1FY2-20/2FY2-20)**

Dr. Nidhi Jain

( Professor)

**Department of Basic Science**

**106 Engineering Physics Lab**

First year of the engineering is dedicated to learning basic concepts of almost every branch of engineering. The student learns basics of mechanics, computers, electrical, electronics and civil concepts during his/her first year of study as engineers. The Engineering Physics Lab is designed to impart practical understanding of various physical concepts that will come in use during rest of their engineering years. The laboratory should help the student apply his or her knowledge of basic physical concepts learnt during his first year.

**LIST OF EXPERIMENT**

|  |  |
| --- | --- |
| **S. No.** | **Title of Experiment** |
| 01. | To determine the wave length of a monochromatic source of light by Newton’s  Rings. |
| 02. | To determine the dispersive power of the material of a prism with the help of a spectrometer by finding the angle of minimum deviation for violet, yellow and red colours of a Hg vapor lamp |
| 03. | To determine the wavelength of prominent lines of mercury by plane diffraction grating with the help of a spectrometer |
| 04. | To study the variation of a semiconductor resistance with temperature and hence determine the band gap of the semiconductor in the form of reverse biased P-N junction diode. |
| 05. | To determine the height of water tank (distance between two line marks on the whiteboard inside the lab) with the help of a Sextant |
| 06. | To study the charging & discharging of a condenser and hence determine the time constant by plotting voltage ~ time graph. |
| 07. | To determine the dielectric constant of the give substance by resonance method |
| 08. | To determine the ferromagnetic constants – coercive field, saturation magnetization, remenant magnetization, permeability and susceptibility of a ferromagnetic sample by tracing M ~ H curve using C.R.O. |
| 09. | To study the variation of thermo e.m.f. of iron-copper thermocouple with temperature and to plot a graph between thermo e.m.f. and temperature of hot junction. |
| 10. | To determine the specific rotation of cane sugar solution. |

**EXPERIMENT NO. 1**

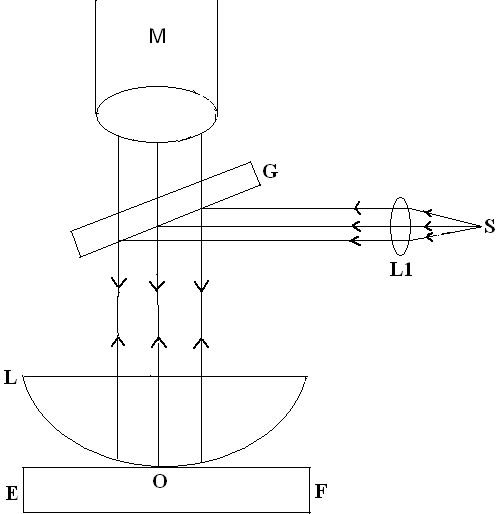
**OBJECTIVE**

To determine the wave length of sodium light (monochromatic source) by Newton’s Rings.

**EQUIPMENT REQUIRED**

A sodium lamp enclosed in wooden enclosure along with a transformer (35Watt) for Sodium lamp, Newton’s ring apparatus consisting of a set of planoconvex lens (L) and glass plate (EF), travelling microscope (M), short focus convex lens (L1), reading lens and spherometer.

**FIGURE**



**Figure 1.1: Set-up for a Newton’s Ring Experiment**

**THEORY**

The wave length of a monochromatic light as determined by Newton’s ring is given by the relation:

where, Dn+p **:** Diameter of (n+p)th dark (or bright) ring

Dn **:** Diameter of nth dark (or bright) ring

R **:** Radius of curvature of convex surface of lens

p **:** Difference in order of fringes

**PROCEDURE**

* + 1. Determine the Least Count of vernier scale of microscope.
    2. Level the microscope with the help of a spirit level.
    3. Make the arrangement as shown in figure 1, glass plate, short focus convex lens, planoconvex lens and plate should be clean.
    4. Adjust the position of short focus convex lens and inclined plate such that the central portion of the lens is illuminated. A spot with ring around it will be seen looking vertically above the lens.
    5. Take a piece of paper marked with X and place it on the surface of the lens. Move the microscope slowly in upward or downward direction till the mark X is well focused. Remove the piece of paper and further adjust the microscope by slightly moving it so that distinct Newton’s rings are visible through microscope. Bring the centre of rings at the centre of field of view by displacing Newton’s apparatus sideways or backward and forward. The microscope is now adjusted more accurately for focusing the cross wires.
    6. If the centre point is not dark and it appears to be somewhat hazy or white then contact between the lens and the plate at the centre is not perfect due to presence of some dust particles etc. In such case clean the surface of glass plate and lens again to get centre point as dark.
    7. Now turn the eye piece or microscope so that one of the cross wires becomes parallel to the horizontal scale whiles the other at right angles to it.
    8. To avoid backlash error move away from the centre to one side say left and fix the cross wire on a dark fringe. Note the reading on horizontal scale and count the number of fringe from the centre says it is 15th.
    9. Using the slow motion screw move the microscope to set the cross wire to the next dark fringe (14th). Note the reading on the horizontal scale. Repeat the above process till cross wire is very near the centre i.e. upto 4th or 5th fringe.
    10. Cross over to the other side of the fringe pattern and note positions of microscope by setting each time the crosswire. This time order of observations will be reversed i.e. from 4th to 5th then 6th and so on. Stop at 15th fringe.
    11. Record all these observations in table form. Each ring will have a set of two readings one on left side and the other on right hand side. The difference in these two readings for each ring gives the diameter for that ring. Similarly determine the diameter D for all the rings and calculate their squares.
    12. Calculate the value of () for p = 5 by taking difference of two sets i.e.(), () and so on. Find the mean value of ().
    13. Determine the radius of the curved surface of the lens in contact with the plate with the help of spherometer.
    14. Now substitute the various values in the formula and calculate λ.

**OBSERVATION**

1. Radius of curvature of plano convex lens **R = \_\_\_\_\_\_\_ cm**
2. **Least Count of microscope:**

Smallest division on main scale, x = \_\_\_\_\_\_\_\_\_\_ cm

Total no. of division on vernier scale, n = \_\_\_\_\_\_

*Least Count = x/n =* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Table: Determination of diameter of Newton’s Ring**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S. No. | Order  of  ring | Microscope reading (cm) | | | | | | Diameter  Dn = (a - b)  (cm) | Dn2  (cm2) |
| on the left side of ring | | | on the right side of ring | | |
| M S R | V S R | Total  (a) | M S R | V S R | Total  (b) |
| 01. | 4 |  |  |  |  |  |  |  | D42 = cm2 |
| 02. | 6 |  |  |  |  |  |  |  | D62 = cm2 |
| 03. | 8 |  |  |  |  |  |  |  | D82 = cm2 |
| 04. | 10 |  |  |  |  |  |  |  | D102= cm2 |
| 05. | 12 |  |  |  |  |  |  |  | D122= cm2 |

**CALCULATION**

1. Determination of wave length of monochromatic light using formula:
2. D62 =……………... cm2 D42 =……………... cm2

λ1 = cm = cm = ………………. cm = ……………... Å

1. D82 =……………... cm2 D62 =……………... cm2

λ1 = cm = cm = ………………. cm = ……………... Å

1. D102 =……………... cm2 D82 =……………... cm2

λ1 = cm = cm = ………………. cm = ……………... Å

1. D122 =……………... cm2 D102 =……………... cm2

λ1 = cm = cm = ………………. cm = ……………... Å

1. Standard value of wavelength, λ = 5893Å

Error = x 100 %

=……………… %

**RESULT**

The wavelength of sodium light was found to be λ = ……..…..… Å with an error of …………… %

**PRECAUTIONS**

* + 1. The surfaces in contact must be thoroughly cleaned.
    2. The radius of the planoconvex lens should be large in order to get larger values of diameters.
    3. The fringes should be focused on cross wires without parallax.
    4. Observations should not be taken for few thick fringes.
    5. Always move the micrometer screw in one direction so as to avoid backlash error.

**VIVA QUESTIONS**

Q1 What are Newton’s rings?

Ans When a beam of light is made to fall normally on the combination of planoconvex lens and plane glass plate, alternate bright and dark concentric rings are observed about the point of contact of the lens and the plate. These rings are first observed and explained by Newton and hence are called Newton’s ring.

Q2 Why are the rings formed?

Ans The rings are formed as a result of interference between the light waves reflected from the top and bottom surfaces of the air film enclosed between the lens and the glass plate.

Q3 Why are the rings circular?

Ans The rings are circular due to the circular symmetry of the wedge shaped air film about the point of contact of lens with the plane glass plate. Because of which the locus of points of the top surface of the air film with same air film thickness is a circle, so the rings are circular.

Q4 Why is the central (zeroth order) ring dark?

Ans The thickness of air film at the point of contact of glass plate with lens is zero but the interfering waves at the point of contact are opposite in phase. Hence the central ring is dark.

Q5 What types of fringes are obtained in a Newton’s ring experiment?

Ans Fringes of equal thickness

Q6 Sometimes it is observed that the central ring is bright. Why?

Ans This is happen when a dust particle comes between the two surfaces at the point of contact such that the effective path difference of the two light waves becomes zero.

Q7 What will happen if few drops of a transparent liquid is introduced between the planoconvex lens and the glass plate?

Ans The diameter of fringes is reduced by a factor of (μ)1/2.

Q8 What will happen when sodium lamp is replaced by white light source?

Ans Few colored fringes will be observed near the centre

Q9 What do you mean by monochromatic source?

Ans The source which produces light of single wavelength

Q10 Why the glass plate is kept at 450 with the vertical?

Ans The glass plate inclined at 450 makes the rays normally incidence on the combination of lens and glass plate as demanded by theory.

Q11 If by mistake plane side of the Plano convex lens is place on the glass plate then what will happen?

Ans Straight band will be seen.

Q12 Where are the rings formed?

Ans The rings are formed in the air film between the curved surface of lens and glass plate.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT No. 2**

**OBJECTIVE**

To determine the dispersive power of the material of a prism with the help of a spectrometer by finding the angle of minimum deviation for violet, yellow and red colours of a Hg vapor lamp

**EQUIPMENT REQUIRED**

Spectrometer, Prism, Hg vapor lamp within a wooden enclosure, Magnifying Lens and Spirit level

**FIGURE**

**Figure: Set-up for Measuring Dispersive Power of Prism**

**THEORY**

The ability of a prism to split white light into its constituent colours is known as its dispersive power. The dispersive power ‘ω’ of the material of a prism is given by the equation:

where = angle of minimum deviation for violet color

= angle of minimum deviation for red color

= angle of minimum deviation for yellow color

**PROCEDURE**

1. Place the prism on the prism table so that its centre lies at the centre of prism table and one of its refracting surface AB lies normal to the rays falling from the collimator. Now rotate the prism through a very small angle so that the incident rays make a small angle to the normal at the face AB.
2. Now look from the other side AC. On seeing through telescope the spectrum of white light of mercury lamp is seem. In spectrum there are lines of different colors in the order of VIBGYOR.
3. Rotate the prism table and telescope simultaneously so that spectrum remains on cross wires. A situation is obtained when by rotating the prism table further only direction of displacement of spectral lines becomes opposite and to keep the spectral lines on crosswire the direction of rotation of telescope is to be changed. This situation is of minimum deviation. At this position prism table and telescope are fixed. Rotating the telescope by means of screw vertical cross wire is set on violet line, yellow line, red line of spectrum and corresponding readings are taken.
4. Remove the prism from prism table and telescope is brought in front of collimator so that vertical cross wire coincides with the direct image of slit. This position of telescope is noted.
5. Find difference in between readings taken at (3) & (4). This will give angle of minimum deviation. The angle of minimum deviation for violet colour (), for red colour () and for yellow colour () are determined.

**OBSERVATION**

1. Determination of Least count of the spectrometer:

Smallest division on main scale ‘x’ = = 30´

Number of divisions on vertical scale ‘n’ = 30

Least count = = = 1´

B. Determination of angle of minimum deviation for violet, yellow and red colours

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S. No. | Colour | Venier | Readings in Minimum Deviation Position | | | Readings in Direct Image Position | | | (a - b) | Mean |
| M.S.R | V.S.R | Total (a ) | M.S.R | V.S.R | Total  (b) |
| 01. | Violet | V1 |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |
| 02. | Yellow | V1 |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |
| 03. | Red | V1 |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |

**CALCULATION**

The dispersive power of the material of a prism is given by:

………………..

Standard value of ω = 0.0193

Percentage Error = x100 = \_\_\_\_\_\_\_\_\_%

**RESULT**

The dispersive power of the material of a prism was found to be =…………. with an error ............%

**PRECAUTIONS**

1. The width of the slit should be very small.
2. Adjustment of telescope, collimator and prism table should be done accurately.
3. The height of prism should be adjusted so that light falls on the whole refracting surface of the prism.
4. At the time of taking observations the telescope and the prism table should be clamped.

**VIVA QUESTIONS**

Q 1. Define refractive index.

Ans: Refractive index of a medium for a particular wave length of light is the ratio of the velocity of light in vacuum to the velocity of light in that medium.

Q 2. What is mean by Dispersion?

Ans: The splitting of white light ray into its constituent colours is called dispersion.

Q 3. On what factors the Dispersive Power depends?

Ans: It depends upon (1) Material (2) wave length of colours.

Q 4. Can you find out the Dispersive power of a prism with sodium light?

Ans: No, this is a monochromatic source of light.

Q 5. Out of the prism of flint and crown glasses which one will you prefer to use?

Ans: We shall prefer a prism of flint glass because it gives greater dispersion.

Q 6. Can any other device also disperse the light?

Ans: Yes, the diffraction grating also disperses white light.

Q 7. What are the names of seven colours of sunlight spectrum?

Ans: The seven colours are Violet, Indigo, Blue, Green, and Yellow. Orange and Red (VIBGYOR)

Q 8. What is angle of deviation?

Ans: The angle between the incident ray and emergent ray of light is known as the angle of deviation.

Q 9. What is the angle of prism?

Ans: The angle between the refracting surfaces of the prism is called angle of prism.

Q 10. Does the deviation depend on the angle of prism?

Ans: Yes, greater the angle of prism more is the deviation.

Q 11. Does the deviation depend on the colours?

Ans: Yes, the deviation is less for red than for violet light.

Q12. Do the light rays of different colours travel with the same velocity in air?

Ans: In air, the light rays of different colours travel with the same velocity.

Q13. What is spectrometer?

Ans: Spectrometer is an optical instrument which is used to study the pure spectrum of light.

Q 14. Why do you take readings from both two venires?

Ans: This is taken to eliminate the error which may arise due to none coincidence of the axis of rotation of the telescope with the center of the circular main scale.

Q 15. How will you define a ‘prism’?

Ans: A prism is portion of transparent medium, bounded by two plane face, inclined to each other at an angle.

\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 3**

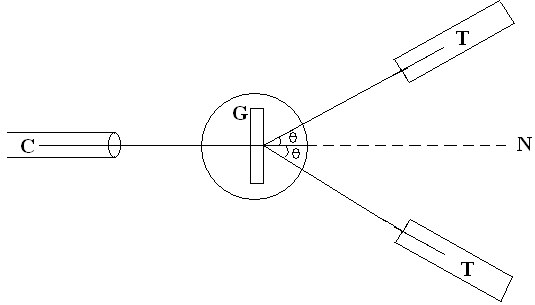
**OBJECTIVE**

To determine the wavelength of prominent lines of mercury by plane diffraction grating with the help of a spectrometer

**EQUIPMENT REQUIRED**

A mercury lamp enclosed in wooden enclosure along with a transformer (125Watt) for Hg lamp, spectrometer, plane diffraction grating, reading lens and a spirit level

**FIGURE**



**Figure 3.1: Set-up for measuring Wavelength by Diffraction Grating**

**THEORY**

The wavelength of the light as measured from a diffraction experiment is given by:

where λ = wavelength of light

(a+b) = grating element (distance between two consecutive lines on the grating)

θ = angle of diffraction

n = order of spectrum

**PROCEDURE**

1. Put the source in front of slit of collimator of spectrometer.
2. Adjust the telescope with the collimator so that direct image of the slit coincides with the vertical cross wire. Note the readings on both the vernier scale.
3. Mount the grating on the prism table symmetrically at the centre.
4. Turn the telescope first to one side, to bring the middle point of the spectral line (first order spectrum) on the point of intersection of cross wires. Take the readings of both the vernier.
5. Next turn the telescope towards the other side and adjust so as to bring the middle of the spectral line on the point of intersection of the cross wires. Note the vernier readings again.
6. The difference in the readings of the same vernier on the two sides gives twice the angle of diffraction i.e. 2θ. Repeat the above process for other spectral lines.
7. Note the number of ruled lines on the grating, its reciprocal gives the value of (a+b), the value of grating elements so obtained will be in inches. Convert it to cm.
8. From the values of (a+b), θ and the order of spectrum n calculate λ from each set of observations and find the mean value.

**OBSERVATION**

1. **Least Count of Spectrometer:**

Smallest division on main scale ‘x’ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Number of divisions on vertical scale ‘n’ = \_\_\_\_\_\_\_\_\_

Least count = = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **Determination of angle of minimum deviation for violet, yellow and red colours**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S. No. | Colour | Venier | Readings on right side of the direct image (degree) | | | Readings on left side of the direct image (degree) | | | 2θ  (a - b) | θ | Mean  θ |
| M.S.R | V.S.R | Total (a) | M.S.R | V.S.R | Total  (b) |
| 01. | Violet | V1 |  |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |  |
| 02. | Yellow | V1 |  |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |  |
| 03. | Red | V1 |  |  |  |  |  |  |  |  |  |
| V2 |  |  |  |  |  |  |  |  |

**CALCULATION**

1. **Determination of Grating Element (a + b):**

Number of lines per inch on the grating N = ……………….

Grating element (a + b) = inch

=\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ inch

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_cm

**2. Determination of Wavelength (λ) of Light from the Formula:**

where, n = 1

Substituting the values of (a + b) and θ in the above formula



= \_\_\_\_\_\_\_\_\_\_\_cm x Sin (\_\_\_\_o\_\_\_\_’\_\_\_\_”)

=\_\_\_\_\_\_\_\_\_\_\_\_\_\_ x \_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å

Standard = 4078Å

Error = x 100 %

Error = x 100 % = \_\_\_\_\_\_\_\_\_\_ %



= \_\_\_\_\_\_\_\_\_\_\_cm x Sin (\_\_\_\_o\_\_\_\_’\_\_\_\_”)

=\_\_\_\_\_\_\_\_\_\_\_\_\_\_ x \_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å

Standard = 5770Å

Error = x 100

Error = x 100 % = \_\_\_\_\_\_\_\_\_\_ %



= \_\_\_\_\_\_\_\_\_\_\_cm x Sin (\_\_\_\_o\_\_\_\_’\_\_\_\_”)

=\_\_\_\_\_\_\_\_\_\_\_\_\_\_ x \_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å

Standard = 7245Å

Error = x 100

Error = x 100 % = \_\_\_\_\_\_\_\_\_\_ %

**RESULT**

The wavelength of various colors obtained from Hg lamp as light source was found to be

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å with an error of \_\_\_\_\_\_\_\_\_\_\_ %

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å with an error of \_\_\_\_\_\_\_\_\_\_\_ %

= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Å with an error of \_\_\_\_\_\_\_\_\_\_\_ %

**PRECAUTIONS**

1. Grating should not be touched by finger, it should be held by its frame.
2. Grating should be normal to the incident light.
3. Readings of both vernier should be taken.
4. At the time of taking observations the telescope and the prism table should be clamped.

**VIVA QUESTIONS**

Q1 What do you mean by diffraction of light?

Ans The bending of light around the edges of the slit or the obstacle and spreading out into geometrical shadow, called diffraction of light.

Q2 What is diffraction grating?

Ans An arrangement of a large number of parallel, equidistant, small rectangular slit of equal width place side by side, called diffraction grating.

Q3 What do you mean by plane diffraction grating?

Ans When the grating, i.e. a group of large number of parallel slits is arranged in a plane, then it is called plane diffraction grating.

Q4 Do you use original plane transmission diffraction grating?

Ans No, only replica grating is used because original grating is too much costly.

Q5 How is a replica grating prepared?

Ans A replica grating is prepared from the original grating. A thin layer of cellulose acetate solution is poured uniformly over the ruled surface of original grating and allowed it to dry. This thin film, when removed from grating surface, is found to retain an expression of the rulings of the original grating. This film is mounted between two transparent glass plate, known as replica grating.

Q6 What is grating element?

Ans The grating element is (a+b) where a is the width of slit and b is the separation between two slits or width of ruled line.

Q7 Which colour is obtained initially in the spectrum, when the telescope is moved left or right side from the direct image?

Ans When the telescope is moved left or right side from the direct image, initially violet colour is seen, followed by blue, green and yellow and in last red colour. Because angle of diffraction (θ) increases with increasing the wavelength of various colour i.e. λviolet < λred or θviolet < θred

Q8 Why direct image or zero order spectrum is white using mercury light (or white light) source?

Ans The angle of diffraction (θ) of all the wavelengths of white light is same, i. e., θ = 0 for zero order spectrum (n=0). Hence all colours combine at the same place (i. e. θ = 0), which gives a white direct image.

Q9 Are the intensities of light equal in all orders of the spectrum?

Ans No, most of the incident energy goes to zero order direct image and rest is distributed among others. The intensity of light is decreased as the order of spectrum is increased. Therefore, the spectra become fainter as we go to higher order.

Q10 Is the width of spectral line increases by decreasing total width of ruled surface?

Ans Yes, the width of the spectral line is inversely proportional to the total ruled surface.

Q11 What is main difference between a prism spectrum and a grating spectrum?

Ans The prism spectrum is formed by dispersion while the grating spectrum is formed by “diffraction”. In prism spectrum the angle of deviation is least for red and greater for violet. While in grating spectrum the angle of diffraction is least for violet and greater for red. The spectral lines in prism spectra are curved while in grating spectra are almost straight.

Q12 What is the necessary for a good grating?

Ans The ruling lines (or slits) should be exactly parallel, uniform, equidistant and of equal width.

Q13 How many lines are drawn on a grating?

Ans The no. of lines drawn on a grating varies from 10000 to15000 per inch and the width of ruled surface from 2 to 4 inches.

Q14 How many orders can be obtained with the help of grating?

Ans nmax = (a+b)/ λ depending upon the grating element and the wavelength of light.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT No. 4**

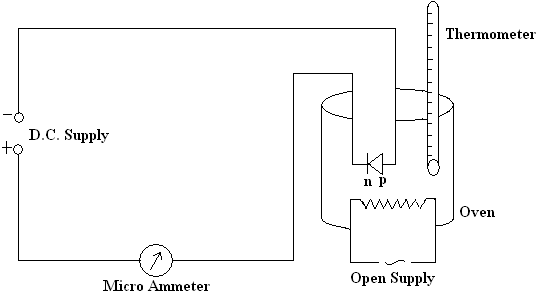
**OBJECTIVE**

To study the variation of a semiconductor resistance with temperature and hence determine the band gap of the semiconductor in the form of reverse biased P-N junction diode.

**EQUIPMENT REQUIRED**

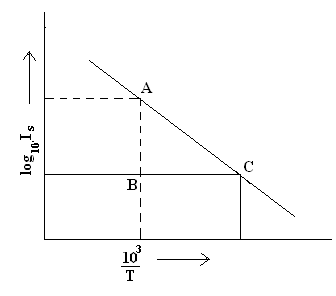
The NEW TECH TYPE DM-113 kit and a thermometer; the training board is self contained with built in power supply, p-n junction diode and micro ammeter on the panel along with a heater.

**FIGURE**

****

**Figure 4.1: Circuit diagram for bandgap determination of a semiconductor**

**THEORY**

In semiconductor an energy gap exists between the top of the valence band and bottom of the conduction band. Its critical conductivity is governed by the no. of electrons in the conduction band and holes in valence band.

When a P-N junction diode is reverse biased the reverse saturation current Is is due to the minority charge carriers (i.e. electrons in the P-type semiconductors and holes in the N-type semiconductors). The reverse saturation current depends on the temperature of P-N junction diode and energy bandgap of the semiconducting material of which the junction diode is formed. The reverse saturation current is given by:

**Figure 4.2: Slope of the graph**

I = Ase-qΔE/KT

or logeI = logeAs - qΔE/KT

where ΔE is the band gap in eV

log10I = log10As – 5.036 (ΔE) (103/T)

where q = 1.6 X 10-19 C is the electronic charge; and K = 1.38 X 10-23 J/K is Boltzmann’s constant

Therefore graph plotted between log10I and (103/T) is a straight line. The negative slope of the line indicates the increase in reverse saturation current with increasing temperature. The gradient or slope of the straight line is given by:

S = 5.036 (ΔE) = (AB/BC) [from figure 4.2]

ΔE = (1/5.036) (AB/BC) eV ………… (1)

**PROCEDURE**

1. Plug the mains lead to the mains socket carrying 220 Volt, 50 Hertz A.C.
2. Insert the thermometer and the junction diode in the socket of the oven.
3. Plug the two leads of the diode in the terminals Red plug to Red terminal and Black to Black terminal i.e. the junction diode is reverse biased.
4. Now put the power ON/OFF switch to ON position.
5. Some suitable reverse bias voltage is applied. Put the oven switch to ON position and allow the temperature to increase up to 700 C or less till the current reaches to nearly 50 Micro Ampere. Then oven switch is put on OFF.
6. When the temperature becomes stable start taking readings of current and temperature. The current readings are taken in steps of 5 µA, starting from 50 µA. The readings should be taken on fall of temperature from 700 C downwards.
7. Plot a graph between (103/T) and (log10Is) taking these on X and Y axes.
8. Now determine the slope of the line and calculate the band gap using relation (1).

**OBSERVATION**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sr. No. | Temperature T (0C) | Temperature T (K) = T(oC + 273) | Current  Is (µA) | 103/T | log10Is |
| 01. | 70 |  |  |  |  |
| 02. | 65 |  |  |  |  |
| 03. | 60 |  |  |  |  |
| 04. | 55 |  |  |  |  |
| 05. | 50 |  |  |  |  |
| 06. | 48 |  |  |  |  |
| 07. | 46 |  |  |  |  |
| 08. | 44 |  |  |  |  |
| 09. | 42 |  |  |  |  |
| 10. | 40 |  |  |  |  |
| 11. | 38 |  |  |  |  |
| 12. | 36 |  |  |  |  |
| 13. | 34 |  |  |  |  |
| 14. | 32 |  |  |  |  |
| 15. | 30 |  |  |  |  |

**GRAPH**

Paste the Graph Paper here

**CALCULATION**

1. The slope of the line from graph is given by

Slope of line = (AB/AC) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Determination of Bandgap:

ΔE = (1/5.036) (AB/BC) eV = = \_\_\_\_\_\_\_\_\_\_\_\_ eV

3. Standard value of band gap = 0.76 eV

and error = X 100 %

= \_\_\_\_\_\_\_\_\_\_ %

**RESULT**

The band gap of the semiconductor P-N junction diode is found to be …………… eV with an error of ………… %

**PRECAUTIONS**

1. All connections should be correct and tight.
2. The maximum temperature should not exceed 700 C.
3. Bulb of the thermometer and diode should be inserted properly in the oven.

**VIVA QUESTIONS**

Q1 What are semiconductors?

Ans Semiconductors are those materials whose resistivity lies between those of conductors and insulators.

Q2 What is forbidden energy gap?

Ans In solids, there is a gap between the valence band and the conduction band which does not contain any allowed energy levels. Hence this gap is known as forbidden energy gap.

Q3 Which type of materials have the forbidden energy gap maximum?

Ans The forbidden energy gap is the maximum for insulators.

Q4 What are holes?

Ans The absence of an electron creates a hole or an effective positive charge. Holes act as carriers of positive charge in valence band whose displacement is in a direction opposite to that of electrons.

Q5 What are the charge carriers in semiconductors?

Ans In semiconductors electrons and holes both are charge carriers for the effective current.

Q6 What are N-type and P-type semiconductors?

Ans When some atoms of pentavalent element like P, As, Sb etc. are mixed as impurity with pure semiconductor, the resulting semiconductor is known as N-type semiconductor and when some atoms of trivalent element like B, Ga, A1, In etc. are mixed as impurity with pure semiconductor the resulting semiconductor is known as P-type semiconductor.

Q7 What are majority and minority charge carriers in semiconductors?

Ans In P-type semiconductors holes are majority carriers and electrons are minority carriers, whereas in N-type semiconductors electrons are majority carriers and holes are minority carriers.

Q8 What is PN junction diode?

Ans When P-type semiconductor and N-type semiconductor crystals are joined together, then a junction diode is formed.

Q9 What is depletion layer in PN junction diode?

Ans In PN diode, electrons fill up the holes in a thin layer at the junction so that free charge carriers do not exist in this layer. Thin layer formed at the junction due to depletion of charge carriers is defined as depletion layer.

Q10 On what factors does the reverse current depend in reverse bias arrangement?

Ans The current in reverse bias arrangement depends on the temperature of the PN junction and the energy band gap.

Q11 What is Zener effect?

Ans When the bias voltage exceeds a certain limit in reverse bias arrangement, the current abruptly increases. This is due to the avalanche breakdown. Thus an effect is known as Zener effect.

Q12 What is the order of current in the two biasing?

Ans In forward bias the current is of the order of mill amperes where as in reverse bias the current is of the order of micro ampere.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 5**

**OBJECTIVE**

To determine the height of water tank (distance between two line marks on the whiteboard inside the lab) with the help of a Sextant

**EQUIPMENT REQUIRED**

Sextant, measuring tape, whiteboard, marker and scale

**FIGURE**

**Figure 5.1: Trigonometric angles and distances for measuring height**

**THEORY**

Let α and β be the angles subtended by the line at E and F respectively as shown in Fig 5.1 and h be the height of the line from the horizon, then

or, Similarly,

Subtracting the two equations, MF – ME = h(cotβ – cotα)

**PROCEDURE**

1. Draw a short horizontal line on a wall (board) with chalk in the level of the eye and place the sextant at a large distance from the wall.
2. Mark this position on the ground, which will be the first point of observation.
3. See a part of the horizontal line through the transparent portion of M2 and the other portion of the same line through the reflecting part of this mirror. Turn the moveable arm R such that the horizontal line is seen continuous
4. Note down the readings on the main scale and vernier scale. This reading will be the zero reading and should coincide with the zero of the main scale. If does not note down the error.
5. Rotate the arm R gradually so that the upper line begins to descend down. Do it continuously till the image of the top line coincides with the image of the bottom line.
6. Note down the reading. The difference between the two reading will give the angular elevation α for this observation point.
7. From this observation point move the sextant to a known distance d (say about 3 feet) away from the wall.
8. Record the zero error with its proper sign at this position and repeat the above procedure and find the angular elevation β at this position.
9. Calculate the distance between the two lines from the above equation.

**OBSERVATIONS**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Distance** | **Zero Error** | | | **Angular Elevation** | | | **Angle of Elevation**  **(θ = a-b)** | **Cot θ** |
| **M.S.R.** | **V.S.R.** | **Total (a)** | **M.S.R.** | **V.S.R.** | **Total (b)** |
| 01. | 0 ft |  |  |  |  |  |  |  |  |
| 02. | 3 ft |  |  |  |  |  |  |  |  |
| 03. | 6 ft |  |  |  |  |  |  |  |  |

**Table: Determination of angle of elevation**

**CALCULATION**

Calculate the distance between the two lines by substituting the values of d, α and β in

Standard h = \_\_\_\_\_ feet

% Error =

**RESULT**

The distance between the two lines drawn on the white board in physics lab was found to be …….... feet with a percentage error ….......... %.

**PRECAUTIONS**

1. Before performing the experiment the adjustments should be made carefully.
2. The plane of the index glass M1 should be perpendicular to the plane of the arc.
3. Least count of the instrument should be calculated accurately.
4. Zero reading must be found separately at different places.
5. In the zero reading the index glass M1 and the horizon glass M2 should be parallel.
6. The various points of observations should be in a straight line.
7. The axis of the telescope must be parallel to the plane of the graduated circular scale and must pass through the centre of M2.

**VIVA QUESTIONS**

Q1 What is sextant and why is it called sextant?

Ans This is an instrument which enables one to determine the angle subtended by the two distant point objects at the place of observation. Its scale is only 1/ 6th of the circle, i.e its scale forms on arc of 60o. So it is called sextant.

Q2 What is the basic principle of sextant?

Ans The sextant is based on the principle of rotation of plane mirror. According to this principle when a plane glass is rotated through an angle θ about an axis perpendicular to the plane of incidence, the reflected ray rotates through an angle 2θ, the direction of the incident ray remain unchanged.

Q3 Is the incident ray fixed here as glass is rotated?

Ans No, the incident ray is not fixed in sextant but the reflected ray is fixed. On account of reversibility of light path, the incident and reflected rays are interchangeable; this is the principle of sextant.

Q4 What adjustments must satisfy for the glass in sextant?

Ans There are two mechanical adjustments for mirror which must be satisfied –

1. Their plane should be perpendicular to the plane of the arc.
2. These glasses should be parallel to each other, when there is no zero error in instrument.

Q5 Give functions of the screw attached with glasses M1& M2?

Ans These glasses are made normal to the bed of the instrument with the help of these screws.

Q6 What are the uses of light filters (coloured glasses) in this experiment?

Ans If the object happens to be too dazzling then light filters are used to cut down the intensity of light.

Q7 What type of telescope is fitted with sextant?

Ans Galilean type of telescope is fitted with sextant and it gives erect image due to concave lens fitted in its eye piece.

Q8 Is the actual angle subtended by the arc appears to be an acute angle?

Ans Yes, the angle is acute.

Q9 Why two images seen when the sextant is pointed towards an object?

Ans One image is formed due to the rays directly entering the telescope through the transparent portion of the horizon glass and the second by those rays which enter the telescope after reflections from the index and horizon glass.

Q10 What is zero error in sextant?

Ans In sextant instrument, when the glasses are exactly parallel, the zero of the vernier should coincide with the zero of the main scale. If it is not so, the instrument is said to have zero.

Q11 Does the zero error in a sextant depend on the distance of the object?

Ans Yes, it is depend on the distance of the object. Zero error is inversely proportional to the distance of the object.

Q12 How will you chose the two points of observation?

Ans The two points of observations are chosen in such a way that they are collinear with the reference mark.

Q13 What are the practical uses of the sextant?

Ans Sextant is used for –

1. To determination of angular diameter of the Sun and Moon
2. To determination of altitude of the Sun and Moon

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 6**

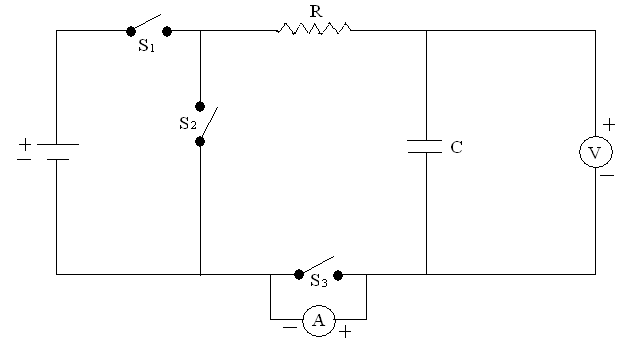
**OBJECTIVE**

To study the charging & discharging of a condenser and hence determine the time constant by plotting voltage ~ time graph.

**EQUIPMENT REQUIRED**

Charging - discharging kit consisting of various capacitors and resistors, voltmeter, ammeter; stop watch and connecting wires.

**FIGURE**

****

**Figure 7.1: Circuit diagram for the charging and discharging of capacitor**

**THEORY**

Consider a capacitor of capacitance C connected in series with a resistor of resistance R along with an applied e.m.f. E as shown in the figure.

1. **Charging of the capacitor through the resistor:**

In Fig 7.1, on closing the switch S1 the capacitor starts charging. At any instant of time t, after closing the switch let the charge on the capacitor be q, and hence the potential difference across the capacitor will be. This potential difference will be opposite in polarity to the supplied e.m.f. because the capacitor will have its positively charged electrode connected to the positive terminal of the supply. The instantaneous current in the circuit at time t will therefore be . Because this current decreases as V grows, and so when the potential difference equals E, the current ceases to flow. At this time the charge on the capacitor will be Q = CE.

At time instant t, the e.m.f. equation for the circuit will be E = iR + q/C

But,

or,

Integrating the above equation, where E and C are taken as constants, we obtain

when t = 0, q = 0, therefore constant = - C*ln*E

so,

or,

or,

or,

or,

but, EC = Q the final charge on the capacitor, when it is at the potential of the supply battery.

This is the equation representing the growth of charges on the capacitor The instantaneous potential difference across the electrodes of the capacitor and the current flowing though it are given by the following equations:

Fig 7.2 shows the variation of voltage and current across the condenser in the circuit with time.

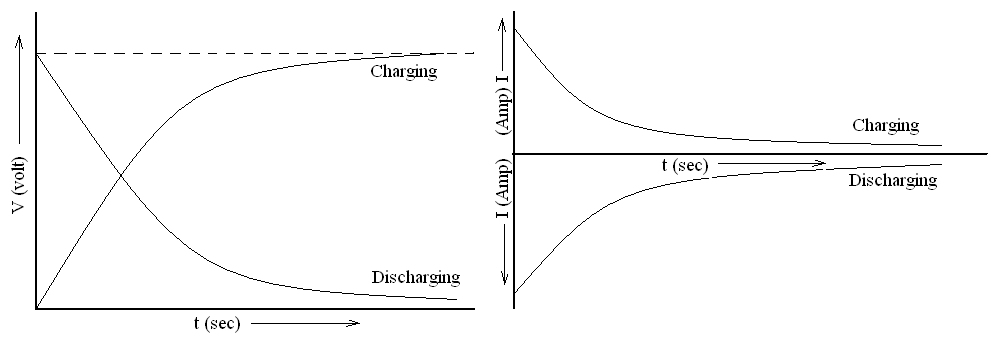
From the above equations we conclude that at time t = 0

q = 0 and *i* = E/R i.e. the charge on the capacitor is zero but the current in the circuit is maximum. With increase in time, charge on the capacitor increases and thereby the potential difference while the current decreases and approaches zero exponentially.

As t →∞, q → CE and *i*→ 0.

When t = RC, then

Thus, the time constant tc is defined as the time taken by the capacitor to acquire 63% of the maximum charge. The smaller is the time constant faster will be the charge accumulation.

****

**Figure 7.2: Charging and discharging characteristic curve of a capacitor**

1. **Discharging of the capacitor through the resistor:**

Let us assume that the capacitor has been charges for long time t » RC i.e. to its maximum value Q = CE. Now, if the source of e.m.f. is removed from the circuit by opening the switch S1 and switches S2 and S3 are closed as shown in Fig a, the capacitor begins discharging through the resistor.

When the source of e.m.f. is removed from the circuit, then at that instant of time t, the e.m.f. equation will be

for E = 0

or,

Integrating the above we obtain,

When, t = 0, q = Q

so,

or,

The above equation represents the exponential discharge of the capacitor through the resistor.

Hence,

The equation shows the exponential decay of current in the circuit. The negative sign indicates that the current is flowing in the sense to decrease the charge on the capacitor.

It is found from above discussion that for charging and discharging of the capacitor, the current always starts from its maximum value and decreases exponentially to zero.

When t = RC,

Therefore, the time constant of the capacitor during discharging is defined as the time taken by the capacitor to lose 63 (= 100 - 37) % of the initial charge.

**PROCEDURE**

**(A) Charging of the capacitor through the resistor:**

1. Make all the connections on the charging discharging kit as shown in Fig A
2. Switch ON the mains supply of the charging discharging kit. Adjust dc supply to 10V
3. Close switch S1 and simultaneously start the stop watch
4. Take readings on the voltmeter after certain equal intervals of time (say 5 secs) till the voltage reaches approximately 10V
5. Plot the graph between the two quantities. The graph will look like the one shown in fig B
6. Draw a horizontal line at V = 0.63x10volt = 6.3volt. Read the value of time on the x-axis where this line intersects the graph. This is the time constant t1

**(B) Discharging of the capacitor through the resistor:**

1. Make all the connections on the charging discharging kit as shown in Fig A
2. Switch ON the mains supply of the charging discharging kit. Adjust dc supply to 10V
3. Close switch S1 and keep it closed till the voltage across the capacitor reaches about 10V
4. Now open switch S1 and close S2 simultaneously start the stop watch.
5. Take readings on the voltmeter after certain equal intervals of time (say 5 secs) till the voltage reaches approximately 0volt
6. Plot the graph between the two quantities. The graph will look like the one shown in fig B
7. Draw a horizontal line at V = 0.37x10volt = 3.7volt. Read the value of time on the x-axis where this line intersects the graph. This is the time constant t2.

The time constant of the capacitor in use is given bysecs

**OBSERVATION**

**Table: (Charging and discharging voltage of the capacitor)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S. No. | Time (sec) | R = ……… Ω C = ……… F | | R = ……… Ω C = ……… F | |
| Voltage across capacitor (volt) | | Voltage across capacitor (volt) | |
| For Charging of capacitor | For Discharging of capacitor | For Charging of capacitor | For Discharging of capacitor |
| 01. | 00 |  |  |  |  |
| 02. | 05 |  |  |  |  |
| 03. | 10 |  |  |  |  |
| 04. | 15 |  |  |  |  |
| 05. | 20 |  |  |  |  |
| 06. | 25 |  |  |  |  |
| 07. | 30 |  |  |  |  |
| 08. | 35 |  |  |  |  |
| 09. | 40 |  |  |  |  |
| 10. | 45 |  |  |  |  |
| 11. | 50 |  |  |  |  |
| 12. | 55 |  |  |  |  |
| 13. | 60 |  |  |  |  |
| 14. | 65 |  |  |  |  |
| 15. | 70 |  |  |  |  |
| 16. | 75 |  |  |  |  |
| 17. | 80 |  |  |  |  |
| 18. | 85 |  |  |  |  |
| 19. | 90 |  |  |  |  |
| 20. | 95 |  |  |  |  |
| 21. | 100 |  |  |  |  |
| 22. | 105 |  |  |  |  |
| 23. | 110 |  |  |  |  |
| 24. | 115 |  |  |  |  |
| 25. | 120 |  |  |  |  |

**CALCULATION**

The theoretical and experimental values of time constant for the two set of experiments was calculated from graph and known values of R and C and is as follows:

Time constant is measured from the graph for set 1 and is given as: \_\_\_\_\_\_ secs

The theoretical value of time constant for set 1 is:\_\_\_\_\_\_ secs

The percentage error in the measurement for set 1 was:

Time constant is measured from the graph for set 2 and is given as: \_\_\_\_\_\_ secs

The theoretical value of time constant for set 2 is: \_\_\_\_\_\_ secs

The percentage error in the measurement for set 2 was:

**RESULT**

The time constant was measured from the graph for the two set of R & C and is tabulated as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Set No. | Time Constant tc | | | | % error |
| Theoretical Value (RC) | For Charging  t1 = 0.63V0 | For discharging  t2 = 0.37V0 | Mean |
| 01. |  |  |  |  |  |
| 02. |  |  |  |  |  |

**PRECAUTIONS**

The following precautions should be taken care of while performing the experiment:

1. Connections should be tight and exactly according to the circuit diagram.
2. The value of R and C combination should be large.
3. R and C should have standard values.
4. Starting of stop watch and connecting/disconnecting of the switches should be done simultaneously.

**VIVA QUESTIONS**

Q1 What is condenser?

Ans It is a device with which the capacity of conductor can be increased. It is also used for storing charges.

Q2 What do you mean by capacity of a condenser?

Ans The capacity of a condenser is numerically equal to the quantity of that charge which increases the potential difference between the plates of the condenser by 1 volt.

Q3 What is SI unit of capacity?

Ans SI unit of capacity is a farad. It is equivalent to coulomb per volt.

Q4 On what factors does the capacity of a condenser depend?

Ans The capacity of a condenser depend on

1. The area of the plate
2. The separation distance between the plates
3. The dielectric constant of the medium between the plates

Q5 What is time constant? Why should its value be large in experiment?

Ans The time in which the charge on capacitor falls to 1/e = 0.37 times of its maximum value during discharging is defined as time constant.

Q6 What is the significance of time constant?

Ans If the time constant RC is low then discharging of capacitor will be quick and if the time constant RC is high then discharging of capacitor through resistance will be slow i.e. discharging will take time.

Q7 Why should the capacitor and keys not leak the charges?

Ans Discharge should take place only through the resistance.

Q8 What do you mean by charging and discharging of a capacitor?

Ans When a capacitor is connected to the terminals of a battery, charge starts accumulation of first plate. This process is known as charging of a capacitor.

Q9 What is the effect of resistance on the rates of the charging and discharging?

Ans The rate of charging or discharging of a capacitor decreases with increases of resistance.

Q10 What will happen if R is reduce to zero in an RC circuit?

Ans The charging or discharging will take place instantly.

Q11 What is time constant of RC circuit?

Ans The product of RC is called time constant of the circuit. The dimension of RC is sec.

Q12 Can you tell any use of these charge-discharge waveforms?

Ans For producing smooth waves.

Q13 Why does a condenser allow a.c. to pass while it does not allow d.c. to pass through it?

Ans Capacitive reactance XC = 1/ωc, for dc., ω = 0. So condenser offers infinity reactance to the flow of direct current.

Q14 What is the function of a dielectric?

Ans It increases the capacity of a condenser.

Q15 For quick discharging what is the value of time constant?

Ans Time constant should be small for quick discharging of capacitor.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 7**

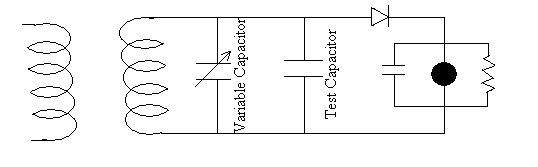
**OBJECTIVE**

To determine the dielectric constant of the give substance by resonance method

**EQUIPMENT REQUIRED**

The unit is compiled on a ‘HYLEM BOARD’ with all its circuitry engraved on it. Different components are also available on the board for experiment.

**FIGURE**



**Figure 8.: Set-up to measure dielectric constant of a substance by resonance method**

**THEORY**

Dielectric constant ‘k’ of the substance is given by:

where C0 = Capacity of test capacitor without dielectric.

C1 = Capacity of variable air capacitor for maximum deflection in microammeter when test capacitor is without dielectric.

C2 = Capacity of variable air capacitor for maximum deflection in microammeter when test capacitor is filled with dielectric.

**PROCEDURE**

* + 1. Connect RF oscillator terminals to the given capacitors. Set the sensitivity of the meter at 50 by vary the sensitivity potentiometer knob.
    2. Now connect another capacitor (test capacitor) to second terminals.
    3. The frequency of oscillator is fixed and is kept constant throughout the experiment.
    4. Keep test capacitor without dielectric and vary capacity of variable capacitor so that deflection in micrometer is maximum. This value of air capacitor is C1.
    5. Now fill the test capacitor with dielectric. Again vary the capacity of variable air capacitor so that deflection in micrometer is maximum. This value of air capacitor is C2.
    6. For measuring dielectric of solids, connect capacitor plates in parallel with gang capacitor. Set micrometer for maximum resonance by varying the variable capacitor. Put dielectric plates in between the gap of capacitor. Resonance changes returns the gang capacitor and note the capacity.

**OBSERVATION**

**Table: Value of C0 at different gap**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Gap between plates** | **Approximate Capacity (C0)** |
| 01. | 1/16” 1.5m.m. | 32 pF |
| 02. | 1/8” 3.0m.m. | 24 pF |
| 03. | 3/16” 4.5m.m. | 19 pF |

**Table: Determination of C1& C2**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Distance between plates** | **Test Capacity without dielectric**  **C1** | **Test Capacity with dielectric**  **C2** |
| 01. | 1.5 m.m. |  |  |
| 02. | 3.0 m.m. |  |  |
| 03. | 4.5 m.m. |  |  |

**CALCULATION**

**RESULT**

The dielectric constant of the given substance was found to be …………………………….

**PRECAUTIONS**

1. Connections should be neat and tight.
2. Test capacitor plates must be light when filled with dielectric material.
3. Two sheets are provided for solid dielectric on sheet is 1.5 mm thick and other is 3 mm each.

**VIVA QUESTIONS**

Q1 What is condenser?

Ans It is a device with which the capacity of conductor can be increased. It is also used for storing charges.

Q2 What do you mean by capacity of a condenser?

Ans The capacity of a condenser is numerically equal to the quantity of that charge which increases the potential difference between the plates of the condenser by 1 volt.

Q3 What is SI unit of capacity?

Ans SI unit of capacity is a farad. It is equivalent to coulomb per volt.

Q4 On what factors does the capacity of a condenser depend?

Ans The capacity of a condenser depend on

1. The area of the plate
2. The separation distance between the plates
3. The dielectric constant of the medium between the plates.

Q5 What is the function of a dielectric?

Ans It increases the capacity of a condenser.

Q6 What is dielectric material?

Ans The non-conducting material is known as is dielectric material.

Q7 What is electrical displacement vector?

Ans Materials that are not conductors when put in external electric field get polarized. An non trivial relation polarization vector and external electric field is given as

D = ε0 E +P

D = ε0E + εE

where D is known as electric displacement vectors.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 8**

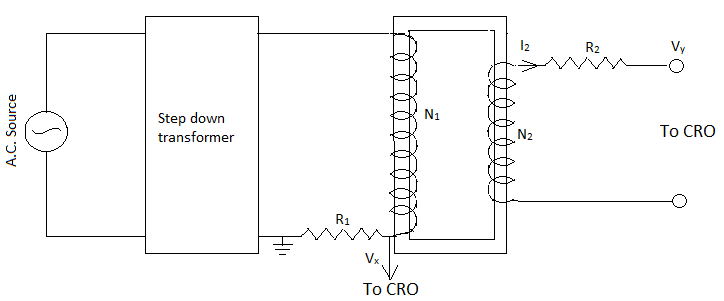
**OBJECTIVE**

To determine the ferromagnetic constants – coercive field, saturation magnetisation, remenant magnetization, permeability and susceptibility of a ferromagnetic sample by tracing M ~ H curve using C.R.O.

**EQUIPMENT REQUIRED**

B-H loop tracer kit, primary and secondary coils, BNC to crocodile cables, connecting wire, CRO, tracing paper and graph paper.

**FIGURE**



**Figure: Set up to determine B-H curve for a ferromagnetic material**

**THEORY**

**Hytersis loop**: Thevaritation of flux density with magnetic filed intensity is not linear. A graph is plotted between B & H as shown in called B – H curve. Ferromegnetic materials exhibit hysteresis. This comes from the Greek word (hysteros – later) and refer to the retardation in the response of a material to a change in the applied filed.

If we consider a ferromagnetic material in completely de magnetization state and make it to undergo through a cycle of magnetization in which H is increased from zero to maximum, then decreases to zero, then reversel and again taken to –Hmax and finally back to zero. The variation of B with respect to H can be represented by a closed Hystersis loop.

**Important terms in this loop:**

**Reversible Permeability :-** This is the slope of the B-H curve in the low field region near the origin. In this region there is no hystersis i.e. if the field is truned off B is back to zero. That is why permeability in this region is called reversible.

**Remanance:-** The residual induction when the field is turned off is µoMr where where Mr – remanent magnetization. The value of magnetic induction Mr which remains after the material has been magnetized and the magnetising force. i. e. has been reduced to zero is known as remanent induction.

The value of remanent induction depends upon the degree of magnetization of the specimen before making H zero. If the magnetic induction B reduces the saturation value before H is reduced to Zero. The liuniting value of remanent induction is known as remanance or retantivity. Thus the magnetic induction left behind when H is reduced to zero after the specimen has reached the saturation stage is represented by OQ. Remanance = OQ

**Coercivity :** The coercive force is the value of reverse field necessary to make B=0 in the sample i.e. the maganitude of the reverse field required to reduce the remenent induction to zero.

The limiting value of coercive force required to reduce remance to zero is known as coercivity magnetic material having shall coercive force are known as soft where as those possessing a large coercive force are know as hard.

**Mathematically derivation:**

From the hysteres is loop

B = µoH + µoM

here, is the magnetic susceptibility and µ0 is the magnetic permeabilty in vaccum.

Also we know that, B = µH Hence,

So, µ = where µ is magnetic permeability of medium. But, is relative permeability.

**PROCEDURE**

* + 1. Set the primary and secondary coils along with the magnetic sample as shown in figure
    2. Connect the output of the M~H loop kit to the CRO using a BNC to crocodile cables as shown in figure
    3. Set the CRO to obtain the M~H loop on its display by pressing the xy button on it.
    4. Plot the M~H loop on the graph paper by properly adjusting the lines on the paper to match with the lines displayed on the CRO monitor.
    5. Note the X-scale and Y-scale from the CRO.

**OBSERVATION**

The following obsevations are made from the graph plotted from the CRO.

1. Loop width \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ cm
2. Intercept \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ cm
3. Tip to tip height \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ cm
4. Slope of the (B – H) Curve \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \_

**CALCULATION**

1. Coercive Field
2. Remenant Magnetization

1. Saturation Magnetization

1. Magnetic Suseptibility
2. Magnetic Permeability

**RESULT**

The coercive field was found to be \_\_\_\_\_\_\_\_\_\_

The Remenant Magnetization was found to be \_\_\_\_\_\_\_\_\_\_

The Saturation Magnetization was found to be \_\_\_\_\_\_\_\_\_\_

The Magnetic Suseptibility was found to be \_\_\_\_\_\_\_\_\_\_

The Magnetic Permeability was found to be \_\_\_\_\_\_\_\_\_\_

**VIVA QUESTIONS**

Q1. Define Hysteresis ?

Ans. It is the difference in output when the measurand value is first approached with increasing and then with decreasing values. It is expressed in percent of full scale during any one-calibeation cycle.

Q2. What is Hysteresis Loop ?

Ans. It is the closed curve obtained for a material by plotting (usually to rectangular coordinates) corresponding values of magnetic induction, B, for ordinates and magnetizing force, H, for abscissa when the material is passing through a complete cycle between definite limits of either magnetizing force, H, or magnetic induction, B.

Q3. Define magnetic flux ?

Ans. It is defined as the “flow” of magnetic field. Mathematically, it is the surface integral of the normal component of the magnetic induction, B, over an area, A. Ø =

where: Ø = magnetic flux, in Maxwells; B = magnetic induction, in gauss; and

dA = an element of area, in square centimeters. When the magnetic induction B, is uniformly distributed and is normal to the area A, the flux, Ø = BA.

Q4. What is unit of magnetic field strength ?

Ans. The unit of magnetic field strength H is measured in ampere/ meter.

Q5. Define permeability ?

Ans. Permeability is the degree of magnetization of a material that responds linearly to an applied magnetic filed. It is the general term used to express various relationships between magnetic induction, B, and the field strength, H.

Q6. What is magnetic field strength ?

Ans. Magnetizing demagnetizing force is the measure of the vector magnetic quantity that determines the ability of an electric currunt, or a magnetic body, to induce a magnetic field at a given point. Generally, it is measured in ampere/meter.

Q7. What is the relationship with M, H, B and µ ?

Ans. A linear relationship between M and H also implies a linear relationship between B and H. In fact, we can B = µH, hera µ = (1 + )

Q8. What is hard and soft magnetic materials, define based on hysteresis loop ?

Ans. For HMM the area of the hysteresis loop is higher then that of the SMM.

Q9. What is CRO ?

Ans. The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and aptitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability, and ease of operation make it suitable as a general-purpose laboratory instrument.

Q10. Define these following in I-H curve or in hysteresis loop: (1) Retentivity (2) Residual Magnetism or Residual Flux (3) Coercive force.

Ans: From the hysteresis loop, a number of primary magnetic properties of a material can be determined.

1. **Retentivity –** It is a measure of the residual flux density corresponding to the saturation induction of a magnetic material. in other words, it is a material’s ability to retain a certain amount of residual magnetic field when the magnetizing force is removed after achieving saturation . ( The value of B at point b on the hysteresis curve.)
2. **Residual Magnetism or Residual Flux –** The magnetic flux density that remains in a material when the magnetizing force is zero. The residual magnetism and retentivity are the same when the material has been magnetized to the saturation point.
3. **Coercive Force –** It is the amount of reverse magnetic field which must be applied to a magnetic material to make the magnetic flux return to zero. ( The value of H at point c on the hysteresis curve.)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

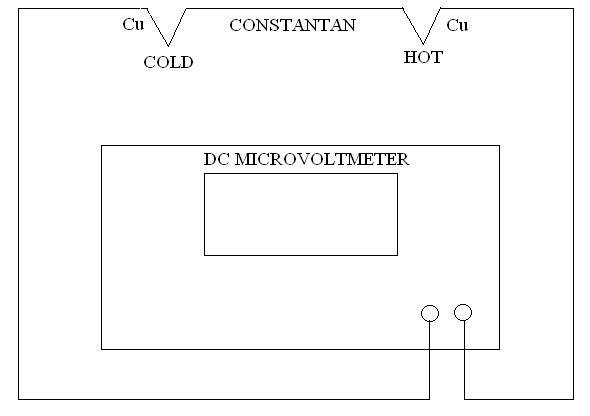
**EXPERIMENT NO. 9**

**OBJECTIVE**

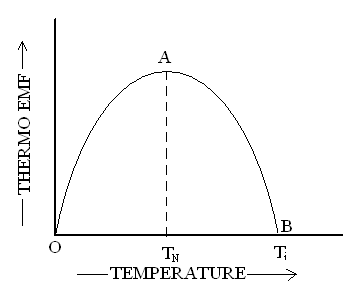
To study the variation of thermo e.m.f. of iron-copper thermocouple with temperature and to plot a graph between thermo e.m.f. and temperature of hot junction.

**EQUIPMENT REQUIRED**

The set up New Tech Type DM-105 which consists of a digital D. C. microvolt meter, a iron-copper thermocouple, two stand with one retot ring and two clamp and boss head, thermometer 00-3600, beaker 250 ml, sand bath,funnel 4”, triport stand, leads with crocodile clips.

**FIGURE**

**Figure (1): Set-up for measuring thermo e.m.f.**

****

**Figure (2): Typical graph between temperature and thermo e.m.f.**

**THEORY**

When two junctions of two dissimilar metals are maintained at different temperatures current called as the thermo electric current flows round the circuit as shown in figure a. The e.m.f. responsible for this current is called thermo e.m.f.. The e.m.f. generated depends on the metals constituting the couple and the difference of temperatures between the junctions.

If a graph is plotted between the temperature of the hot junction and the thermo e.m.f., keeping temperature of cold junction constant the graph is parabolic as shown in figure (2). The temperature of hot junction at which maximum current flows in the circuit is known as neutral temperature for the couple. The neutral temperature for a given thermo couple is fixed and remains constant whatever may be the temperature of cold junction. Point A (figure (2)) represents the neutral temperature. Beyond this temperature the e.m.f. begins to decrease till the temperature is reached where the e.m.f. falls to zero and changes sign. This is called temperature of inversion. Point B (figure (2)) represents temperature of inversion. The temperature of inversion is not fixed. It is as much above the neutral temperature as cold junction is below the neutral temperature.

**PROCEDURE**

1. Connect thermo couple to the DC microvolt meter.
2. Put the cold junction of the thermo couple in the ice taken in funnel. Place beaker under the funnel to collect the water.
3. Hot junction of the thermo couple is put in sand bath. One thermometer is placed in sand bath to note the temperature of hot junction.
4. Heat the hot junction and note down thermo e.m.f. from DC microvolt meter at different temperatures of hot junction.
5. Plot graph between temperature and thermo e.m.f..
6. From the graph find the neutral temperature and temperature of inversion.

**OBSERVATION**

Temperature of cold junction = \_\_\_\_\_\_\_\_\_ 0C

**Table: Determination of thermo e.m.f.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Temperature of Hot junction (θ in 0C)** | **Thermo e.m.f. E (in µV)** |  | **Sr. No.** | **Temperature of Hot junction (θ in 0C)** | **Thermo e.m.f. E (in µV)** |
| 01. | 40 |  | 31. | 190 |  |
| 02. | 45 |  | 32. | 195 |  |
| 03. | 50 |  | 33. | 200 |  |
| 04. | 55 |  | 34. | 205 |  |
| 05. | 60 |  | 35. | 210 |  |
| 06. | 65 |  | 36. | 215 |  |
| 07. | 70 |  | 37. | 220 |  |
| 08. | 75 |  | 38. | 225 |  |
| 09. | 80 |  | 39. | 230 |  |
| 10. | 85 |  | 40. | 235 |  |
| 11. | 90 |  | 41. | 240 |  |
| 12. | 95 |  | 42. | 245 |  |
| 13. | 100 |  | 43. | 250 |  |
| 14. | 105 |  | 44. | 255 |  |
| 15. | 110 |  | 45. | 260 |  |
| 16. | 115 |  | 46. | 265 |  |
| 17. | 120 |  | 47. | 270 |  |
| 18. | 125 |  | 48. | 275 |  |
| 19. | 130 |  | 49. | 280 |  |
| 20. | 135 |  | 50. | 285 |  |
| 21. | 140 |  | 51. | 290 |  |
| 22. | 145 |  | 52. | 295 |  |
| 23. | 150 |  | 53. | 300 |  |
| 24. | 155 |  | 54. | 305 |  |
| 25. | 160 |  | 55. | 310 |  |
| 26. | 165 |  | 56. | 315 |  |
| 27. | 170 |  | 57. | 320 |  |
| 28. | 175 |  | 58. | 325 |  |
| 29. | 180 |  | 59. | 330 |  |
| 30. | 185 |  | 60. |  |  |

**CALCULATION**

A graph is plotted between temperature difference and thermo e.m.f. and from the graph it is found that a. Neutral temperature, TN = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ oC and

b. Temperature of inversion Ti = \_\_\_\_\_\_\_\_\_\_\_\_\_oC

**RESULT**

The neutral temperature of thermo couple was found to be TN = …………………….

The temperature of inversion of thermo couple was found to be Ti = ……………………..

**PRECAUTIONS**

1. In the thermo couple the two dissimilar metals should be in contact with each other only at the junction.
2. The ends of the connections wires should be properly cleaned.
3. The connections should be neat and tight.

**VIVA QUESTIONS**

Q 1. What is thermo e.m.f.?

Ans: The e.m.f. generated due to temperature difference between two junctions of metals is called thermo e.m.f.

Q 2. What is thermo couple?

Ans: A junction of two different metal wires is called thermo couple.

Q 3. What is Seebeck effect?

Ans: When two wires of different metal are joined to make a close circuit and the two junctions of metals is kept at different temperature then a current flow in the circuit from cold to hot junction. This is known as See beck effect.

Q 4. What is Peltier effect?

Ans: When current is passing through junctions of wires of two different metals then one junction is heated up while the other is cooled.

Q 5. What is Thomson effect?

Ans: Set up of a potential difference due to temperature difference in a conductor, called Thomson effect.

Q 6. What is a junction in thermocouple?

Ans: The point at which two thermocouple alloys are joined. In a typical thermocouple circuit there is a measuring junction and a reference junction.

Q 7. What do you mean by neutral temperature in the thermocouple?

Ans: The temperature of the hot junction of a thermocouple at which the e.m.f. of the thermocouple attaints its maximum value, when the cold junction is maintained at a constant temperature of 0oC. In other words the temperature at which maximum current flows in the circuit.

Q 8. What is the temperature of inversion for a thermocouple?

Ans: The temperature to which one junction of a thermocouple must be raised in order to make the thermo electric electromotive force in the circuit equal to zero, when the other junction of the thermocouple is held at constant low temperature.

Q 9. Define absolute zero temperature.

Ans: The absolute zero is the lowest possible temperature and body would have no heat energy.

Q 10. What is the general nature of the thermo e.m.f. v/s temperature curve?

Ans: The general nature of the thermo e.m.f. v/s temperature curve is parabola

Q 11. What is the nature of the curve that you have obtained?

Ans: We obtained a straight line, because the temperature of the hot junction is much lower than the natural temperature of the couple.

Q 12. How will the e.m.f. change if the temperature of the hot junction is increased beyond the natural temperature?

Ans: The e.m.f. will decrease with increase of temperature and at a temperature, called the temperature of inversion, the e.m.f. will be reduced to zero. After the Inversion temperature the polarity of thermo e.m.f. will reverse.

Q 13. Define thermal conductivity.

Ans: It is the property of a material to conduct heat in the form of thermal energy.

Q 14. Does the temperature of the cold junction affect the variation of e.m.f. in any way?

Ans: Yes, the inversion temperature is lowered if the cold junction is at a higher temperature than zero.

Q 15. What are the uses of thermo couple?

Ans: Thermo couples are used

1. To detect heat radiation
2. In thermo galvanometers to measure high frequency
3. In thermopile to study infrared radiations

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)

**EXPERIMENT NO. 10**

**OBJECTIVE**

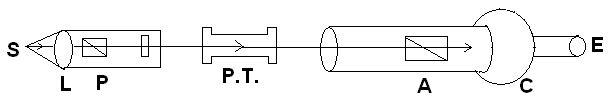
To determine the specific rotation of cane sugar solution.

**EQUIPMENT REQUIRED**

The experimental set up New Tech Type CM-122 consists of Bi-quartz polarimeter, source of light on stand, Beaker, Funnel, Pipette, Graduated cylinder.

Other items required: Physical balance, weight box, sugar, filter paper.

**FIGURE**



**Figure: Set-up for measuring Angle of Rotation**

**THEORY**

The specific rotation of cane sugar solution is given by

S = 10θ/lc = 10θV/lm

Where θ – Angle of rotation

l – Length of solution in cm

m – Amount of sugar in solution in gm

V – Volume of solution in C.C.

**PROCEDURE**

1. Weigh 10 gm sugar by a physical balance and place it in graduated cylinder.

2. Pour some distilled water in the cylinder and stir it till sugar is dissolved. Add some more distilled water so that volume of solution is 100 C.C.

3. Filter the solution by a filter paper.

4. Take out polarimeter tube; clean it and the circular glass plates fixed at its two ends. Fill it with distilled water. Be careful so that no air bubble is left inside the tube when the end caps are screwed. Place the tube at its proper position in the polarimeter.

5. Find least count of the vernier and circular scale fitted with analyzer.

6. Switch on the source of light. Look through the eyepiece the circular field of view will have the two halves of different colours – blue and red. Rotate the analyzer till the two halves have the same tint of colour. Note the reading on the scale.

7. Rotate the analyzer by 1800 and obtain the same state as in (6) again note the reading.

8. Remove the distilled water from the polarimeter tube. Rinse it with a small amount of the sugar solution. Fill it completely with the solution and place it in its proper position.

9. On looking through the eyepiece you will find the setting of same tint disturbed. Rotate the analyzer to get same tint of two halves of field of view. Note the reading on the scale.

10. Rotate the analyzer by 1800 and again adjust to get equal tint of passage. Note the reading on the scale.

11. Take a known volume of sugar solution and dilute it with a known quantity of distilled water. Calculate the concentration of sugar in the new solution. Using this solution repeat the above procedure.

12. Take about three sets of observations with solutions of different strengths.

13. Find the difference of the scale readings with distilled water and the corresponding readings with solution. It will give the angles of rotation in the two settings. Find the mean rotation to each case.

14. Measure the length of polarimeter tube in cm and temperature of solution.

**OBSERVATION**

1. Length of polarimeter tube l = ……………cm

2. Room temperature t = ……………..0C

3. Least count of analyzer:

Smallest division on main scale (x) = 10

Total no. of division on vernier scale (n) = 10

Least count = x/n = 10/10 = 60’/10 = 6’

**Table:** **Determination of Angle of Rotation**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S. No. | Reading of analyzer scale for equal tint of passage | | | | | | | | | | | | | Angle of Rotation  (Degrees) | | |
| With Distilled Water | | | | | | With Sugar Solution | | | | | | |
| First position  (Degrees) | | | Position after rotation by 1800 (Degrees) | | | Conc.  Of  Sugar  Sol.  Gm/CC | First position  (Degrees) | | | Position after rotation by 1800 (Degrees) | | |
| M.S.R. | V.S.R. | Total (a) | M.S.R. | V.S.R. | Total (b) | M.S.R. | V.S.R. | Total (c) | M.S.R. | V.S.R. | Total (d) | θ1=(c-a) | θ2=(d-b) | Mean θ  = (θ1+θ2)/2 |
| 1. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**CALCULATION**

1. Determination of specific rotation of cane sugar solution:

S = 10θ/lc = 10θV/lm

= ………………0/Deci./gm/CC

2. Standard value of S = 660/Deci./gm/CC

And error = X 100 %

=………………%

**RESULT**

The specific rotation of cane sugar solution is S =………0/Deci./gm/CC with error ………%.

**PRECAUTIONS**

1. The polarimeter should be neat and clean.

2. Always rinse the tube atleast twice from the solution whose rotation is to be determined.

3. While filling the experimental tube with solution no air bubble should remain in it.

4. Solution should be filtered before use.

5. Position of equal tint of passage i.e. same colour of two halves of field of view should be accurately determined.

**VIVA QUESTIONS**

Q.1 What is polarization?

Ans. The property of light by virtue of which the plane of vibration of waves is limits in one particular direction at right angle to the direction of propagation of waves is defined polarization.

Q.2 What is angle of polarization?

Ans. The angle of incidence corresponding to which the reflected light is completely polarized, is called angle of polarization

Q.3 What is Polari meter?

Ans. The instrument which is used to measure the angle of rotation of the plane of polarization of polarized light by optically active substance is called Polari meter.

Q.4 What is Nicol prism?

Ans. Nicol prism is device made by calcite crystal and used to produce plane polarized light and analyses it.

Q.5 What do you mean by angle of optical rotation?

Ans. The angle through which the plane of vibration of plane polarized light is rotated called angle of optical rotation.

Q.6 How does sugar solution behave?

Ans. It is dextro rotatory type i.e. it rotates the plane of polarization towards right.

Q.7 What is meant by specific rotation?

Ans. The specific rotation ‘S’ of a substance at a given temperature and for a given wavelength of light, is defined as the rotation (in degree ) produced by one decimeter length of the substance in solution when the concentration of the solution is l gm./cm3.

Q.8 On what factors specific rotation depends?

Ans. The specific rotation depends upon-

(1)The nature of the solvent and the solute.

(2)The wavelength of the light used.

(3)The temperature of the solution.

Q. 9 What is biquartz plate?

Ans. It consists of two semicircular plates of quartz of same thickness such that one of them is left handed circularly polarized and another one is right handed circularly polarized. Both are cut perpendicularly to optic axis and joined together along diameter.

Q.10 What is ‘sensitive tint’ or ‘tint of the passage’?

Ans. If the principal section of the analyzing Nicol is set in such a way that the yellow light will not transmitted through the analyzer, while pink and blue light will be present in the same proportion in each half therefore, the two halves of the field will appear reddish-violet coloured. This colour is called ‘sensitive tint ‘or ‘tint of passage’.

Q.11 What is meant by optically active substance?

Ans. The substance which can rotate the plane of polarization of polarized light.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Signature of the Faculty with Date)