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Experiment - 12

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"Half Shade Polarimeter"

Objective :- To determine specific rotation of sugar solution with the help of Laurent's half shade polarimeter.

Apparatus required :- Polarimeter, source of monochromatic light, beaker, 100ml measuring flask, physical balance and weight box.

Formula used :- The specific rotation of cane sugar solution is given by

$$\alpha_\lambda^T = \frac{\theta}{l.c} = \frac{\theta.V}{l.m} \quad {}^\circ dm^{-1} gm^{-1} cm^3$$

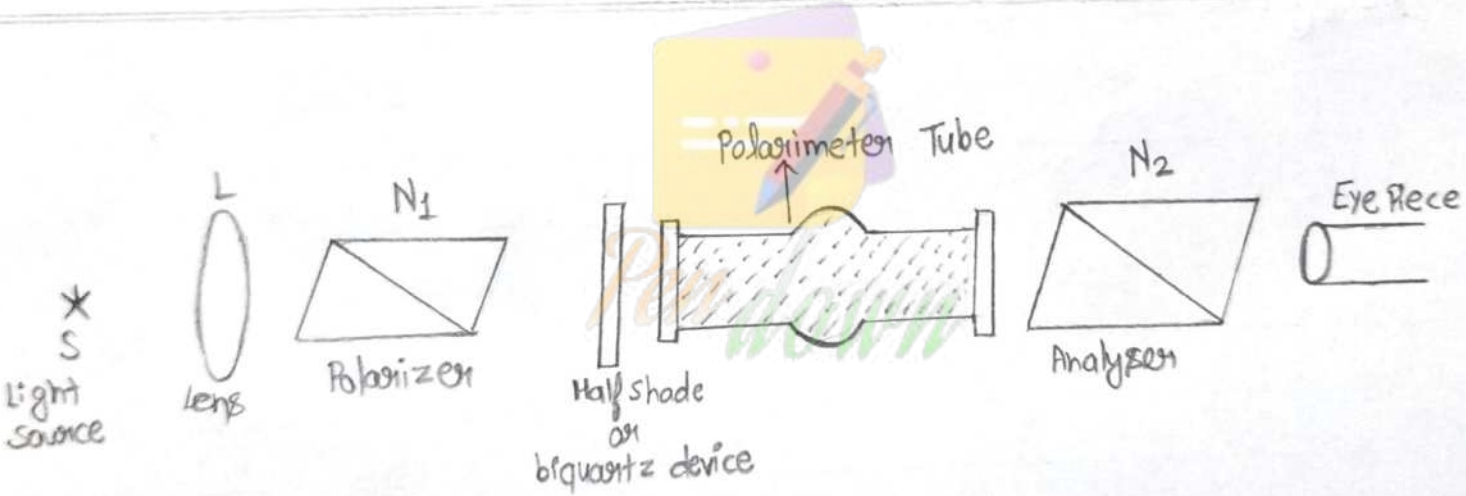
where θ = rotation produced in degrees,
l = length of tube in decimeter
$c = \frac{m}{V}$ = Concentration of sugar solution in $gm\ cm^{-3}$.

Theory :- The polarimeter uses half shade plate to split the light beam. The first half is made up of ordinary glass and other half is made up of wave plate. Let beam 1 (unmodified) makes 0° from vertical and beam 2 makes θ° from vertical.

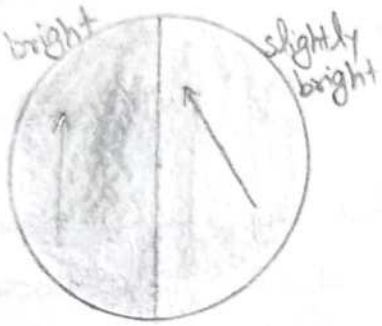
by Law of Mallus, Intensity of light $\propto \cos^2\theta$

$$\boxed{I = I_0 \cos^2\theta}$$

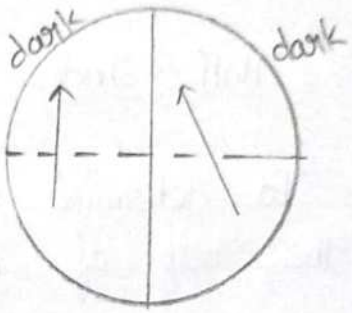
- Schematic of half shade plate. The plate consists of two parts.
  Left half is made of ordinary glass.
  Right half is made of biquartz plate.
  The thickness of plate is chosen such that the plate behaves as half wave plate.



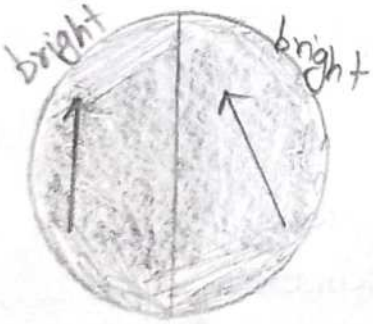
- Setup for the Experiment.
  Polarimeter Tube contain optically active solution.
  Readings will be taken from eye piece of Analyser.



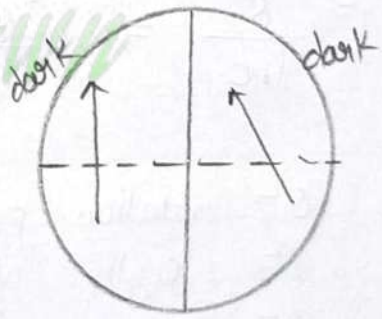
(1) when Analyser make 0° with vertical, both bright



(2) when Analyser make 90° with vertical, both dark



(3) Analyser makes 180° with vertical, both bright



(4) Analyser makes 270° with vertical. both dark

Procedure :- (i) Swich on the light source. Fill the polarimeter tube with distilled water such that there is no air bubble inside the tube.
Now look through eye piece of analyser.

(ii) Two half of unequal intensity are observed. Now slowly rotate the analyser clockwise so that two half just become equally bright in field of view. (θ_1)

(iii) Rotate Analyser clockwise until two halves just becomes equally bright at 180° apart. Record the reading (θ_2)

(iv) Rotate further such that one half become dark and again rotate for both half equally bright. (θ_3)

(v) Rotate analyser in anti-clockwise direction until the two halves in the field of view just become equally bright at 180° apart. (θ_4)

(vi) Prepare Sugar solution of known strength and replace the distilled water with sugar solution. and repeat above steps to calculate θ_1', θ_2', θ_3' and θ_4'.

Observations :-

Mass of Petri dish = 0 gm
Mass of Petri dish + Sugar = 2 gm
Mass of Sugar m = 2 gm
Volume of distilled water V = 100 ml

Concentration of Sugar solution, $c = \frac{m}{V} = \frac{2}{100} = 0.02$ gm/ml

Length of polarimeter Tube ; l = 20 cm = 2 dm
Room Temperature, T = 32°C
Least Count of Analyser scale = 0.1°.

Table 1: Measurement of angle of rotation of plane polarized light by sugar solution:

S.NO	Analyser reading with Distilled water					Sugar solution					$\Delta\theta$
	clockwise rotation		anti-clockwise rotation		Mean θ	clockwise rotation		anticlockwise rotation		Mean θ'	$\theta - \theta'$
	initial θ_1 (°)	180° apart θ_2 (°)	initial θ_3 (°)	180° apart θ_4 (°)	(°)	initial θ_1' (°)	180° apart θ_2' (°)	initial θ_3' (°)	180° apart θ_4' (°)	(°)	(°)
1.	2.5°	182.8°	181.6°	2.6°	92.375°	3.4°	184.6°	184.5°	4.2°	94.175°	-1.800°
2.	1.2°	181.3°	181.6°	1.1°	91.300°	4.2°	184.4°	183.5°	4.4°	94.125°	-2.825°
3.	1.9°	181.4°	181.5°	1.1°	91.475°	4.4°	183.2°	184.2°	4.6°	94.100°	-2.625°

Mean of $\Delta\theta = \frac{-1.800^\circ - 2.825^\circ - 2.625^\circ}{3} = -2.417^\circ$

Taking $|\text{Mean of } \Delta\theta| = 2.417^\circ$ i.e $(\theta' - \theta)$

Calculations :- at $T = 32^\circ C$, for sodium light source, $\lambda = 5893\,\text{Å}$

$$\alpha_\lambda^T = \frac{\Delta\theta}{l.c} = \frac{\Delta\theta \cdot V}{l \cdot m} = \frac{2.417 \times 100}{2 \times 2} \quad {}^\circ dm^{-1} gm^{-1} cm^3$$

$$\boxed{\alpha_\lambda^T = 60.425\ {}^\circ dm^{-1} gm^{-1} cm^3}$$

Result :- The value of specific rotation of Cane sugar solution at $32^\circ C$ temperature and wavelength $\lambda = 5893\,\text{Å}$ is determined and comes out to be $60.425^\circ dm^{-1} gm^{-1} cm^3$.

Precautions :- (i) The polarimeter Tube should be well cleaned.
(ii) There should be no air bubble inside the tube.
(iii) Readings should be taken when two halves of the field of view just become equally bright for both clockwise and anticlockwise rotation of analyzer.

Remark :- In half shade polarimeter, the half wave plate create a phase difference of π.
If Intensity of half glass side is maximum at $\theta = 0^\circ$ and due to second beam slightly less than maximum. on rotating the analyser clockwise, Intensity of beam 1 decreasing and at 90° Intensity due to beam 1 is zero (completely dark).
It all happen by law of mallus i.e $I = I_0 \cos^2\theta$ by applying it, we can calculate Intensity at any θ.