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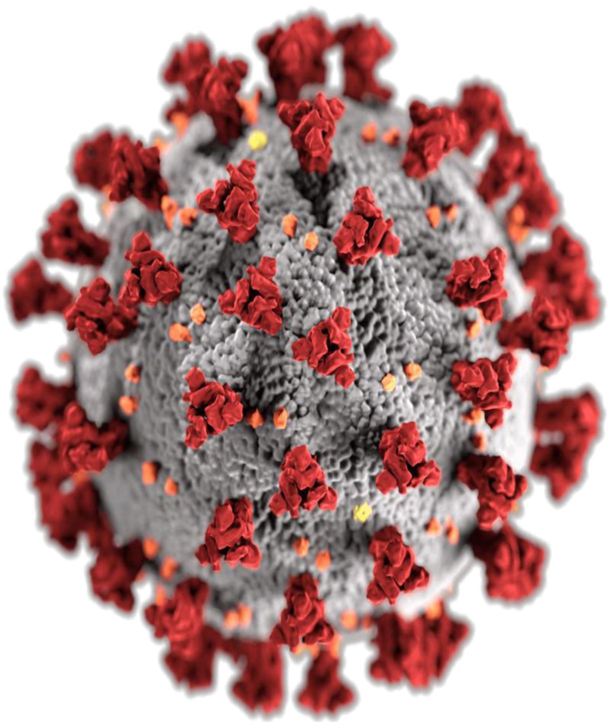
Welcome to my Class

Physics Ph 1109

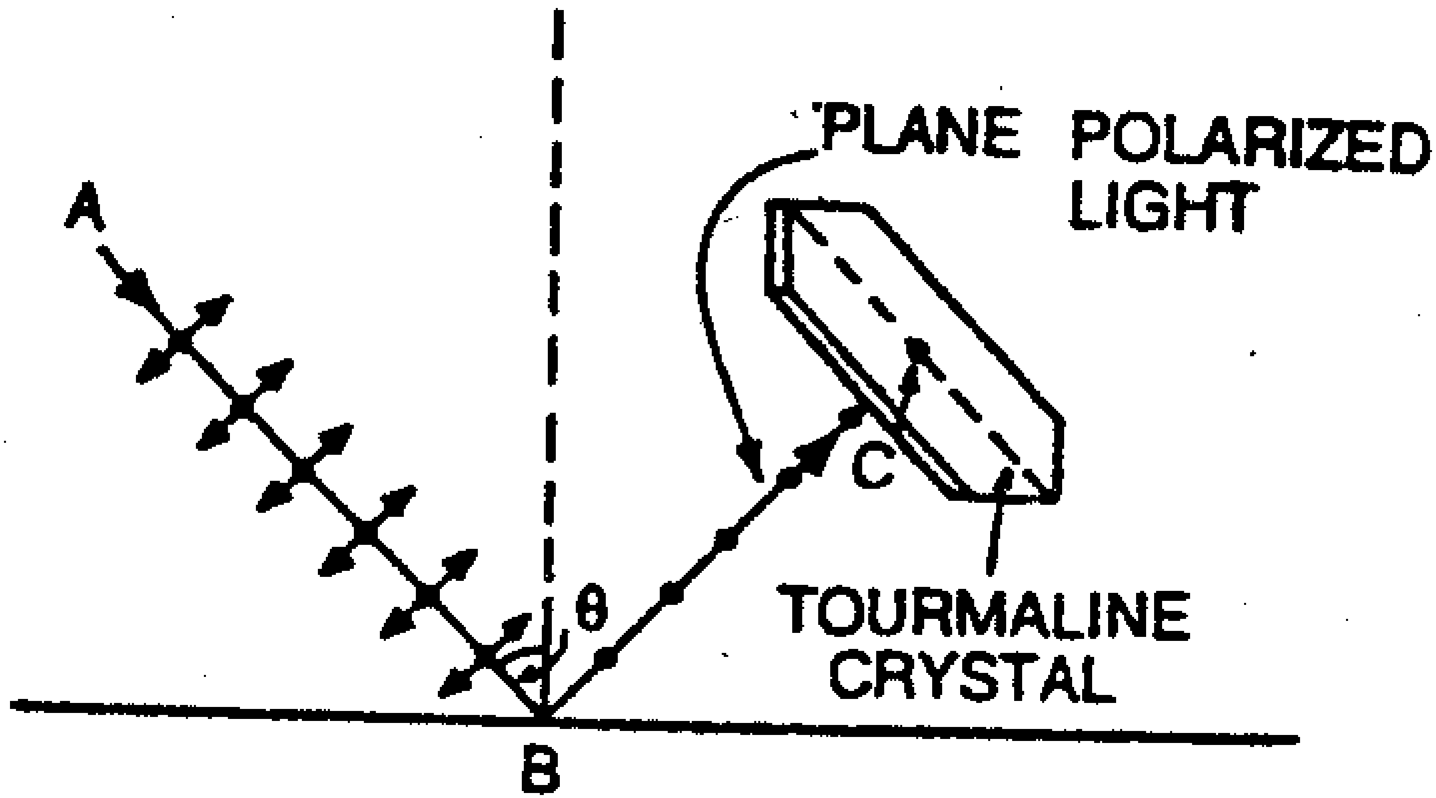
11:45 AM
November 17, 2020

COVID-19 Precautions



- Don’t be afraid
- Be aware of the pandemic
- Use appropriate outfits if you compelled to go out
- Try to maintain proper diet
- Do not forget to exercise (at least one hour) regularly
- Try to follow the guidelines of WHO and Bangladesh Government
- Try to stay at home

Polarization by Reflection

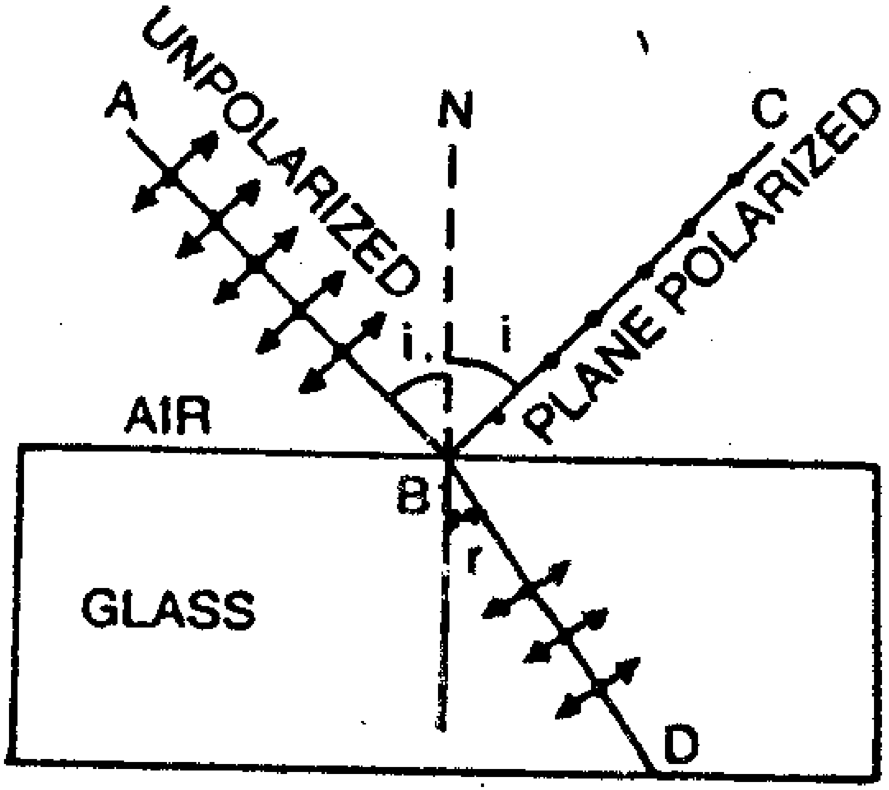


Polarization of right by reflection from the surface of glass was discovered by Malus in 1808. He found that polarized light is obtained when ordinary light is reflected by a plane sheet of glass.

Consider the light incident along the path AB on the glass surface. Light is reflected along BC. In the path of BC, place a tourmaline crystal and rotate it slowly. It will be observed that light is completely extinguished only at one particular angle of incidence. This angle of incidence is equal to 57.5^o for a glass surface and is known as the polarizing angle. Similarly polarized light by reflection can be produced from water surface also.

Brewster's Law

In 1811, Brewster performed a number of experiments to study the polarization of light by reflection at the surfaces of different media.



He was able to prove that the tangent of the angle of polarization is numerically equal to the refractive index of the medium. Moreover, the reflected and the refracted rays are perpendicular to each other.

Suppose, the unpolarized light is incident at an angle equal to the polarizing angle on the glass surface. It is reflected along BC and refracted along BD

From Snell's law

$$\mu = \frac{\sin i}{\sin r} \qquad (1)$$

From Brewster's law

$$\mu = tani = \frac{sini}{cosi} \qquad (2)$$

Comparing (1) and (2)

$$cosi = sinr = \cos\left(\frac{\pi}{2} - r\right)$$

$$\therefore \quad i = \frac{\pi}{2} - r$$

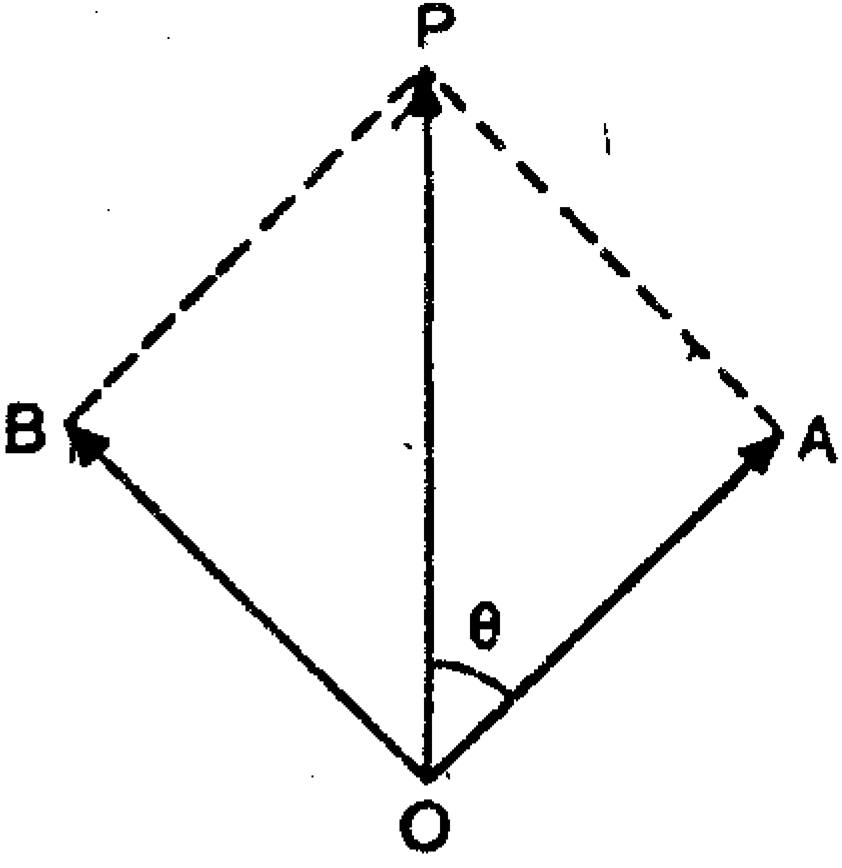
$$or \qquad i + r = \frac{\pi}{2}$$

$$As \quad i + r = \frac{\pi}{2}, \qquad \angle CBD \; is \; also \; equal \; to \; \frac{\pi}{2}$$

Malus Law

When a beam of light, polarized by reflection at one plane surface is allowed to fall on the second plane surface at the polarizing angle the intensity of the twice reflected beam varies with the angle between the planes of the two surfaces.

The law of Malus states that the intensity of the polarized light transmitted through the analyzer varies as the square of the cosine of the angle between the plane of transmission of the analyzer and the plane of the polarizer.



Let OP = a be the amplitude of the vibrations transmitted or reflected by the polarizer and ϴ is the angle between the planes of the polarizer and the analyzer.

Resolve OP into two components,

(i) a cos ϴ along OA and
(ii) a sin ϴ along OB.

Only the a cos ϴ component is transmitted through the analyzer.

The intensity of the transmitted light through the analyzer

$$E_1 = (a cos\theta)^2 = a^2 cos^2\theta$$

$$But \quad E = a^2$$

where E is the intensity of incident polarized light

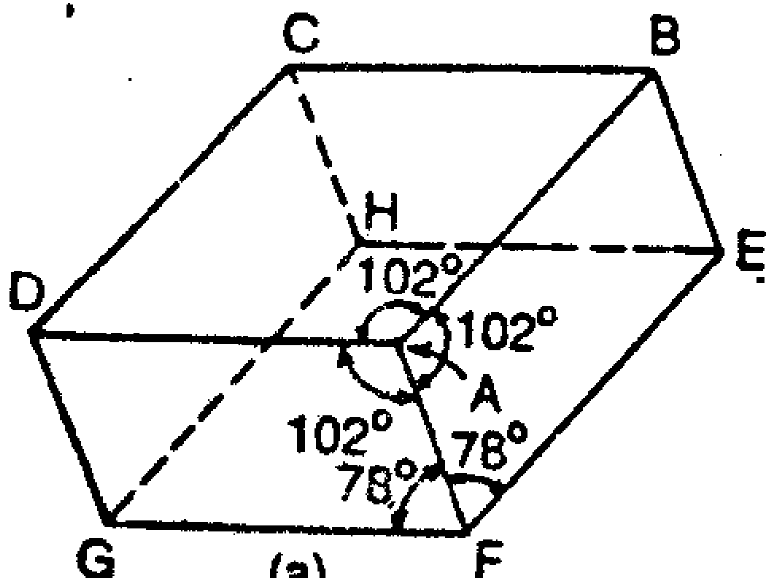
$$\therefore \quad E_1 = E cos^2\theta$$

$$or \quad E_1 \propto cos^2\theta$$

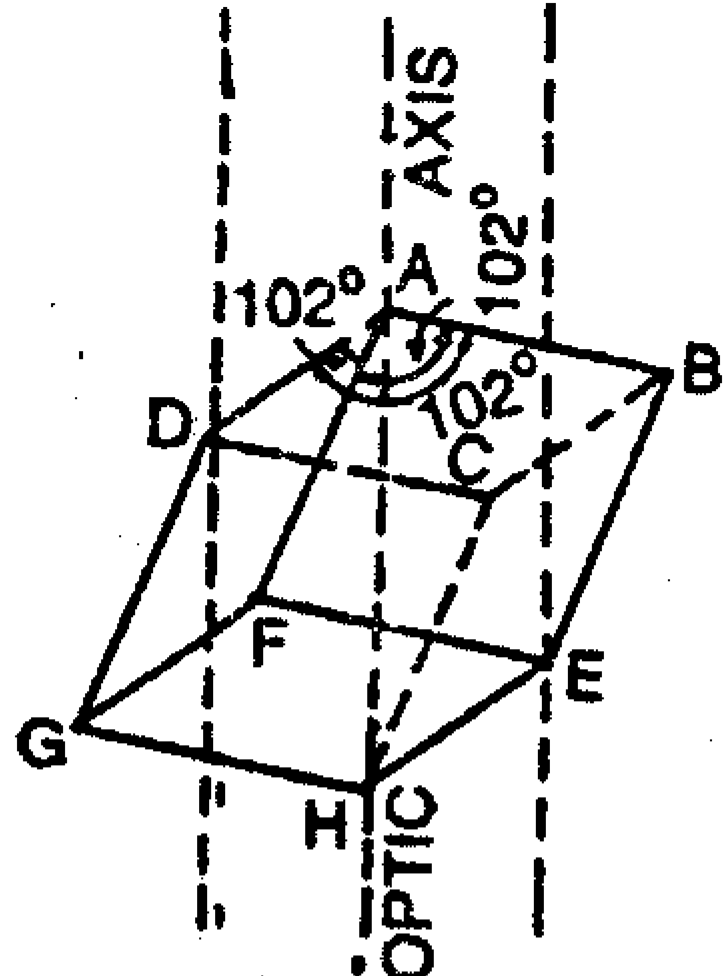
Double Refraction

Erasmus Bartholinus discovered, in 1669, that when a ray of light is refracted by a crystal of calcite gives two refracted rays. This phenomenon is called double refraction.

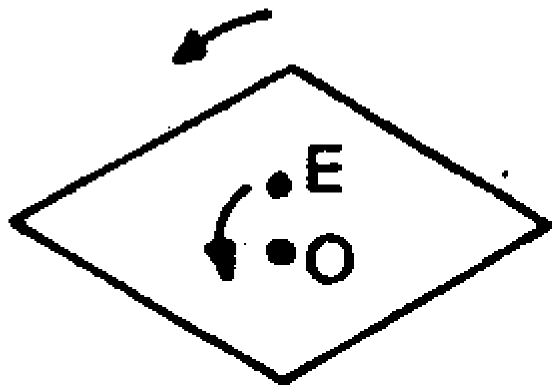
Calcite or Iceland spar is crystallized calcium carbonate ($CaCO_3$) and was found in large quantities in Iceland as very large transparent crystals. Due to this reason calcite is also known as Iceland spar. It crystallizes in many forms and can be reduced by cleavage or breakage into a rhombohedron bounded by six parallelograms with angles equal to 102^o and 78^o (more accurately $101^o55'$ and $78^o5'$)

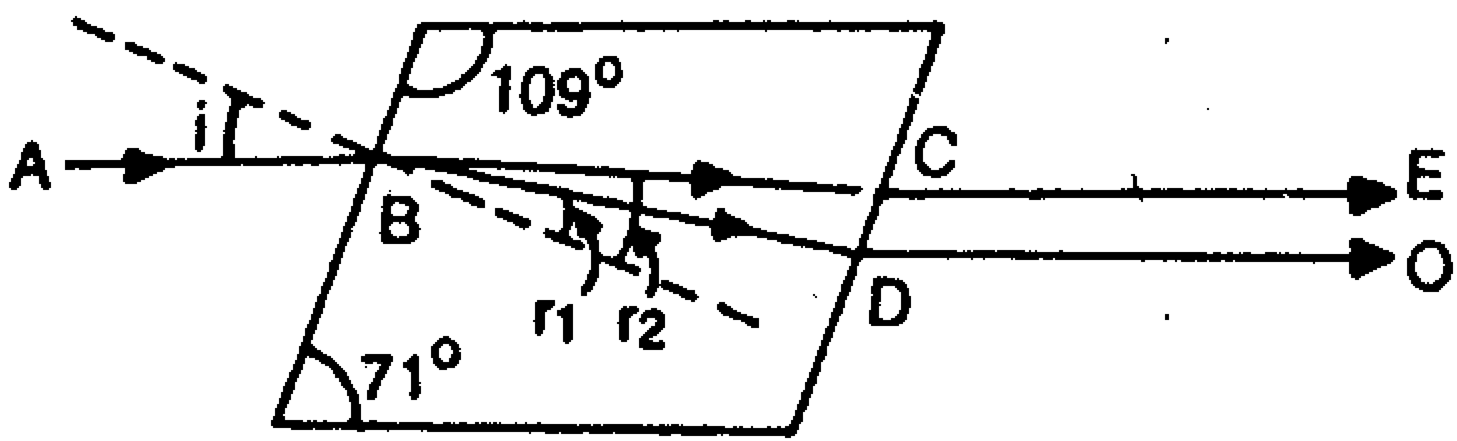


(a)



(b)


E
O


109°
i
A
C
E
B
D
O
r1
r2
71°

The phenomenon of double refraction is absent when light is allowed to enter the crystal along the optic axis

Mark an ink dot on a piece of paper. place a calcite crystal over this dot on the paper. Two images will be observed. Now rotate the crystal slowly. Place your eye vertically above the crystal. It is found that one image remains stationary and the second image rotates with the rotation of the crystal.

The stationary image is known as the ordinary image while the second one is known as the extraordinary image.

The ordinary ray has a refractive index

$$\mu_O = \frac{sini}{sinr_1}$$

The extraordinary ray has a refractive index

$$\mu_e = \frac{sini}{sinr_1}$$

In the case of calcite $\mu_o > \mu_e$, because r_1 is less than r_2. Therefore the velocity of light for the ordinary ray inside the crystal will be less compared to the velocity of light for the extraordinary ray.

Principal Section of the Crystal

A plane which contains the optic axis and is perpendicular to the opposite faces of the crystal is called the principal section of the crystal.

As a crystal has six faces, therefore, for every point there are three principal sections.

A principal section always cuts the surface of a calcite crystal in a parallelogram with angles 109^o and 71^o.

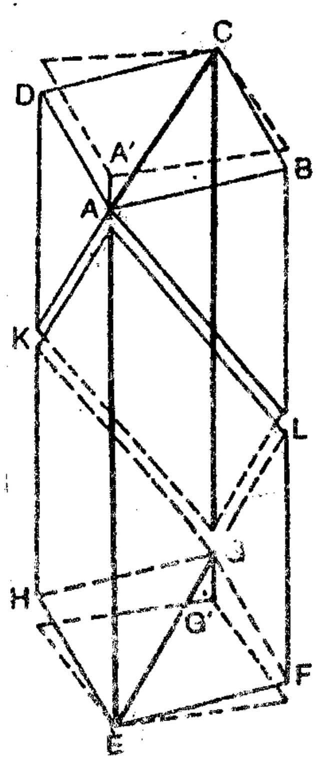
Principal Plane

A plane in the crystal drawn through the optic axis and the ordinary ray is defined as the principal plane of the ordinary ray. Similarly, a plane in the crystal drawn through the optic axis and the extraordinary ray is defined as the principal plane of the extraordinary ray.

In general, the two planes do not coincide. In a particular case, when the plane of incidence is a principal section then the principal section of the crystal and the principal planes of the ordinary and the extraordinary rays coincide.

Nicol Prism

It is an optical device used for producing and analyzing plane polarized light. It was invented by William Nicol, in 1828, who was an expert in cutting and polishing gems and crystals.



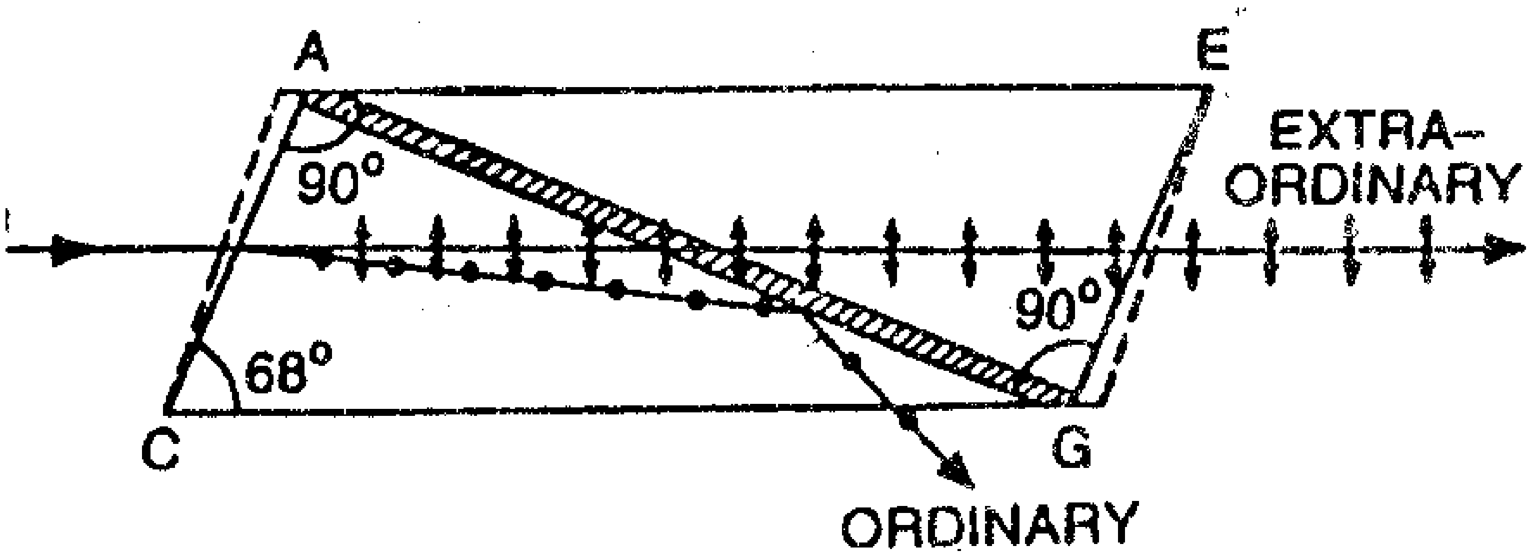
A calcite crystal whose length is three times its breadth is taken. A‘BCDEFG’H represent such a crystal having A' and G' as its blunt corners and A‘CG’E is one of the principal sections with A'CG' = 71^o.

The faces A'BCD and EFG'H are grounded in such a way that the angle ACG becomes = 68° instead of 71°. The crystal is then cut along the plane AKGL. The two cut surfaces are grounded and polished optically flat and then cemented together by Canada balsam whose refractive index lies between the refractive indices for the ordinary and the extraordinary rays for calcite.

Refractive index for the ordinary $\mu_o = 1.658$

Refractive index for Canada balsam $\mu_B = 1.550$

Refractive index for the extra ordinary $\mu_e = 1.486$



Refractive index for ordinary ray with respect to Canada balsam

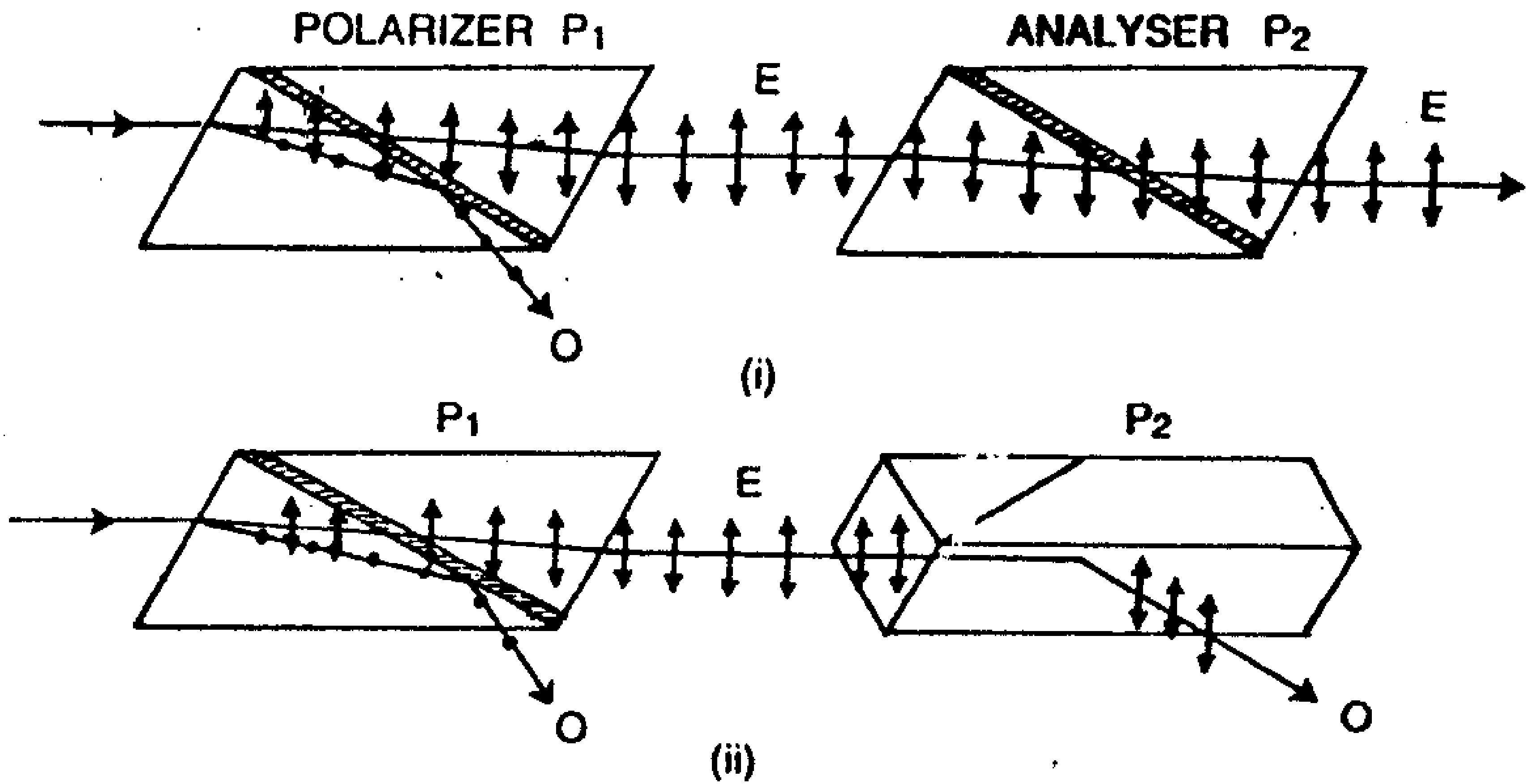
$$\mu = \frac{1.658}{1.550}$$

$$\therefore \quad sin\theta = \frac{1}{\mu}$$

$$\therefore \quad \theta = 69^o$$

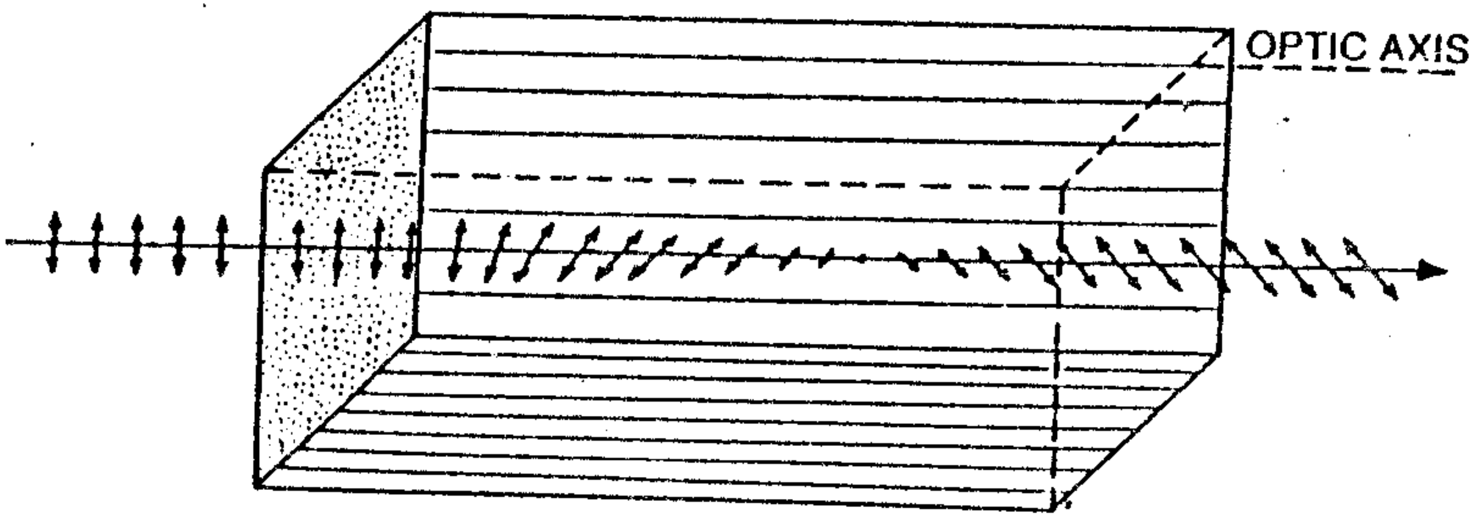
Nicol Prism as an Analyzer

Nicol prism can be used for the production and detection of plane polarized light.



Optical Activity

When a polarizer and an analyzer are crossed, no light emerges out of the analyzer. When a quartz plate cut with its faces parallel to the optic axis is introduced between N_1 and N_2 such that light falls normally upon the quartz plate, the light emerges out of N_2.



The quartz plate turns the plane of vibration. The plane polarized light enters the quartz plate and its plane of vibration is gradually rotated.

The amount of rotation through which the plane of vibration is turned depends upon the thickness of the quartz plate and the wavelength of light.

The action of turning the plane of vibration occurs inside the body of the plate and not on its surface. This phenomenon or the property of rotating the plane of vibration by certain crystals or substances is known as optical activity and the substance is known as an optically active substance.

Some of the substances rotate the plane of vibration to the right and they are called dextrorotatory or right handed. Right handed rotation means that when the observer is looking towards light travelling towards him, the plane of vibration is rotated in a clockwise direction.

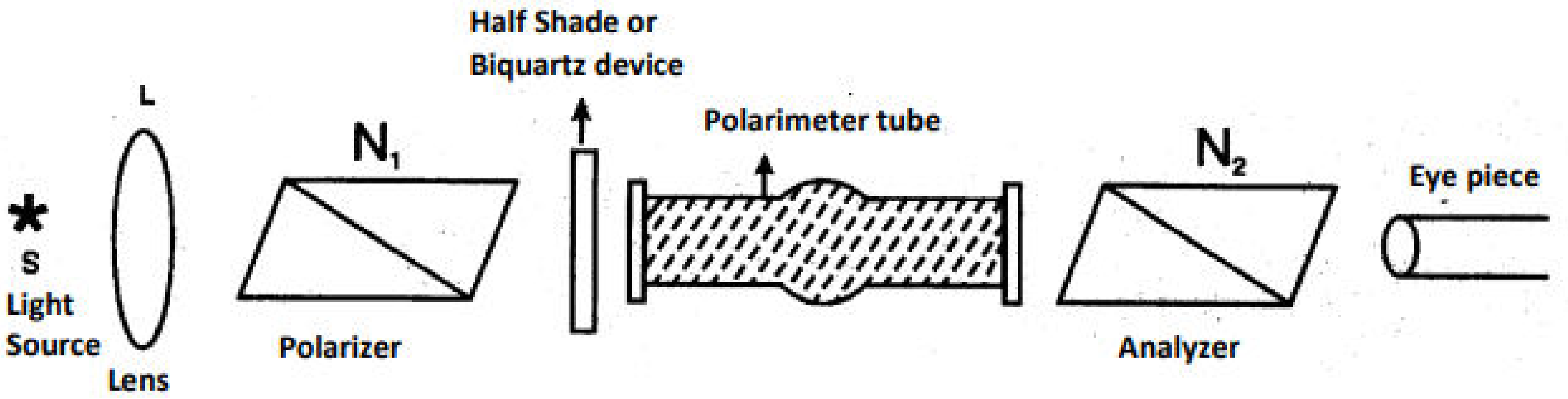
The substances that rotate the plane of vibration to the left (anti-clockwise from the point of view of the observer) are known as laevorotatory or left-handed.

Specific Rotation

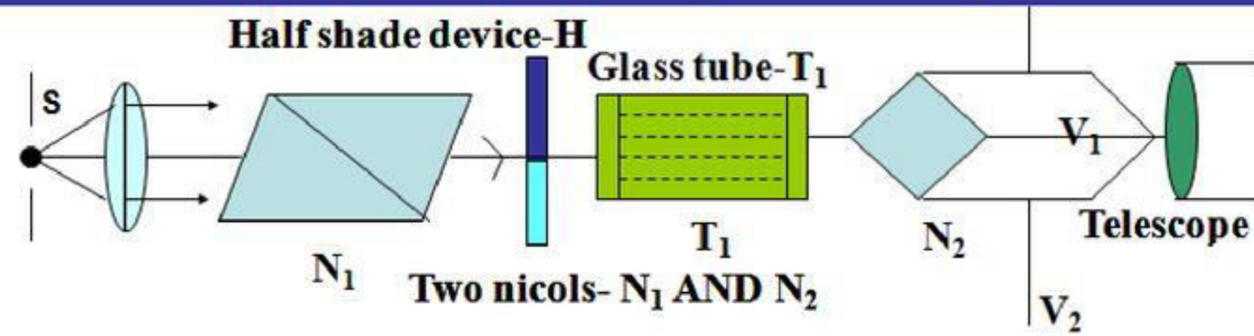
Specific rotation is defined as the rotation produced by a decimeter (10cm) long column of the liquid containing 1 gm of the active substance in one cc of the solution. Therefore

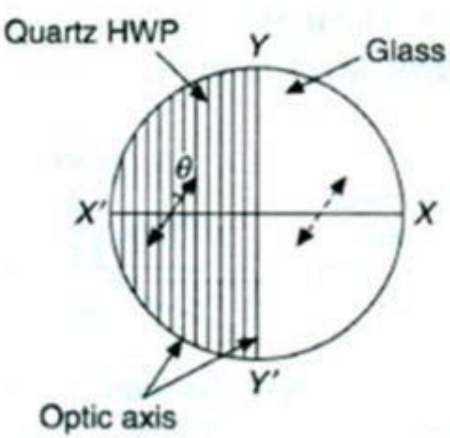
$$S_{\lambda}^{t} = \frac{10\theta}{lc}$$

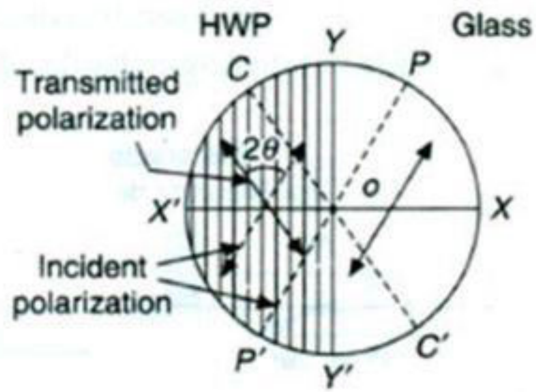
Determination of Specific Rotation of Sugar Solution

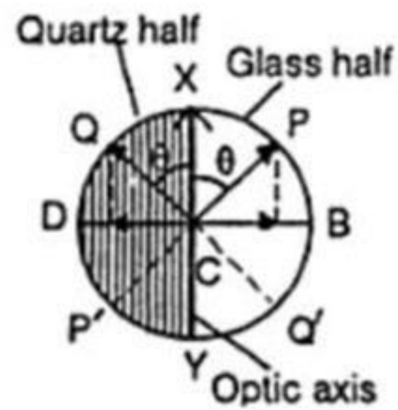


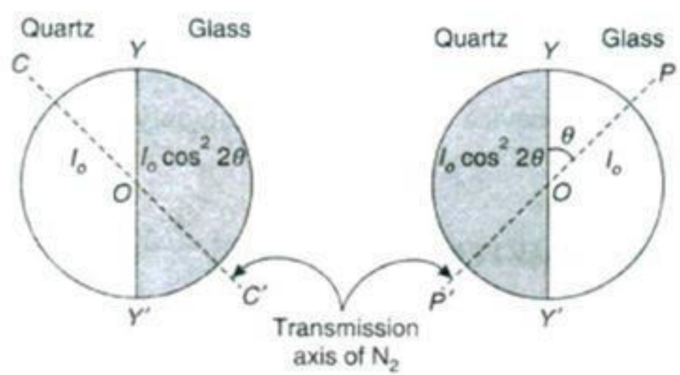
Laurent's Half shade polarimeter

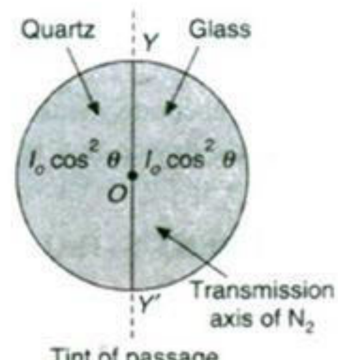













I Thank you