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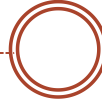
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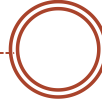
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POLARISATION BY REFRACTION

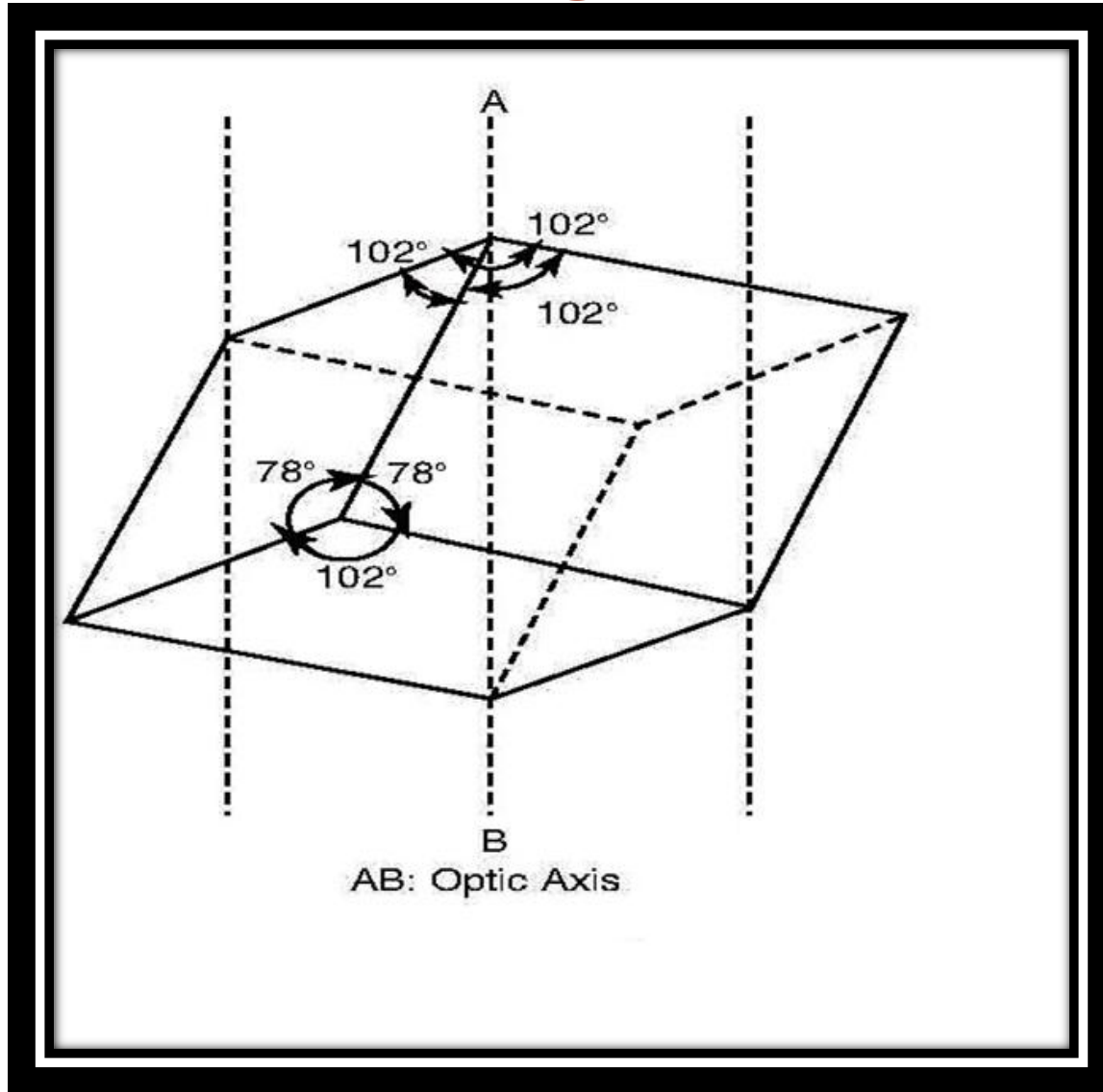
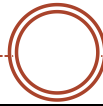
- Polarisation can also take place by the refraction of light, which occurs when a beam of light passes from one material into another material.
- Under this situation, the path of the light beam changes its direction at the surface of the two materials and then the refracted beam acquires some degree of polarisation.
- Mostly, the polarisation occurs in a plane perpendicular to the surface.
- The light is split into two beams upon entering the crystal and both the refracted light beams are polarised - one in a direction parallel to the surface and the other in a direction perpendicular to the surface.
- Since these two refracted rays are polarised with a perpendicular orientation, a polarising filter can be used to completely stop one of the images.

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Optic Axis

- You would have learnt in the experiments using lenses that there exists a line which passes through the centre of curvature of a lens surface such that the light rays are neither reflected nor refracted.
- This is called the optic axis or the principal axis. Similar situation arises for a particular type of crystal such as calcite crystal or tourmaline crystal.
- For these substances there exists a specific direction within the crystal known as the optic axis or the principal axis, which is determined by the atomic configuration of the crystal.
- The optic axis of a calcite crystal denoted by dotted line AB. Any ray of ordinary unpolarised light incident along the optic axis or parallel to this axis does not split up into two rays.

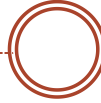


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- The light ray gets split into two rays called as ordinary ray (O-ray) and extraordinary ray (E-ray) only when it makes an angle with the optic axis.
- It is observed that the ordinary and extraordinary rays propagate at the same speed along the optic axis.
- This is true for any direction which is parallel to the optic axis.
- The crystal in which only one such axis (direction) exists is called uniaxial crystal.
- The examples of uniaxial crystals are calcite, tourmaline and quartz. The crystal in which two directions exist along which the speeds of O-ray and E-ray are the same is called biaxial crystal.
- The examples of the biaxial crystals are topaz and aragonite.

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Principal Section of a Crystal

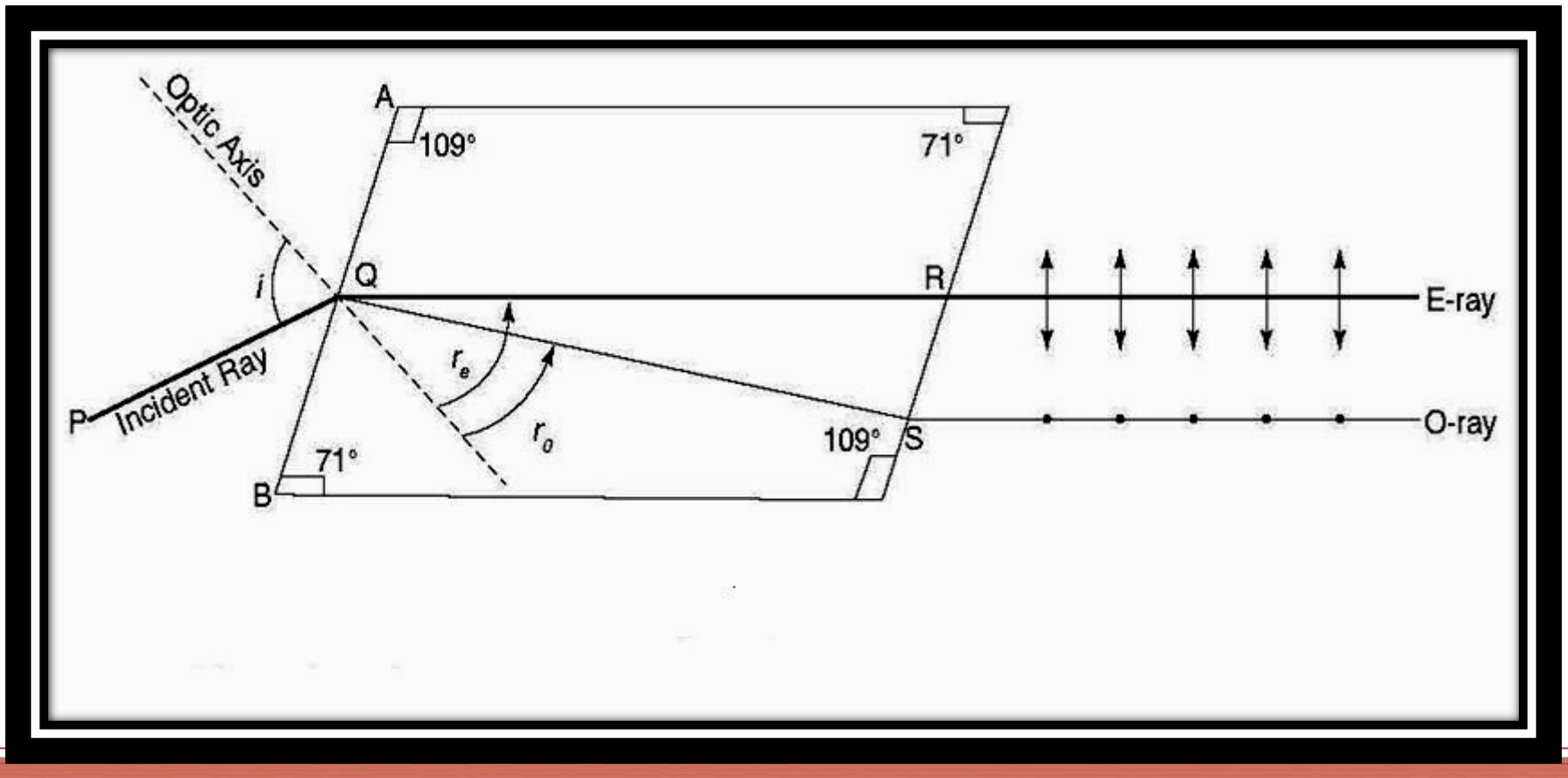
- The plane containing the optic axis and the perpendicular to the pair of opposite faces of the crystal is known as principal section for that pair of faces of the crystal.
- Since the crystal has six faces, for each pair of opposite faces of the crystal, there are three principal sections.

Geometry of Calcite Crystal

- The calcite or calcspar is the commonest crystalline form of calcium carbonate (CaCO_3). It is also known as Iceland spar.
- It is a colorless crystal which is transparent for visible and ultraviolet light.
- It occurs in nature in different variety of crystal form, for example in the rhombohedral class of the hexagonal system.

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- It breaks readily into simple cleavage rhombohedrons, whose shape is shown in Fig. 3. 8. It can be seen from the figure that its each face is a parallelogram with angles as 78° and 102° .
- An interesting feature of calcite is that each crystal can be made to slice or break along cleavage planes into two or more smaller crystals with faces that are parallelograms with angles 71° and 109° .



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Geometry of Calcite Crystal

- Double refraction is an optical property in which a single ray of unpolarised light when passes through a uniaxial crystal gets split into two refracted rays, each propagating in a different direction.
- These two rays are named as O-ray and E-ray. Therefore, the phenomenon of splitting of light into two rays is known as *double refraction*.
- If a narrow beam of unpolarised light PQ is incident on the face AB of the crystal at an angle i , *it splits up into O-ray and E-ray inside the crystal.*
- *O-ray makes an angle of refraction r_o whereas the E-ray makes an angle r_e with the optic axis inside the crystal. Both the rays are plane polarised and their vibrations are at right angles to each other and to the direction of propagation.*
- *The refractive index for O-ray is observed to be constant in all the directions whereas the refractive index for E-ray varies according to the direction taken.*

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- *This is because it has components that are both parallel and perpendicular to the optic axis of the crystal. Since the speed of light wave in a medium is the ratio of its speed in vacuum and the index of refraction for that wavelength, an E-ray can move either faster or slower than an O-ray.*
- *However, the velocity of O-ray inside the crystal is same in all the directions while the E-ray travels in the crystal with different velocities in different directions. For example, in a negative crystal such as calcite, where the refractive index for E-ray is smaller than that for O-ray ($\mu_e < \mu_o$; $\mu_o = 1.6584$, $\mu_e = 1.4864$), the velocity of E-ray is larger than the velocity of O-ray in the crystal.*
- *On the other hand, in a positive crystal such as quartz, where the refractive index for E-ray is greater than that for O-ray ($\mu_e > \mu_o$), the velocity of E-ray is smaller than the velocity of R-ray in the crystal.*

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the refractive indices for O-ray and E-ray can be written as

$$\mu_o = \frac{\sin i}{\sin r_o} \text{ and } \mu_e = \frac{\sin i}{\sin r_e}$$

Since the velocity of O-ray and hence the refractive index μ_o inside the crystal is same in all the directions, this ray obeys Snell's Law. However, the E-ray does not obey Snell's Law as it travels in the crystal with different velocities in different directions, leading to different μ_e in different directions.