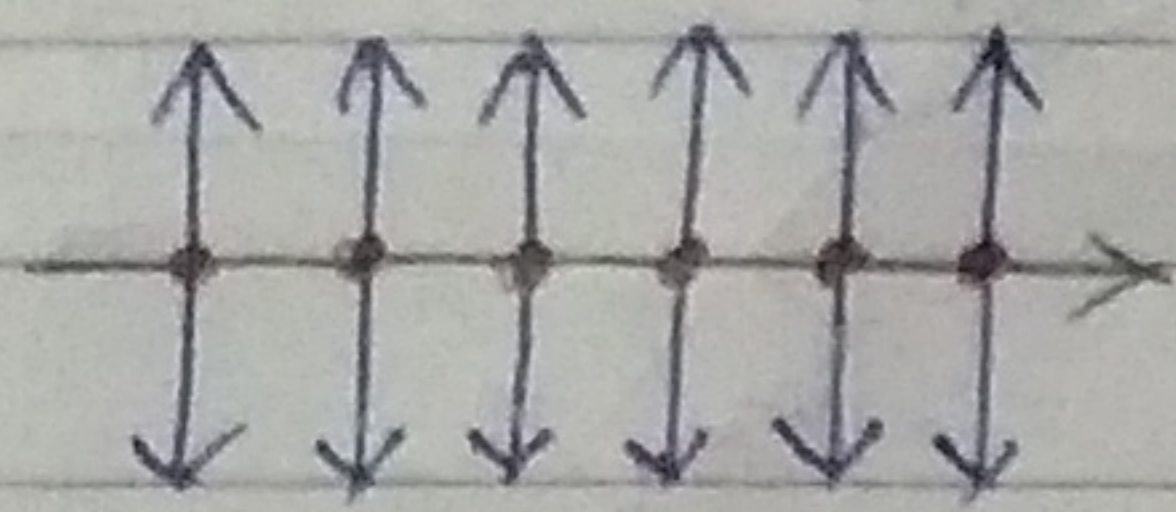


POLARISATION

When light is passed through certain crystals the crystal absorbs vibrations except those parallel to its axis. The transmitted light has a property of having vibrations only in one plane. This phenomenon in which the light vibrations are confined to a single plane is called polarisation of light and the light is called polarised light.

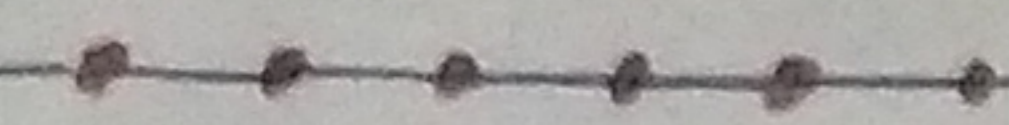
Representation of unpolarised and polarised light



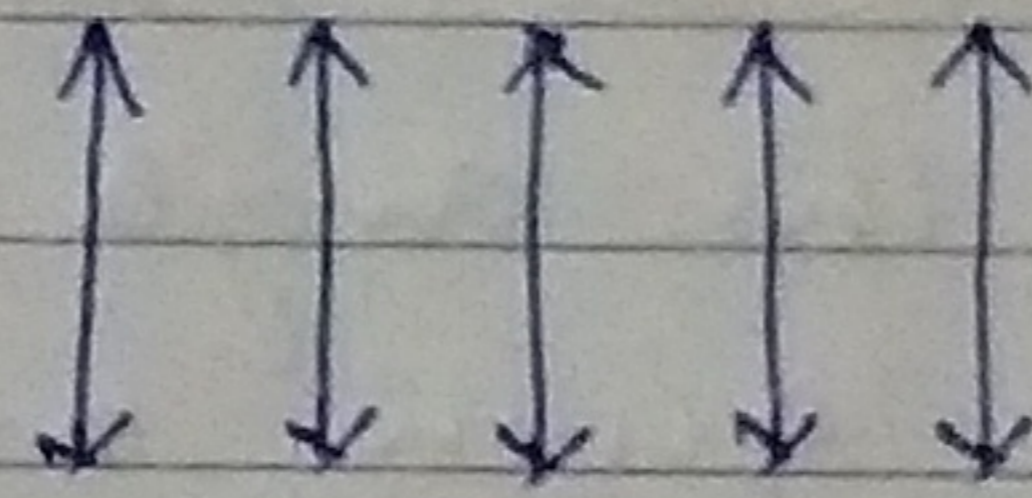
unpolarised light

arrowed lines - vibration in the plane of paper

dots - vibrations at right angles to the paper



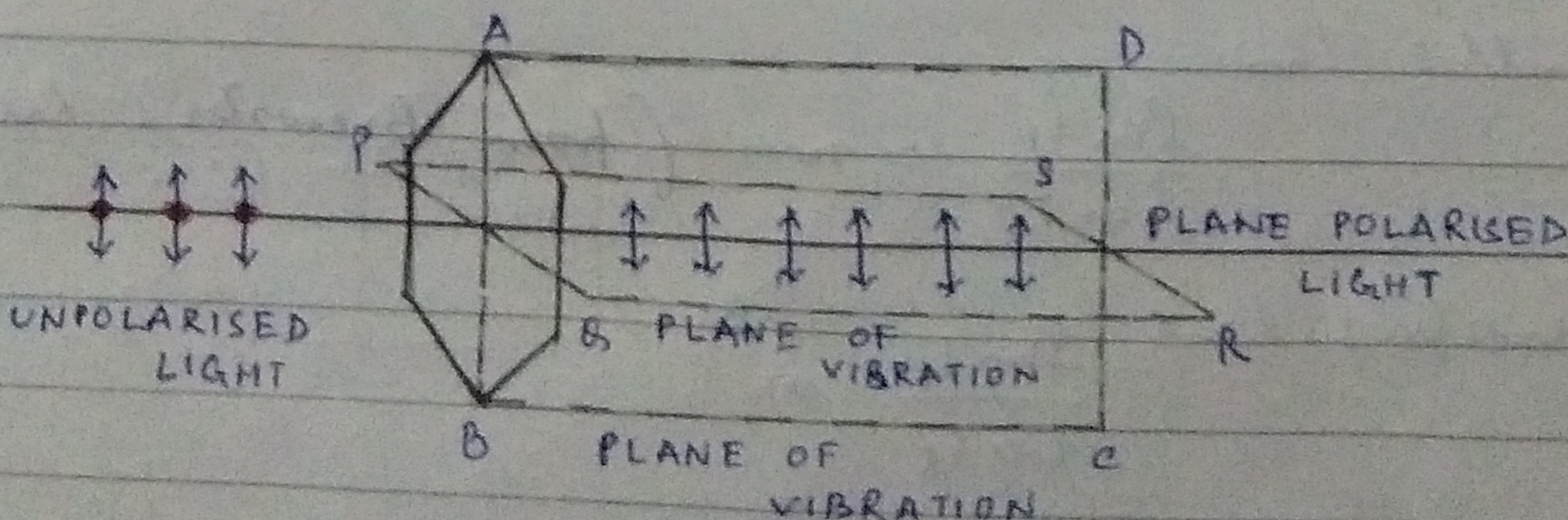
plane polarised light



plane polarised light

having vibrations in one plane.

The phenomenon due to which the vibrations of light are restricted in a particular plane is called the polarisation of light

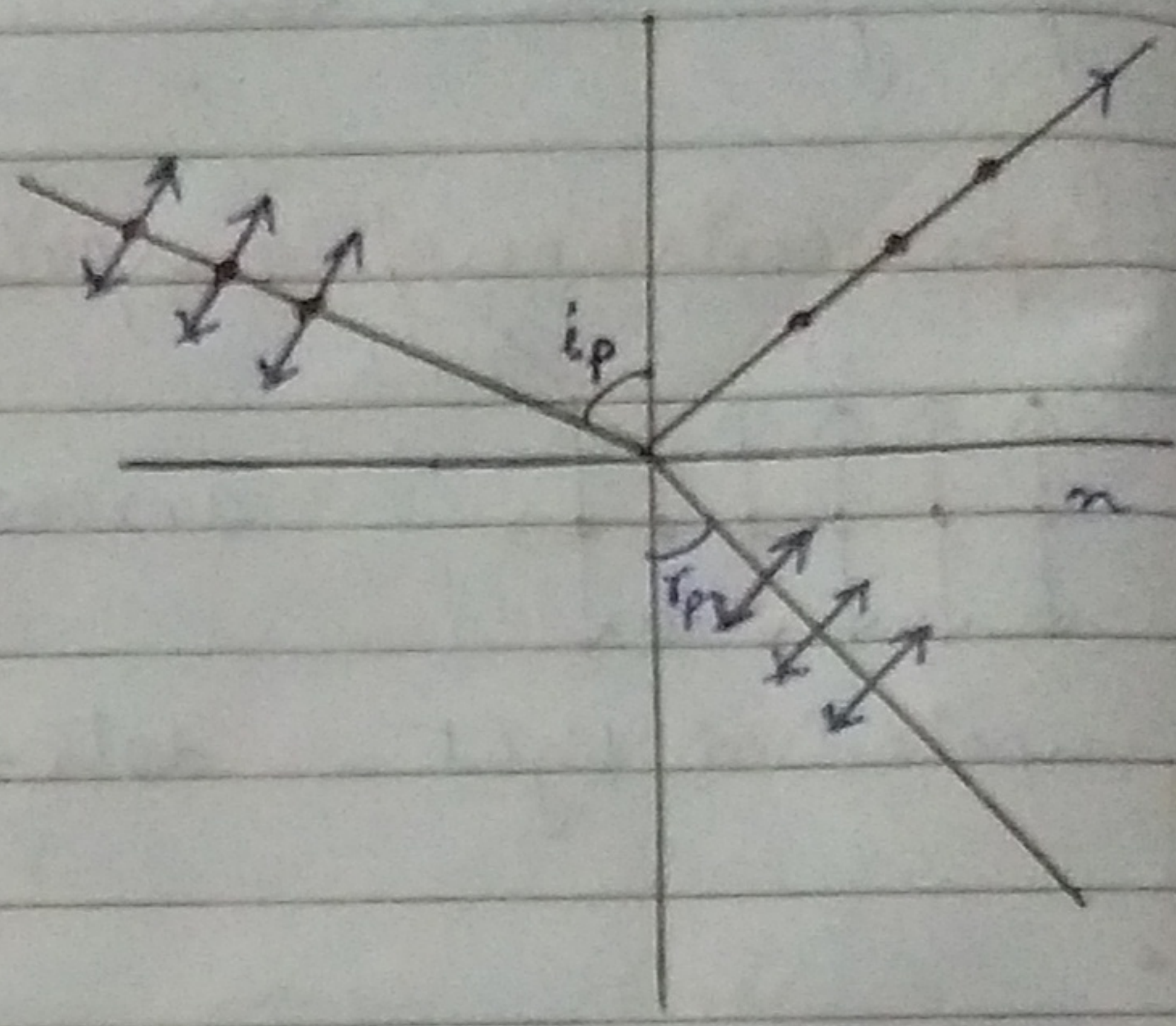


The plane ABCD which contains the vibrations of plane polarised light is called the plane of vibration.

The plane PQR perpendicular to the plane of vibrations is called the plane of polarisation.

* Polarisation of light by reflection → Brewster's Law.

For a particular angle of incidence the reflected light is completely plane polarised. This angle of incidence is called polarising angle i_p .



Statement of Brewster's Law:

The tangent of the angle of polarisation for a given medium is numerically equal to the refractive index of the medium.

ie. $\tan i_p = n$.

i_p → polarising angle
 n → refractive index of the material of the reflecting surface.

At the polarising angle the reflected and refracted rays are perpendicular to each other.

from Snell's law

$$\frac{\sin i_p}{\sin r_p} = n \quad \text{--- (1)}$$

from Brewster's Law

$$\frac{\sin i_p}{\cos i_p} = n \quad \text{--- (2)}$$

from (1) and (2)

$$\frac{\sin i_p}{\sin r_p} = \frac{\sin i_p}{\cos i_p}$$

$$\therefore \cos i_p = \sin r_p$$

$$\text{or } \sin(90 - i_p) = \sin r_p$$

$$\text{or } r_p = 90 - i_p$$

$$\text{or } i_p + r_p = 90^\circ$$

Hence the reflected and refracted rays are perpendicular to each other at the polarising angle.

Polaroids

Polaroids are artificially made large sheets or plates and capable of producing a strong beam of plane polarised light.

Small needle-shaped crystals of the organic compound quinine idosulphate have the property of polarising light but due to their small size, they cannot be used as such. A large thin sheet of these crystals can be formed by arranging these needle like crystals with their axes parallel to each other between two sheets of plastic. Such an arrangement is called polaroid.

Tourmaline crystal \rightarrow natural polarising material.

Uses :-

1. In sun glass.
2. In wind shield in automobiles.
3. In window panes.
4. In three dimensional motion pictures.

* Methods of Polarisation:-

1. Reflection
2. Refraction
3. double refraction
4. selective absorption
5. scattering.

SHORT ANSWER QUESTIONS

1. What is polarisation ?
2. Explain the terms polariser and analyser.
3. Describe an experiment to show polarisation of light.
4. Draw a diagram to show (i) unpolarised light, and (ii) polarised light.
5. Is it possible to polarise sound waves ? Why ?
6. What is polarising angle ? Explain Brewster's law.
7. A light ray strikes the surface of transparent material such that the reflected light and refracted rays are mutually perpendicular. What is the nature of (i) the reflected light, and (ii) refracted light ?
8. Using a diagram explain how polarised light is produced by scattering.
9. Explain how plane polarised light is produced using pile of plates.
10. State Malus law.
11. What is double refraction ?
12. What is the difference between *O*-ray and *E*-ray ?
13. A cross mark is made on a paper and is viewed through (i) a glass slab, and (ii) a calcite crystal. Discuss the nature of the images seen in the two cases.
14. Unpolarised light is passed through a calcite crystal plate. Is there any direction along which there is no double refraction ?
15. What is dichroism ?
16. Explain the working of a polaroid.
17. What is the difference between *H*-polaroid and *K*-polaroid ?
18. What are the uses of a polaroid ?
19. You are given plane polarised light and unpolarised light. How will you identify them ?
20. How will you distinguish between polarised light and partially polarised light ?
21. Mention the uses of polarised light.
22. What evidence is there to show that sound is not electromagnetic in nature ?
23. Can a naked eye detect polarisation of light ? If not, how is polarisation of light detected ?
24. Differentiate between polarised and unpolarised light. How are they represented ?
25. Explain the meaning of the term 'crossed polaroids'.
26. How will you verify that sun light scattered by air is partially polarised ?

UNSOLVED PROBLEMS

Selected from the previous years ISC, AISSCE, HSSCE, Various State Boards Qns. and NCERT text.]

1. A ray of light is incident on the surface of a glass plate of refractive index 1.732 at the polarising angle. Calculate the angle of refraction of the ray. [Ans. 30°]
2. The polarising angle for a ray travelling from air to ice is $52^\circ 26'$. What is the polarising angle of the light ray when travels from ice to air? [Ans. 37.57°]
3. When a beam of light of wavelength 5893 \AA is incident on the surface of a liquid at grazing angle 36.9° , the reflected light, is completely plane polarised. Calculate the wavelength of the refracted ray. [Ans. 4430.8 \AA]
4. For a given medium, the polarising angle is 60° . What will be the critical angle for the medium. [Ans. 35.26°]
5. A ray of light strikes a glass plate at an angle of incidence 60° . If the reflected and refracted rays are perpendicular to each other, find the index of refraction of glass. [Ans. $\sqrt{3}$]
6. When a ray of light from air is incident on the surface of glass with angle of incidence equal to the angle of polarisation it suffers a deviation of 22° on entering glass. Calculate the angle of polarisation. [Ans. 56°]
7. Find the polarising angle for a light incident from (i) water to glass, and (ii) glass to water? Refractive indices of glass and water are 1.54 and 1.33 respectively. [Ans. (i) 49.18° , (ii) 40.81°]
8. The polarising angle for a ray travelling from air to ice is $52^\circ 26'$. What is the polarising angle if the light ray travels from ice to air? [Ans. 37.57°]
9. Find the degree of polarisation of a beam of light passing through a pile of glass plates consisting of 15 plates, if at a particular angle the coefficient of reflection of glass plate is 5% for vibration in the plane of incidence and 10% for vibrations perpendicular to the plane of incidence. (Assume that no light is absorbed). [Ans. 67%]
10. Two polarising crystals have their polarising directions parallel so that the intensity of transmitted light is maximum. Through what angle must either sheet be rotated so that the intensity of light transmitted becomes one half the initial value. [Ans. $\pm 45^\circ$, $\pm 135^\circ$]