Ques:- Describe the construction and principle of working of Nicol prism. Discuss one of its important application.

Ans:- Nicol prism:- Nicol prism is an optical device which is used to produce plane polarised light from unpolarised light. Nicol prism is used in many optical instruments to produce and analyse plane polarised light. Nicol prism is made from double refracting crystal (anisotropic crystal) such as calcite crystal. Nicol prism was first designed by William Nicol in 1820. On his name, the prism is named as Nicol prism.

Construction of Nicol prism:- Nicol prism is made by taking a rhombohedron of calcite crystal obtained by cleavage from the original crystal. Length of rhombohedron crystal is about three times of its thickness. ABCD represents principal section of the crystal with $\angle ABC = 71°$ and $\angle BAD = 109°$ as shown in fig-1.

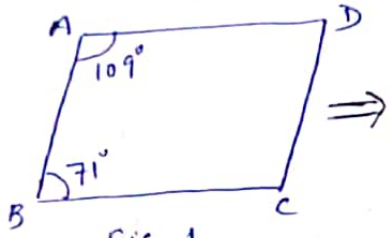

Fig-1

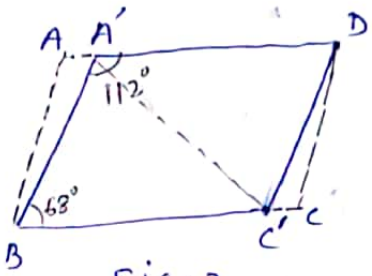

Fig-2

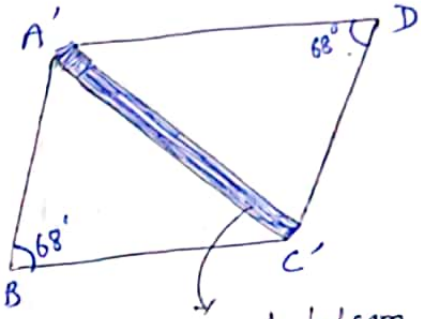

Fig-3: Nicol prism

The end faces AB and CD of the calcite crystal ABCD are grounded (rubbed) until it become A'BC'D such as $\angle A'BC' = 68°$ and $\angle BA'D = 112°$ as shown in fig-2. Now the calcite crystal into two parts along the diagonal A'C' perpendicular to the principal section. The two parts of the calcite crystal are now cemented together with canada balsam whose refractive index lies between the refractive indices of calcite for the o-ray and e-ray. $\mu_o = 1.66$, $\mu_e = 1.486$ and $\mu_{canada\ balsam} = 1.55$. Fig-3 represents complete construction of Nicol prism. The refractive index for e-ray depends upon the direction in which e-ray is propagating in the crystal. The difference between refractive

indices of o-ray and e-ray goes on increasing with the angle between the two rays in the crystal. When this angle is 90° then the difference $\mu_e - \mu_o$ is a maximum. Here $\mu_o = 1.486$ represents the maximum value. The edge BC' is coated with lamp black so that the o-ray is completely absorbed by lamp black after total internal reflection from canada balsam.

Principle of working of Nicol prism:- Nicol prism works on the principle of double refraction (birefringence).

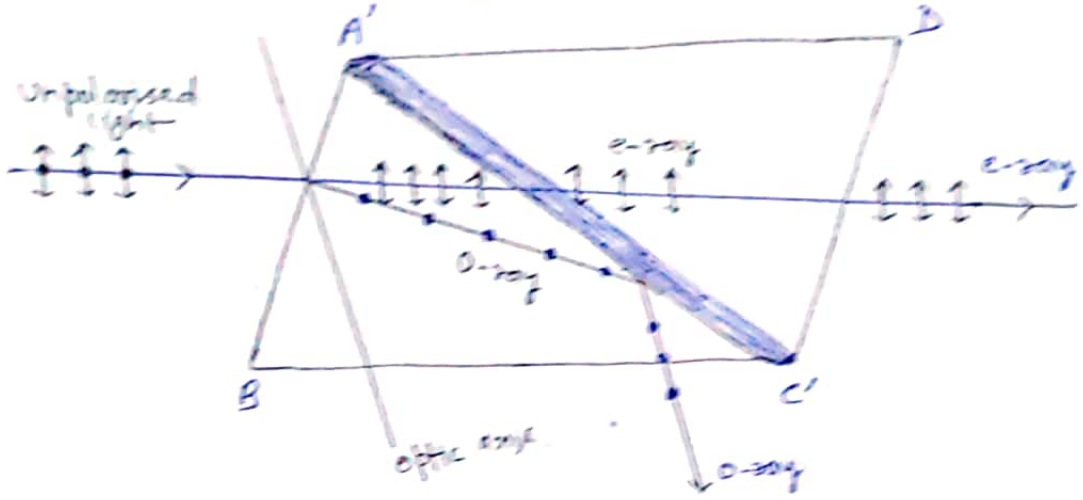

Fig-4:-

When unpolarised light is made to fall on the Nicol prism at an angle of 15° (near about 15°) then the light split up into two parts inside the Nicol prism due to double refraction as shown in fig-4. One part is e-ray (extra ordinary ray) and other part is o-ray (ordinary ray). The value of refractive indices and the angle of incidence at the canada balsam layer are such that the e-ray is transmitted through the prism while the o-ray is totally internally reflected. Since the face BC', where the o-ray is incident after total internal reflection, is coated with lamp black so the o-ray is completely absorbed by the face BC'. Thus we get only the plane polarised e-ray coming out of the Nicol prism. Hence the Nicol prism works as a polarizer.

Application of Nicol prism:- For studying the optical properties of transparent substances, two Nicol prisms are used- one as a polariser and other as an analyser.

When two Nicol prisms P (polariser) and A (Analyser) are placed adjacent to each other as shown in fig-5 such that their principal sections be parallel to each other.

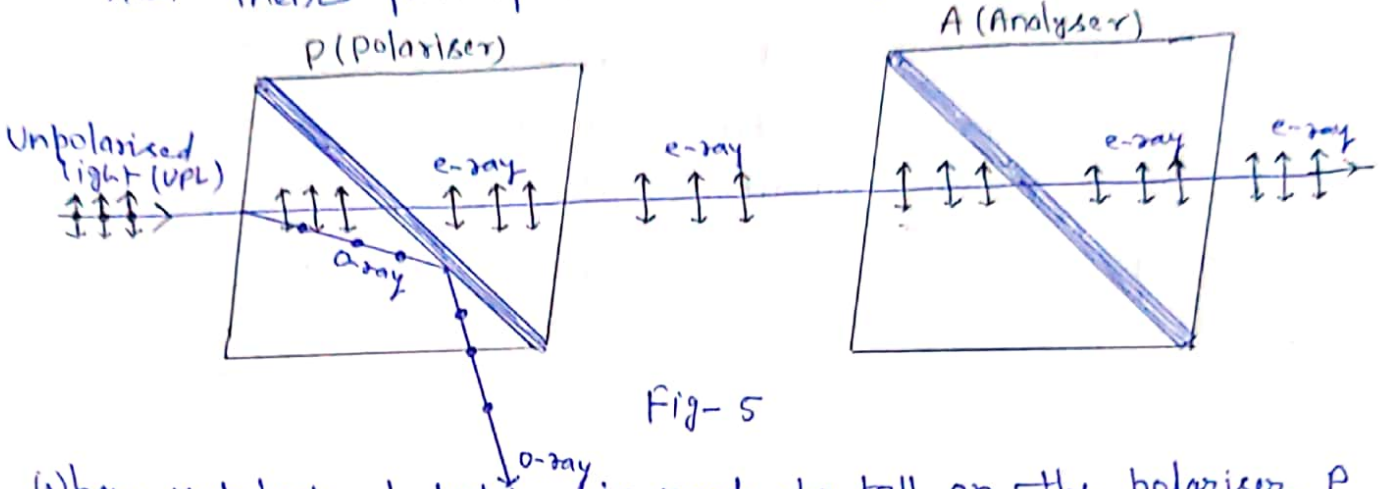

Fig- 5

When unpolarised light is made to fall on the polariser P then a linearly polarised e-ray emerges from the polariser P with its virbration direction lying in the principal section of P incident on the analyser A. Since principal sections of both P and A are parallel so the polarised e-ray is completely passed through the analyser A as shown in fig-5.

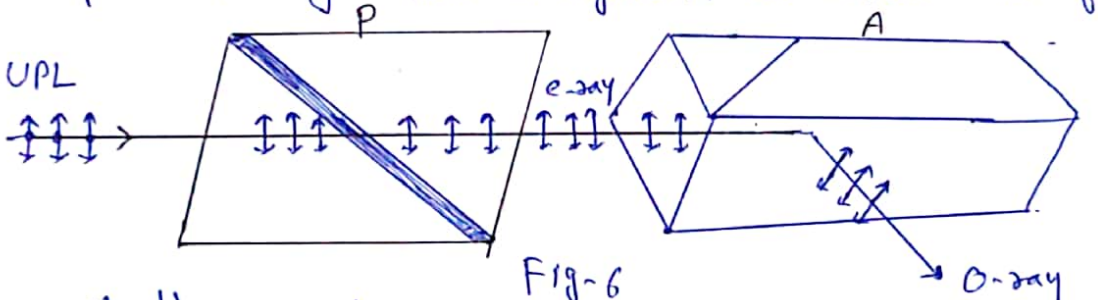

Fig-6

If the Nicol prism A (Analyser) is gradually rotated the intensity of transmitted e-ray through the analyser A decreases. When its principal section becomes perpendicular to that of the Nicol prism P as shown in fig-6 then the vibration of the ray emerging from P and incident on A, will become perpendicular to the principal section of the analyser A.

In this case, the ray behaves as o-ray inside the Nicol prism A (analyser) and it is totally internally reflected by the canada balsam layer. Hence no light is transmitted by the analyser A. In this configuration, the two Nicol prisms P and A are said to be crossed. If the analyser A is further rotated by 90° then principal sections of P and A again become parallel and intensity of transmitted light through analyser A becomes maximum. Hence the Nicol prism P produces linearly polarised light and the Nicol prism A detects it. Therefore the prism P is polariser and A is analyser.