Viva Voce Questions on Polarimeter

Q. 1. What are you doing ?

Ans. Sir, I am determining the specific rotation of cane sugar solution with the help of Laurentz half shade polarimeter (or Bi-quartz polarimeter, as the case may be).

Q. 2. What do you mean by specific rotation ?

Ans. The specific rotation of an optically active substance at a given temperature for a given wavelength of light is defined as the rotation (in degrees) of plane of polarisation of incident polarised beam produced by one decimeter length the of substance of unit density (concentration).

If θ is the rotation produced by l decimeter length of a substance, the concentration of its solution is C gm/cc, then specific rotation S at a given temperature t for a given wavelength λ is expressed as

$$S_\lambda^t = \frac{\theta}{lC}$$

Q. 3. What do you mean by optically active substance ?

Ans : Certain substances have a tendency to rotate the plane of polarisation (or plane of vibration) of a plane polarised light when propagated through it. Such substances are called optically active substances.

Q. 4. How many types of optically active substances do you know ?

Ans : There are two types of optically active substances : (*i*) Right handed or dextro-rotatory substances and (*ii*) Left handed or laevo-rotatory substances.

Q. 5. What do you mean by right handed or dextro-rotatory and left handed or laevo-rotatory substances ?

Ans : The substances that rotate the plane of polarisation (or plane of polarisation) in the clockwise direction as seen by an observer facing the emergent light is said to be right handed or dextro-rotatory.

The substances that rotate the plane of polarisation (or plane of polarisation) in the anti-clockwise direction as seen by an observer facing the emergent light is said to be left handed or laevo-rotatory.

Q. 6. Give few examples of above two types of substances ?

Ans : The examples of right handed or dextro-rotatory substances are; the solution of camphor in alcohol, cane sugar (without crystaline structure). Glucose, solution of tartaric acid in water, amorphous tartaric acid, *d*-quartz etc. The left handed or laevo-rotatory substances are ; Fructose, Nicotine, turpentine oil and *l*-quartz.

Q. 7. What do you mean by optically inactive substances ? Give one or two examples.

Ans : Optically inactive substances are those, when a plane polarised light passes through them its plane of polarisation (or plane of vibration) remains unrotated. Thus the plane of polarisation of emergent beam is same as that of incident polarised beam. The examples of optically inactive substances are; fused quartz (quartz in an amorphous form), calcite etc.

Q. 8. What do you understand by rotatory polarisation and optically active substances ?

Ans : It is found that when a beam of plane polarised light propagates through certain substances or crystals, the plane of polarisation (or plane of vibrations) of the emergent beam is not the same as that of the incident polarised beam but has been rotated through a certain angle about its direction of propagation. This phenomenon of rotation of the plane of polarisation (or plane of vibration) is called rotatory polarisation. The substances or crystals which exhibit this property are called optically active substances.

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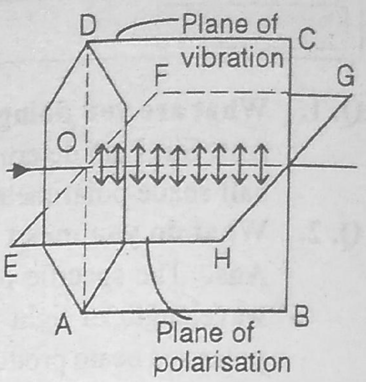

Fig. 1

Q. 9. What is plane of polarisation and plane of vibration ?

And: Plane of vibration : The plane containing the direction of vibration and the direction of propagation of light is called the plane of vibration. In the adjoining Fig. 1 , *ABCD* is the plane of vibration.

Plane of polarisation : The plane passing through the direction of propagation and containing no vibration is called the plane of polarisation. The plane of polarisation is always perpendicular to the plane of vibration. In fig. 1 , *EFGH* is the plane of polarisation.

Q. 10. In rotatory polarisation, which plane is rotated plane of polarisation or plane of vibration ?

Ans. In rotatory polarisation, both plane of polarisation as well as plane of vibration are rotated because both planes are perpendicular to each other.

Q. 11 What is rotatory dispersion ?

Ans : The angle of rotation is approximately inversely proportional to the square of the wavelength of light used. More precisely for quartz, we have

$$\theta = A + \frac{B}{\lambda^2}, \text{ where } A \text{ and } B \text{ are constants.}$$

Therefore, when a beam of composite (white) plane polarised light falls normally on a quartz crystal, the plane of polarisation of different colours (or wavelengths) are rotated with different angles. Therefore, the field of view appears coloured. This phenomenon is called rotatory polarisation.

Q. 12. On what factors does the angles of rotation of the plane of polarisation depend ?

Ans : According to the experimentally observed fact that the angle of rotation of the plane of polarisation is directly proportional to the thickness of the crystal, the wavelength of light employed and the nature of the optically active substances. For solutions rotation is also proportional to the concentration and hence it is proportional to the number of molecules in the line of sight.

Q. 13. Does specific rotation depends upon the temperature ?

Ans. Yes, Specific rotation depends on temperature. In some substances like turpentine, it decreases with rise in temperature, while in others like quartz specific rotation increases with temperature.

Q. 14. What is the unit of specific rotation ?

Ans. The unit of specific rotation is degree/decimeter/gm/c.c. or degree/decimeter/kg/m^3

Q. 15 What is the value of specific rotation of cane sugar solution in water ?

Ans. Specific rotation of cane sugar solution in water at 20°C is + 66.5°

Q. 16. What is the significance of plus sign in the above value of specific rotation ?

Ans. The plus sign indicates that the rotation is clockwise or right handed.

Q. 17. What will be the resultant rotation if a number of optically active substances are present in a solution ?

Ans : In that case, the net rotation will be equal to the algebraic sum of rotations produced separately by each individual substance.

Q. 18. What is the practical utility of the measurement of this specific rotation ?

Ans : It is extensively used in sugar factories for the estimation of the percentage of sugar in a given solution in sugar factories. This method is also used to determine the amount of sugar present in the urine of a diabetic patient.

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Q. 19. What is Saccharimeter ?

Ans : Saccharimeter is the name of a polarimeter used for the analysis of sugar.

Q. 20. Can you determine the strength of the sugar solution ?

Ans. Yes, the strength of the sugar solution is determined with the help of the following formula

$$C = \frac{\theta}{l} \times \frac{100}{S}$$

where C is the strength (gms of the substance present in 100 *c.c.* of the solution), S the specific rotation of the substance, θ the angle of rotation in degrees and l the length of solution in decimeter.

Q. 21. What is molecular rotation ?

Ans : The molecular rotation is the product of specific rotation and molecular weight of the substance, that is, molecular rotation = specific rotation × molecular weight of the substance.

Q. 22. What is a polarimeter ?

Ans. Polarimeter is a device used for the measurement of optical rotation and the angle of rotation of the plane of polarisation rotated by an optically active substance.

Q. 23 What are the main parts of a polarimeter ?

Ans. The main parts of a polarimeter are; a polariser, an analyser and a polarimeter tube (or glass tube broaden in the middle) kept between them.

Q. 24. What are the functions of polariser and analyser ?

Ans : As it is clear from their names, the polariser is used to convert an ordinary light into plane polarised light and analyser is used to analyse the light transmitted through the optically active substance and half shade or bi-quartz devices.

Q. 25. What is the difference between polariser and analyser ?

Ans : There is no basic difference between the polariser and analyser. Both are simply nicol prisms made of calcite crystals. They differ only in their uses.

Q. 26. If the polariser and analyser are same devices, can we interchange polariser and analyser ?

Ans : Yes, we can interchange both of them.

Q. 27. What is a nicol prism ?

Ans : William Nicol invented and constructed an optical device made from a calcite crystal for producing and analysing plane polarised light.

Q. 28. Is there any possibility of rotation of plane of polarisation of plane polarised light, when it passes through nicol prism ?

Ans. No, because the nicol prism is made of calcite crystal which is an optically inactive substance.

Q. 29. On what principle the working of a nicol prism is based ?

Ans : It is well known that, when an unpolarised beam enters the calcite crystal, it splits up into two plane polarised rays : O-ray and E-ray with vibrations in two mutually perpendicular planes. If by some optical means, we eliminate one of the two beams, then we would obtain only one plane polarised beam. The nicol prism is designed in a such a way so as to eliminate the ordinary ray by total internal reflection. Hence only the extraordinary ray is transmitted through them.

Q. 30. What are ordinary and extra ordinary rays ?

Ans : The ordinary (O-rays) and extra ordinary (E-rays) rays are plane polarised rays having vibrations perpendicular to each other. The ordinary ray obeys the ordinary laws of refraction, whereas an extra-ordinary ray behaves extra ordinarily and does not follows any laws of refraction.

Q. 31. What do you mean by phenomenon of double refraction ?

Ans. When an unpolarised beam of light enters in certain crystals, like calcite or quartz, it splits up into two plane polarised refracted beams travelling in different directions. The phenomenon of splitting of an unpolarised beam into two plane polarised rays : O-ray and E-ray with vibrations in two mutually perpendicular planes is called phenomenon of double refraction.

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Q. 32. What do you mean by parallel nicols and crossed nicols ?

Ans. When the principal section of the analyser (one nicol) is parallel to that of polariser (second nicol), then the vibrations of E-ray emerging from the polariser will be in the principal section of

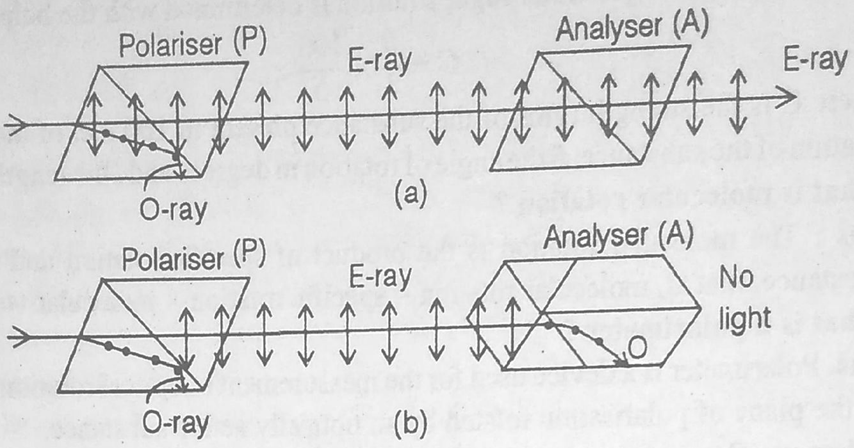

Fig. 2.

the analyser and hence E-ray from P is freely transmitted by A just as it was freely transmitted by P subsequently the intensity of emergent light is maximum. Hence when the principal sections of the polariser and analyser are parallel, then nicols are said to be parallel nicols [Fig. 2. (a)]. On the other hand when the principal sections of polariser and analyser are at right angle to each other, no light emerges from the analyser because, in that case, the vibrations of the E-ray emerging from the polariser will be normal to the principal section of the analyser and hence totally internally reflected just as O-ray. Hence, when the principal section of polariser is perpendicular to the principal section of analyser, the nicols are said to be crossed nicols [Fig. 2. (b)].

Q. 33. What is principal plane ?

Ans : The plane containing the optic axis and the ordinary ray is called principal plane of the ordinary ray. Similarly the plane containing the optic axis and extra-ordinary ray is called the principal plane of the extra-ordinary ray.

Q. 34. What is the principal section ?

Ans : A plane containing the optic axis of the crystal and perpendicular to two opposite refracting faces is called the principal section of the crystal for that pair of faces (Fig. 3). As, a crystal has six faces there are three sections corresponding to each pair of opposite faces.

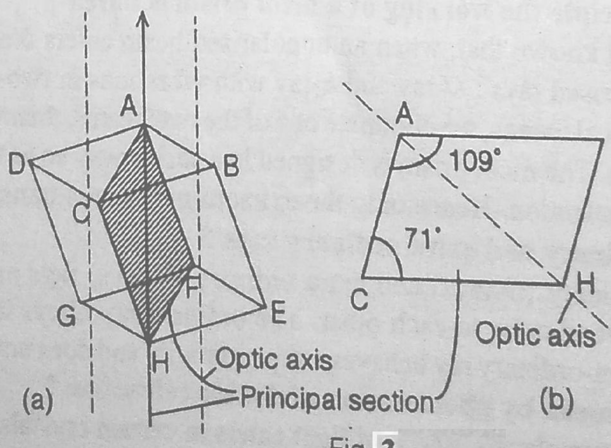

Fig. 3

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Q. 35. What is an optic axis ?

Ans : The optic axis of a doubly refracting crystals is a direction along which all the plane waves are transmitted with a single velocity without showing the effect of double refraction. Thus the optic axis is a direction along a line passing through any one of the blunt corners and making equal angles with each of the three edges which meet there. Hence optic axis is not a line but it is a direction.

Q. 36. What is the use of half shade device in your experiment ?

Ans : A half shade device is used in the experiment to judge the accurate position of complete darkness of the field of view. The analyser is unable to detect the exact position of complete darkness. When the analyser is rotated through some angle to detect the position of complete darkness, the field of view remains practically dark even after the analysing nicol has been rotated through 5 or 6° near the crossed position.

Q. 37. How does the half shade device judge the accurate position ?

Ans. Half shade device divides the field of view in two equal halves which are adjusted for equal brightness or darkness. When these halves are viewed simultaneously and side by side, the equal brightness or darkness of the two halves can be easily judged by the eye.

Q. 38. Where and how is the half shade device placed in the polarimeter ?

Ans. Half shade device is placed in between the polariser and glass tube (polarimeter tube) containing the solution under study. It is adjusted by the manufacturer in such a position that the shorter diagonal of the nicol makes a small angle with the optic axis of the quartz plate so that the plane of vibration of the plane polarised light incident on them makes small angles with the optic axis.

Q. 39. What is the construction of half shade device ?

Ans : It consists of two semi-circular plates. One semi-circular plate is of ordinary glass, whereas the other is of calcite. Both are cemented together along the diameter. The quartz is a half plate, it introduces a path difference of $\lambda/2$. The thickness of the glass plate is so chosen as to absorb and reflect the same amount of light as the quartz plate.

Q. 40. What is the principle of a half-shade device used in your experiment ?

Ans.

Q. 41. Why is an arrangement of two crossed nicols not preferable in a polarimeter ?

Ans : Because, cross-nicols alone could not give accurate position of complete extinction (or darkness) or equality of brightness. Therefore in order to increase the sensitiveness of the pair of crossed nicols half shad device is used in the polarimeters.

Q. 42. Why do you use sodium light with half shade device ?

Ans : The half shade device in the polarimeter produces a path difference of $\lambda/2$ (or phase difference of π) between ordinary and extra-ordinary rays for a particular wavelength λ for which it is designed. Generally this wavelength is matched with the wavelength of sodium D line. Hence the use of sodium light is necessary.

Q. 43. Is there any device which can work with white light ?

Ans : Yes, bi-quartz device.

Q. 44. What is the construction and working of a bi-quartz device ?

Ans : Bi-quartz device consists of two semicircular plates of left handed and right handed quartz which are cemented together to form a circular disc. Each of the plate cut perpendicular to the optic axis and their thickness is taken for which angle of rotation for yellow colour is 90°.

When a beam of polarised composite (or white) light enters normally into the Bi-quartz device, the plane of polarisation for different wavelength (or colour) will be rotated through different

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angles [as θ is different for different wavelengths, that is $\theta \propto (1/\lambda^2)$]. The observations are taken at the tint of passage or when two halves are of same (grey) colour.

Q. 45. What is the main difference in the working of half shade and Bi-quartz polarimeters ?

Ans : The main difference in the working of half shade and bi-quartz polarimeter is as follows : In the half shade polarimeter, the monochromatic sodium light is used and in it two halves in eye-piece appears of different illumination, whereas in bi-quartz device, white light is used and in it two halves in eye-piece appears of different colours.

Q. 46. Which is superior out of half shade and Bi-quartz polarimeters ?

Ans. Bi-quartz polarimeter is superior over half-shade polarimeter because it permits white light which is convenient to arrange and it is easier to judge the contrast of colours more accurately rather then contrast of intensities. Hence it is more sensitive device.

Q. 47. When white light is used in Bi-quartz, for which colour does it give rotation ?

Ans : The biquartz gives the rotation for yellow colour, for it is this colour which is absent from the field of view in the setting of the analyser.

Q. 48. Can you determine the direction of rotation of plane of polarisation from your experiment ?

Ans: No.

Q. 49. How will you modify your experiment for the determination of direction of rotation of plane polarised light ?

Ans : For this purpose the experimental set up is modified in such a way that the rotation produced by two different lengths of a solution is studied. When θ is larger for longer lengths, the direction of rotation will give the direction of the plane of polarisation.

Q. 50. What are unpolarised, polarised and plane polarised light ?

Ans. Unpolarised light : In general ordinary light, having vibrations along all possible plane perpendicular to the direction of propagation is said to be unpolarised. Thus, the unpolarised light is one which is symmetrical about its direction of propagation.

Polarised light : There is a lack of symmetry about the direction of propagation in the case of polarised light. Thus the light which is asymmetrical about the direction of propagation is called polarised light.

Plane polarised light : The light having vibrations only along a single direction perpendicular to the direction of propagation of light is said to be plane polarised light.

Q. 51. How will you get polarised light in your laboratory ?

Ans : In the laboratory, the polarised light can be produced by reflection, by refraction or by double refraction.