CBSE Test Paper-04

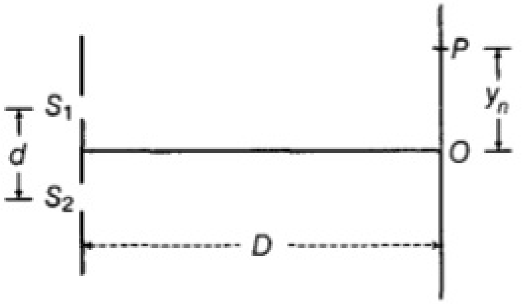
Class - 12 Physics (Wave Optics)

1. According to Huygens, construction relation between old and new wave fronts is-
   a. New wave front is backward to old wave front
   b. The new wave front is inclined at an angle to the old wave front.
   c. New wave front is perpendicular to the old wave front
   d. The new wave front is the forward envelope of the secondary wavelet.
2. The resolving power of a telescope whose lens has a diameter of 1.22 m for a wavelength of $5000\overset{o}{A}$ is:
   a. 2×10^4
   b. 2×10^5
   c. 2×10^6
   d. 2×10^2
3. Newton gave the corpuscular theory on the basis of :
   a. Wavefront
   b. Newton's rings
   c. Certain corpuscles
   d. Rectilinear motion
4. Shape of the wave front of light emerging out of a convex lens when a point source is placed at its focus.
   a. hyperboloid
   b. conical
   c. spherical
   d. plane
5. Two coherent monochromatic light beams of intensities I and 4I are superposed. The maximum and minimum possible intensities in the resulting beam are
   a. 5I and 3I
   b. 5I and 2I
   c. 5I and I
   d. 9I and I
6. What type of wavefront will emerge from a

i. point source
ii. distant light source?

7. What is the relation of a wave front with a ray of light?

8. How does the resolving power of microscope change on
   i. decreasing wavelength of light,
   ii. decreasing diameter of objective lens.
9. The figure shows a double slit experimental set up for observing interference fringes due to different interference component colours of white light. What would be the predominant colour of the fringes observed at the point



   i. O(the central point)
   ii. P, where, $S_2P - S_1P = \frac{\lambda_b}{2}$? (Here, λ_b is the wavelength of the blue colour).

10. A ray of light falls an a transparent slab of $\mu = 1.732$. If reflected and refracted rays are mutually perpendicular, what is the angle of incidence?

11. State Brewster's law. The value of Brewster angle for a transparent medium is different for light of different colours. Give reason.

12. What is an unpolarised light? Explain with the help of suitable ray diagram, how an unpolarised light can be polarised by reflection from a transparent medium? Write an expression for Brewster's angle in terms of the refractive index of denser medium.

13. In a single slit diffraction experiment, a slit of width d is illuminated by red light of wavelength 650 nm. For what value of d will
   i. the first minimum fall is at an angle of diffraction of 30°and
   ii. the first maximum fall is at an angle of diffraction of 30°?

14. In a single slit diffraction experiment, when a tiny circular obstacle is placed in the

path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why? State two points of difference between the interference pattern obtained in Young's double slit experiment and the diffraction pattern due to a single slit?

15. Explain how Newton's Corpuscular theory predicts the speed of light in a medium, say water, to be greater than the speed of light in vacuum. Is the prediction confirmed by the experimental determination of speed of light in water? If not, which alternative picture of light is consistent with experiment?

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Answers

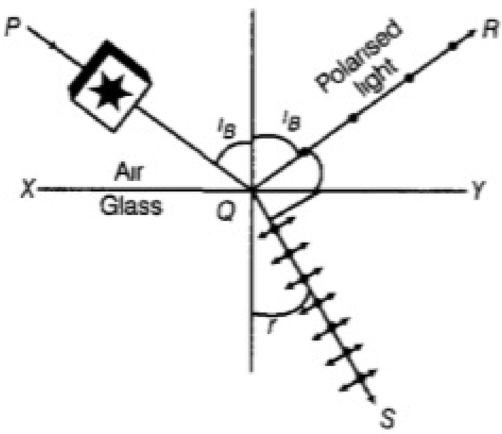
1. d. The new wave front is the forward envelope of the secondary wavelet.
   Explanation: Huygens' construction tells us that the new wavefront is the forward envelope of the secondary waves.
2. c. 2×10^6
   Explanation: The resolving power of telescope is given by $\frac{D}{1.22\lambda}$
   $\frac{1.22}{1.22 \times 5000 \times 10^{-10}}$
   2×10^6
3. d. Rectilinear motion
   Explanation: IT takes into account the particle nature of light where light travels in the form of rays.
4. d. plane
   Explanation: The rays of light becomes parallel after passing through a convex lens if the object is placed at focus. The shape of wavefront is plane as wavefront is perpendicular to rays.
5. d. 9I and I
   Explanation: $I_{max} = (\sqrt{I}_1 + \sqrt{I}_2)^2$
   I_1 = I, I_2 = 4I
   On putting these values,
   $I_{max} = (\sqrt{I} + \sqrt{4}I)^2$
   I_{max} = 9I
   $I_{min} = (\sqrt{I}_1 - \sqrt{I}_2)^2$
   $I_{min} = (\sqrt{I} - \sqrt{4}I)^2$
   I_{min} = I
6. i. When source of light is a point source, the wavefront is spherical. Example - Light coming from an electric bulb.
   ii. At very large distances from the source, a portion of spherical or cylindrical wavefront appears to be plane wavefront. Example - Light coming from the sun.

7. Notice that the rays are always perpendicular to the wavefronts. In other words, the wavefront always moves in a direction at right angles to itself.
   For example As the waves move farther and farther from the centre, where the rock hit the water, the wavefronts are larger and larger circles. But if you look at a small piece of the wavefront, it nearly looks flat.

8. i. increases,
   ii. decreases.
9. i. At point O , White colour fringe is obtained. As all components of colour wavelength undergo constructive interference fringe pattern .
   ii. In the second case , yellow colour fringe would be obtained at P because the light of blue colour interfere destructively and hence this colour would subtract from white light .

10. Using formula,
    $\tan i_p = \mu$
    $\Rightarrow \tan i_p = 1.732$
    or $i_p = \tan^{-1}(1.732) = \tan^{-1}\left(\sqrt{3}\right)$
    or $i_p = 60^\circ$

11. According to Brewster's law, when a light ray falls on a surface of transparent medium in such a way that reflected ray is perpendicular to the refracted ray, the reflected ray is a totally polarised ray.
    The angle of incidence in this case is called Brewster's angle i_B.



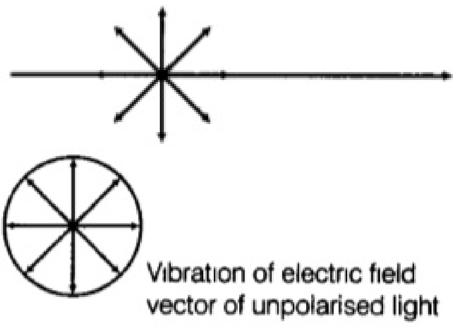
Polarisation by reflection

The tangent of the polarising angle of incidence of a transparent medium is equal to its refractive index, i.e. $\mu = \tan(i_B)$

$\therefore$ Brewster's angle $i_B = \tan^{-1}\mu$

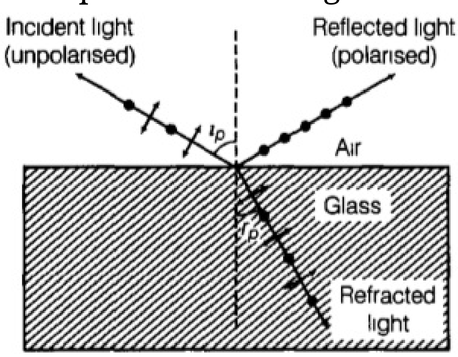
As we have seen, the value of i_B depends on the refractive index of the medium and the refractive index of a medium depends on the wavelength of incident light by the formula, $\mu = \frac{\lambda}{\lambda'}$ (λ *and* λ' are the wavelength of a particular colour in air and in the medium respectively). Thus, the value of i_B will be different for different colours of light for a particular medium of fixed refractive index(since different colours of light contain different wavelengths).

12. **Unpolarised light**: A light wave that is vibrating in more than one plane is referred to as unpolarised light . Example - Light emitted by the sun, by a lamp in the classroom, or by a candle flame is unpolarized light. Such light waves are created by electric charges that vibrate in a variety of directions, thus creating an electromagnetic wave that vibrates in a variety of directions.



Polarisation by reflection from a transparent medium

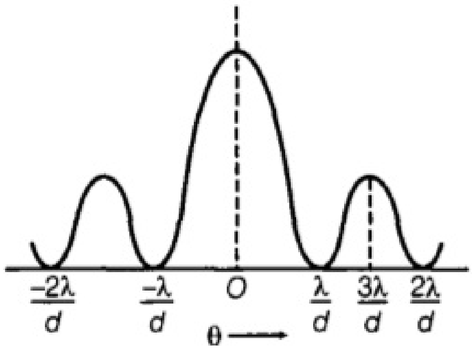
When an unpolarised light beam is incident on a refracting transparent medium at a particular angle of incidence, known as polarising angle(i_p), the reflected light is plane polarised. Thus, plane polarised light is produced by reflection from a partially transparent refracting medium .



Brewster's law states that the tangent of polarising angle for a transparent medium is equal to the refractive index of the medium i.e. $\mu = \tan i_p$

where, μ = refractive index of transparent
denser medium, i_p = polarising angle

13. i. In single slit diffraction pattern, first minimum occurs at $d \sin\theta = \lambda$ [θ and λ are diffraction angle and wavelength of the light used]
$\therefore$ Slit width, $d = \frac{\lambda}{\sin\theta}$ ....(a)
Given, $\lambda = 650 \times 10^{-9}\text{m } and\ \theta = 30^\circ$
Now from equation (a) we get slit width, $d = \frac{650\times10^{-9}}{\sin 30^\circ} = \frac{650}{(1/2)} \times 10^{-9}$
$= 1300 \times 10^{-9}$ m
$\therefore d = 1.3 \times 10^{-6}\text{m} = 1.3\ \mu m$
ii. In single slit diffraction pattern, maximum and minima occurs as per the below diagram -



Now for first maximum,
$d \sin\theta = \frac{3\lambda}{2}\left[using,\ d\sin\theta = (2n+1)\frac{\lambda}{2}\right]$
where, n = 1(for first maximum)
$\Rightarrow \quad d = \frac{3\lambda}{2\sin\theta}$
where, $\theta = 30^\circ, \lambda = 650 \times 10^{-9}\text{m}$
$\therefore d = \frac{3\lambda}{2\sin\theta}$
$= \frac{3\times650\times10^{-9}}{2\times\sin 30^\circ}$
$= 1950 \times 10^{-9}\text{m}$
$\therefore d = 1.95 \times 10^{-6}\text{m} = 1.95\ \mu m$

14. Waves diffracted from the edge of circular obstacle interfere constructively at the center of the shadow of the obstacle resulting in the formation of a bright spot.

Characteristics	**Interference**	**Diffraction**
	All bright	

Fringe width	and dark fringes are of equal width	The central bright fringe have got double width to that of width of secondary maxima or minima.
Intensity of bright fringes	All bright fringes are of same intensity	Central fringe is the brightest and intensity of secondary maxima, decreases with the increase of order of secondary maxima on either side of central maxima.

15. According to Newton's Corpuscular theory of light, when corpuscles of light strike the interface XY, figure separating a denser medium from a rarer medium, the component of their velocity along XY remains the same:

If v_1 is velocity of light in rarer medium (air)

v_2 is velocity of light in denser medium (water)

i is the angle of incidence,
r is angle of refraction,
Then component of v_1 along XY = v_1 sin i

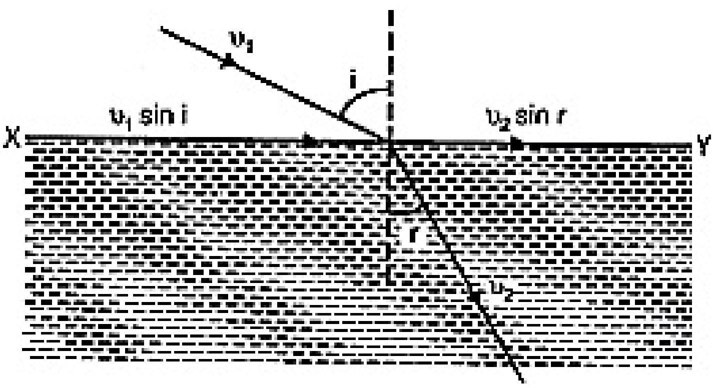
Component of v_2 along XY = v_2 sin r

As $v_1 \sin i = v_2 \sin r$

$\therefore \frac{v_2}{v_1} = \frac{\sin i}{\sin r} = \mu$

As $\mu > 1 \therefore v_2 > v_1$

i.e. light should travel faster in water than in air. This prediction of Newton's theory is opposite to the experiment result.



Huygens wave theory predicts that $v_2 < v_1$, which is consistent with experiment.