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OBJECTIVE TYPE QUESTIONS

(PHYSICS)

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CLASS
12
TERM 2

RACHNA
SAGAR

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8 ELECTROMAGNETIC WAVES

Multiple Choice Questions

1. A linearly polarized electromagnetic wave given as $E = E_0 \hat{i} \cos (kz - \omega t)$ is incident normally on a perfectly reflecting infinite wall at $z = a$. Assuming that the material of the wall is optically inactive, the reflected wave will be given as

(*a*) $E_r = -E_0 \hat{i} \cos(kz - \omega t)$. (*b*) $E_r = E_0 \hat{i} \cos(kz + \omega t)$.

(*c*) $E_r = -E_0 \hat{i} \cos(kz + \omega t)$. (*d*) $E_r = E_0 \hat{i} \sin(kz - \omega t)$.

Ans. (*b*)

2. Light with an energy flux of 20 W/cm^2 falls on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2, the total momentum delivered (for complete absorption) during 30 minutes is

(*a*) 36×10^{-5} kg m/s. (*b*) 36×10^{-4} kg m/s.

(*c*) 108×10^{4} kg m/s. (*d*) 1.08×10^{7} kg m/s.

Ans. (*b*)

3. The electric field intensity produced by the radiations coming from 100 W bulb at a 3 m distance is E. The electric field intensity produced by the radiations coming from 50 W bulb at the same distance is

(*a*) $\frac{E}{2}$ (*b*) $2E$.

(*c*) $\frac{E}{\sqrt{2}}$ (*d*) $\sqrt{2}E$

Ans. (*d*)

4. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along

(*a*) E (*b*) B (*c*) $B \times E$ (*d*) $E \times B$

Ans. (*d*)

5. An EM wave radiates outwards from a dipole antenna, with E_0 as the amplitude of its electric field vector. The electric field E_0 which transports significant energy from the source falls off as

(*a*) $\frac{1}{r^3}$ (*b*) $\frac{1}{r^2}$ (*c*) $\frac{1}{r}$ (*d*) remains constant.

Ans. (*c*)

6. An electromagnetic wave travels in vacuum along *z* direction: $E = (E_1\hat{i} + E_2\hat{j})\cos(kz - \omega t)$. Choose the correct options from the following:

(*a*) The associated magnetic field is given as

$$B = \frac{1}{c}(E_1\hat{i} - E_2\hat{j})\cos(kz - \omega t)$$

(*b*) The associated magnetic field is given as

$$B = \frac{1}{c}(E_1\hat{i} + E_2\hat{j})\cos(kz - \omega t)$$

(*c*) The given electromagnetic field is circularly polarised.

(*d*) The given electromagnetic wave is plane polarised.

Ans. (*b*), (*d*)

7. A plane electromagnetic wave propagating along *x* direction can have the following pairs of *E* and *B*

(*a*) E_x, B_y. (*b*) E_y, B_z. (*c*) B_x, E_y. (*d*) E_z, B_y

Ans. (*b*), (*d*)

8. A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz. For producing electromagnetic waves which one is not true?

(*a*) They will have frequency of 10^9 Hz. (*b*) They will have frequency of 2×10^9 Hz.

(*c*) They will have a wavelength of 0.3 m. (*d*) They fall in the region of radiowaves.

Ans. (*a*), (*c*), (*d*)

9. The source of electromagnetic waves can be a charge

(*a*) moving with a constant velocity. (*b*) moving in a circular orbit.

(*c*) at rest. (*d*) falling in an electric field.

Ans. (*b*), (*d*)

10. Which of the following has minimum wavelength?

(*a*) Blue light (*b*) γ-rays

(*c*) Infrared rays (*d*) Microwave

Ans. (*b*) γ-rays have maximum frequency so minimum wavelength among electromagnetic waves.

11. Which of the following has maximum penetrating power?

(*a*) Ultraviolet radiation (*b*) Microwaves

(*c*) γ-rays (*d*) Radiowaves

Ans. (*c*) γ-rays have maximum frequency and energy of proton, therefore maximum penetrating power.

12. Electromagnetic waves travelling in a medium having relative permeability $\mu_r = 1.3$ and relative permittivity $E_r = 2.14$. The speed of electromagnetic waves in medium must be

(*a*) 1.8×10^8 ms^{-1} (*b*) 1.8×10^4 ms^{-1} (*c*) 1.8×10^6 ms^{-1} (*d*) 1.8×10^2 ms^{-1}

Ans. (*a*) Speed of Emw $(v) = \dfrac{c}{\sqrt{\mu_r \varepsilon_r}} = \dfrac{3 \times 10^8}{\sqrt{2.14 \times 1.3}} = 1.8 \times 10^8 \text{ms}^{-1}$

13. In electromagnetic waves, the phase difference between electric and magnetic field vectors are

(*a*) zero (*b*) $\dfrac{\pi}{4}$ (*c*) $\dfrac{\pi}{2}$ (*d*) π

Ans. (*a*) Electric and magnetic field vectors always vary in same phase.

14. The quantity $\sqrt{\mu_0 \varepsilon_0}$ represents

(*a*) speed of sound (*b*) speed of light in vacuum

(*c*) speed of electromagnetic wave (*d*) inverse of speed of light in vacuum

Ans. (*d*) Speed of light in vacuum, $c = \dfrac{1}{\sqrt{\varepsilon_0 \mu_0}} \Rightarrow \sqrt{\mu_0 \varepsilon_0} = \dfrac{1}{c}$

15. In electromagnetic wave if u_e and u_m are mean electric and magnetic energy densities respectively, then

(*a*) $u_e = u_m$ (*b*) $u_e > u_m$ (*c*) $u_e < u_m$ (*d*) $u_e^2 = \dfrac{1}{2} u_m^2$

Ans. (*a*) Energy is equally distributed among electric field and magnetic field.

16. Which of the following is called heat radiation?

(*a*) X-rays (*b*) γ-rays

(*c*) Infrared radiation (*d*) Microwave

Ans. (*c*) Infrared waves are called heat energy waves.

17. From Maxwell's hypothesis, a charging electric field gives rise to

(*a*) an electric field. (*b*) an induced emf.

(*c*) a magnetic field. (*d*) a magnetic dipole.

Ans. (*c*) A charging electric field gives rise to a magnetic field.

18. Electromagnetic waves are transverse in nature is evident by

(*a*) polarisation. (*b*) interference. (*c*) reflection. (*d*) diffraction.

Ans. (*a*) Only transverse waves can be polarised.

19. Which of the following are not electromagnetic waves?

(*a*) UV rays (*b*) γ-rays (*c*) β-rays (*d*) X-rays

Ans. (*c*) β-rays consists of electrons which are not electromagnetic nature.

20. The structure of solids is investigated by using

(*a*) cosmic rays (*b*) X-rays (*c*) γ-rays (*d*) infrared rays

Ans. (*b*) X-rays are used to investigate structure of solids.

21. The condition under which a microwave over heats up a food item containing water molecules most efficiently is

(*a*) The frequency of the microwaves must match the resonant frequency of the water molecules.

(*b*) The frequency of the microwaves has no relation with natural frequency of the water molecules.

(*c*) Microwaves are heat waves, so always produce heating.

(*d*) Infrared waves produce heating in a microwave oven.

Ans. (*a*) When frequency of microwave matches with frequency of water molecules i.e., resonant condition. Maximum energy is transferred to water molecules as their K.E. energy.

22. Which radiations are used in treatment of muscle ache?

(*a*) Infrared (*b*) Ultraviolet (*c*) Microwave (*d*) X-rays

Ans. (*a*) Infrared radiations are used in the treatment of muscle ache.

23. The correct option, if speeds of gamma rays, X-rays and microwave are v_g, v_x and v_m respectively will be

(*a*) $v_g > v_x > v_m$ (*b*) $v_g < v_x < v_m$ (*c*) $v_g > v_x > v_m$ (*d*) $v_g = v_x = v_m$

Ans. (*d*) All electromagnetic waves travel with the speed of light in space.

24. Waves in decreasing order of their wavelength are

(*a*) X-rays, infrared rays, visible rays, radio waves

(*b*) radio waves, visible rays, infrared rays, X-rays.

(*c*) radio waves, infrared rays, visible rays, X-rays.

(*d*) radio waves, ultraviolet rays, visible rays, X-rays.

Ans. (*c*) radio waves > microwaves > infrared rays > visible rays > ultraviolet rays > X-rays > Y-rays

25. The electric field associated with an e.m wave in vacuum is given by $\vec{E} = 40 \cos (kz - 6 \times 10^8 t)\, \vec{i}$, where E, z and t are in volt/m, metre and seconds respectively. The value of wave vector k is

(*a*) 2 m^{-1} (*b*) 0.5 m^{-1} (*c*) 6 m^{-1} (*d*) 3 m^{-1}

Ans. (*a*) Wave vector, $k = \dfrac{\omega}{c} = \dfrac{6 \times 10^8}{3 \times 10^8} = 2 \text{ m}^{-1}$

26. The oscillating magnetic field in a plane electromagnetic wave is given as

$B_y = (8 \times 10^{-6}) \sin [2 \times 10^{11} t + 300\pi x]$ T,

wavelength of the electromagnetic wave is

(*a*) 0.80 cm (*b*) 1×10^3 m (*c*) 2×10^{-2} cm (*d*) 0.67 cm

Ans. (*d*) Wavelength, $\lambda = \dfrac{2\pi}{300\pi} = \dfrac{1}{150}$ m = 0.67 cm

27. One requires 11 eV of energy to dissociate a carbon monoxide molecule into carbon and oxygen atoms. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in

(*a*) visible region. (*b*) infrared region. (*c*) ultraviolet region. (*d*) microwave region.

Ans. (*c*)

28. The ratio of contributions made by the electric field and magnetic field components to the intensity of an EM wave is

(*a*) **c** : 1 (*b*) **c^2** : 1 (*c*) 1 :1 (*d*) $\sqrt{c}$: 1

Ans. (*c*)

29. An EM wave of intensity I falls on a surface kept in vacuum and exerts radiation pressure p on it. Which of the following is are true?

(*a*) Radiation pressure is I/c if the wave is totally absorbed.

(*b*) Radiation pressure is I/c if the wave is totally reflected.

(*c*) Radiation pressure is $2I/c$ if the wave is totally reflected.

(*d*) Radiation pressure is in the range $I/c < p < 2I/c$ for real surfaces.

Ans. (*a*), (*c*), (*d*)

Assertion-Reason Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

30. **Assertion (A):** Electromagnetic waves exert radiation pressure.

Reason (R): This is because they carry energy.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

31. **Assertion (A):** Microwaves have more energy than the radio wave.

Reason (R): $E = h\nu$

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Explanation: Since $E = h\nu$, frequency of microwaves is more as compared to radio waves.

32. **Assertion (A):** In an electromagnetic waves magnitude of magnetic field is less than the magnitude of electric field.

Reason (R): $c = \frac{E}{B} = 3 \times 10^8 \text{ ms}^{-1}$

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

33. **Assertion (A):** The velocity of all electromagnetic waves in vacuum is different.

Reason (R): Because all waves are of different frequency.

Ans. (*d*) Assertion (A) is false and Reason (R) is also false.

34. Assertion (A): Welders wear special glass goggles or face masks with glass windows.

Reason (R): To protect their eyes from large amount of UV radiations.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

35. Assertion (A): In greenhouse effect, visible radiation plays an important role to maintain average temperature.

Reason (R): Visible Rays has low range wavelength.

Ans. (*d*) Assertion (A) is false and Reason (R) is also false.

Case-based Questions

36. In 1865, *Maxwell* discovered the electromagnetic waves and predicted that the light waves were electromagnetic waves. In 1887, *Hertz* produced and detected radiowaves (wavelength $\simeq$ 6m). Till this time, the only electromagnetic waves recognised were the visible light and radio waves. In 1895, Indian physicist *JC Bose* succeeded in producing and detecting electromagnetic waves of much shorter wavelength. These waves are called microwaves. However, like *Hertz*, his experiment was also confined to the laboratory. In 1899, an Italian engineer *Guglielmo Marconi* modified Hertz's experiment, and successfully sent a wireless signal across English Channel over a distance of 50 km. *Marconi's* discovery on the use of e.m. waves for long distance communication, marked the begining of communication using electromagnetic waves.

(*i*) Electromagnetic waves are produced by

(*a*) a static charge
(*b*) a charge moving with constant velocity
(*c*) an accelerated charge
(*d*) a neutral particle in motion

(*ii*) An electromagnetic radiation of frequency ν, wavelength λ travelling with a velocity '*c*' in air, enters a glass slab of refractive index μ. The frequency, wavelength and velocity of light in glass slab will be

(*a*) $\nu, \frac{\lambda}{\mu}$ and $\frac{c}{\mu}$
(*b*) $\frac{\nu}{\mu}, \frac{\lambda}{\mu}$ and $\frac{c}{\mu}$
(*c*) ν, 2λ and $\frac{c}{\mu}$
(*d*) $\frac{\nu}{\mu}, \frac{\lambda}{\mu}$ and c

(*iii*) The phase and orientation of the magnetic vector associated with electromagnetic oscillations differ respectively from those of the corresponding electric vector by

(*a*) zero and zero
(*b*) zero and $\pi/2$
(*c*) $\pi/2$ and $\pi/2$
(*d*) $\pi/2$ and zero

(*iv*) The structure of solids is investigated by using

(*a*) cosmic rays
(*b*) X-rays
(*c*) microwaves
(*d*) γ-rays

(*v*) If λ_v; λ_x and λ_m represent the wavelengths of visible light, X-rays and microwaves respectively, then

(*a*) $\lambda_m > \lambda_x > \lambda_v$
(*b*) $\lambda_v > \lambda_m > \lambda_x$
(*c*) $\lambda_v > \lambda_x > \lambda_m$
(*d*) $\lambda_m > \lambda_v > \lambda_x$

Ans. (*i*) (*c*)

(*ii*) (*a*) R.I = $\mu = \frac{c}{v} = \frac{\lambda_{air}}{\lambda_{med}}$ and frequency(ν) remains same.

(*iii*) (*b*)

(*iv*) (*b*)

(*v*) (*d*)

37. Figure below shows the parts of the electromagnetic spectrum.

γ-rays and x-rays	Ultra-violet	Visible	Infra-red	radio waves

(*i*) Identify the type of radiation that has a higher frequency than ultraviolet.

(*a*) Gamma Ray (*b*) X-Rays

(*c*) Both (*a*) and (*b*) (*d*) Visible Ray

(*ii*) Some X-rays emitted from a radioactive source has a speed in air of 3×10^8 m/s and a wavelength of 1.0×10^{-12} m, the frequency of the x-rays is:

(*a*) 2×10^{18} Hz (*b*) 3×10^{15} Hz

(*c*) 2×10^{20} Hz (*d*) 3×10^{20} Hz

(*iii*) Gamma Rays are produced by:

(*a*) bombardment of nucleus with α-particle

(*b*) radioactive decay of the nucleus

(*c*) nuclear fission

(*d*) nuclear fussion

(*iv*) Which type of radiation used in the electronic system such as TV sets, video recorders etc.?

(*a*) Visible (*b*) Ultraviolet

(*c*) Infrared (*d*) X–Rays

Ans. (*i*) (*c*) (*ii*) (*d*)

(*iii*) (*b*) (*iv*) (*c*)

9 RAY OPTICS AND OPTICAL INSTRUMENTS

Multiple Choice Questions

1. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen.

(*a*) half the image will disappear.

(*b*) incomplete image will be formed.

(*c*) intensity of image will decrease but complete image is formed.

(*d*) intensity of image will increase but image is not distinct.

Ans. (*c*) Because focal length of lens does not change but amount of light passing through lens becomes half.

2. Air bubble in water behaves as

(*a*) sometimes concave, sometimes convex lens

(*b*) concave lens

(*c*) convex lens

(*d*) always refracting surface

Ans. (*b*) Air bubble in water behaves as a concave lens.

3. We combine two lenses, one is convex and other is concave having focal lengths f_1 and f_2 and their combined focal length is F. Combination of the lenses will behave like concave lens, if

(*a*) $f_1 > f_2$ (*b*) $f_1 = f_2$ (*c*) $f_1 < f_2$ (*d*) $f_1 \leq f_2$

Ans. (*a*) Focal length of the combination, $F = \frac{f_1 f_2}{f_1 + f_2}$, as f_2 is negative so denominator $f_1 + f_2$ must be positive or $f_1 > f_2$.

4. The length of an astronomical telescope for normal vision (relaxed eye) will be

(*a*) $f_o - f_e$ (*b*) $\frac{f_o}{f_e}$ (*c*) $f_o \times f_e$ (*d*) $f_o + f_e$

Ans. (*d*) In normal vision, length of telescope $L = f_o + f_e$.

5. The focal length of a biconvex lens of radii of each surface 50 cm and refractive index 1.5, is

(*a*) 40.4 cm (*b*) 75 cm (*c*) 50 cm (*d*) 80 cm

Ans. (*c*) $$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5 - 1)\left(\frac{1}{50} + \frac{1}{50}\right)$$

$$f = 50 \text{ cm}$$

6. A metal coin is at bottom of a beaker filled with a liquid of refractive index = 4/3 to height of 6 cm. To an observer looking from above the surface of liquid, coin will appear at a depth

(*a*) 1.5 cm (*b*) 6.75 cm (*c*) 4.5 cm (*d*) 7.5 cm

Ans. (*c*) Apparent depth $= \dfrac{\text{Real depth}}{\mu} = \dfrac{6}{4/3} = 4.5$ cm

7. Four lenses of focal lengths ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be

(*a*) + 15 cm (*b*) + 150 cm (*c*) – 150 cm (*d*) – 15 cm

Ans. (*a*) For telescope magnification, $m = \dfrac{f_o}{f_e}$

$f_e < f_o$ to produce large magnification.

8. If a convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined together, what will be their resulting power?

(*a*) + 6.5 D (*b*) – 6.5 D (*c*) + 7.5 D (*d*) – 0.75 D

Ans. (*d*) Focal length of the combination

$$\frac{1}{F} = \frac{1}{F_1} + \frac{1}{F_2} = \frac{1}{80} + \frac{1}{(-50)}$$

$$P = \frac{1}{F} = -\,0.75 \text{ D}$$

9. A convex lens and a concave lens, each having the same focal length of 25 cm, are put in contact to form a combination of lenses. The power of the combination (in dioptres) is

(*a*) zero (*b*) 25 (*c*) 50 (*d*) infinity

Ans. (*a*) $$P = \frac{1}{F} = \frac{1}{F_1} + \frac{1}{F_2} = \frac{1}{25} - \frac{1}{25} = 0$$

10. The refractive index of the material of an equilateral prism is $\sqrt{3}$. What is the angle of minimum deviation?

(*a*) 45° (*b*) 60° (*c*) 37° (*d*) 30°

Ans. (*b*) At minimum deviation position, $r = \dfrac{A}{2} = 30°$ [A = 60° as prism is equilateral]

$$\mu = \frac{\sin i}{\sin r}$$

or $$\sin i = \mu \times \sin r = \frac{\sqrt{3}}{2} \quad \text{or} \quad i = 60°$$

Also, $$i + i = A + \delta$$

$\Rightarrow$ $$60° + 60° = 60° + \delta \quad \text{or} \quad \delta = 60°$$

11. An object is immersed in a fluid. In order that the object becomes invisible, it should

(*a*) behave as a perfect reflector.

(*b*) absorb all light falling on it.

(c) have refractive index one.

(*d*) have refractive index exactly matching with that of the surrounding fluid.

Ans. (*d*)

12. A biconvex lens of focal length f is cut into two identical plano convex lenses. The focal length of each part will be

(*a*) f (*b*) $f/2$ (*c*) $2f$ (*d*) $4f$

Ans. (*c*) $2f$

Focal length of a bifocal convex lens of focal length f is

$$\frac{1}{f} = (\mu - 1)\frac{2}{R} \qquad ...(i)$$

Focal length of a plano convex lens, f' is

$$\frac{1}{f'} = (\mu - 1)\frac{1}{R} \qquad ...(ii)$$

$\therefore$ Dividing (*i*) by (*ii*)

$$\frac{f'}{f} = (\mu - 1)\frac{2}{R} \times \frac{R}{(\mu - 1)} = 2$$

$$\therefore \qquad f' = 2f.$$

13. A ray of light incident at an angle θ on a refracting face of a prism emerges from the other face normally. If the angle of the prism is 5° and the prism is made of a material of refractive index 1.5, the angle of incidence is

(*a*) 7.5° (*b*) 5° (*c*) 15° (*d*) 2.5°

Ans. (*a*)

14. A short pulse of white light is incident from air to a glass slab at normal incidence. After travelling through the slab, the first colour to emerge is

(*a*) blue (*b*) green (*c*) violet (*d*) red

Ans. (*d*) velocity of red colour is maximum as $\lambda_R < \lambda_V$

15. An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus. The image

(*a*) moves away from the lens with an uniform speed 5 m/s.

(*b*) moves away from the lens with an uniform accleration.

(*c*) moves away from the lens with a non-uniform acceleration.

(*d*) moves towards the lens with a non-uniform acceleration.

Ans. (*c*)

16. You are given four sources of light each one providing a light of a single colour – red, blue, green and yellow. Suppose the angle of refraction for a beam of yellow light corresponding to a particular angle of incidence at the interface of two media is 90°. Which of the following statements is correct if the source of yellow light is replaced with that of other lights without changing the angle of incidence?

(*a*) The beam of red light would undergo total internal reflection.

(*b*) The beam of red light would bend towards normal while it gets refracted through the second medium.

(*c*) The beam of blue light would undergo total internal reflection.

(*d*) The beam of green light would bend away from the normal as it gets refracted through the second medium.

Ans. (*c*) $\mu = \frac{1}{\sin c}$, c is smallest for blue colour and μ will be large.

17. The radius of curvature of the curved surface of a plano-convex lens is 20 cm. If the refractive index of the material of the lens be 1.5, it will

(*a*) act as a convex lens only for the objects that lie on its curved side.

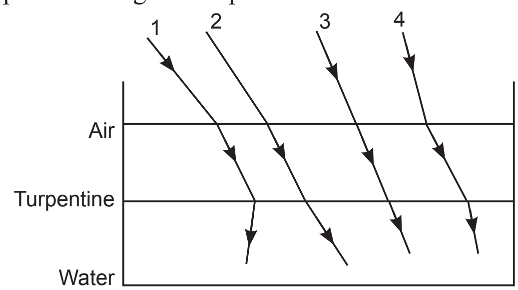
(*b*) act as a concave lens for the objects that lie on its curved side.

(*c*) act as a convex lens irrespective of the side on which the object lies.

(*d*) act as a concave lens irrespective of side on which the object lies.

Ans. (*c*)

18. The optical density of turpentine is higher than that of water while its mass density is lower. Figure shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in figure the path shown is correct?



(*a*) 1 (*b*) 2 (*c*) 3 (*d*) 4

Ans. (*b*)

19. Consider an extended object immersed in water contained in a plane trough. When seen from close to the edge of the trough the object looks distorted. Which of the following is not correct?

(*a*) The apparent depth of the points close to the edge are nearer the surface of the water compared to the points away from the edge.

(*b*) The angle subtended by the image of the object at the eye is smaller than the actual angle subtended by the object in air.

(*c*) Some of the points of the object far away from the edge may not be visible because of total internal reflection.

(*d*) Water in a trough acts as a lens and magnifies the object.

Ans. (*d*)

20. A magnifying glass is used, as the object to be viewed can be brought closer to the eye than the normal near point. This results in

(*a*) a larger angle to be subtended by the object at the eye and hence viewed in greater detail.

(*b*) the formation of a real inverted image.

(*c*) increase in the field of view.

(*d*) infinite magnification at the near point.

Ans. (*a*)

21. A double convex lens of refractive index μ_1 is immersed in a liquid of refractive index μ_2. The lens will act as transparent plane sheet when

(*a*) $\mu_1 = \mu_2$ (*b*) $\mu_1 > \mu_2$ (*c*) $\mu_1 < \mu_2$ (*d*) $\mu_1 = \frac{1}{\mu_2}$

Ans. (*a*)

22. When a ray of light enters from one medium to another, then which of the following does not change?

(*a*) Frequency (*b*) Wavelength (*c*) Speed (*d*) Amplitude

Ans. (*a*)

23. A diver at a depth 12 m inside water ($\mu = 4/3$) sees the sky in a cone of semi-vertical angle

(*a*) $\sin^{-1}\frac{4}{3}$ (*b*) $\tan^{-1}\frac{4}{3}$ (*c*) $\sin^{-1}\frac{3}{4}$ (*d*) 90°

Ans. (*c*)

24. The astronomical telescope consists of objective and eyepiece. The focal length of the objective is

(*a*) equal to that of the eyepiece.
(*b*) shorter than that of eyepiece.
(*c*) greater than that of eyepiece.
(*d*) five times shorter than that of eyepiece.

Ans. (*c*)

25. If the focal length of objective lens is increased then magnifying power of

(*a*) microscope will increase but that of telescope decrease.
(*b*) microscope and telescope both will increase.
(*c*) microscope and telescope both will decrease.
(*d*) microscope will decrease but that of telescope will increase.

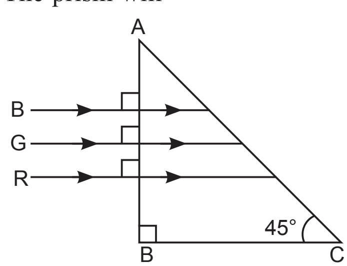
Ans. (*d*)

26. A microscope is focussed on a mark on a piece of paper and then a slab of glass of thickness 3 cm and refractive index 1.5 is placed over the mark. How should the microscope be moved to get the mark in focus again?

(*a*) 2 cm upward
(*b*) 1 cm upward
(*c*) 4.5 cm downward
(*d*) 1 cm downward

Ans. (*b*)

27. A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will



(*a*) separate the red colour part from the green and blue colours.

(*b*) separate the blue colour part from the red and green colours.

(*c*) separate all the three colours from one another.

(*d*) not separate the three colours at all.

Ans. (*a*)

28. A passenger in an aeroplane shall

(*a*) never see a rainbow.

(*b*) may see a primary and a secondary rainbow as concentric circles.

(*c*) may see a primary and a secondary rainbow as concentric arcs.

(*d*) shall never see a secondary rainbow.

Ans. (*b*)

29. The phenomena involved in the reflection of radiowaves by ionosphere is similar to

(*a*) reflection of light by a plane mirror.

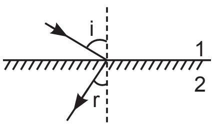
(*b*) total internal reflection of light in air during a mirage.

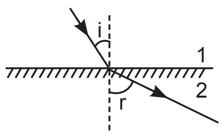
(*c*) dispersion of light by water molecules during the formation of a rainbow.

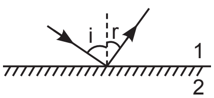
(*d*) scattering of light by the particles of air.

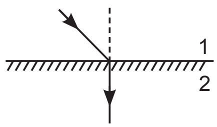
Ans. (*b*)

30. There are certain material developed in laboratories which have a negative refractive index. A ray incident from air (medium 1) into such a medium (medium 2) shall follow a path given by

(*a*) 

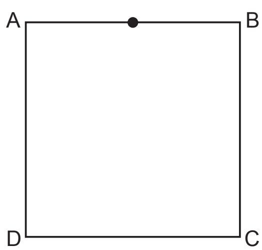
(*b*) 

(*c*) 

(*d*) 

Ans. (*a*)

31. A rectangular block of glass ABCD has a refractive index 1.6. A pin is placed midway on the face AB (given in fig.) When observed from the face AD, the pin shall



(*a*) appear to be near A.

(*b*) appear to be near D.

(*c*) appear to be at the centre of AD.

(*d*) not be seen at all.

Ans. (*d*)

32. Optical denseness of a medium is measured in terms of ____________

(*a*) refractive index (*b*) rarer medium

(*c*) denser medium (*d*) dispersion

Ans. (*a*)

33. Choose the correct relation between critical angle and refractive index.

(*a*) $\sin i_c = \mu$ (*b*) $\frac{1}{\mu} = \sin i_c$ (*c*) $\mu^2 = \sin i_c$ (*d*) $\frac{\sin i_c}{\mu} = 1$

Ans. (*b*)

34. Combination of lenses help to

(*a*) increase the magnification of the image (*b*) decrease the magnification of the image

(*c*) decreases the field of view (*d*) both (*b*) and (*c*)

Ans. (*a*)

35. Which of the following properties of light changes during the phenomenon of refraction?

(*a*) velocity and frequency (*b*) frequency and wavelength

(*c*) velocity and wavelength (*d*) velocity and frequency

Ans. (*c*)

Assertion-Reason Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

36. **Assertion (A):** A lens has two principal focal lengths which may differ.

Reason (R): Light can fall on either surface of the lens. The two principal focal lengths differ when the medium on the two sides of the lens has different refractive indices.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

37. **Assertion (A):** A combination of a convex lens and a concave lens forms a real image when the focal length of convex lens is more than the focal length of concave lens.

Reason (R): Because $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

Ans. (*c*) Assertion (A) is true but Reason (R) is false.

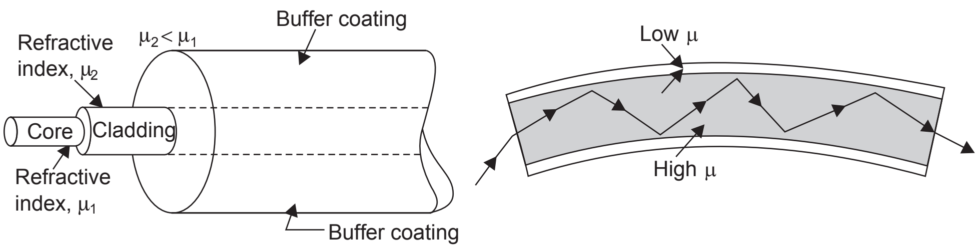
38. **Assertion (A):** A glass slab of refractive index $\mu = 1.5$ is placed on a cross-mark on a paper. The cross-mark appears to be raised by 1 cm if thickness of slab is 3 cm.

Reason (R): Refractive index = $\frac{\text{Real depth}}{\text{Apparant depth}}$

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Case-based Questions

39. **Optical fibres:** Now-a-days optical fibres are extensively used for transmitting audio and video signals through long distances. Optical fibres too make use of the phenomenon of total internal reflection. Optical fibres are fabricated with high quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflections along the length of the fibre and finally comes out at the other end. Since light undergoes total internal reflection at each stage, there is no appreciable loss in the intensity of the light signal. Optical fibres are fabricated such that light reflected at one side of inner surface strikes the other at an angle larger than the critical angle. Even if the fibre is bent, light can easily travel along its length. Thus, an optical fibre can be used to act as an optical pipe.



(*i*) Which of the following statement is not true?

(*a*) Optical fibres is based on the principle of total internal reflection.

(*b*) The refractive index of the material of the core is less than that of the cladding.

(*c*) an optical fibre can be used to act as an optical pipe.

(*d*) there is no appreciable loss in the intensity of the light signal while propagating through an optical fibre.

(*ii*) What is the condition for total internal reflection to occur?

(*a*) angle of incidence must be equal to the critical angle.

(*b*) angle of incidence must be less than the critical angle.

(*c*) angle of incidence must be greater than the critical angle.

(*d*) None of the above.

(*iii*) Which of the following is not an application of total internal reflection?

(*a*) Mirage

(*b*) Sparkling of diamond

(*c*) Splitting of white light through a prism.

(*d*) Totally reflecting prism.

(*iv*) Optical fibres are used extensively to transmit

(*a*) Optical Signal (*b*) current

(*c*) Sound waves (*d*) None of the above

Ans. (*i*) (*b*) (*ii*) (*c*) (*iii*) (*c*) (*iv*) (*a*)

40. A telescope is an optical device used for observing celestial objects. Its object is at infinity. It forms image at infinity or at least distance of distinct vision depending on its adjustments, which can be done by rack and pinion arrangement. Celestial objects are generally viewed during night.

(*i*) Can a telescope produce image of size larger than that of object?

(*a*) Yes, it can produce only linear magnification.

(*b*) Yes, it can produce both linear and angular magnification.

(*c*) No, it can't produce both kind of magnification.

(*d*) No, it can produce only angular magnification.

(*ii*) The aperture of objective of telescope is large to

(*a*) increase magnification

(*b*) decrease magnification

(*c*) increase brightness and resolution of image

(*d*) increase the size of telescope

(*iii*) If the focal lengths of objective lens and eyepiece are 120 cm and 5 cm respectively, then in normal adjustment, the length of the telescope will be

(*a*) 125 cm (*b*) 24 cm

(*c*) 115 cm (*d*) 126.25 cm

(*iv*) In (*iii*) part, if the final image is seen at least distance of distinct vision, the tube length will be

(*a*) 125 cm (*b*) 124.16 cm

(*c*) 115 cm (*d*) 126.25 cm

(*v*) If the focal length of objective lens is increased to 140 cm, then how will its resolving power and magnification change, while the diameter of the aperture and the focal length of eyepiece remain the same?

(*a*) Magnifying power and resolving power both increase.

(*b*) Magnifying power and resolving power both decrease.

(*c*) Magnifying power increases and resolving power decreases.

(*d*) Magnifying power increases and resolving power remains the same.

Ans. (*i*) (*d*) (*ii*) (*c*)

(*iii*) (*a*) Reason: $L = f_o + f_e = 120 + 5 = 125$ cm

(*iv*) (*b*) Reason: $v_o = f_o = 120$ cm; $v_e = -25$ cm, $f_e = 5$ cm

$$\therefore \quad \frac{1}{u_e} = -\frac{1}{25} - \frac{1}{5} = -\frac{6}{25}$$

$$\therefore \quad u_e = -4.16 \text{ cm}$$

$$\because \quad L = |v_o| + |u_e| = 124.16 \text{ cm}$$

(*v*) (*d*)

41. When light travels from an optically denser medium to rarer medium at the interface, it is partly reflected back into the same medium and partly refracted to the second medium. This reflection is called total internal reflection. When light gets reflected by a surface, normally some fraction of it gets transmitted. Reflected ray is always less intense than the incident ray. Optical fiber is one the best example of total internal reflection.

(*i*) The light pipe is one of the example of optical fibers. Which phenomena is used in it?

(*a*) Multiple reflection (*b*) Total internal reflection

(*c*) All of the above (*d*) None of the above.

(*ii*) A ray of light from object bends towards

(*a*) Normal (*b*) Away from normal

(*c*) Light doesn't bend (*d*) Normal to the surface.

(*iii*) Critical angle of a given pair of media is satisfied. When,

(*a*) Angle of refraction is greater than 90°.

(*b*) Angle of incidence corresponds to angle of refraction 90°.

(*c*) For $i > i_c$ no refraction is possible.

(*d*) All of the above.

(*iv*) One can say emergent ray is parallel to incident ray in refraction from a slab. If,

(*a*) $r_2 = i_2$ (*b*) $r_2 = i_1$

(*c*) $r_2 = r_1$ (*d*) $r_1 = i_1$

(*v*) What is the condition for Snell's law of refraction?

(*a*) $i > i_c$ (*b*) $i < i_c$

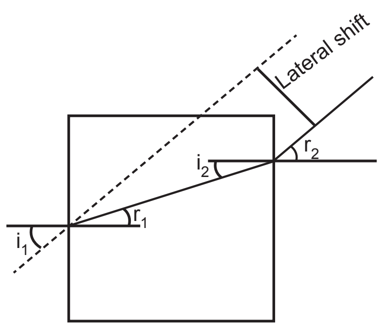
(*c*) $i = i_c$ (*d*) $\frac{\sin i}{\sin r} = i_c$

Ans. (*i*) (*b*) based on the phenomenon the total internal reflection, optical fibers transmit light over very large distances.

(*ii*) (*a*)

(*iii*) (*b*) $\theta_{cric} = \sin^{-1}\left(\frac{\mu_r}{\mu_i}\right)$

(*iv*) (*b*)



(*v*) (*c*) angle of incidence = angle of emergence $\sin i_c = \sin i$

10 WAVE OPTICS

Multiple Choice Questions

1. The wavefront due to a source situated at infinity is

(*a*) spherical (*b*) cylindrical (*c*) planar (*d*) circular

Ans. (*c*) The wavefront due to any source situated at infinity is planar.

2. A laser beam is coherent because it contains

(*a*) waves of several wavelengths.
(*b*) incoherent waves of a single wavelength.
(*c*) coherent waves of several wavelengths
(*d*) coherent waves of a single wavelength.

Ans. (*d*) coherent waves of a single wavelength.

3. If two sources have a randomly varying phase difference $\phi(t)$, the resultant intensity will be given by

(*a*) $I_0\sqrt{2}$
(*b*) $\frac{I_0}{2}$
(*c*) $2I_0$
(*d*) $\frac{I_0}{\sqrt{2}}$

Ans. (*c*) $2I_0$, For two incoherent sources, the resultant intensity at every point is just twice of the two individual intensities.

4. According to Huygens' principle, light is a form of

(*a*) particle (*b*) rays (*c*) wave (*d*) radiation

Ans. (*c*) According to Huygens' principle, light travels in the form of a longitudinal wave.

5. Two coherent monochromatic light beams of intensities I and $4I$ superimpose. The maximum and minimum possible intensities in the resulting beam are:

(*a*) $5I$ and I (*b*) $5I$ and $3I$ (*c*) $3I$ and I (*d*) $9I$ and I

Ans. (*d*) $9I$ and I,

Using, $$I_{max} = I_1 + I_2 + 2\sqrt{I_1 \times I_2} = 9I$$

$$I_{min} = I_1 + I_2 - 2\sqrt{I_1 \times I_2} = I$$

6. What is path difference for destructive interference?

(*a*) $n\lambda$ (*b*) $n(\lambda + 1)$ (*c*) $(2n+1)\frac{\lambda}{2}$ (*d*) $(n+1)\frac{\lambda}{2}$

Ans. (*c*) $(2n+1)\frac{\lambda}{2}$, For destructive interference, the path difference is an odd multiple of $\lambda/2$.

7. When exposed to sunlight, thin films of oil on water often exhibit brilliant colours due to the phenomenon of

(*a*) interference (*b*) diffraction (*c*) dispersion (*d*) polarisation

Ans. (*a*) interference

8. What happens, if the monochromatic light used in Young's double slit experiment is replaced by white light?

(*a*) No fringes are observed.

(*b*) All bright fringes become white.

(*c*) All bright fringes have colour between violet and red.

(*d*) Only the central fringe is white and all other fringes are coloured.

Ans. (*d*) At central, bright fringes of all wavelength overlap to produce white central fringe.

9. When compact disk is illuminated by a source of white light, coloured lines are observed. This is due to

(*a*) dispersion (*b*) diffraction

(*c*) interference (*d*) refraction

Ans. (*b*) The small ripples on the compact disc diffracted white light into the constituent colours.

10. A double slit interference experiment is carried out in air and the entire arrangement is dipped in water. The fringe width

(*a*) increases (*b*) decreases

(***c***) remains unchanged. (*d*) fringe pattern disappears.

Ans. (*b*) Decreases

Fringe width $\beta_{water} = \frac{\beta_{water}}{\mu}$ because $\lambda_{water} = \frac{\lambda_{air}}{\mu}$, $\beta = \frac{\lambda D}{d}$

11. In Young's double slit experiment, if the monochromatic source of yellow light is replaced by red light, the fringe width

(*a*) increases (*b*) decreases.

(*c*) remains unchanged. (*d*) the fringes disappear

Ans. (*a*) Increases, as fringe width $\beta \propto \lambda(\lambda_{yellow} < \lambda_{red})$

12. In Young's double-slit experiment, the intensity at the central maximum is I_0 if one of the slit is covered, then the intensity at the central maximum become:

(*a*) $\frac{I_0}{2}$ (*b*) $\frac{I_0}{\sqrt{2}}$ (*c*) $\frac{I_0}{4}$ (*d*) I_0

Ans. (*c*) $\frac{I_0}{4}$, $I_0 = 4I$, $I_{max} = \frac{I_0}{4}$

13. In Young's double-slit experiment, the intensity is I at a point, where the path difference is $\frac{\lambda}{6}$ (λ – wavelength of light used). If I_0 denotes the maximum intensity then $\frac{I}{I_0}$ is equal to

(*a*) $\frac{\sqrt{3}}{2}$ (*b*) $\frac{1}{2}$ (*c*) $\frac{3}{4}$ (*d*) $\frac{1}{\sqrt{2}}$

Ans. (*c*) As phase difference,

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{\pi}{3}$$

$$I(\text{Intensity}) = a^2 + a^2 + 2a^2 \cos 60° = 3a^2$$

$$I_0 = I_{max} = a^2 + a^2 + 2a^2 \cos 0° = 4a^2$$

$$\frac{I}{I_0} = \frac{3}{4}$$

14. Consider sunlight incident on a slit of width 10^4 A. The image seen through the slit shall

(*a*) be a fine sharp slit white in colour at the centre.

(*b*) a bright slit white at the centre diffusing to zero intensities at the edges.

(*c*) a bright slit white at the centre diffusing to regions of different colours.

(*d*) only be a diffused slit white in colour.

Ans. (*a*)

15. In a Young's double slit experiment, the source is white light. One of the holes is covered by a red filter and another by a blue filter. In this case

(*a*) there shall be alternate interference patterns of red and blue.

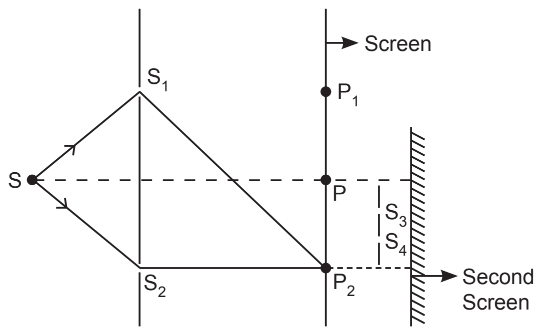
(*b*) there shall be an interference pattern for red distinct from that for blue.

(*c*) there shall be no interference fringes.

(*d*) there shall be an interference pattern for red mixing with one for blue.

Ans. (*c*)

16. Figure shows a standard two slit arrangement with slits S_1, S_2, P_1, P_2 are the two minima points on either side of P (Figure). At P_2 on the screen, there is a hole and behind P_2 is a second 2- slit arrangement with slits S_3, S_4 and a second screen behind them.



(*a*) There would be no interference pattern on the second screen but it would be lighted.

(*b*) The second screen would be totally dark.

(*c*) There would be a single bright point on the second screen.

(*d*) There would be a regular two slit pattern on the second screen.

Ans. (*d*)

17. Consider the diffraction pattern for a small pinhole. As the size of the hole is increased

(*a*) the size decreases.
(*b*) the intensity remain same
(*c*) the size increases.
(*d*) the intensity decreases.

Ans. (*a*)

18. For the light diverging from a point source

(*a*) the wavefront is spherical.
(*b*) the intensity increases in proportion to the distance squared.
(*c*) the wavefront is parabolic.
(*d*) the intensity at the wavefront does not depend on the distance.

Ans. (*a*)

19. Two waves are said to be coherent if they have.

(*a*) same phase and different amplitude.
(*b*) different frequency phase and amplitude.
(*c*) same frequency but different amplitude.
(*d*) same frequency, constant phase and same amplitude.

Ans. (*d*) Two waves are coherent if they have same frequency and constant phase difference but amplitude may or may not be same.

20. An interference pattern is observed by Young's double slit experiment. If now the separation between coherent sources is halved and the distance of screen from coherent sources is doubled, the new fringe width

(*a*) becomes double.
(*b*) becomes one-fourth.
(*c*) remains the same.
(*d*) becomes four times.

Ans. (*d*) Fringe width becomes four time,

$$\text{As } \beta = \frac{D\lambda}{d},\ \beta' = \frac{2\times 2D\lambda}{d} = 4\beta$$

21. Consider sunlight incident on a pinhole of width 10^3 A. The image of the pinhole seen on a screen shall be

(*a*) a sharp white ring.
(*b*) same as the geometrical image.
(*c*) a diffused central spot, white in colour.
(*d*) diffused coloured region around a sharp central white spot.

Ans. (*d*) diffused coloured region around a sharp central white spot.

22. How do you define constructive interference?

(*a*) Superposition of two waves in the same phase to produce maximum intensity
(*b*) Superposition of two waves in the opposite phase to produce maximum intensity
(*c*) Superposition of two waves in the same phase to produce minimum intensity
(*d*) Superposition of two waves in the opposite phase to produce minimum intensity

Ans. (*a*)

23. What would be the expression of phase difference between wave for a destructive interference?

(*a*) $\frac{(2n+1)}{\pi}$ (*b*) $(2n + 1)\pi$ (*c*) $(2n - 1)\pi$ (*d*) $2n\pi$

Ans. (*c*)

24. Path difference between waves, having wavelength λ and undergoing constructive interference is

(*a*) $(n + 1)\lambda$ (*b*) $\frac{(n-1)\pi}{\lambda}$ (*c*) $\left(\frac{n+1}{\pi}\right)\lambda$ (*d*) $n\lambda$

Ans. (*d*)

25. What is the width of dark and bright fringes in interference of waves?

(*a*) Unequal (*b*) Equal

(*c*) Dark fringe is more (*d*) Bright fringe is more

Ans. (*b*)

26. A wavefront is an imaginary surface where

(*a*) phase difference continuously changes between the points

(*b*) phase changes at certain points on the surface

(*c*) phase is same for all points

(*d*) phase changes at constant rate at all points along the surface

Ans. (*c*)

27. A plane wavefront falls on a concave lens, the emergent wavelength is

(*a*) Plane (*b*) cylindrical

(*c*) spherical diverging (*d*) spherical converging

Ans. (*c*)

28. When two light waves meet at a place

(*a*) Their displacements are added up (*b*) Their intensities are added up

(*c*) Both are added up (*d*) Energy and momentum becomes zero

Ans. (*a*)

29. In Young's double slit experiment, the separation between the slits is halved and the distance between the slits and the screen is doubled. The fringe width is

(*a*) Unchanged (*b*) halved (*c*) doubled (*d*) quadrupled

Ans. (*d*)

30. In Young's double slit experiment, the separation between the slits is doubled and the distance between the slits and the screen is halved. The fringe width is

(*a*) unchanged (*b*) halved (*c*) one fourth (*d*) quadrupled

Ans. (*c*)

31. In a double slit experiment instead of taking slits of equal width, one slit is made twice as wide as the other, then in the interference pattern

(*a*) The intensities of both maxima and minima increase

(*b*) The intensity of the maxima increase and the minima zero intensity

(*c*) The intensity of the maxima decreases and that of the minima increases

(*d*) The intensity of the maxima decreases and the minima has zero intensity

Ans. (*a*) $$\frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{a^2}{b^2}$$

Given $w_2 = 2w_1$

Substituting $b = a\sqrt{2}$

$$I_{max} \propto (a + a\sqrt{2})^2 = 5.8a^2$$

$$I_{min} \propto (a\sqrt{2} - a)^2 = 0.17a^2$$

32. In a Young's double slit experiment, the slit width ratio is 1:36, then the ratio of the maximum and minimum intensity of the interfernece of light is

(*a*) $\frac{24}{29}$ (*b*) $\frac{49}{25}$ (*c*) $\frac{121}{49}$ (*d*) $\frac{49}{121}$

Ans. (*b*) Use the formula $$\frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{A_1^2}{A_2^2},\ \frac{I_{max}}{I_{min}} = \left[\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right]^2 = \frac{(A_1+A_2)^2}{(A_1-A_2)^2} = \frac{\left(\frac{A_1}{A_2}+1\right)^2}{\left(\frac{A_1}{A_2}-1\right)^2}$$

33. In a Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength is changed to 400 nm, the number of fringes formed in the same segment of the screen is

(*a*) 12 (*b*) 18 (*c*) 24 (*d*) 30

Ans. (*b*) $$\frac{12\lambda_1 D}{d} = \frac{n\lambda_2 D}{d}$$

34. In Young's double slit experiment, the intensity at a point is $1/4^{th}$ of the maximum intensity. Angular position of this point is

(*a*) $\sin^{-1}\left(\frac{\lambda}{d}\right)$ (*b*) $\sin^{-1}\left(\frac{\lambda}{2d}\right)$ (*c*) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$ (*d*) $\sin^{-1}\left(\frac{\lambda}{4d}\right)$

Ans. (*b*) $$I_{max} = 4I$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Substitute $I_1 = I_2 = I$ we get $\phi = \frac{2\pi}{3}$; $2\pi \rightarrow \lambda$

$$\frac{2\pi}{3} \rightarrow \frac{\lambda}{3}$$

$$d\sin\theta = \frac{\lambda}{3}$$

$$\theta = \sin^{-1}\left(\frac{\lambda}{3d}\right)$$

Assertion-Reason Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

35. Assertion (A): The width of central maxima of diffraction is 2 times as compared to other maxima.

Reason (R): Diffraction is superposition of a continuous family of waves originating from each point of single slit.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

36. Assertion (A): Diffraction and interferences is consistent with principle of conservation of energy.

Reason (R): There is no gain or loss of energy, it get redistributed in dark and bright fringe.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

37. Assertion (A): To observe diffraction of light the size of the obstacle/aperture should be of the order of 10^{-7} m.

Reason (R): 10^{-7} m is the order of the wavelength of visible light.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

38. Assertion (A): In interference, only redistribution of light energy occurs.

Reason (R): Average energy in the interference pattern is the same as that, if there were no interference.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Case-based Questions

39. Each point on a wavefront is a source of new disturbance this is called secondary wavefront. They spread in all directions with speed of light. A wavefront is locus of particles which are vibrating in same phase, rays are perpendicular to the wavefronts. Light will take time to travel from source to the observer. Speed of light in any medium is less than the speed of light in vacuum. This speed can be co-related the wavelength of the wave also. Since the refractive index gives the relation between speeds of different media, the wavelength in different media can be determined by using the refractive index.

(*i*) Speed of light in two different media is v_1 and v_2. What is the ratio of their wavelengths?

(*a*) $\frac{\lambda_1}{\lambda_2}$ (*b*) $\frac{\lambda_2}{\lambda_1}$

(*c*) $\frac{3\lambda_2}{\lambda_1}$ (*d*) $\frac{\lambda_1}{2\lambda_2}$

(*ii*) The characteristic which remains unchanged after reflection or refraction is:

(*a*) speed (*b*) wavelength

(*c*) frequency (*d*) momentum

(*iii*) Speed of light in diamond is ($\mu_d = 2.47$)

(*a*) 1.2×10^8 m/s (*b*) 1.7×10^8 m/s

(*c*) 1.9×10^8 m/s (*d*) 10^8 m/s

(*iv*) Wavelength of light of 487 nm in water is

(*a*) 300 nm (*b*) 520 nm

(*c*) 350 nm (*d*) 366 nm

(*v*) The wavefront of beam of parallel light is

(*a*) Spherical (*b*) Plane

(*c*) Cylindrical (*d*) None

Ans. (*i*) (*a*)

$$v = \nu\lambda$$

$$\frac{v_1}{v_2} = \frac{\nu\lambda_1}{\nu\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

(*ii*) (*c*) Frequency is the characteristic property of the source.

(*iii*) (*a*)

$$\mu = \frac{c}{v}$$

$$v = \frac{c}{\mu} = \frac{3\times10^8 \text{ m/s}}{2.47}$$

$$= 1.2 \times 10^8 \text{ m/s}$$

(*iv*) (*d*)

$$\mu = \frac{v_1}{v_2} = \frac{\nu\lambda_1}{\nu\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

$$\lambda_2 = \frac{\lambda_1}{\mu} = \frac{487}{1.33} = 366 \text{ nm}$$

(*v*) (*b*) For parallel beam, wavefronts are plane.

40. Coherent sources emit light waves with same frequency or same wavelength, with a phase difference which is either zero or constant. On the other hand, non-coherent sources do not emit light waves which have a constant or zero phase difference. Interference pattern can be produced only when the light emitting sources are coherent. The intensity of pattern is maximum when phase difference is integral even multiple of π and minimum for odd multiple of π.

(*i*) The maximum intensity of interference pattern is

(*a*) $(I_1 + I_2)^2$ (*b*) $(I_1 - I_2)^2$

(*c*) $\sqrt{I_1} + \sqrt{I_2}$ (*d*) $\left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

(*ii*) A phase difference of 2π corresponds to the path difference of

(*a*) $\lambda/2$ (*b*) λ

(*c*) 3λ (*d*) $3\lambda/2$

(*iii*) The intensity of light at a point on screen where the path difference is λ is k units. Find the intensity where path difference is $\frac{\lambda}{6}$.

(*a*) k (*b*) $\frac{k}{2}$

(*c*) $\frac{3k}{4}$ (*d*) $\frac{3k}{2}$

(*iv*) For a sustained interference pattern, which of the following is true?

(*a*) Sources should be coherent. (*b*) Sources should be monochromatic.

(*c*) Sources should be narrow. (*d*) All of the above.

(*v*) What happens to the interference pattern in Young's double slit experiment when a monochromatic source is replaced by a white source of light?

(*a*) The pattern disappears.

(*b*) The fringe width decreases.

(*c*) Coloured fringe pattern is obtained.

(*d*) The pattern does not change.

Ans. (*i*) (*d*) When $\cos\phi = +1$, the intensity will be maximum

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

$$= I_1 + I_2 + 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

(*ii*) (*b*) A wave completes λ wavelength while traversing phase difference of 2π.

(*iii*) (*c*)

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Let $I_1 = I_2 = I_0$

$$I = 2I_0 + 2I_0\cos\phi$$

$$= 2I_0[1 + \cos\phi] = 2I_0 \times 2\cos^2\frac{\phi}{2} = 4I_0\cos^2\frac{\phi}{2}$$

For λ = path difference

$\phi = 2\pi$

$I = 4I_0 = k =$ units

For $\frac{\lambda}{6}$ = path difference, $\phi = \frac{2\pi}{6} = \frac{\pi}{3}$

$$I = 4I_0\cos^2\frac{\pi}{6} = \frac{3k}{4}$$

(*iv*) (*d*) All of the above. All the stated conditions are important for a sustained interference pattern.

(*v*) (*c*) Coloured fringes are obtained in place of the dark and light fringes.

41. Proof of wave nature of light was demonstrated by Young through double slit experiment. When he observed that there is alternate dark and bright fringes which are equally spaced. This proved that the combination of two light sources can even produce darkness called as interference. We get straight fringes even if the sources are point sources. There is a diffraction pattern. Number of interference fringes depends on ratio of distance between two slits and width of a slit.

(*i*) The relation between fringe width and wavelength is

(*a*) $\beta \propto \lambda^{-1}$ (*b*) $\beta \propto \lambda$

(*c*) $\beta \propto \lambda^2$ (*d*) $\beta \propto \lambda^{-2}$

(*ii*) What make us think that light also behaves like a wave?

(*a*) Patterns obtained by single slit.

(*b*) Patterns due to monochromatic light source.

(*c*) When experiment with electron gave same result.

(*d*) None of the above.

(*iii*) What is the separation of central maximum from 1st null of diffraction pattern?

(*a*) λ/a (*b*) λa

(*c*) $\lambda + a$ (*d*) $\lambda - a$

(*iv*) How the radius of central bright region depends on width of slit?

(*a*) inversely proportional to width.

(*b*) directly proportional to width.

(*c*) inversely proportional to width square.

(*d*) directly proportional to width square.

Ans. (*i*) (*b*) Fringe width is directly proportional to the wavelength.

(*ii*) (*c*)

(*iii*) (*a*) The separation is $\frac{\lambda}{a}$.

(*iv*) (*a*) $r \propto \frac{1}{d}$. Here r = radius of central bright region, d = width of slit.

11 DUAL NATURE OF RADIATION AND MATTER

Multiple Choice Questions

1. Light of frequency 1.9 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes

(*a*) quadrupled (*b*) doubled

(*c*) halved (*d*) zero

Ans. (*d*) As $\nu_i = 0.95\ \nu_0$. No photoelectric emission takes place.

2. Threshold wavelength for a metal having work function W_0 is λ. What is the threshold wavelength for the metal having work function $2W_0$?

(*a*) 4λ (*b*) 2λ (*c*) λ/2 (*d*) λ/4

Ans. (*c*) Since $$W_0 = h\frac{c}{\lambda}$$

$$2W_0 = h\frac{c}{\lambda_1} \Rightarrow 2 = \frac{\lambda}{\lambda_1} \text{ or } \lambda_1 = \frac{\lambda}{2}$$

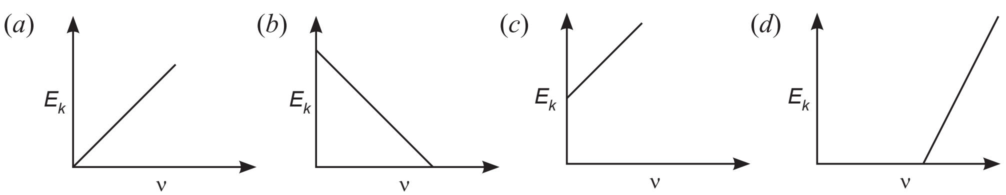
3. Radiations of frequency ν are incident on a photosensitive metal. The maximum K.E. of the photoelectrons is *E*. When the frequency of the incident radiation is doubled, what is the maximum kinetic energy of the photoelectrons?

(*a*) $2E$ (*b*) $4E$ (*c*) $E + h\nu$ (*d*) $E - h\nu$

Ans. (*c*) Using Einstein's photoelectric equation

$$h\nu - W_0 = E \quad \text{or} \quad h\nu - h\nu_0 = E$$

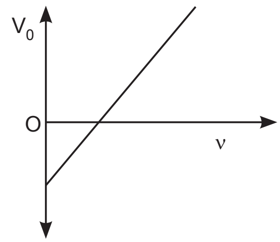
4. Maximum kinetic energy (E_k) of a photoelectron varies with frequency (ν) of the incident radiation as



Ans. (*d*) Using Einstein's photoelectric equation

$$h\nu = h\nu_0 + E_k$$

5. The stopping potential V_0 for photoelectric emission from a metal surface is plotted along *y*-axis and frequency ν of incident light along *x*-axis. A straight line is obtained as shown. Planck's constant is given by



(a) slope of the line
(b) product of the slope of the line and charge on electron
(c) intercept along y-axis divided by charge on the electron
(d) product of the intercept along x-axis and mass of the electron

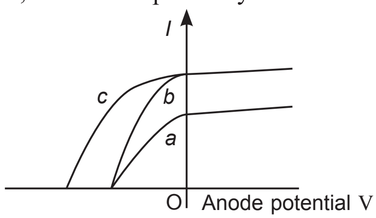
Ans. (d) Using Einstein's photoelectric equation. $h = m \times e$

6. The energy of photon of wavelength 450 nm is

(a) 2.5×10^{-17} J (b) 1.25×10^{-17} J (c) 4.4×10^{-19} J (d) 2.5×10^{-19} J

Ans. (c) Using $$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{450 \times 10^{-9}} \text{ J} = 4.4 \times 10^{-19} \text{ J}$$

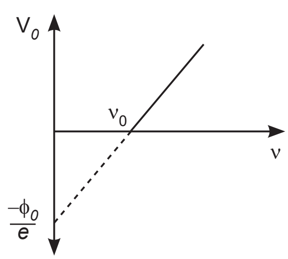
7. Below figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and ν_a, ν_b and ν_c be the frequencies for the curves a, b and c respectively. Then the correct relation is



(a) $\nu_a = \nu_b$ and $I_a \neq I_b$ (b) $\nu_a = \nu_c$ and $I_a = I_c$
(c) $\nu_a = \nu_b$ and $I_a = I_b$ (d) $\nu_b = \nu_c$ and $I_b = I_c$

Ans. (a)

8. The slope of the stopping potential versus frequency graph for photoelectric effect is equal to



(a) h (b) he (c) h/e (d) e

Ans. (c) Using Einstein's equation for photoelectric effect

$$h\nu = h\nu_0 + eV_0 \quad \Rightarrow \quad \frac{h}{e}\nu = \frac{h}{e}\nu_0 + V_0$$

9. A proton and an α-particle are accelerated by the same potential difference. The ratio of their de broglie wavelengths $(\lambda_p/\lambda_\alpha)$ is

(*a*) 1 : 2 (*b*) 2 : 1

(*c*) $\sqrt{8}$: 1 (*d*) $\frac{1}{\sqrt{8}}$

Ans. (*c*) Using $\lambda = \frac{h}{\sqrt{2meV}}, \lambda_p = \frac{h}{\sqrt{2m\,eV}}$

$$\lambda_\alpha = \frac{h}{\sqrt{2\,.\,4m\,.\,2e\,.\,V}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \frac{\sqrt{8}}{1}$$

10. Work function of three metals A, B and C are 4.5 eV, 4.3 eV and 3.5 eV respectively. If a light of wavelength 4000 Å is incident on the metals then

(*a*) photoelectrons are emitted from A.
(*b*) photoelectrons are emitted from B.
(*c*) photoelectrons are emitted from C.
(*d*) photoelectrons will not emitted from all the metals.

Ans. (*d*) Since energy of incident photon

$$E = \frac{hc}{\lambda} = \frac{6.62\times10^{-34}\times3\times10^{8}}{4000\times10^{-10}\times1.6\times10^{-19}}\text{ eV} = 3.09\text{ eV}$$

Energy of the photons is less than the work function of all three metals. So, photoelectrons will not emitted from all the metals.

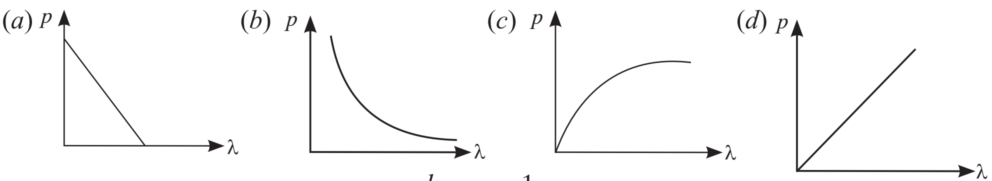
11. The photoelectric effect can be explained by

(*a*) Corpuscular theory of light (*b*) Wave nature of light

(*c*) Bohr's theory (*d*) Quantum theory of light

Ans. (*d*)

12. The graph showing the correct variation of linear momentum (p) of a charged particle with its de-Broglie wavelength (λ) is – **[CBSE 2020]**



Ans. (*b*) From de Broglie hypothesis, $p = \frac{h}{\lambda};\ p \propto \frac{1}{\lambda}$

13. According to Einstein's photoelectric equation the plot of the kinetic energy of the emitted photoelectrons from a metal vs the frequency of the incident radiation gives a straight line whose slope

(*a*) depends on the nature of the metal used.
(*b*) depends on the intensity of the radiation.
(*c*) depends both on the intensity of the radiation and the metal used.
(*d*) is the same for all metals and independent of the intensity of the radiation.

Ans. (*d*) Since slope $= \frac{h}{e}$

14. If K.E. of free electron is doubled, its de Broglie wavelength will change by factor

(*a*) $\frac{1}{\sqrt{2}}$ (*b*) $\sqrt{2}$ (*c*) $\frac{1}{2}$ (*d*) 2

Ans. (*a*) Since $\lambda = \frac{h}{\sqrt{2\,Km}}$ ot $\lambda \propto \frac{1}{\sqrt{K}}$

15. Work function of metal is

(*a*) the minimum energy required to free an electron from surface against coulomb forces.

(*b*) the minimum energy required to free an nucleon.

(*c*) the minimum energy to ionise an atom.

(*d*) the minimum energy required to eject an electron orbit.

Ans. (*a*)

16. The rest mass of a photon of wavelength λ is

(*a*) zero (*b*) $\frac{h}{c\lambda}$ (*c*) $\frac{h}{\lambda}$ (*d*) $\frac{hc}{\lambda}$

Ans. (*a*)

17. Photoelectric effect is based on the law of conservation of

(*a*) energy (*b*) mass

(*c*) linear momentum (*d*) angular momentum

Ans. (*a*)

18. Einstein's photoelectric equation is:

(*a*) $h\nu = h\nu_0 + \frac{1}{2}mv^2$ (*b*) $h\nu_0 = h\nu + \frac{1}{2}mv^2$

(*c*) $h\nu = h\nu_0 - \frac{1}{2}mv^2$ (*d*) $2h\nu = h\nu_0 + mv^2$

Ans. (*a*)

19. In photoelectric effect, the number of photoelectrons emitted is proportional to

(*a*) intensity of incident beam.

(*b*) frequency of incident beam.

(*c*) velocity of incident beam.

(*d*) work function of photo cathode.

Ans. (*a*)

20. For a given kinetic energy which of the following has smallest de Broglie wavelength?

(*a*) Electron (*b*) Proton

(*c*) Deutron (*d*) α-particle

Ans. (*d*) Since de Broglie wavelength

$$\lambda = \frac{h}{\sqrt{2meV}} \text{ or } \frac{h}{\sqrt{2mE_k}}$$

or $\lambda \propto \frac{1}{\sqrt{m}}$ for same K.E. Out of given particle, mass of ∝-particle is maximum.

21. Which of the following shows particle nature of light?

(*a*) Photoelectric effect (*b*) Refraction

(*c*) Interference (*d*) Polarisation

Ans. (*a*)

22. A particle is dropped from a height H. The de Broglie wavelength of the particle as a function of height is proportional to

(*a*) H (*b*) $H^{1/2}$ (*c*) H^0 (*d*) $H^{-1/2}$

Ans. (*d*) $\lambda \propto \frac{1}{p} \propto \frac{1}{v} \propto \frac{1}{\sqrt{H}}$

23. A proton, a neutron, an electron and an α-particle have same energy. Then their de Broglie wavelengths compare as

(*a*) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ (*b*) $\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$

(*c*) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$ (*d*) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

Ans. (*b*)

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$$\lambda_p : \lambda_n : \lambda_e : \lambda_\alpha = \frac{1}{\sqrt{m_p}} : \frac{1}{\sqrt{m_e}} : \frac{1}{\sqrt{m_n}} : \frac{1}{\sqrt{m_\alpha}}$$

As, $m_\alpha > m_p$ therefore $\lambda_\alpha < \lambda_p$

As, $m_e < m_n$ therefore $\lambda_e > \lambda_n$ and $m_p = m_n$, $\lambda_p = \lambda_n$ so, $\lambda_\alpha < \lambda_p = \lambda_n > \lambda_e$

24. Relativistic corrections become necessary when the expression for the kinetic energy $1/2\ mv^2$, becomes comparable with mc^2, where m is the mass of the particle. At what de Broglie wavelength, will relativistic corrections become important for an electron?

(*a*) $\lambda = 10$ nm (*b*) $\lambda = 10^{-1}$ nm (*c*) $\lambda = 10^{-4}$ nm (*d*) $\lambda = 10^{-3}$ nm

Ans. (*c*)

25. Two particles A_1 and A_2 of masses m_1, $m_2 (m_1 > m_2)$ have the same de Broglie wavelength. Then,

(*a*) their momenta are the same.

(*b*) their energies are the same.

(*c*) energy of A_1 is greater than the energy of A_2.

(*d*) momentum of A_2 is more than momentum of A_1.

Ans. (*a*)

26. Photons absorbed in a matter are converted to heat. A source emitting n photon/sec of frequency ν is used to convert 1 kg of ice at 0°C to water at 0°C. Then, the time T taken for the conversion

(*a*) increases with increasing n, with ν fixed

(*b*) decreases with n fixed, ν increasing.

(*c*) does not remain constant with n and ν changing such that $n\nu$ = constant

(*d*) increases when the product $n\nu$ increases.

Ans. (*b*) $T = \frac{mL}{nH\nu}$

27. A particle moves in a closed orbit around the origin, due to a force which is directed towards the origin. The de Broglie wavelength of the particle varies cyclically between two values λ_1, λ_2 with $\lambda_1 > \lambda_2$. Which of the following statements are true?

(*a*) The particle could not be moving in a circular orbit with origin as centre.

(*b*) The particle could not be moving in an elliptic orbit with origin as its focus.

(*c*) When the de Broglie wavelength is λ_1, the particle is nearer the origin than when its value is λ_2.

(*d*) When the de Broglie wavelength λ_2, the particle is nearer the origin than when its value λ_1.

Ans. (*d*)

28. In photoelectric effect what determines the maximum velocity of electron after reaching the collector plate?

(*a*) Frequency of incident radiation alone

(*b*) Work function of metal

(*c*) Potential difference between the emitter and the collector

(*d*) All of these

Ans. (*d*) As per Einstein's photoelectric equation

$$h\nu = h\nu_0 + \frac{1}{2}mv^2_{max}, \qquad v_{max} - \text{depends on } \nu, \nu_0$$

or $$h\nu_0 - h\nu_0 = \frac{1}{2}\, mv^2_{max} = eV$$

29. A proton and an α-particle have the same de Broglie wavelength. What is same for both of them?

(*a*) Mass (*b*) Energy (*c*) Frequency (*d*) Momentum

Ans. (*d*) Since $\lambda = \frac{h}{p}$, for the same wavelength, momentum is also same.

30. The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1 MeV energy is nearly

(*a*) 1.2 nm (*b*) 1.2×10^{-3} nm (*c*) 1.2×10^{-6} nm (*d*) 1.2×10^{1} nm

Ans. (*b*) $$E = \frac{hc}{\lambda},\ \lambda = \frac{hc}{E} = \frac{1240}{10^6}\text{ nm} = 1.24 \times 10^{-3}\text{ nm}$$

31. An electron is moving with an initial velocity $v = v_0\hat{i}$ and is in a magnetic field $B = B_0\,\hat{j}$. Then, its de Broglie wavelength

(*a*) remains constant. (*b*) increases with time.

(*c*) decreases with time. (*d*) increases and decreases periodically.

Ans. (*a*) $F = q(v \times B) = F = qvB \sin\theta$. As this force is perpendicular to v and B, so the magnitude of v will not change, i.e. momentum ($p = mv$) will remain constant in magnitude.

De Broglie wavelength $\lambda = \frac{h}{mv}$ remains constant

32. The frequency associated with photon of energy 3.3×10^{-10} J is:

(*a*) 4×10^{20} Hz (*b*) 5×10^{23} Hz (*c*) 6×10^{22} Hz (*d*) 7×10^{23} Hz

Ans. (*b*) Use the formula, $E = h\nu$, $h = 6.6 \times 10^{-34}$, $v = \frac{E}{h} = \frac{3.3 \times 10^{-10}}{6.6 \times 10^{-34}} = 5 \times 10^{23}$ Hz

33. What is the momentum of a photon of energy 1 MeV?

(*a*) 3.26×10^{-22} Kg m/s (*b*) 4.35×10^{-20} Kg m/s

(*c*) 5.33×10^{-22} Kg m/s (*d*) 6.22×10^{-22} Kg m/s

Ans. (*c*) $P = \frac{E}{C}$

34. Choose the element with highest work function.

(*a*) Platinum (*b*) Silver (*c*) Caesium (*d*) Copper

Ans. (*a*)

35. A radio transmitter at a frequency of 880 kHz and a power of 10 kW. The number of photons emitted per second is:

(*a*) 2.315×10^{20} (*b*) 3.612×10^{30}

(*c*) 1.218×10^{31} (*d*) 1.716×10^{31}

Ans. (*d*) $N = \frac{p}{hv}$

36. What is the de-Broglie wavelength (in Å) associated with an e^- accelerated through a potential of 100 V?

(*a*) 1.227 Å (*b*) 2.116 Å (*c*) 1.318 Å (*d*) 2.212 Å

Ans. (*a*)

37. An electron and an α-particle have same kinetic energy, which of these particles has the shortest de-Broglie wavelength?

(*a*) Electron (*b*) Alpha Particle (*c*) Both (*a*) and (*b*) (*d*) Neither (*a*) nor (*b*)

Ans. (*b*)

Assertion-Reason Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

38. Assertion (A): Number of electrons emitted in one second is directly proportional to the intensity of incident radiation.

Reason (R): Higher numbers of photons can target higher number of electrons in the metal surface.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

39. Assertion (A): For a particle to have De-Broglie wave associated with it, it must carry charge.

Reason (R): De-Broglie waves are electromagnetic in nature.

Ans. (*c*) Assertion (A) is true but Reason (R) is false.

40. **Assertion (A):** Macroscopic objects have a De-Broglie wavelength which is very small.

Reason (R): De-Broglie wavelength is inversely proportional to the mass of material particle.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Case-based Questions

41. According to wave picture, light is an EM wave consisting of electric and magnetic fields with continuous distribution of energy over the region of space of wave. This wave nature didn't explain the photoelectric effect. The e^- needs to be supplied with more energy than work function of material. We know photoelectric emission is an instantaneous process. Photon is called quanta of energy.

(*i*) The kinetic energy of the e^- emitted depends on which parameter?

(*a*) Frequency of incident light. (*b*) Intensity of incident light.

(*c*) Work function of material. (*d*) Potential applied.

(*ii*) Does the matter wave picture elegantly incorporated the Heisenberg's uncertainty principle?

(*a*) Yes (*b*) No

(*c*) May be (*d*) Can't say

(*iii*) How does amplitude of electric and magnetic vary with intensity of radiation?

(*a*) If the intensity increases then amplitude also increases.

(*b*) Intensity increases and amplitude decreases.

(*c*) Amplitude doesn't depend on intensity.

(*d*) None of the above.

(*iv*) Is there any specific region of absorption of e^- on wavefront?

(*a*) Continuously over the right of wavefront.

(*b*) Continuously over the left of wavefront.

(*c*) Continuously over the entire wavefront.

(*d*) None of the above.

(*v*) Does photon get deflected by electric and magnetic fields?

(*a*) Yes (*b*) No

(*c*) May be (*d*) Depending on situation

Ans. (*i*) (*a*) $E = h\nu$, if this frequency is greater than minimum energy needed to exceeds (ϕ_0). Then emitted e^- will have K.E.

(*ii*) (*a*) Yes, it does incorporate.

(*iii*) (*a*) Intensity of the wave is directly proportional to the square of its amplitude.

(*iv*) (*c*) Absorption of energy by e^- takes place continuously over the entire wavefront. Each secondary wavefront acts as wavefront.

(*v*) (*b*) Photons are electrically neutral. So does not deflected by electric and magnetic fields.

42. In 1887, German physicist Heinrich Hertz noticed that shining a beam of ultraviolet light onto a metal plate could cause it to shoot sparks. It is due to the emission of negatively charged particles called electrons from the metal surface into the surrounding space.

Hallwachs and Lenard also observed that when ultraviolet light fell on the emitter plate, no electrons were emitted at all when the frequency of the incident light was smaller than a certain minimum frequency.

Experimental study shows that different metals required different minimum frequencies of light for the emission of electron. When brightness of the incident light increases, more electrons were produced, without increasing their energy, and increasing the frequency of the light produced electrons with higher energies, but without increasing the number produced. This is known as the photoelectric effect, and it would be understood in 1905 by a young scientist named Albert Einstein.

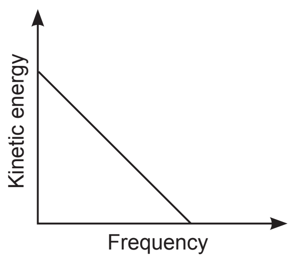
(*i*) In photoelectric effect, the kinetic energy of emitted electrons from the metal surface depends upon

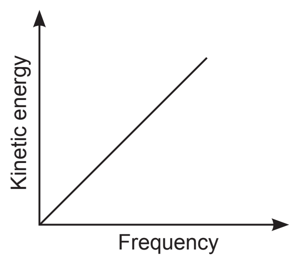
(*a*) frequency of incident light
(*b*) velocity of incident light
(*c*) intensity of light
(*d*) angular momentum of emitted electron.

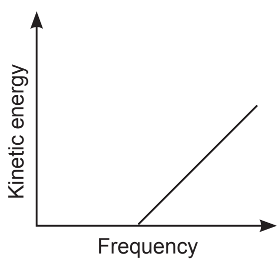
(*ii*) When monochromatic radiation of intensity I falls on a metal surface, the number of photoelectron and their maximum kinetic energy are n and K respectively. If the intensity of radiation is $2I$, the number of emitted photoelectron and their maximum kinetic energy will be

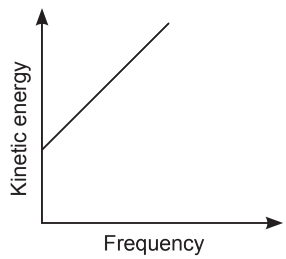
(*a*) n and $2K$
(*b*) $2n$ and $2K$
(*c*) $2n$ and K
(*d*) n and K

(*iii*) According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is

(*a*)


(*b*)


(*c*)


(*d*)


(*iv*) If the momentum of an electron is changed by p, then the de-Broglie wavelength associated with it changes by 0.4%. The initial momentum of electron will be

(*a*) 100 P
(*b*) 250 P
(*c*) 300 P
(*d*) 200 P

(*v*) Which of the following property does not support wave theory of light?

(*a*) Light waves get polarised

(*b*) Light obeys Laws of refraction and reflection

(*c*) Light shows phenomenon of diffraction

(*d*) Light shows photoelectric effect.

Ans. (*i*) (*a*) the kinetic energy of emitted photo-electrons depends upon frequency of incident light.

(*ii*) (*c*) Number of photoelectrons = $2n$

$$KE_{max} = K$$

Increase in intensity of radiation increases the number of emitted photoelectrons. Energy of emitted photoelectron depends on frequency of incident radiation.

(*iii*) (*c*) According to Einstein equation, $K_{\text{max}} = hv - \phi_0$. On comparing it with $y = mx + c$, we find that $K_{\text{max}} \propto v$, *i.e* the graph between K_{max} and v is a straight line with positive slope (h), intercept on horizontal axis equal to v_0 and negative intercept hv_0 on KE axis.

(*iv*) (*b*)

$$\lambda = \frac{h}{P_0}$$

$$\frac{d\lambda}{\lambda} = -\frac{dP_0}{P_0} = \frac{|d\lambda|}{\lambda} = \frac{|dP_0|}{P_0}$$

$$\frac{0.4}{100} = \frac{P}{P_0} \quad \Rightarrow \quad P_0 = 250\text{ P}$$

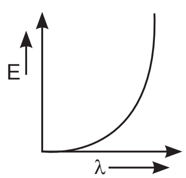
(*v*) (*d*) Photoelectric effect cannot be explained on the basis of wave theory of light.

43. Einstein's Planck's quantum theory explains photoelectric emission. He assumed that radiation is not a wave but a particle(photon) to quantised energy and emission of electron is the result of the elastic collision between the incident particle(photon) and electrons of atoms on/inside the surface of metals.

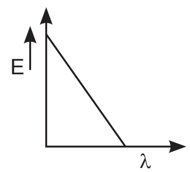
In 1924, Louis de Broglie put forward a hypothesis that like radiation, matter should also possess dual nature. It means that moving particles of matter display wave like properties.

(*i*) The correct graph for depicting energy of a photon 'E' as a function of its wavelength λ is:

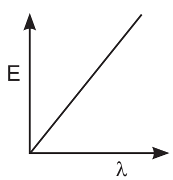
(*a*)



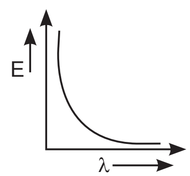
(*b*)



(*c*)



(*d*)



(*ii*) The momentum of a photon of wavelength 5000 Å will be

(*a*) 1.3×10^{-27} kg ms^{-1} (*b*) 1.3×10^{-28} kg ms^{-1}

(*c*) 4×10^{-19} kg ms^{-1} (*d*) 4×10^{-18} kg ms^{-1}

(*iii*) An electron and a photon have equal de Broglie wavelength. Which of them will have greater kinetic energy?

(*a*) Electron (*b*) Proton

(*c*) Both will move with same speed (*d*) None of these

(*iv*) De Broglie wavelength for the electrons accelerated through a potential difference of 64V is approximately:

(*a*) 0.153 Å (*b*) 1.53 nm

(*c*) 1.53 Å (*d*) 15.3 Å

(*v*) The wavelength of light incident on a metal surface is increased keeping the intensity constant. Then the

(*a*) number of emitted electrons will increase.

(*b*) energy of emitted electrons will decrease.

(*c*) number of emitted electrons remains the same.

(*d*) stopping potential required will increase.

Ans. (*i*) (*d*) $\because$ $$E = \frac{hc}{\lambda} \propto \frac{1}{\lambda}$$

(*ii*) (*a*) $$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{5000 \times 10^{-10}} = 1.3 \times 10^{-27} \text{ kg ms}^{-1}$$

(*iii*) (*b*) Given $$\lambda_e = \lambda_{ph} = \lambda$$

$$\frac{(K.E.)_{ph}}{(K.E.)_{elec}} = \frac{h\nu}{\frac{1}{2}mv^2} = \frac{2\lambda.\nu}{v} = \frac{2c}{v}$$

$\because$ $$\frac{h}{mv} = \lambda, \text{ and } c = \lambda\cdot v$$

$\therefore$ $$\frac{K_{ph}}{K_e} > 1 \quad K_{ph} > K_e \qquad (\because c > v)$$

(*iv*) (*c*) $$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å} = \frac{12.27}{\sqrt{64}} \text{ Å} = 1.53 \text{ Å}$$

(*v*) (*b*) Energy of incident photon = $\frac{hc}{\lambda}$, on increasing λ, energy decreases.

12 ATOMS

Multiple Choice Questions

1. If 13.6 eV energy is required to ionise the hydrogen atom, then energy required to remove an electron from $n = 2$ is

(*a*) 10.2 eV (*b*) 0 eV

(*c*) 3.4 eV (*d*) 6.8 eV

Ans. (*c*) $E_n = \dfrac{-13.6}{n^2}$ eV, $\Delta E_\infty - E_2 = 0 + \dfrac{13.6}{2^2} = 3.4$ eV

2. In Bohr's model of an atom which of the following is an integral multiple of $\dfrac{h}{2\pi}$?

(*a*) Kinetic energy (*b*) Radius of an atom

(*c*) Potential energy (*d*) Angular momentum

Ans. (*d*) Angular momentum $L = mvr = \dfrac{nh}{2\pi}$

3. The transition from the state $n = 5$ to $n = 1$ in a hydrogen atom results in UV radiation. Infrared radiation will be obtained in the transition

(*a*) $2 \to 1$ (*b*) $3 \to 2$ (*c*) $4 \to 3$ (*d*) $6 \to 2$

Ans. (*c*)

4. In Bohr's model, the atomic radius of the first orbit is r_0. Then, the radius of the third orbit is

(*a*) $r_0/9$ (*b*) r_0 (*c*) $9r_0$ (*d*) $3r_0$

Ans. (*c*) $r_n = r_0 n^2 \quad \therefore \quad r_3 = 9r_0$.

5. The K.E. of the electron in an orbit of radius r in hydrogen atom is proportional to

(*a*) $\dfrac{e^2}{r}$ (*b*) $\dfrac{e^2}{2r}$ (*c*) $\dfrac{2e^2}{r}$ (*d*) $\dfrac{e^2}{3r}$

Ans. (*b*) $\dfrac{e^2}{2r}$, Since, K.E. $= \dfrac{e^2}{2r}$

6. The hydrogen atom can give spectral lines in the Lyman, Balmer and Paschen series. Which of the following statement is correct?

(*a*) Lyman series is in the infrared region. (*b*) Balmer series is in the visible region.

(*c*) Paschen series is in the visible region. (*d*) Balmer series is in the ultraviolet region.

Ans. (*b*)

7. The ratio between Bohr radii is

(*a*) 1 : 2 : 3 (*b*) 2 : 4 : 6

(*c*) 1 : 4 : 9 (*d*) 1 : 3 : 5

Ans. (*c*) 1 : 4 : 9, In Bohr's atomic model, $r_n \propto n^2$

8. Which of the relation is correct between time period and number of orbits while an electron is revolving in an orbit?

(*a*) $T \propto \frac{1}{n^2}$ (*b*) $T \propto n^2$ (*c*) $T \propto n^3$ (*d*) $T \propto \frac{1}{n}$

Ans. (*c*)

9. Energy of an electron in the second orbit of hydrogen atom is E and the energy of electron in 3rd orbit of He will be

(*a*) $E_3 = \frac{16E}{3}$ (*b*) $E_3 = \frac{16E}{9}$ (*c*) $E_3 = \frac{4E}{9}$ (*d*) $E_3 = \frac{4E}{3}$

Ans. (*b*) As $E_n = \frac{Z^2}{n^2} E_0$

For H-atom: $Z = 1$ and $n = 2$, $E_2 = \frac{E_0}{4} = E$

For He atom: $Z = 2$ and $n = 3$

$\therefore\ E_3 = \frac{4}{9} E_0$

Hence $E_3 = \frac{16}{9} E$

10. The longest wavelength in Balmer series of hydrogen spectrum will be

(*a*) 6557 Å (*b*) 1216 Å (*c*) 4800 Å (*d*) 5600 Å

Ans. (*a*) 6557 Å

For longest wavelength in Balmer series $n_1 = 2$ and $n_2 = 3$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right],\ R = 1.1 \times 10^7\ \text{m}^{-1}$$

11. In terms of Rydberg constant R, the wave number of the first Balmer line is

(*a*) R (*b*) $3R$ (*c*) $\frac{5R}{36}$ (*d*) $\frac{8R}{9}$

Ans. (*c*)

For first Balmer line $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$

12. The energy of hydrogen atom in the nth orbit is E_n, then the energy in the nth orbit of single ionised helium atom is

(*a*) $\frac{E_n}{2}$ (*b*) $2E_n$ (*c*) $4E_n$ (*d*) $\frac{E_n}{4}$

Ans. (*c*) As energy $E \propto Z^2$

For hydrogen atom $Z = 1$, for Helium $Z = 2$

$$E_{He} = 4E_n$$

13. The spectral lines in the Brackett series arise due to transition of electron in hydrogen atom from higher orbits to the orbit with

(*a*) $n = 1$ (*b*) $n = 2$ (*c*) $n = 3$ (*d*) $n = 4$

Ans. (*d*)

14. On moving up in the energy states of a H-like atom, the energy difference between two consecutive energy states

(*a*) decreases. (*b*) increases.

(*c*) first decreases then increases. (*d*) first increases then decreases.

Ans. (*a*) As, $E_n = \dfrac{-13.6}{n^2}$

15. The transition of electron from $n = 4, 5, 6, ...$ to $n = 3$ corresponds to

(*a*) Lyman series (*b*) Balmer series (*c*) Paschen series (*d*) Brackett series

Ans. (*c*) In transition from $n_1 = 3$ and $n_2 = 4, 5, 6, ...$

Infrared radiation of Paschen series is emitted.

16. As per Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of double ionized Li atom ($Z = 3$) is

(*a*) 1.51 eV (*b*) 13.6 eV (*c*) 40.8 eV (*d*) 122.4 eV

Ans. (*d*) Since energy of electron in *n*th state of hydrogen like atom is

$$E_n = \frac{-13.6\, Z^2}{n^2}\ \text{eV}$$

$$\Delta E = E_\infty - E_1 = 13.6\, Z^2 = 122.4\ \text{eV}$$

17. Which of the following spectral series in hydrogen atom gives spectral line of 4860 Å?

(*a*) Lyman (*b*) Balmer

(*c*) Paschen (*d*) Brackett

Ans. (*b*) Since spectral line of wavelength 4860 Å lies in the visible region of the spectrum which is Balmer series of the spectrum.

18. In terms of Rydberg constant R, the shortest wavelength in Balmer series of hydrogen atom spectrum will have wavelength

(*a*) $\dfrac{1}{R}$ (*b*) $\dfrac{4}{R}$

(*c*) $\dfrac{3}{2R}$ (*d*) $\dfrac{9}{R}$

Ans. (*b*) For shortest wavelength $n_1 = \infty$, $n_2 = 2$

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - 0\right) \quad \Rightarrow \quad \lambda = \frac{4}{R}$$

19. Taking the Bohr radius as $a_0 = 53$ pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about

(*a*) 53 pm (*b*) 27 pm (*c*) 18 pm (*d*) 13 pm

Ans. (*c*)

20. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because

(*a*) of the electrons not being subject to a central force.

(*b*) of the electrons colliding with each other.

(*c*) of screening effects.

(*d*) the force between the nucleus and an electron will no longer be given by Coulomb's law.

Ans. (*a*)

21. For the ground state, the electron in the H-atom has an angular momentum = h, according to the simple Bohr model. Angular momentum is a vector and hence there will be infinitely many orbits with the vector pointing in all possible directions. In actuality, this is not true,

(*a*) because Bohr model gives incorrect values of angular momentum.

(*b*) because only one of these would have a minimum energy.

(*c*) angular momentum must be in the direction of spin of electron.

(*d*) because electrons go around only in horizontal orbits.

Ans. (*a*)

22. O_2 molecule consists of two oxygen atoms. In the molecule, nuclear force between the nuclei of the two atoms

(*a*) is not important because nuclear forces are short-ranged.

(*b*) is as important as electrostatic force for binding the two atoms.

(*c*) cancels the repulsive electrostatic force between the nuclei.

(*d*) is not important because oxygen nucleus has equal number of neutrons and protons.

Ans. (*a*)

23. Two H atoms in the ground state collide inelastically. The maximum amount by which their combined kinetic energy is reduced is

(*a*) 10.20 eV (*b*) 20.40 eV

(*c*) 13.6 eV (*d*) 27.2 eV

Ans. (*a*)

24. A set of atoms in an excited state decays.

(*a*) in general to any of the states with lower energy.

(*b*) into a lower state only when excited by an external electric field.

(*c*) all together simultaneously into a lower state.

(*d*) to emit photons only when they collide.

Ans. (*a*)

25. An ionised H-molecule consists of an electron and two protons. The protons are separated by a small distance of the order of angstrom. In the ground state,

(*a*) the electron would move in circular orbits.

(*b*) the energy would be $(2)^4$ times that of a H-atom.

(*c*) the electrons, orbit would go around the protons.

(*d*) the molecule will soon decay in a proton and a H-atom.

Ans. (*c*)

26. The Balmer series for the H-atom can be observed

(*a*) if we measure the frequencies of light emitted when an excited atom falls to the ground state.

(*b*) if we measure the frequencies of light emitted due to transitions between excited states and the first excited state.

(*c*) in any transition in a H-atom.

(*d*) as a sequence of frequencies with the lower frequencies getting closely packed.

Ans. (*b*)

27. The Bohr model of an atom

(*a*) assumes that the angular momentum of electrons is quantised.

(*b*) uses Einstein's potoelectric equation.

(*c*) predicts continuous emission spectra for atoms.

(*d*) predicts the same emission spectra for all types of atoms.

Ans. (*a*)

28. The electrons in the Bohr's orbit have

(*a*) K.E. greater than P.E. (*b*) P.E. greater than K.E.

(*c*) the same values (*d*) none of these

Ans. (*a*) As K.E. $= \frac{13.6\, Z^2}{n^2}$ eV, P.E. $= \frac{-27.2\, Z^2}{n^2}$ eV

29. The binding energy of a H-atom, considering an electron moving around a fixed nuclei (proton), is

$$B = -\frac{me^4}{8n^2\varepsilon_0^2h^2}.\ (m = \text{electron mass})$$

If one decides to work in a frame of reference where the electron is at rest, the proton would be moving around it. By similar arguments, the binding energy would be

$$B = -\frac{Me^4}{8n^2\varepsilon_0^2h^2}\ (M = \text{proton mass})$$

This last expression is not correct because

(*a*) n would not be integral.

(*b*) Bohr-quantisation applies only to electron.

(*c*) the frame in which the electron is at rest is not inertial.

(*d*) the motion of the proton would not be in circular orbits, even approximately.

Ans. (*c*)

30. Consider aiming a beam of free electrons towards free protons. When they scatter, an electron and a proton cannot combine to produce a H-atom,

(*a*) because of energy loss.

(*b*) without simultaneously releasing energy in the form of radiation.

(*c*) because of momentum conservation.

(*d*) because of angular momentum conservation.

Ans. (*b*)

31. The Bohr model for the spectra of a H-atom

(*a*) will be applicable to hydrogen in the molecular from.

(*b*) will not be applicable as it is for a He-atom.

(*c*) is valid only at room temperature.

(*d*) predicts continuous as well as discrete spectral lines.

Ans. (*b*)

32. At distance of closest approach, kinetic energy of α-particle is

(*a*) never zero (*b*) always zero (*c*) greater than zero (*d*) undefined

Ans. (*b*)

33. Number of possible spectral lines emitted on dexcitation of electron from energy level n to ground state is equal to ____________

(*a*) $\frac{n(n+1)}{2}$ (*b*) $\frac{n^2}{2}$ (*c*) $\frac{n(n-1)}{2}$ (*d*) $\frac{n(n^2-1)}{2}$

Ans. (*c*)

34. PFund series of line spectrum of hydrogen atom belongs to _________ region

(*a*) ultraviolet (*b*) infrared (*c*) visible (*d*) microwave

Ans. (*b*)

35. Ground state energy of hydrogen atom is _______ eV.

(*a*) 11.7 (*b*) 13.6 (*c*) – 13.6 (*d*) 14.2

Ans. (*c*)

36. What is the distance of closest approach when a 5 MeV proton approaches a gold nucleus ($Z = 79$)?

(*a*) 1.7×10^{-12} m (*b*) 2.3×10^{-14} m (*c*) 3.7×10^{-13} m (*d*) 5.7×10^{-10} m

Ans. (*b*) $\left[r_0 = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{K}\right]$

37. In Bohr's theory of model of Hydrogen atom, name the physical quantity which equals to an integral multiple of $\frac{h}{2\pi}$.

(*a*) Angular Momentum (*b*) Orbital Momentum

(*c*) Kinetic Energy (*d*) Potential Energy

Ans. (*a*)

38. For an electron in the second orbit of hydrogen, what is the moment of linear momentum as per the Bohr's Model?

(*a*) $\frac{\pi}{h}$ (*b*) $\frac{h}{\pi}$ (*c*) $h \times \pi$ (*d*) $h^2\pi$

Ans. (*b*)

39. Calculate the frequency of the photon which can excite an electron to – 3.4 eV to – 13.6 eV.

(*a*) 4.2×10^{10} Hz (*b*) 3.7×10^{14} Hz (*c*) 2.5×10^{15} Hz (*d*) 5.6×10^{15} Hz

Ans. (*c*) Use the formula, $E = hv$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$
$$h = 6.63 \times 10^{-34} \text{ Js}$$

40. The ratio of energy of Bohr's hydrogen atom and He^+ atom in the first orbit is :

(*a*) 1 : 2 (*b*) 4 : 1 (*c*) 1 : 4 (*d*) 2 : 9

Ans. (*c*) [$E \propto Z^2$; for $n = 1$]

Assertion-Reason Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Choose the correct alternative from the choice given below.

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

41. **Assertion (A):** The total energy of revolving electron in any stationary orbit is negative.

Reason (R): Energy is a scalar quantity. It can have positive or negative values.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Explanation: Energy is negative because electrons are bound to the nucleus by attractive forces.

42. **Assertion (A):** Nuclear density is extremely large.

Reason (R): Most mass of the atom is concentrated in the nucleus, but its volume is 10^{-15} times smaller compared to volume of the atom.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

43. **Assertion (A):** An electron in hydrogen atom passes from $n = 3$ to $n = 1$ level. The maximum number of photons emitted is 3.

Reason (R): The number of photons emitted can be calculated using the expression $\frac{n(n-1)}{2}$.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Case-based Questions

44. In 1912, Neils Bohr studied the spectrum of hydrogen in Rutherford Laboratory and concluded that the limitations of Rutherford's atomic model cannot be explained using classical mechanics and electromagnetism. He proposed the first quantum model of the atom by combining concepts of classical and quantum mechanics. He explained the structure of atom and its stability.

(*i*) In Rutherford's atomic model, the electrons

(*a*) experience no force in the innermost orbit
(*b*) always experience a net force
(*c*) experience equal force in all orbits
(*d*) experience maximum force in the outermost orbit.

(*ii*) In terms of Bohr radius r_0, the radius of second Bohr orbit of hydrogen atom is given by

(*a*) $4\, r_0$ (*b*) $8\, r_0$
(*c*) $\sqrt{2}\, r_0$ (*d*) $2r_0$

(*iii*) The kinetic energy of electron in the first excited state is 3.4 eV. Its potential energy in this state is

(*a*) – 3.4 eV (*b*) 6.8 eV
(*c*) – 6.8 eV (*d*) 3.4 eV

(*iv*) The ionisation energy of electron in a hydrogen atom is 13.6 eV. The energy required to remove electron from the second excited state is

(*a*) – 13.6 eV (*b*) 1.51 eV
(*c*) – 1.51 eV (*d*) – 3.4 eV

(*v*) The largest wavelength in the UV region of hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum is:

(*a*) 802 nm (*b*) 823 nm
(*c*) 1882 nm (*d*) 1648 nm

Ans. (*i*) (*b*)

(*ii*) (*a*) $\because r_n \propto n^2$ and $n = 2$ in second orbit.

(*iii*) (*c*) $\because$ P.E. = – 2 K.E.

(*iv*) (*c*) $\because$ $E_1 = -13.6$ eV in ground state

$$E_3 = \frac{-13.6}{3^2} \text{ eV in second excited state}$$
$$= -1.51 \text{ eV}$$

(*v*) (*b*)
$$\frac{1}{\lambda_{UV}} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}R$$
$$\frac{1}{122 \times 10^{-9}} = \frac{3}{4}R$$
$$\Rightarrow \quad R = \frac{4}{3 \times 122 \times 10^{-9}} \text{ m}^{-1} \quad \ldots(i)$$
$$\frac{1}{\lambda_{IR}} = R\left[\frac{1}{3^2} - \frac{1}{\infty}\right] = \frac{R}{9} \quad \ldots(ii)$$

On solving equation (*i*) and (*ii*)

$$\Rightarrow \qquad \lambda_{IR} = \frac{9 \times 3 \times 122}{4} \times 10^{-9} \text{ m}$$

$$\lambda_{IR} = 823.5 \text{ nm}$$

45. Bohr Model is valid only for one e^- system. The energy value allowed for each orbit depends on the principal quantum no. denoted by *n*. For a multi electron atom of ion this is not true. The third postulate of Bohr incorporated into atomic theory which was developed on the basis of Planck and Einstein. We can determine energies of different energy states, but this requires radius *r* of electron orbit.

(*i*) What is the dependence of angular momentum on radius of the orbit?

(*a*) Directly proportional (*b*) Inversely proportional

(*c*) Not dependent (*d*) Square of radius

(*ii*) What is the second postulate of Bohr?

(*a*) The angular momentum is dependent on mass.

(*b*) Angular momentum is integral multiple of $\left(\frac{h}{2\pi}\right)$.

(*c*) There is no dependence of angular momentum on mass.

(*d*) All of the above.

(*iii*) What does the –ve sign in total energy indicates?

(*a*) Nucleus and e^- are repelling each other.

(*b*) That e^- is bound to nucleus.

(*c*) Both (*a*) and (*b*)

(*d*) None of the above

(*iv*) Which of the assumption is deriving for energy of the e^- in the orbit?

(*a*) The energy is dissipated.

(*b*) Energy is given to make system stable.

(*c*) e^- is stationary.

(*d*) e^- orbit is circular.

(*v*) How the frequency of the emitted photon is related to energy difference?

(*a*) $h\nu = E_i - E_f$ (*b*) $h\nu = E_f - E_i$

(*c*) $E_f = E_i - h\nu$ (*d*) $E_f = E_i$

Ans. (*i*) (*a*) It depends directly on the radius of orbit.

(*ii*) (*b*) as we know $L = mvr = nh/2n$

(*iii*) (*b*) e^- is bound to the nucleus and attractive force is acting between the two.

(*iv*) (*d*) Electronic orbit is circular the orbits under inverse square force is elliptical.

(*v*) (*b*) Change in energy is directly proportional to frequency.

13 NUCLEI

Multiple Choice Questions

1. The gravitational force between a H-atom and another particle of mass m will be given by Newton's law:

$$F = G\frac{M.m}{r^2}, \text{ where } r \text{ is in km and}$$

(a) $M = m_{proton} + m_{electron}$.

(b) $M = m_{proton} + m_{electron} - \frac{B}{c^2}$ (B = 13.6 eV).

(c) M is not related to the mass of the hydrogen atom.

(d) $M = m_{proton} + m_{electron} - \frac{|V|}{c^2}$ ($|V|$ = magnitude of the potential energy of electron in the H-atom).

Ans. (b)

2. The quantity which is not conserved in a nuclear reaction is

(a) momentum   (b) charge

(c) mass   (d) none of these.

Ans. (c) Energy equivalent to mass defect is released.

3. Ratio of the radii of the nuclei with mass numbers 8 and 27 would be

(a) $\frac{27}{8}$ (b) $\frac{8}{27}$ (c) $\frac{2}{3}$ (d) $\frac{3}{2}$

Ans. (c) Using $r \propto A^{1/3}$

$$\therefore \quad \frac{r_8}{r_{27}} = \sqrt[3]{\frac{8}{27}} = \frac{2}{3}$$

4. In a nuclear reactor, moderators slow down the neutrons which come out in a fission process. The moderators used have light nuclei. Heavy nuclei will not serve the purpose because

(a) they will break up.

(b) elastic collision of neutrons with heavy nuclei will not slow them down.

(c) the net weight of the reactor would be unbearably high.

(d) substances with heavy nuclei do not occur in liquid or gaseous state at room temperature.

Ans. (b)

5. Fusion processes, like combining two deuterons to form a He nucleus are impossible at ordinary temperatures and pressure. The reasons for this can be traced to the fact:

(*a*) nuclear forces have long range.

(*b*) nuclei are positively charged.

(*c*) the original nuclei must be completely ionized before fusion can take place.

(*d*) the original nuclei must first break up before combining with each other.

Ans. (*b*)

6. Isotopes have

(*a*) same number of protons. (*b*) same number of nucleons.

(*c*) same number of neutrons. (*d*) same number of positrons.

Ans. (*a*)

7. Atomic species of the same element differing in mass are called

(*a*) isobars (*b*) isotones

(*c*) isotopes (*d*) isochoric

Ans. (*c*)

8. Nucleus of the lightest atom of hydrogen, which has a relative abundance of 99.985% is called

(*a*) electron (*b*) neutron (*c*) deuterium (*d*) protium

Ans. (*d*)

9. Nuclides with same neutron number but different atomic numbers are called

(*a*) isobars (*b*) isochoric (*c*) isotones (*d*) isotopes

Ans. (*c*)

10. Masses of the nuclei of hydrogen, deuterium and tritium are in the ratio:

(*a*) 3 : 2 : 1 (*b*) 5 : 2 : 1 (*c*) 2 : 3 : 1 (*d*) 1 : 2 : 3

Ans. (*d*)

11. Distance of closest approach to a gold nucleus of an α-particle of kinetic energy 5.5 MeV is about

(*a*) 2×10^{-10} m (*b*) 3×10^{-12} m (*c*) 4×10^{-14} m (*d*) 6×10^{-10} m

Ans. (*c*)

12. Energy equivalent of 1 g of substance is:

(*a*) 6×10^{10} J (*b*) 8×10^{12} J (*c*) 9×10^{13} J (*d*) 10^4 J

Ans. (*c*)

$$E = 10^{-3} \times (3 \times 10^8)^2$$
$$= 10^{-3} \times 9 \times 10^{16} = 9 \times 10^{13} \text{ J}$$

13. Choose the strongest force from the following forces.

(*a*) Coulomb force (*b*) Gravitational force

(*c*) Nuclear force (*d*) Electrostatic force

Ans. (*c*)

14. The source of energy in nuclear reactors, which produce electricity is:

(*a*) Nuclear fusion

(*b*) Mechanical energy

(*c*) Nuclear fission

(*d*) Electrical energy

Ans. (*c*)

15. Choose the correct example for nuclear fission:

(*a*) ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$

(*b*) ${}^{1}_{0}n + {}^{235}_{93}U \rightarrow {}^{237}_{92}U \rightarrow {}^{140}_{52}Ba + {}^{88}_{34}Kr + 2\,{}^{1}_{0}n$

(*c*) ${}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3\,{}^{1}_{0}n$

(*d*) $2\,{}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 2\,{}^{1}_{0}n$

Ans. (*a*)

16. What is the relation between the radius of the atom and the mass number?

(*a*) size $\propto A^2$ (*b*) size $\propto A^{1/2}$ (*c*) size $\propto A^3$ (*d*) size $\propto A^{1/3}$

Ans. (*d*)

17. What is the ratio of the nuclear densities of two nuclei having mass numbers in the ratio 1 : 4?

(*a*) 4:1 (*b*) 2:1 (*c*) 1:1 (*d*) 3:1

Ans. (*c*)

18. How many electrons, protons and neutrons are there in an element of atomic number (*Z*) 11 and mass number (A) 24?

(*a*) 11, 12, 13 (*b*) 12, 11, 13 (*c*) 11, 11, 13 (*d*) 11, 12, 14

Ans. (*c*)

19. Choose the pairs of isotopes from the following.

(*i*) ${}^{13}C_6$ (*ii*) ${}^{14}N_7$ (*iii*) ${}^{30}P_{15}$ (*iv*) ${}^{31}P_{15}$

(*a*) (*i*) and (*ii*) (*b*) (*ii*) and (*iii*) (*c*) (*iii*) and (*iv*) (*d*) (*i*) and (*iv*)

Ans. (*c*)

20. By what factor must the mass number change for the nuclear radius to become twice?

(*a*) $3^{1/3}$ (*b*) $4^{1/3}$ (*c*) $2^{1/3}$ (*d*) $5^{1/3}$

Ans. (*c*)

Assertion-Reason Questions

Directions: In the following questions, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

21. **Assertion (A):** The nuclear density is not dependent on the size of the nucleus.

Reason (R): Volume of nucleus is directly proportional to the nuclear mass or the mass number of an element.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

22. **Assertion (A):** Nuclear force is the strongest interaction known in nature.

Reason (R): Nuclear force is a short range force.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

23. **Assertion (A):** The difference of masses between nucleus and its constituents is called mass defect.

Reason (R): The mass of nucleus is never equal to sum of mass of it's neutrons and protons.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Case-based Questions

24. In 1919, Rutherford succeeded in bringing about the first artificial transmutation by bombarding nitrogen nuclei with α-particles which produced an isotopes of oxygen and a proton. Such an artificial nuclear transformation in termed as nuclear reaction. Soon after the discovery of neutron by Chadwick (1920), Enrico fermi found that when neutrons bombard various elements, new radioactive elements are produced. This is a nuclear fission reaction. The fragment nuclei produced in fission are highly neutron-rich and unstable.

Energy can be released if two light nuclei combine to form a single layer nucleus, a process called nuclear fusion.

(*i*) Which of the following statement is true?

(*a*) Fusion and fission reaction are equally energetic.

(*b*) Fusion reaction is more energetic than fission reaction.

(*c*) Fusion reaction is less energetic than fission reaction.

(*d*) Neither fusion nor fission

(*ii*) Which celestial body losing mass due to thermonuclear fusion?

(*a*) Sun

(*b*) Moon

(*c*) Jupiter

(*d*) Neptune

(*iii*) When ${}_{3}^{7}Li$ is bombarded with a certain particle, two alpha particles are produced. Which one of the following is the bombarding particle?

(*a*) ${}_1H^2$ (*b*) ${}_1H^3$

(*c*) ${}_1H^1$ (*d*) ${}_2He^4$

(*iv*) "Neutron is so effective as bombarding particle". Choose the correct option:

(*a*) Neutron carries positive charge

(*b*) Neutron carries negative charge

(*c*) Neutron carries no charge

(*d*) Neutron has very small mass

(*v*) Nuclear fusion difficult to carry out in laboratory because it requires

(*a*) high temperature (*b*) low temperature

(*c*) high pressure (*d*) both (*a*) (*c*)

Ans. (*i*) (*b*) more energy is released in fusion reaction

(*ii*) (*a*) In each fusion reaction, a small mass of sun changes into thermal energy.

(*iii*) (*c*) ${}_{3}^{7}Li + {}_{1}H^{1} \longrightarrow {}_{2}^{4}He + {}_{2}^{4}He$

${}_{1}H^{1}$ is a proton.

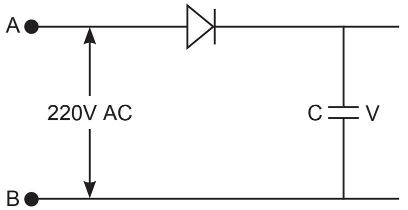
(*iv*) (*c*) Neutron carries no charge so it can easily penetrate even a heavy nucleus without being repelled or attracted by nuclear and electrons.

(*v*) (*d*) High pressure and high temperature are necessary for nuclear fusion reaction.

14 SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

Multiple Choice Questions

1. A 220 V AC supply is connected between points A and B (figure). What will be the potential difference V across the capacitor?

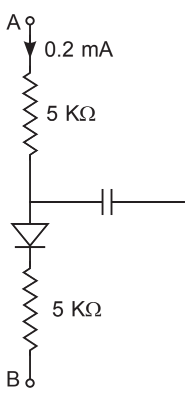


(*a*) 220 V (*b*) 110 V (*c*) 0 V (*d*) $220\sqrt{2}\ V$

Ans. (*d*) As *p-n* junction diode will conduct during positive half cycle only and during negative half cycle diode is reverse biased. During this diode will not give any output. So potential difference across the capacitor C = peak voltage of the given AC voltage.

$$V_O = V_{rms}\sqrt{2} = 220\sqrt{2}\ \text{V}.$$

2. In the circuit shown in figure below, if the diode forward voltage drop is 0.3 V, the voltage difference between A and B is



(*a*) 1.3 V (*b*) 2.3 V (*c*) 0 V (*d*) 0.5 V

Ans. (*b*) Suppose the potential difference between *A* and *B* is V_{AB}.

Then, $V_{AB} - 0.3 = [(r_1 + r_2)10^3] \times (0.2 \times 10^{-3})$ $[\because\ V_{AB} = ir]$

$= [(5 + 5)10^3] \times (0.2 \times 10^{-3})$

$$= 10 \times 10^3 \times 0.2 \times 10^{-3} = 2$$

$$\Rightarrow \quad V_{AB} = 2 + 0.3 = 2.3 \text{ V}$$

3. When an electric field is applied across a semiconductor:

(*a*) holes move from lower energy level to higher energy level in the conduction band.

(*b*) electrons move from higher energy level to lower energy level in the conduction band.

(*c*) holes in the valence band move from higher energy level to lower energy level.

(*d*) holes in the valence band move from lower energy level to higher energy level.

Ans. (*c*) When electric field is applied across a semiconductor, the electrons in the conduction band move from lower energy level to higher energy level. While the holes in valence band move from higher energy level to lower energy level, where they will be having more energy.

4. In the depletion region of a diode

(*a*) there are mobile charges.

(*b*) equal number of holes and electrons exist, making the region neutral.

(*c*) number of electrons are more than hole.

(*d*) immobile charged ions do not exist.

Ans. (*b*)

5. The breakdown in a reverse biased *p-n* junction is more likely to occur due to

(*a*) large velocity of the majority charge carriers if the doping concentration is small.

(*b*) large velocity of the minority charge carriers if the doping concentration is large.

(*c*) strong electric field in a depletion region if the doping concentration is small.

(*d*) strong electric field in the depletion region if the doping concentration is large.

Ans. (*d*)

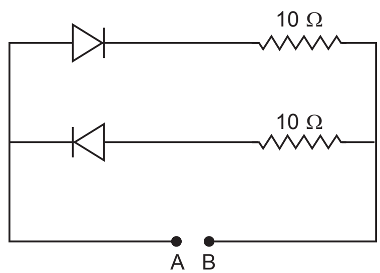
6. A *p*-type semiconductor can be obtained by adding

(*a*) arsenic to pure silicon. (*b*) gallium to pure silicon.

(*c*) antimony to pure germanium. (*d*) phosphorus to pure germanium.

Ans. (*b*) Ga has a valency of 3.

7. A 2V battery is connected across the points *A* and *B* as shown in the figure. Assuming that the resistance of each diode is zero in forward bias and infinity in reverse bias, the current supplied by the battery when its positive terminal is connected to *A* is

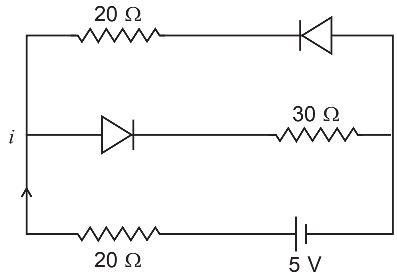


(*a*) 0.2 A (*b*) 0.4 A (*c*) Zero (*d*) 0.1 A

Ans. (*a*) Since diode in upper branch is forward biased and in lower branch is reverse biased. So current through circuit $i = \frac{V}{R + r_d}$, here r_d is diode resistance in forward biasing = 0

$$\therefore \; i = \frac{V}{R} = \frac{2}{10} = 0.2\text{A}$$

8. Current in the circuit will be

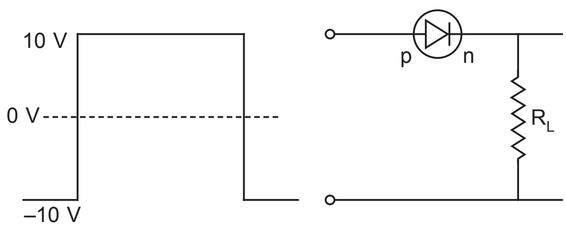


(*a*) 5/40 A (*b*) 5/50 A (*c*) 5/10 A (*d*) 5/20 A

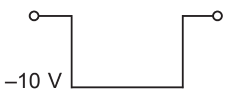
Ans. (*b*) The diode in lower branch is forward biased and diode in upper branch is reverse biased.

$$i = \frac{5}{20 + 30} = \frac{5}{50}\text{ A}$$

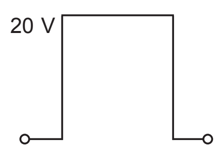
9. If the following input signal is sent through a *p-n* junction diode, then the output signal across R_L will be



(*a*)

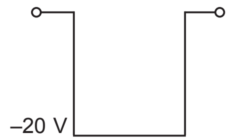


(*b*)



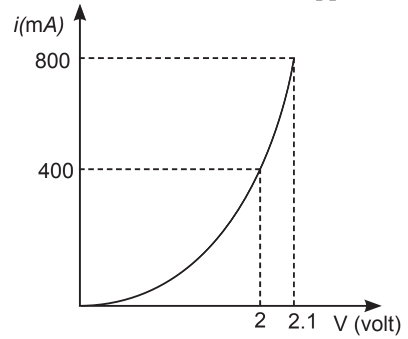
(*c*)

(*d*)



Ans. (*c*) When input voltage is –10 V, the diode is reverse biased and no output is obtained. On the other hand, when input is +10 V, the diode is forward biased and output is obtained which is +10 V.

10. The *I-V* characteristic of a *p-n* junction diode is shown below. The approximate dynamic resistance of the *p-n* junction when a forward bias of 2 volt is applied



(*a*) 1 Ω (*b*) 0.25 Ω (*c*) 0.5 Ω (*d*) 5 Ω

Ans. (*b*) The current at 2 V is 400 mA and at 2.1 V it is 800 mA. The dynamic resistance in this region.

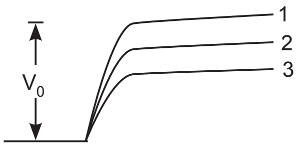
$$R = \frac{\Delta V}{\Delta i} = \frac{(2.1-2)}{(800-400)\times 10^{-3}} = \frac{1}{4} = 0.25\ \Omega$$

11. The conductivity of a semiconductor increases with increase in temperature, because

(*a*) number density of free current carriers increases.
(*b*) relaxation time increases.
(*c*) both number density of carriers and relaxation time increase.
(*d*) number density of carriers increases, relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density.

Ans. (*d*)

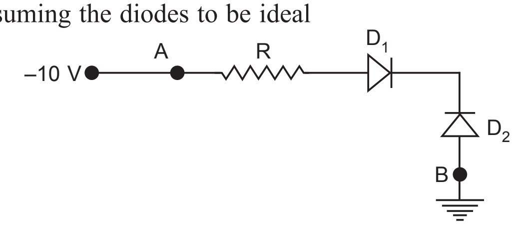
12. In the given figure V_0 is the potential barrier across a *p-n* junction, when no battery is connected across the junction.



(*a*) 1 and 3 both correspond to forward bias of junction.
(*b*) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction.
(*c*) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.
(*d*) 3 and 1 both correspond to reverse bias of junction.

Ans. (*b*) Height of potential barrier decreases when *p-n* junction is forward bias and in reverse bias, potential barrier increases.

13. In figure given, assuming the diodes to be ideal



(a) D_1 is forward biased and D_2 is reverse biased and hence current flows from A to B.

(b) D_2 is forward biased and D_1 is reverse biased and hence no current flows from B to A and vice versa.

(c) D_1 and D_2 are both forward biased and hence current flows from A to B.

(d) D_1 and D_2 are both reverse biased and hence no current flows from A to B and vice versa.

Ans. (b) –10V is the lower voltage in the circuit. Now p side of the p-n junction diode D_1 is connected to lower voltage and n- side of D_1 to higher voltage , thus D_1 is reverse biased. In D_2 p-side of p-n junction diode is at higher potential and n-side is at lower potential, therefore D_2 is forward biased. Hence no current flows through junction from B to A and A to B.

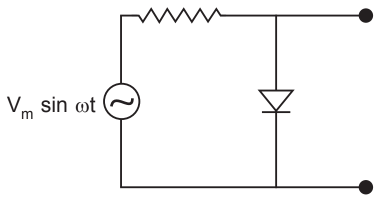
14. The _________, a property of materials C, Si and Ge depends upon the energy gap between their conduction and valence bands.

(a) conductivity (b) density

(c) elasticity (d) plasticity

Ans. (a) conductivity

15. The output of the given circuit in figure given below.



(a) would be zero at all times.

(b) would be like a half-wave rectifier with positive cycles in output.

(c) would be like a half-wave rectifier with negative cycles in output.

(d) would be like that of a full-wave rectifier.

Ans. (c) When the diode is forward biased, the resistance of pn junction diode will be low then current in the circuit is maximum. In this situation, a maximum potential difference will appear across resistance connected in a series of circuit. This result into zero output voltage across p-n junction.

Similarly, during –ve half cycle, diode will be in reverse bias, resistance maximum and potential difference negative. So we get only negative output.

16. What happens during regulation action of a Zener diode?

(a) The current in and voltage across the Zener remains fixed.

(b) The current through the series resistance (R_s) does not change.

(c) The Zener resistance is constant.

(d) The resistance offered by the Zener changes.

Ans. (d)

17. Electrical conductivity of a semiconductor

(*a*) decreases with the rise in its temperature.

(*b*) increases with the rise in its temperature.

(*c*) does not change with the rise in its temperature.

(*d*) first increases and then decreases with the rise in its temperature.

Ans. (*b*) With temperature rise, the conductivity of semiconductor increases.

18. The wavelength and intensity of light emitted by a LED depend upon

(*a*) forward bias and energy gap of the semiconductor

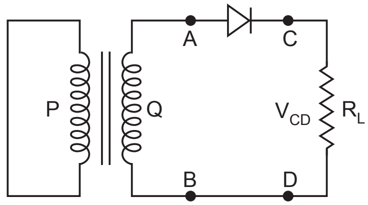
(*b*) energy gap of the semiconductor and reverse bias

(*c*) energy gap only

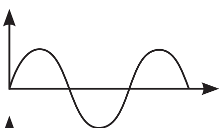
(*d*) forward bias only

Ans. (*a*) $\lambda = \frac{c}{\nu} = \frac{c}{\frac{E_g}{h}} = \frac{hc}{E_g}$, and a heavily droped and strongly forward biased p-n junction provides lots of majority carriers and lots of photons.

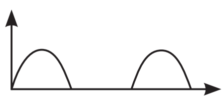
19. In the half-wave rectifier circuit shown. Which one of the following waveforms is true for V_{CD} the output across C and D?



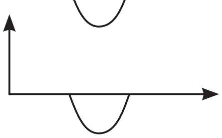
(*a*)



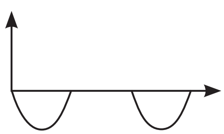
(*b*)



(*c*)

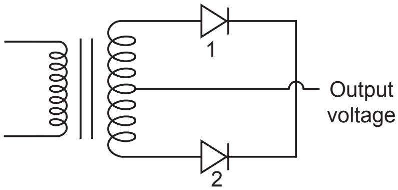


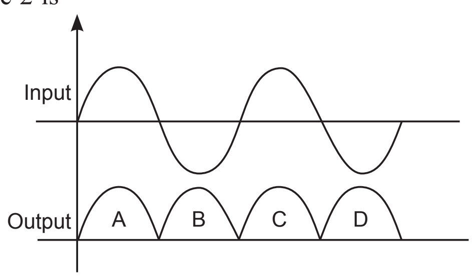
(*d*)



Ans. (*b*) Half wave rectifier rectifies only the half cycle of the input ac signal and it blocks the other half.

20. A full-wave rectifier circuit along with the input and output voltages is shown in the figure. The contribution to output voltage from diode 2 is

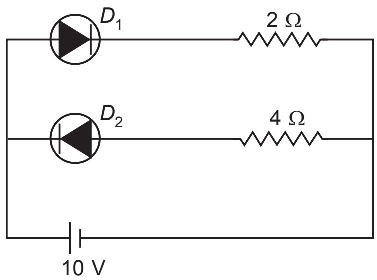




(*a*) A, C (*b*) B, D (*c*) B, C (*d*) A, D

Ans. (*b*) In the positive half cycle of input ac signal diode D_1 is forward biased and D_2 is reverse biased so in the output voltage signal, A and C are due to D_1. In negative half cycle of input ac signal, D_2 conducts, hence output signals B and D are due to D_2.

21. Find the current passing through 2Ω and 4Ω resistances, respectively, in the circuit shown in figure.



(*a*) 1A, 0A (*b*) 4A, 3A (*c*) 5A, 0A (*d*) 1A, 2.5A

Ans. (*c*) In a given circuit diode D_1 is forward biased and D_2 is reverse-biased. So D_1 will conduct electricity and D_2 will not conduct electricity. Therefore, current through 4Ω is zero and through 2Ω is $\frac{10}{2} = 5A$.

22. Three photodiodes D_1, D_2, D_3 are made of semiconductor having band gap of 2.5 eV, 2 eV and 3.5 eV respectively. Which one will be able to detect light of wavelength 6000 Å?

(*a*) D_1 (*b*) D_2 (*c*) D_3 (*d*) None of these

Ans. (*b*) Energy of incident light is

$$E(\text{in } eV) = \frac{12375}{\text{Wavelength (in Å)}}$$

$$E(\text{in } eV) = \frac{12375}{6000} = 2.06\ eV$$

This incident radiation can only be able to cross the band gap of D_2 diode, so D_2 will detect this radiation.

23. A *p*-type semiconductor can be obtained by adding

(*a*) arsenic to pure phosphorus (*b*) gallium to pure silicon

(*c*) antimony to pure silicon (*d*) phosphorus to pure germanium

Ans. (*b*) A *p*-type semiconductor can be made by replacing silicon atoms in the crystal lattice with gallium (a trivalent impurity).

24. In pure semiconductors, the number of conduction electrons is 6×10^{18} per cubic metre. How many holes are there in a sample of size 1 cm × 1 cm × 1 mm?

(*a*) 6×10^{11} (*b*) 5×10^{18} (*c*) 4×10^{15} (*d*) 3×10^{13}

Ans. (*a*) Here $n_e = 6 \times 10^{18}$

Volume of sample = 1 cm × 1 cm × 1 mm = 10^{-7} m^3

So number of holes in the sample = $6 \times 10^{18} \times 10^{-7} = 6 \times 10^{11}$

25. Carbon, Silicon and germanium have four valence electrons each. These are characterized by valence and conduction bands separated by an energy band gap, respectively, equal to $(E_g)_C$; $(E_g)_{Si}$; $(E_g)_{Ge}$. Which of the following statement is true?

(*a*) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$ (*b*) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

(*c*) $(E_g)_C < (E_g)_{Ge}$; $(E_g)_{Si}$ (*d*) $(E_g)_{Ge} < (E_g)_{Si} < (E_g)_C$

Ans. (*b*) E_g maximum for carbon, less for silicon and least for germanium.

26. Forbidden energy gap in a semiconductor is nearly equal to

(*a*) 0.5eV (*b*) 6eV (*c*) 0eV (*d*) 1eV

Ans. (*d*)

27. With fall in temperature, the forbidden energy gap of a semiconductor

(*a*) increases

(*b*) decreases

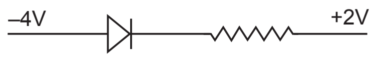
(*c*) sometimes increases and sometimes decreases

(*d*) remains unchanged

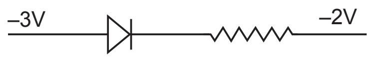
Ans. (*d*)

28. The forward biased diode connection is

(*a*) 

(*b*) 

(*c*) 

(*d*) 

Ans. (*c*)

29. Random motion of free electrons and holes due to thermal agitation is called:

(*a*) Pressure (*b*) Diffusion (*c*) Ionisation (*d*) None of the above

Ans. (*b*)

30. The cause of potential barrier in a *p-n* junction diode is

(*a*) depletion of positive charge near the junction

(*b*) concentration of positive charge near the junction

(*c*) depletion of negative charge near the junction

(*d*) concentration of positive and negative charge near the junction

Ans. (*d*)

31. In half wave rectification, the input frequency is 50 Hz. What is the output frequency of a full wave rectifier for the same input frequency?

(*a*) 60 Hz (*b*) 100 Hz (*c*) 50 Hz (*d*) 70 Hz

Ans. (*b*)

32. A *p-n* photodiode is fabricated from a semiconductor with band gap of 2.8eV. Can it detect a wavelength of 6000 nm?

(*a*) Yes (*b*) No

(*c*) Can't determined (*d*) Insufficient information

Ans. (*b*) $E = \dfrac{hc}{\lambda} = 0.207\ eV < 2.8\ eV$

33. In good conductor, the energy gap between the conduction band and valence band is

(*a*) infinite (*b*) wide (*c*) narrow (*d*) zero

Ans. (*d*) In good conductor, the conduction band and valence band overlap each other.

34. SI unit of mobility is:

(*a*) $m^2V^{-2}s^{-1}$ (*b*) $m^2V^{-1}s^{-1}$ (*c*) $m^{-2}V^{-1}s^{-1}$ (*d*) No unit

Ans. (*b*) SI unit of mobility is calculated by its formula

$$\text{Mobility} = \text{Drift velocity/Electric Field} = \frac{m}{s} \times \frac{m}{V} = \frac{m^2}{V-s}$$

35. When intrinsic semiconductor is exposed to light radiations of energy E greater than band gap of E_g then:

(*a*) electrons from conduction band jump to valence band.

(*b*) electrons from valence band jump to conduction band.

(*c*) holes from conduction band jump to valence band.

(*d*) holes from valence band jump to conduction band.

Ans. (*b*)

Assertion-Reason Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

36. **Assertion (A):** Conductivity of a semiconductor increases on doping with pentavalent atoms.

Reason (R): Pentavalent atoms can easily donate electrons due to their less ionisation energy.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

37. **Assertion (A):** For transistor action, base region is very thin and lightly doped.

Reason (R): The emitter base junction is forward biased and base collector junction is reverse biased.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

38. **Assertion (A):** For a transistor amplifier the voltage gain is low at high and low frequencies but constant at mid-frequencies.

Reason (R): The voltage gain is the ratio of input voltage to output voltage.

Ans. (*c*) Assertion (A) is true but Reason (R) is false.

Case-based Questions

39. There are different techniques of fabrication of *p-n* junction. In one such technique, called fused junction techniques, an aluminium film is kept on the wafer of *n*-type semiconductor and the combination is then heated to a high temperature (about 600°C). As a result, aluminium fused into silicon and produces *p*-type semiconductor and in this way a *p-n* junction is formed.

(*i*) When a *p-n* junction is reverse biased, then

(*a*) no current flows.

(*b*) the depletion region is reduced.

(*c*) height of potential barrier is decreased.

(*d*) height of potential barrier is increased.

(*ii*) The cause of potential barrier in *p-n* junction is:

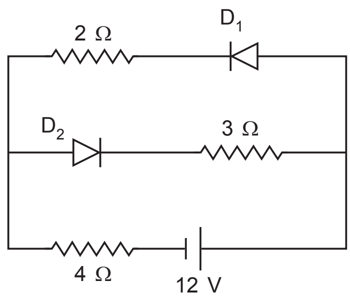
(*a*) depletion of positive charges near the junction.

(*b*) concentration of –ve charges near the junction.

(*c*) concentration of +ve and –ve charges near the junction.

(*d*) depletion of –ve charges near the junction.

(*iii*) The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit?



(*a*) 1.17 A (*b*) 2.0 A

(*c*) 2.31 A (*d*) 1.33 A

(*iv*) Carbon, germanium and silicon all are fourteenth group elements, then

(*a*) C and Ge are semiconductors

(*b*) C and Si are semiconductors

(*c*) all C, Si and Ge are semiconductors

(*d*) Si and Ge are semiconductors

(*v*) When a *p-n* junction is forward biased, then

(*a*) only diffusion current flows.

(*b*) both diffusion current and drift current flow but diffusion current is more than drift current.

(*c*) only drift current flows.

(*d*) both diffusion and drift current flow but drift current exceeds the diffusion current.

Ans. (*i*) (*d*) **Reason:** In reverse biased *p-n* junction, potential difference across a junction becomes $(V + V_B)$.

(*ii*) (*c*)

(*iii*) (*b*) **Reason:** D_2 is in R.B. and D_1 is in F.B.

$\therefore$ 2 Ω and 4 Ω are in series and are connected to 12 V.

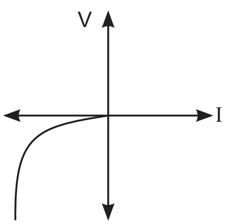
$$\therefore \qquad I = \frac{12}{2+4} = 2\text{A}$$

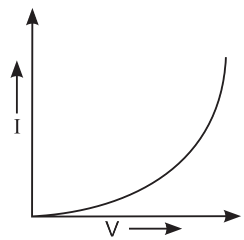
(*iv*) (*d*)

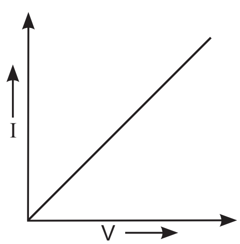
(*v*) (*b*)

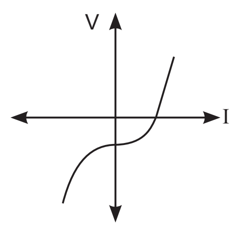
40. In Forward bias arrangement, the *p*-side of a *p-n* junction is connected to the positive terminal of battery and *n*-side to negative terminal of battery, the current first increases very slowly till a certain threshold voltage is reached. Beyond this value, the diode current increases exponentially even for a very small increment in diode bias voltage. In reverse bias, the current suddenly increases at very high reverse bias. This is called breakdown voltage.

(*i*) The VI characteristic curve for *p-n* junction in forward bias is:

(*a*)


(*b*)


(*c*)


(*d*)


(*ii*) The value of threshold voltage for a silicon diode is approximately.

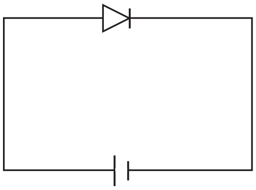
(*a*) 0.7 V (*b*) 0.14 V

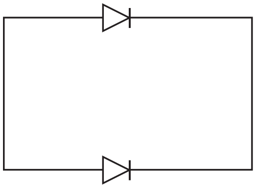
(*c*) 0.7 eV (*d*) 0.14 eV

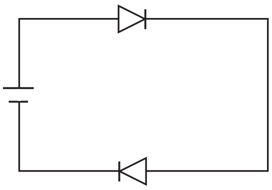
(*iii*) Name a semiconductor device which emits visible light when it is forward biased.

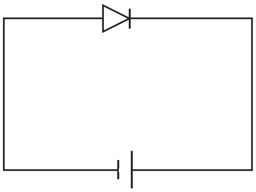
(*a*) Transistor (*b*) LED

(*c*) *p-n* junction (*d*) None of the above (*iv*) Which diagram represents the reverse bias of a *p-n* junction diode?

(*a*) 

(*b*) 

(*c*) 

(*d*) 

(*v*) How does current under reverse bias depend on applied voltage?

(*a*) Varies directly with potential
(*b*) Varies inversely with potential
(*c*) Almost independent of applied potential upto critical voltage.
(*d*) remains unchanged after critical voltage is reached.

Ans. (*i*) (*b*) Current suddenly rises at critical voltage.
(*ii*) (*a*) as per known value.
(*iii*) (*b*) LED or light emitting diode.
(*iv*) (*d*) Connection as shown in diagram.
(*v*) (*c*) Current almost remains unchanged till critical voltage is reached.

41. SEMICONDUCTOR:

A pure semiconductor germanium or silicon, free of every impurity is called intrinsic semiconductor. At room temperature, a pure semiconductor has very small number of current carriers (electrons and holes). Hence its conductivity is low.

When the impurity atoms of valance five or three are doped in a pure semiconductor, we get respectively *n*- type or *p*- type extrinsic semiconductor. In case of doped semiconductor $n_e n_h = n_i^2$. Where n_e and n_h are the number density of electron and hole charge carriers in a pure semiconductor. The conductivity of extrinsic semiconductor is much higher than that of intrinsic semiconductor.

Answer the following questions:

(*i*) Which of the following statements is not true?

(*a*) The resistance of intrinsic semiconductor decreases with increase of temperature.
(*b*) Doping pures Si with trivalent impurities gives *p*-type semiconductors.
(*c*) The majority charges in *n*-type semiconductors are holes.
(*d*) A *p-n* junction can act as semiconductor diode.

(*ii*) The impurity atoms with which pure Si should be doped to make a *p*-type semiconductor is:

(*a*) Phosphorus (*b*) Boron

(*c*) Arsenic (*d*) Antimony

(*iii*) Holes are majority charge carriers in:

(*a*) Intrinsic semiconductors. (*b*) Ionic Solids

(*c*) *p*-type semiconductors (*d*) Metals

(*iv*) At absolute zero, Si acts as:

(*a*) Non-metal (*b*) Metal

(*c*) Insulator (*d*) None of these

Ans. (*i*) (*c*) The majority Charges carriers in *n*-type semiconductors are holes.

(*ii*) (*b*) Boron

(*iii*) (*c*) *p*-type semiconductors.

(*iv*) (*c*) Insulators

Part-II

[Practice Papers]

1 | PRACTICE PAPER

[Time Allowed: 90 minutes] [Maximum Marks: 35]

General Instructions:

(i) This question paper contains three sections:
(ii) Section A has 25 questions. Attempt any 20 questions.
(iii) Section B has 24 questions. Attempt any 20 questions.
(iv) Section C has 6 questions. Attempt any 5 questions.
(v) All questions carry equal marks.
(vi) There is no negative marking.

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attemped, ONLY first 20 will be considered for evaluation.

1. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen.

(*a*) half the image will disappear.
(*b*) incomplete image will be formed.
(*c*) intensity of image will decrease but complete image is formed.
(*d*) intensity of image will increase but image is not distinct.

Ans. (*c*) Because focal length of lens does not change but amount of light passing through lens becomes half.

2. A linearly polarized electromagnetic wave given as $E = E_0 \hat{i} \cos(kz - \omega t)$ is incident normally on a perfectly reflecting infinite wall at $z = a$. Assuming that the material of the wall is optically inactive, the reflected wave will be given as

(*a*) $E_r = E_0 \hat{i} \cos(kz - \omega t)$
(*b*) $E_r = E_0 \hat{i} \cos(kz + \omega t)$
(*c*) $E_r = -E_0 \hat{i} \cos(kz + \omega t)$
(*d*) $E_r = -E_0 \hat{i} \sin(kz - \omega t)$

Ans. (*b*)

3. Air bubble in water behaves as
(*a*) sometimes concave, sometimes convex lens
(*b*) concave lens
(*c*) convex lens
(*d*) always refracting surface

Ans. (*b*) Air bubble in water behaves as a concave lens.

4. The wavefront due to a source situated at infinity is
(*a*) spherical
(*b*) cylindrical
(*c*) planar
(*d*) circular

Ans. (*c*) The wavefront due to any source situated at infinity is planar.

5. Light of frequency 1.9 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes
(*a*) quadrupled
(*b*) doubled
(*c*) halved
(*d*) zero

Ans. (*d*) As $\nu_i = 0.95\ \nu_0$. No photoelectric emission takes place.

6. We combine two lenses, one is convex and other is concave having focal lengths f_1 and f_2 and their combined focal length is F. Combination of the lenses will behave like concave lens, if
(*a*) $f_1 > f_2$
(*b*) $f_1 = f_2$
(*c*) $f_1 < f_2$
(*d*) $f_1 \leq f_2$

Ans. (*a*) Focal length of the combination $F = \dfrac{f_1 f_2}{f_1 + f_2}$ as f_2 is negative so denominator $f_1 + f_2$ must be positive or $f_1 > f_2$.

7. Threshold wavelength for a metal having work function W_0 is λ. What is the threshold wavelength for the metal having work function $2W_0$?
(*a*) 4λ
(*b*) 2λ
(*c*) $\lambda/2$
(*d*) $\lambda/4$

Ans. (*c*) Since $W_0 = h\dfrac{c}{\lambda}$

$$2W_0 = h\frac{c}{\lambda_1} \Rightarrow 2 = \frac{\lambda_1}{\lambda_1} \text{ or } \lambda_1 = \frac{\lambda}{2}$$

8. Light with an energy flux of 20 W/cm^2 falls on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2, the total momentum delivered (for complete absorption) during 30 minutes is
(*a*) 36×10^{-5} kg m/s.
(*b*) 36×10^{-4} kg m/s.
(*c*) 108×10^{4} kg m/s.
(*d*) 1.08×10^{7} kg m/s.

Ans. (*b*)

9. We combine two lenses, one is convex and other is concave having focal lengths f_1 and f_2 and their combined focal length is F. Combination of the lenses will behave like concave lens, if
(*a*) $f_1 > f_2$
(*b*) $f_1 = f_2$
(*c*) $f_1 < f_2$
(*d*) $f_1 \leq f_2$

Ans. (*a*) Focal length of the combination $F = \dfrac{f_1 f_2}{f_1 + f_2}$ as f_2 is negative so denominator $f_1 + f_2$ must be positive or $f_1 > f_2$.

10. Radiations of frequency ν are incident on a photosensitive metal. The maximum K.E. of the photoelectrons is E. When the frequency of the incident radiation is doubled, what is the maximum kinetic energy of the photoelectrons?

(*a*) $2E$ (*b*) $4E$

(*c*) $E + h\nu$ (*d*) $E - h\nu$

Ans. (*c*) Using Einstein's photoelectric equation

$$h\nu - W_0 = E$$

11. The electric field intensity produced by the radiations coming from 100 W bulb at a 3 m distance is E. The electric field intensity produced by the radiations coming from 50 W bulb at the same distance is

(*a*) $\dfrac{E}{2}$ (*b*) $2E$.

(*c*) $\dfrac{E}{\sqrt{2}}$ (*d*) $\sqrt{2}E$

Ans. (*d*)

12. We combine two lenses, one is convex and other is concave having focal lengths f_1 and f_2 and their combined focal length is F. Combination of the lenses will behave like concave lens, if

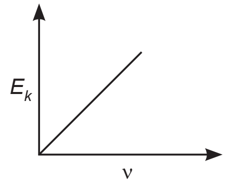
(*a*) $f_1 > f_2$ (*b*) $f_1 = f_2$

(*c*) $f_1 < f_2$ (*d*) $f_1 \le f_2$

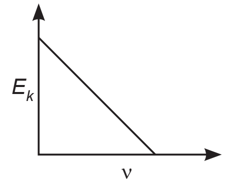
Ans. (*a*) Focal length of the combination $F = \dfrac{f_1 f_2}{f_1 + f_2}$ as f_2 is negative so denominator $f_1 + f_2$ must be positive or $f_1 > f_2$.

13. Maximum kinetic energy (E_k) of a photoelectron varies with frequency (ν) of the incident radiation as

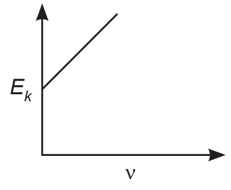
(*a*)



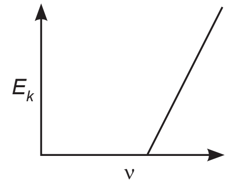
(*b*)



(*c*)



(*d*)



Ans. (*d*) Using Einstein's photoelectric equation

$$h\nu = h\nu_0 + E_k$$

14. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along

(*a*) E. (*b*) B.

(*c*) $B \times E$. (*d*) $E \times B$.

Ans. (*d*)

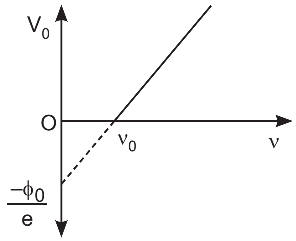
15. The length of an astronomical telescope for normal vision (relaxed eye) will be

(*a*) $f_o - f_e$ (*b*) $\frac{f_o}{f_e}$

(*c*) $f_o \times f_e$ (*d*) $f_o + f_e$

Ans. (*d*) In normal vision, length of telescope $L = f_o + f_e$.

16. The stopping potential V_0 for photoelectric emission from a metal surface is plotted along y-axis and frequency ν of incident light along ***x***-axis. A straight line is obtained as shown. Planck's constant is given by



(*a*) slope of the line

(*b*) product of the slope of the line and charge on electron

(*c*) intercept along y-axis divided by charge on the electron

(*d*) product of the intercept along x-axis and mass of the electron

Ans. (*d*) Using Einstein's photoelectric equation.

17. The electric field intensity produced by the radiations coming from 100 W bulb at a 3 m distance is E**.** The electric field intensity produced by the radiations coming from 50 W bulb at the same distance is

(*a*) $\frac{E}{2}$ (*b*) $2E$.

(*c*) $\frac{E}{\sqrt{2}}$ (*d*) $\sqrt{2}E$

Ans. (*d*)

18. If 13.6 eV energy is required to ionise the hydrogen atom, then energy required to remove an electron from $n = 2$ is

(*a*) 10.2 eV (*b*) 0 eV

(*c*) 3.4 eV (*d*) 6.8 eV

Ans. (*c*) $E_n = \frac{-13.6}{n^2}$ eV, $\Delta E_\infty - E_2 = 0 + \frac{13.6}{2^2} = 3.4$ eV

19. The focal length of a biconvex lens of radii of each surface 50 cm and refractive index 1.5, is

(*a*) 40.4 cm (*b*) 75 cm

(*c*) 50 cm (*d*) 80 cm

Ans. (*c*) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5 - 1)\left(\frac{1}{50} + \frac{1}{50}\right) \Rightarrow f = 50$ cm

20. The gravitational force between a H-atom and another particle of mass m will be given by Newton's law:

$F = G\frac{M.m}{r^2}$, where r is in km and

(*a*) $M = m_{proton} + m_{electron}$.

(*b*) $M = m_{proton} + m_{electron} - \frac{B}{c^2}$ (B = 13.6 eV).

(*c*) M is not related to the mass of the hydrogen atom.

(*d*) $M = m_{proton} + m_{electron} - \frac{|V|}{c^2}$ ($|V|$ = magnitude of the potential energy of electron in the H-atom).

Ans. (*b*)

21. In Bohr's model of an atom which of the following is an integral multiple of $\frac{h}{2\pi}$?

(*a*) Kinetic energy (*b*) Radius of an atom

(*c*) Potential energy (*d*) Angular momentum

Ans. (*d*) Angular momentum $L = mvr = \frac{nh}{2\pi}$

22. The quantity which is not conserved in a nuclear reaction is

(*a*) momentum. (*b*) charge.

(*c*) mass. (*d*) none of these.

Ans. (*c*) Energy equivalent to mass detect is released.

23. The transition from the state $n = 5$ to $n = 1$ in a hydrogen atom results in UV radiation. Infrared radiation will be obtained in the transition

(*a*) $2 \rightarrow 1$ (*b*) $3 \rightarrow 2$

(*c*) $4 \rightarrow 3$ (*d*) $6 \rightarrow 2$

Ans. (*c*)

24. Ratio of the radii of the nuclei with mass numbers 8 and 27 would be

(*a*) $\frac{27}{8}$ (*b*) $\frac{8}{27}$

(*c*) $\frac{2}{3}$ (*d*) $\frac{3}{2}$

Ans. (*c*) Using $r \propto A^{1/3}$

$$\therefore \quad \frac{r_8}{r_{27}} = \sqrt[3]{\frac{8}{27}} = \frac{2}{3}$$

25. In Bohr's model, the atomic radius of the first orbit is r_0. Then, the radius of the third orbit is

(*a*) $r_0/9$ (*b*) r_0

(*c*) $9r_0$ (*d*) $3r_0$

Ans. (*c*) $r_n = r_0 n^2 \quad \therefore \quad r_3 = 9r_0$.

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

26. The conductivity of a semiconductor increases with increase in temperature, because

(*a*) number density of free current carriers increases.

(*b*) relaxation time increases.

(*c*) both number density of carriers and relaxation time increase.

(*d*) number density of carriers increases, relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density.

Ans. (*d*)

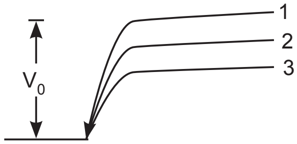
27. The K.E. of the electron in an orbit of radius *r* in hydrogen atom is proportional to

(*a*) $\frac{e^2}{r}$ (*b*) $\frac{e^2}{2r}$

(*c*) $\frac{2e^2}{r}$ (*d*) $\frac{e^2}{3r}$

Ans. (*b*) $\frac{e^2}{2r}$, Since, K.E. $= \frac{ke^2}{2r}$

28. In the given figure V_0 is the potential barrier across a *p-n* junction, when no battery is connected across the junction.



(*a*) 1 and 3 both correspond to forward bias of junction.

(*b*) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction.

(*c*) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.

(*d*) 3 and 1 both correspond to reverse bias of junction.

Ans. (*b*) Height of potential barrier is decreases when *p-n* junction is forward bias.

29. The hydrogen atom can give spectral lines in the Lyman, Balmer and Paschen series. Which of the following statement is correct?

(*a*) Lyman series is in the infrared region.

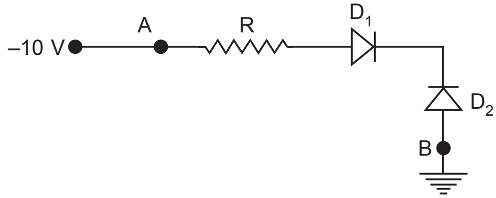
(*b*) Balmer series is in the visible region.

(*c*) Paschen series is in the visible region.

(*d*) Balmer series is in the ultraviolet region.

Ans. (*b*)

30. In figure given, assuming the diodes to be ideal



(*a*) D_1 is forward biased and D_2 is reverse biased and hence current flows from A to B.

(*b*) D_2 is forward biased and D_1 is reverse biased and hence no current flows from B to A and vice versa.

(*c*) D_1 and D_2 are both forward biased and hence current flows from A to B.

(*d*) D_1 and D_2 are both reverse biased and hence no current flows from A to B and vice versa.

Ans. (*b*) Explanation:

10 V is the lower voltage in the circuit. Now *p* side of the *p-n* junction diode D_1 is connected to lower voltage and *n*- side of D_1 to higher voltage , thus D_1 is reverse biased. In D_2 *p*-side of *p-n* junction diode is at higher potential and *n*-side is at lower potential, therefore D_2 is forward biased. Hence current flows through junction from B to A.

31. The ratio between Bohr radii is

(*a*) 1 : 2 : 3 (*b*) 2 : 4 : 6

(*c*) 1 : 4 : 9 (*d*) 1 : 3 : 5

Ans. (*c*) 1 : 4 : 9, In Bohr's atomic model, $r_n \propto n^2$

32. The __________, a property of materials C, Si and Ge depends upon the energy gap between their conduction and valence bands.

Ans. conductivity/resistivity.

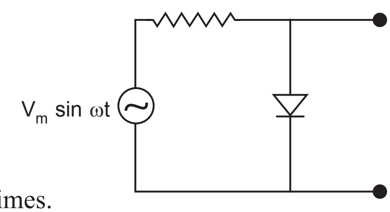
33. Which of the relation is correct between time period and number of orbits while an electron is resolving in an orbit?

(*a*) $T \propto \frac{1}{n^2}$ (*b*) $T \propto n^2$

(*c*) $T \propto n^3$ (*d*) $T \propto \frac{1}{n}$

Ans. (*c*)

34. The output of the given circuit in figure is given below.



(*a*) would be zero at all times.

(*b*) would be like a half-wave rectifier with positive cycles in output.

(*c*) would be like a half-wave rectifier with negative cycles in output.

(*d*) would be like that of a full-wave rectifier.

Ans. (*b*) Explanation:

When the diode is forward biased, the resistance of pn junction diode will be low then current in the circuit is maximum. In this situation, a maximum potential difference will appear across resistance connected in a series of circuit. This result into zero output voltage across *p-n* junction.

35. What happens during regulation action of a Zener diode?

(*a*) The current in and voltage across the Zener remains fixed.

(*b*) The current through the series resistance (R_s) does not change.

(*c*) The Zener resistance is constant.

(*d*) The resistance offered by the Zener changes.

Ans. (*d*)

36. Electrical conductivity of a semiconductor

(*a*) decreases with the rise in its temperature.

(*b*) increases with the rise in its temperature.

(*c*) does not change with the rise in its temperature.

(*d*) first increases and then decreases with the rise in its temperature.

Ans. (*b*) With temperature rise, the conductivity of semiconductor increases.

37. The wavelength and intensity of light emitted by a LED depend upon

(*a*) forward bias and energy gap of the semiconductor

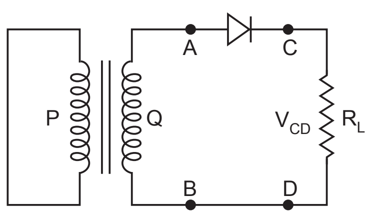
(*b*) energy gap of the semiconductor and reverse bias

(*c*) energy gap only

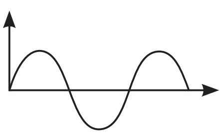
(*d*) forward bias only

Ans. (*a*) $l = \frac{c}{\nu} = \frac{c}{\frac{E_g}{h}} = \frac{hc}{E_g}$, and a heavily droped and strongly forward biased *p-n* junction provides lots of majority carriers and lots of photons.

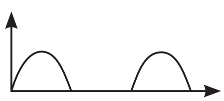
38. In the half-wave rectifier circuit shown. Which one of the following waveforms is true for V_{CD} the output across *C* and *D*?



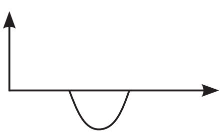
(*a*)



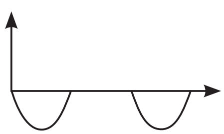
(*b*)



(*c*)

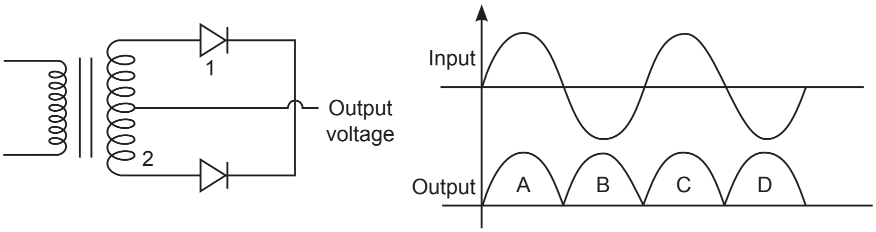


(*d*)



Ans. (*b*) Half wave rectifier rectifies only the half cycle of the input ac signal and it blocks the other half.

39. A full-wave rectifier circuit along with the input and output voltages is shown in the figure The contribution to output voltage from diode 2 is

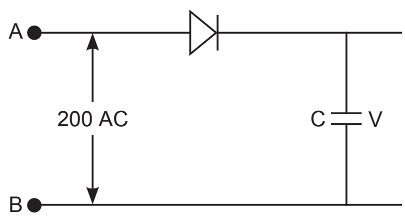


(*a*) A, C (*b*) B, D

(*c*) B, C (*d*) A, D

Ans. (*b*) In the positive half cycle of input ac signal diode D_1 is forward biased and D_2 is reverse biased so in the output voltage signal, A and C are due to D_1. In negative half cycle of input ac signal, D_2 conducts, hence output signals B and D are due to D_2

40. A 220 V AC supply is connected between points A and B (figure). What will be the potential difference V across the capacitor?



(*a*) 200 V

(*b*) 110 V

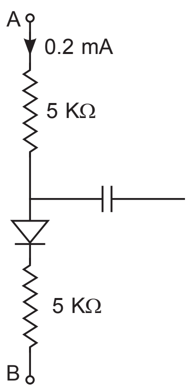
(*c*) 0 V

(*d*) $220\sqrt{2}\ V$

Ans. (*d*) As *p-n* junction diode will conduct during positive half cycle only and during negative half cycle diode is reverse biased. During this diode will not give any output. So potential difference across the capacitor C = peak voltage of the given AC voltage.

$V_O = V_{\text{rms}}\sqrt{2} = 200\sqrt{2}$ V.

41. In the circuit shown in figure below, if the diode forward voltage drop is 0.3 V, the voltage difference between A and B is



(*a*) 1.3 V (*b*) 2.3 V

(*c*) 0 (*d*) 0.5 V

Ans. (*b*) Suppose the potential difference between A and B is V_{AB}.

Then, $V_{AB} - 0.3 = [(r_1 + r_2)10^3] \times (0.2 \times 10^{-3})$ $[\because V_{AB} = ir]$

$= [(5 + 5)10^3] \times (0.2 \times 10^{-3})$

$= 10 \times 10^3 \times 0.2 \times 10^{-3} = 2$

$\Rightarrow V_{AB} = 2 + 0.3 = 2.3$ V

42. When an electric field is applied across a semiconductor

(*a*) holes move from lower energy level to higher energy level in the conduction band.

(*b*) electrons move from higher energy level to lower energy level in the conduction band.

(*c*) holes in the valence band move from higher energy level to lower energy level.

(*d*) holes in the valence band move from lower energy level to higher energy level.

Ans. (*c*) When electric field is applied across a semiconductor, the electrons in the conduction band move from lower energy level to higher energy level. While the holes in valence band move from higher energy level to lower energy level, where they will be having more energy.

43. In the depletion region of a diode

(*a*) there are mobile charges.

(*b*) equal number of holes and elections exist, making the region neutral.

(*c*) recombination of holes and electrons has taken place.

(*d*) immobile charged ions do not exist.

Ans. (*b*)

44. The breakdown in a reverse biased *p-n* junction is more likely to occur due to

(*a*) large velocity of the majority charge carriers if the doping concentration is small.

(*b*) large velocity of the minority charge carriers if the doping concentration is large.

(*c*) strong electric field in a depletion region if the doping concentration is small.

(*d*) strong electric field in the depletion region if the doping concentration is large.

Ans. (*d*)

Assertion-Reason Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct alternative from the choices give below:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

45. **Assertion (A):** The nuclear density is not dependent on the size of the nucleus.

Reason (R): Volume of nucleus is directly proportional to the nuclear mass or the mass number of an element.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

46. **Assertion (A):** The width of central maxima of diffraction is 2 times as compared to other maxima.

Reason (R): Diffraction is superposition of a continuous freely waves originating from each point of single slit.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

47. **Assertion (A):** The total energy of revolving electron in any stationary orbit is negative.

Reason (R): Energy is a scalar quantity. It can have positive or negative values.

Ans. (*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Explanation: Energy is negative because electrons are bound to the nucleus by attractive forces.

48. **Assertion (A):** Diffraction and interferences is inconsistent with principle of conservation of energy.

Reason (R): There is no gain or loss of energy, it get redistributed in dark and bright fringe.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

49. **Assertion (A):** Number of electrons emitted in one second is directly proportional to the intensity of incident radiation.

Reason (R): Higher numbers of photons can target higher number of electrons in the metal surface.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5 questions. In case more than desirable number of questions are attempted, ONLY first 5 will be considered for evaluation.

50. The hydrogen atom can give spectral lines in the Lyman, Balmer and Paschen series. Which of the following statement is correct?

(*a*) Lyman series is in the infrared region.

(*b*) Balmer series is in the visible region.

(*c*) Paschen series is in the visible region.

(*d*) Balmer series is in the ultraviolet region.

Ans. (*b*)

51. The energy of photon of wavelength 450 nm is

(*a*) 2.5×10^{-17} J (*b*) 1.25×10^{-17} J

(*c*) 4.4×10^{-19} J (*d*) 2.5×10^{-19} J

Ans. (*c*) Using $E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{450 \times 10^{-9}}$ J

Case-based Questions

Read the following paragraph and answer the following questions.

Each point on a wavefront is a source of new disturbance this is called secondary wavefront. They spread in all directions with speed of light. A wavefront is locus of particles which are vibrating in same phase rays are perpendicular to the wavefronts. Light will take time to travel from source to the observer. Speed of light in any medium is less than the speed of light in vacuum. This speed can be co-related the wavelength of the wave also. Since the refractive index gives the relation between speeds of different media, the wavelength in different media can be determined using the refractive index.

52. Speed of light in two different media is v_1 and v_2. What is the ratio of their wavelengths?

(*a*) $\frac{\lambda_1}{\lambda_2}$ (*b*) $\frac{\lambda_2}{\lambda_1}$

(*c*) $\frac{3\lambda_2}{\lambda_1}$ (*d*) $\frac{\lambda_1}{2\lambda_2}$

Ans. (*a*) $\frac{\lambda_1}{\lambda_2}$

$$v = \nu\lambda$$

$$\frac{v_1}{v_2} = \frac{\nu\lambda_1}{\nu\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

53. The characteristic which remains unchanged after reflection or refraction is:

(*a*) speed (*b*) wavelength

(*c*) frequency (*d*) momentum

Ans. (*c*) Frequency is the characteristic property of the source.

54. Speed of light in diamond is ($\mu_d = 2.47$)

(*a*) 1.2×10^8 m/s (*b*) 1.7×10^8 m/s

(*c*) 1.9×10^8 m/s (*d*) 10^8 m/s

Ans. (*a*) 1.2×10^8 m/s

$$\mu = \frac{c}{v}$$

$$v = \frac{c}{\mu} = \frac{3 \times 10^8 \text{ m/s}}{2.47}$$

$$= 1.2 \times 10^8 \text{ m/s}$$

55. Wavelength of light of 487 nm in water is

(*a*) 300 nm (*b*) 520 nm

(*c*) 350 nm (*d*) 366 nm

Ans. (*d*) 366 nm

$$\mu = \frac{v_1}{v_2} = \frac{\nu\lambda_1}{\nu\lambda_2} = \frac{\lambda_1}{\lambda_2}$$

$$\lambda_2 = \frac{\lambda_1}{\mu} = \frac{487}{1.33} = 366 \text{ nm}$$

2 PRACTICE PAPER

[Time Allowed: 90 minutes] [Maximum Marks: 35]

General Instructions:

(i) This question paper contains three sections.
(ii) Section A has 25 questions. Attempt any 20 questions.
(iii) Section B has 24 questions. Attempt any 20 questions.
(iv) Section C has 6 questions. Attempt any 5 questions.
(v) All questions carry equal marks.
(vi) There is no negative marking.

Section A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

1. A magnifying glass is used, as the object to be viewed can be brought closer to the eye than the normal near point. This results in

(*a*) a larger angle to be subtended by the object at the eye and hence viewed in greater detail.

(*b*) the formation of a real inverted image.

(*c*) increase in the field of view.

(*d*) infinite magnification at the near point.

Ans. (*a*)

2. The oscillating magnetic field in a plane electromagnetic wave is given as

$B_y = (8 \times 10^{-6}) \sin [2 \times 10^{11} t + 300\pi x]$ T,

wavelength of the em wave is

(*a*) 0.80 cm (*b*) 1×10^3 m

(*c*) 2×10^{-2} cm (*d*) 0.67 cm

Ans. (*d*) wavelength $\lambda = \frac{2\pi}{300\pi} = \frac{1}{150}$ m $= 0.67$ cm

3. Consider an extended object immersed in water contained in a plane trough. When seen from close to the edge of the trough the object looks distorted. Which of the following is not correct.
   (*a*) the apparent depth of the points close to the edge are nearer the surface of the water compared to the points away from the edge.
   (*b*) the angle subtended by the image of the object at the eye is smaller than the actual angle subtended by the object in air.
   (*c*) some of the points of the object far away from the edge may not be visible because of total internal reflection.
   (*d*) water in a trough acts as a lens and magnifies the object.

Ans. (*d*)

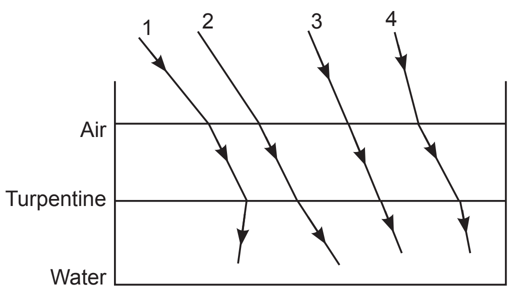
4. For light diverging from a point source
   (*a*) the wavefront is spherical.
   (*b*) the intensity increases in proportion to the distance squared.
   (*c*) the wavefront is parabolic.
   (*d*) the intensity at the wavefront does not depend on the distance.

Ans. (*a*)

5. A particle moves in a closed orbit around the origin, due to a force which is directed towards the origin. The de Broglie wavelength of the particle varies cyclically between two values λ_1, λ_2 with $\lambda_1 > \lambda_2$. Which following statements are true?
   (*a*) The particle could not be moving in a circular orbit with origin as centre.
   (*b*) The particle could not be moving in an elliptic orbit with origin as its focus.
   (*c*) When the de Broglie wavelength is λ_1, the particle is nearer the origin than when its value is λ_2.
   (*d*) When the de Broglie wavelength λ_2, the particle is nearer the origin than when its value λ_1.

Ans. (*d*)

6. The optical density of turpentine is higher than that of water while its mass density is lower. Figure shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in figure the path shown is correct?



   (*a*) 1 (*b*) 2
   (*c*) 3 (*d*) 4

Ans. (*b*)

7. Photons absorbed in a matter are converted to heat. A source emitting *h* photon/sec of frequency ν is used to convert 1 kg or ice at 0 °C to water at 0 °C. Then, the time *T* taken for the conversion

(*a*) increases with increasing *n,* with ν fixed

(*b*) decreases with *n* fixed, ν increasing.

(*c*) does not remain constant with *n* and ν changing such that *n*ν = constant

(*d*) increases when the product *n*ν increases.

Ans. (*b*)

8. The electric field associated with an e.m wave in vacuum is given by $\vec{E} = 40 \cos (kz - 6 \times 10^8 t)\, \vec{i}$, where *E*, *Z* and *t* are in volt/m, metre and seconds respectively. The value of wave vector *K* is

(*a*) 2 m^{-1} (*b*) 0.5 m^{-1}

(*c*) 6 m^{-1} (*d*) 3 m^{-1}

Ans. (*a*) Wave vector, $k = \frac{\omega}{c} = \frac{6 \times 10^8}{3 \times 10^8} = 2 \text{ m}^{-1}$

9. The radius of curvature of the curved surface of a plano-convex lens is 20 cm. If the refractive index of the material of the lens be 1.5, it will

(*a*) act as a convex lens only for the objects that lie on its curved side.

(*b*) act as a concave lens for the objects that lie on its curved side.

(*c*) act as a convex lens irrespective of the side on which the object lies.

(*d*) act as a concave lens irrespective of side on which the object lies.

Ans. (*c*)

10. Relativistic corrections become necessary when the expression for the kinetic energy 1/2 mv^2, becomes comparable with mc^2, where *m* is the mass of the particle. At what de Broglie wavelength, will relativistic corrections become important for an electron?

(*a*) $\lambda = 10$ nm (*b*) $\lambda = 10^{-1}$ nm

(*c*) $\lambda = 10^{-4}$nm (*d*) $\lambda = 10^{-3}$ nm

Ans. (*c*)

11. Waves in decreasing order of their wavelength are

(*a*) X-rays, infrared rays, visible rays, radio waves

(*b*) radio waves, visible rays, infrared rays, X-rays.

(*c*) radio waves, infrared rays, visible rays, X-rays.

(*d*) radio waves, ultraviolet rays, visible rays, X-rays.

Ans. (*c*)

12. You are given four sources of light each one providing a light of a single colour – red, blue, green and yellow. Suppose the angle of refraction for a beam of yellow light corresponding to a particular angle of incidence at the interface of two media is 90°. Which of the following statements is correct if the source of yellow light is replaced with that of other lights without changing the angle of incidence?

(*a*) The beam of red light would undergo total internal reflection.

(*b*) The beam of red light would bend towards normal while it gets refracted through the second medium.

(*c*) The beam of blue light would undergo total internal reflection.

(*d*) The beam of green light would bend away from the normal as it gets refracted through the second medium.

Ans. (*c*)

13. Two particles A_1 and A_2 of masses m_1, $m_2 (m_1 > m_2)$ have the same de Broglie wavelength. Then,

(*a*) their momenta are the same.

(*b*) their energies are the same.

(*c*) energy of A_1 is greater than the energy of A_2.

(*d*) energy of A_1 is equal to the energy of A_2.

Ans. (*a*)

14. The correct option, if speeds of gamma rays, X-rays and microwave are V_g, V_x and V_m respectively will be.

(*a*) $V_g > V_x > V_m$ (*b*) $V_g < V_x < V_m$

(*c*) $V_g > V_x > V_m$ (*d*) $V_g = V_x = V_m$

Ans. (*d*) All electromagnetic waves travel with the speed of light in space.

15. An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus. The image

(*a*) moves away from the lens with an uniform speed 5 m/s.

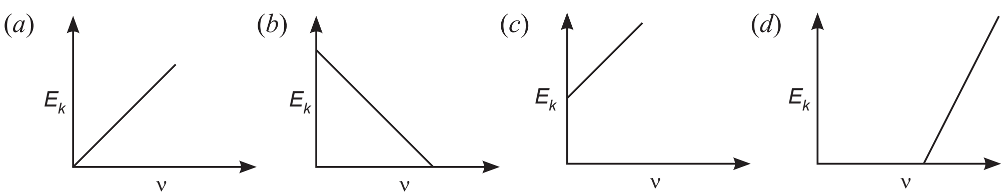
(*b*) moves away from the lens with an uniform accleration.

(*c*) moves away from the lens with a non-uniform acceleration.

(*d*) moves towards the lens with a non-uniform acceleration.

Ans. (*c*)

16. Maximum kinetic energy (E_k) of a photoelectron varies with frequency (ν) of the incident radiation as



Ans. (*d*) Using Einstein's photoelectric equation

$$h\nu = h\nu_0 + E_k$$

17. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along

(*a*) E. (*b*) B.

(*c*) $B \times E$. (*d*) $E \times B$.

Ans. (*d*)

18. The Balmer series for the H-atom can be observed

(*a*) if we measure the frequencies of light emitted when an excited atom falls to the ground state.

(*b*) if we measure the frequencies of light emitted due to transitions between excited states and the first excited state.

(*c*) in any transition in a H-atom.

(*d*) as a sequence of frequencies with the lower frequencies getting closely packed.

Ans. (*b*)

19. A short pulse of white light is incident from air to a glass slab at normal incidence. After travelling through the slab, the first colour to emerge is

(*a*) blue (*b*) green

(*c*) violet (*d*) red

Ans. (*d*)

20. In a nuclear reactor, moderators slow down the neutrons which come out in a fission process. The moderators used have light nuclei. Heavy nuclei will not serve the purpose because

(*a*) they will break up.

(*b*) elastic collision of neutrons with heavy nuclei will not slow them down.

(*c*) the net weight of the reactor would be unbearably high.

(*d*) substances with heavy nuclei do not occur in liquid or gaseous state at room temperature.

Ans. (*b*)

21. An ionised H-molecule consists of an electron and two protons. The protons are separated by a small distance of the order of angstrom. In the ground state,

(*a*) the electron would move in circular orbits.

(*b*) the energy would be $(2)^4$ times that of a H-atom.

(*c*) the electrons, orbit would go around the protons.

(*d*) the molecule will soon decay in a proton and a H-atom.

Ans. (*c*)

22. Fusion processes, like combining two deuterons to form a He nucleus are impossible at ordinary temperatures and pressure.

The reasons for this can be traced to the fact:

(*a*) nuclear forces are long range.

(*b*) nuclei are positively charged.

(*c*) the original nuclei must be completely ionized before fusion can take place.

(*d*) the original nuclei must first break up before combining with each other.

Ans. (*b*)

23. Two H atoms in the ground state collide inelastically. The maximum amount by which their combined kinetic energy is reduced is

(*a*) 10.20 eV (*b*) 20.40 eV

(*c*) 13.6 eV (*d*) 27.2 eV

Ans. (*a*)

24. Isotopes have

(*a*) same number of protons. (*b*) same number of nucleons.

(*c*) same number of neutrons. (*d*) same number of positrons.

Ans. (*a*) Same number of protons

25. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because

(*a*) of the electrons not being subject to a central force.

(*b*) of the electrons colliding with each other.

(*c*) of screening effects.

(*d*) the force between the nucleus and an electron will no longer be given by Coulomb's law.

Ans. (*a*)

Section B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

26. A *p*-type semiconductor can be obtained by adding

(*a*) arsenic to pure silicon. (*b*) gallium to pure silicon.

(*c*) antimony to pure germanium. (*d*) phosphorus to pure germanium.

Ans. (*b*) Ga has a valency of 3.

27. O_2 molecule consists of two oxygen atoms. In the molecule, nuclear force between the nuclei of the two atoms

(*a*) is not important because nuclear forces are short-ranged.

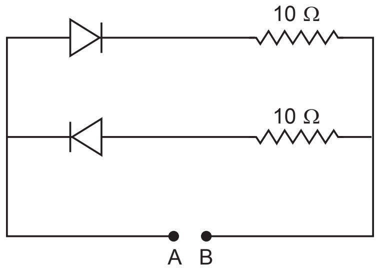
(*b*) is as important as electrostatic force for binding the two atoms.

(*c*) cancels the repulsive electrostatic force between the nuclei.

(*d*) is not important because oxygen nucleus has equal number of neutrons and protons.

Ans. (*a*)

28. A 2V battery is connected across the points *A* and *B* as shown in the figure. Assuming that the resistance of each diode is zero in forward bias and infinity in reverse bias, the current supplied by the battery when its positive terminal is connected to *A* is



(*a*) 0.2 A (*b*) 0.4 A

(*c*) Zero (*d*) 0.1 A

Ans. (*a*) Since diode in upper branch is forward biased and in lower branch is reverse biased. So current through circuit $i = \dfrac{V}{R + r_d}$, here r_d is diode resistance in forward biasing = 0

$\therefore\ i = \dfrac{V}{R} = \dfrac{2}{10} = 0.2\text{A}$

29. For the ground state, the electron in the H-atom has an angular momentum = $\hbar$, according to the simple Bohr model. Angular momentum is a vector and hence there will be infinitely many orbits with the vector pointing in all possible directions. In actuality, this is not true,

(*a*) because Bohr model gives incorrect values of angular momentum.

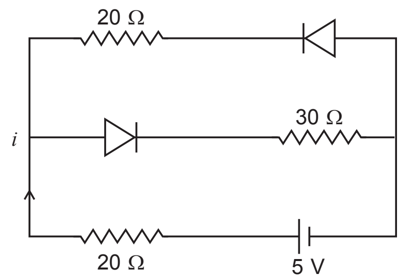
(*b*) because only one of these would have a minimum energy.

(*c*) angular momentum must be in the direction of spin of electron.

(*d*) because electrons go around only in horizontal orbits.

Ans. (*a*)

30. Current in the circuit will be



(*a*) 5/40 A

(*b*) 5/50 A

(*c*) 5/10 A

(*d*) 5/20 A

Ans. (*b*) The diode in lower branch is forward biased and diode in upper branch is reverse biased

$$i = \frac{5}{20 + 30} = \frac{5}{50}\text{ A}$$

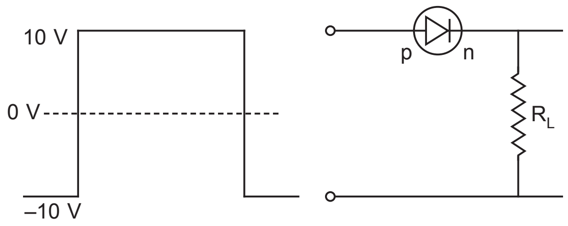
31. Taking the Bohr radius as a_0 = 53 pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about

(*a*) 53 pm (*b*) 27 pm

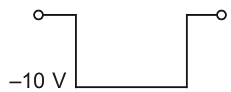
(*c*) 18 pm (*d*) 13 pm

Ans. (*c*)

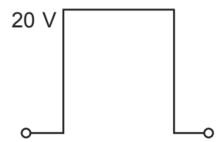
32. If the following input signal is sent through a *p-n* junction diode, then the output signal across R_L will be



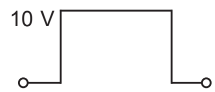
(*a*)



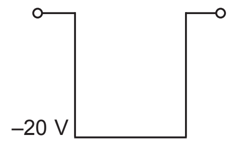
(*b*)



(*c*)



(*d*)



Ans. (*c*) When input voltage is –10 V, the diode is reverse biased and no output is obtained. On the other hand, when input is +10 V, the diode is forward biased and output is obtained which is +10 V.

33. In terms of Rydberg constant *R*, the shortest wavelength in Balmer series of hydrogen atom spectrum will have wavelength

(*a*) $\frac{1}{R}$ (*b*) $\frac{4}{R}$

(*c*) $\frac{3}{2R}$ (*d*) $\frac{9}{R}$

Ans. (*b*) For shortest wavelength $n_1 = \infty$, $n_2 = 2$

$$E_1 = \frac{-13.6}{\infty}\text{ eV}, E_2 = \frac{-13.6}{2^2}\text{ eV}$$

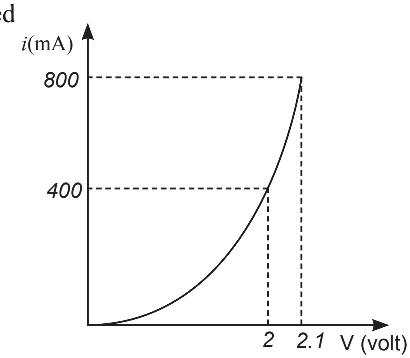
34. The *I-V* characteristic of a *p-n* junction diode is shown below. The approximate dynamic resistance of the *p-n* junction when a forward bias of 2 volt is applied

(*a*) 1 Ω

(*b*) 0.25 Ω

(*c*) 0.5 Ω

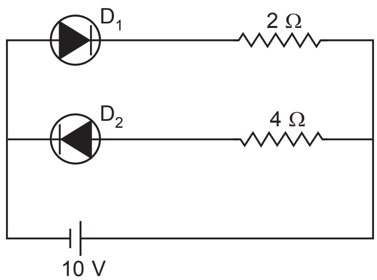
(*d*) 5 Ω



Ans. (*b*) The current at 2 V is 400 mA and at 2.1 V it is 800 mA. The dynamic resistance in this region.

$$R = \frac{\Delta V}{\Delta i} = \frac{(2.1 - 2)}{(800 - 400) \times 10^{-3}} = \frac{1}{4} = 0.25\ \Omega$$

35. Find the current passing through 2Ω and 4Ω resistances, respectively, in the circuit shown in figure



(*a*) 1A, 0A
(*b*) 4A, 3A
(*c*) 5A, 0A
(*d*) 1A, 2.5A

Ans. (*c*) Explanation:

In a given circuit diode D_1 is forward biased and D_2 is reverse-biased. So D_1 will conduct electricity and D_2 will not conduct electricity. Therefore, current through 4Ω is zero and through 2Ω is $\frac{10}{2} = 5A$.

36. Three photodiodes D_1, D_2, D_3 are made of semiconductor having band gap of 2.5 eV, 2 eV and 3.5 eV respectively. Which one will be able to detect light of wavelength 6000 Å?

(*a*) D_1
(*b*) D_2
(*c*) D_3
(*d*) None of these

Ans. (*b*) Explanation:

Energy of incident light is

$$E(\text{in } eV) = \frac{12375}{\text{wavelength (in Å)}}$$

$$E(\text{in } eV) = \frac{12375}{6000} = 2.06\ eV$$

This incident radiation can only be able to cross the band gap of D_2 diode, so D_2 will detect this radiation.

37. A *p*-type semiconductor can be obtained by adding

(*a*) arsenic to pure phosphorus
(*b*) gallium to pure silicon
(*c*) antimony to pure silicon
(*d*) phosphorus to pure germanium

Ans. (*b*) Explanation:

As *p*-type semiconductor can be made by replacing silicon atoms in the crystal lattice with gallium (a trivalent impurity)

38. In pure semiconductors, the number of conduction electrons is 6×10^{18} per metre. How many holes are there is a sample of size 1 cm × 1 cm × 1 mm?

(*a*) 6×10^{11} (*b*) 5×10^{18}

(*c*) 4×10^{15} (*d*) 3×10^{13}

Ans. (*a*) Explanation:

Here $n_e = 6 \times 10^{18}$

Volume of sample = 1 cm × 1 cm × 1 mm = 10^{-7} m^3

So number of holes in the sample = $6 \times 10^{18} \times 10^{-7} = 6 \times 10^{11}$

39. Carbon, Silicon and germanium have four valence electrons each. These are characterized by valence and conduction bands separated by an energy band gap, respectively, equal to $(E_g)_C$; $(E_g)_{Si}$; $(E_g)_{Ge}$. Which of the following statements is true?

(*a*) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$ (*b*) $(E_g)_C < (E_g)_{Si} < (E_g)_{Ge}$

(*c*) $(E_g)_C < (E_g)_{Ge}$; $(E_g)_{Si}$ (*d*) $(E_g)_{Ge} < (E_g)_{Si} < (E_g)_C$

Ans. (*b*)

40. Forbidden energy gap in a semiconductor is nearly equal to

(*a*) 0.5eV (*b*) 6eV

(*c*) 0eV (*d*) 3eV

Ans. (*d*)

41. With fall in temperature, the forbidden energy gap of a semiconductor

(*a*) increases

(*b*) decreases

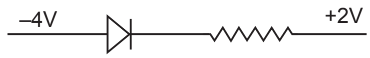
(*c*) sometimes increases and sometimes decreases

(*d*) remains unchanged

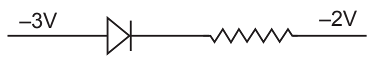
Ans. (*d*)

42. The forward biased diode connection is

(*a*) 

(*b*) 

(*c*) 

(*d*) 

Ans. (*c*)

43. Random motion of free electrons and holes due to thermal agitation is called:

(*a*) Pressure (*b*) Diffusion (*c*) Ionisation (*d*) None of the above

Ans. (*b*)

44. The cause of potential barrier in a *p-n* junction diode is

(*a*) depletion of positive charge near the junction

(*b*) concentration of positive charge near the junction

(*c*) depletion of negative charge near the junction

(*d*) concentration of positive and negative charge near the junction

Ans. (*d*)

Assertion-Reason Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct alternative from the choices give below:

(*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is true but Reason (R) is false.

(*d*) Assertion (A) is false and Reason (R) is also false.

45. **Assertion:** The nuclear density is not dependent on the size of the nucleus.

Reason: Volume of nucleus is directly proportional to the nuclear mass or the mass number of an element.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

46. **Assertion:** To observe diffraction of light the size of the obstacle/aperture should be of the order of 10^{-7} m.

Reason: 10^{-7} m is the order of the wavelength of visible light.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

47. **Assertion:** Nuclear density is extremely large.

Reason: Most mass of the atom is concentrated in the nucleus, but its volume is 10^{-15} times smaller compared to volume of the atom.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

48. **Assertion:** In interference, only redistribution of light energy occurs.

Reason: Average energy in the interference pattern is the same as the would be, if there were no interference.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

49. **Assertion:** Macroscopic objects have a De-Broglie wavelength which is very small.

Reason: De-Broglie wavelength is inversely proportional to the mass of material particle.

Ans. (*a*) Both Assertion (A) and Reason (R) are true but R is the correct explanation of Assertion (A).

Section C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, ONLY first 5 will be considered for evaluation.

50. The transition of electron from $n = 4, 5, 6, ...$ to $n = 3$ corresponds to

(*a*) Lyman series
(*b*) Balmer series
(*c*) Paschen series
(*d*) Brackett series

Ans. (*c*) In transition from $n_1 = 3$ and $n_2 = 4, 5, 6, ...$
Infrared radiation of Paschen spectral is emitted.

51. Einstein's photoelectric equation is:

(*a*) $h\nu = h\nu_0 + \frac{1}{2}mv^2$

(*b*) $h\nu_0 = h\nu + \frac{1}{2}mv^2$

(*c*) $h\nu = h\nu_0 - \frac{1}{2}mv^2$

(*d*) $2h\nu = h\nu_0 + mv^2$

Ans. (*a*)

Case-based Questions

Read the following paragraph and answer the following questions:

In our daily life, we observe various optical phenomenons every day but do not realize what is occurring to produce this phenomenon. Light reflected from a film of oil floating on water or soap bubble that reflects a variety of beautiful colours when illuminated by natural or artificial light sources are the examples of one of the important optical phenomenon exhibit by the light wave.

52. Which of the optical phenomenon exhibit by the light wave shown in the given paragraph?

(*a*) Interference

(*b*) Polarisation

(*c*) Diffraction

(*d*) Tyndall effect

Ans. (*a*)

53. To demonstrate the phenomenon of interference we require two sources which emit radiation of

(*a*) nearly the same frequency

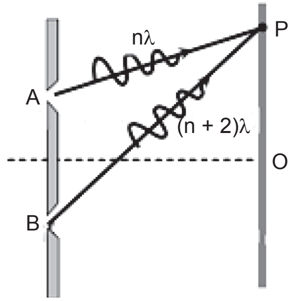
(*b*) different wavelength

(*c*) the same frequency and having definite phase relationship

(*d*) the same wavelength and having different phase relationship.

Ans. (*d*)

54. The figure shows a double slit experiment A and B are the slits. The path lengths AP and BQ are $n\lambda$ and $(n + 2)\lambda$ respectively, where n is a whole number and λ is the wavelength. Taking the central fringe at O as zero, what is formed at P?



(*a*) First bright

(*b*) First dark

(*c*) Second bright

(*d*) Second dark

Ans. (*c*) For brightness, path difference = $n\lambda = 2\lambda$, So second bright fringe is formed at P.

55. The fringe width in Young's double slit experiment increases when

(*a*) Wavelength increases

(*b*) Distance between the source and screen decreases

(*c*) Distance between the slits increases

(*d*) The width of the slits increases.

Ans. (*d*) $\beta = \dfrac{\lambda D}{d} \quad \Rightarrow \quad \beta \propto \lambda$