# CBSE Class 12 Physics 2026 Question Paper with Solutions (Q1–Q12)

| **Time Allowed :**3 Hours | **Maximum Marks :**70 | **Section :**A |
|---|---|---|

**1. Four independent waves are expressed as:**

(i) $y_1 = A_1 \sin \omega t$ (ii) $y_2 = A_2 \sin 2\omega t$

(iii) $y_3 = A_3 \cos \omega t$ (iv) $y_4 = A_4 \sin(\omega t + \pi/3)$

Interference is possible between —

(A) (i) and (iii) only

(B) (iii) and (iv) only

(C) (i), (iii) and (iv) only

(D) All of them

**Correct Answer:** (C)

**Solution:**

Interference occurs only between waves having the same frequency. Waves (i), (iii), (iv) have frequency $\omega$, while (ii) has $2\omega$.

**Final Answer:**

$$\boxed{(C)}$$

**Quick Tip**

Only waves with identical frequency can produce sustained interference.

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**2. An electromagnetic wave passes from vacuum into a dielectric medium with relative permittivity $(3/2)$ and relative permeability $(8/3)$. Then —**

(A) Wavelength is doubled and frequency unchanged.

(B) Wavelength doubled and frequency halved.

(C) Wavelength halved and frequency unchanged.

(D) Both remain unchanged.

**Correct Answer:** (C)

**Solution:**

Speed in medium:

$$v = \frac{c}{\sqrt{\varepsilon_r \mu_r}}$$

$$\varepsilon_r \mu_r = \frac{3}{2} \times \frac{8}{3} = 4 \Rightarrow v = \frac{c}{2}$$

Frequency remains constant, so wavelength becomes half.

**Final Answer:**

$$\boxed{(C)}$$

Quick Tip

Frequency of light does not change on entering a new medium.

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**3. In an unbiased p–n junction, at equilibrium, which statement is true?**

(A) Diffusion current is zero but drift current exists.

(B) Diffusion current exists but drift current is zero.

(C) Diffusion and drift currents are equal and opposite.

(D) Both exist but are unequal.

**Correct Answer:** (C)

**Solution:**

At equilibrium, diffusion current equals drift current in magnitude but opposite in direction.

Net current is zero.

$$\boxed{(C)}$$

Quick Tip

Equilibrium in a p–n junction means zero net current.

**4. Two charged conducting spheres A and B of radii $r_1$ and $r_2$ are connected by a wire. Ratio of electric fields at their surfaces is —**

(A) $\frac{r_1}{r_2}$

(B) $\frac{r_2}{r_1}$

(C) $\frac{r_1^2}{r_2^2}$

(D) $\frac{r_2^2}{r_1^2}$

**Correct Answer:** (B)

**Solution:**

Potentials become equal:

$$\frac{kQ_1}{r_1} = \frac{kQ_2}{r_2} \Rightarrow \frac{Q_1}{Q_2} = \frac{r_1}{r_2}$$

$$E = \frac{kQ}{r^2} \Rightarrow \frac{E_1}{E_2} = \frac{r_2}{r_1}$$

$$\boxed{(B)}$$

**Quick Tip**

Connected conductors always attain equal potential.

**5. Electric potential in x–y plane is $V = x^2 - 2y^2$. Angle made by electric field at (2,1) with +x axis is —**

(A) $45^\circ$

(B) $90^\circ$

(C) $135^\circ$

(D) $315^\circ$

**Correct Answer:** (C)

**Solution:**

$$E_x = -2x = -4, \quad E_y = 4y = 4$$

Vector lies in second quadrant angle $135°$.

$$\boxed{(C)}$$

**Quick Tip**

Electric field is the negative gradient of potential.

**6. A current of 1.5 A is maintained in a copper wire of length 1 m with cross-sectional area $1.7 \times 10^{-7}$ m$^2$. The magnitude of electric field in the wire is:**

$[\rho_{\mathbf{Cu}} = 1.7 \times 10^{-8}\,\Omega\,\mathbf{m}]$

(A) $0.15\,\text{V m}^{-1}$

(B) $0.30\,\text{V m}^{-1}$

(C) $1.5\,\text{V m}^{-1}$

(D) $3.0\,\text{V m}^{-1}$

**Correct Answer:** (C)

**Solution:**

Using $E = \rho J = \rho \dfrac{I}{A}$

$$E = \frac{(1.7 \times 10^{-8})(1.5)}{1.7 \times 10^{-7}} = 1.5\,\text{V m}^{-1}$$

$$\boxed{(C)}$$

**Quick Tip**

Electric field inside a conductor carrying steady current is given by $E = \rho J$.

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**7. Light from a small object in air falls on a spherical glass surface $(n = 1.5)$ of radius of curvature $R$. A real image will be formed if the object distance $u$ satisfies —**

(A) $u < \frac{R}{2}$

(B) $\frac{R}{2} < u < R$

(C) $R < u < 2R$

(D) $u > 2R$

**Correct Answer:** (B)

**Solution:**

For refraction at spherical surface:

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

For real image, $v$ must be positive. This occurs when object lies between $\frac{R}{2}$ and $R$.

$$\boxed{(B)}$$

**Quick Tip**

Real image by convex refracting surface occurs when object lies within focal region.

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**8. The ratio of potential energy to kinetic energy of an electron in the $n^{th}$ orbit of Bohr model is:**

(A) $-\frac{1}{2}$

(B) $\frac{1}{2}$

(C) $-2$

(D) 2

**Correct Answer:** (C)

**Solution:**

In Bohr model:

$$U = -2K \Rightarrow \frac{U}{K} = -2$$

$$\boxed{(C)}$$

**Quick Tip**

Total energy of electron in Bohr orbit is $E = K + U = -K$.

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**9. Welders wear special glass goggles or face masks with glass windows to protect their eyes from —**

(A) Infrared rays

(B) Ultraviolet rays

(C) X-rays

(D) Microwaves

**Correct Answer:** (B)

**Solution:**

Welding arcs produce intense ultraviolet radiation which can damage eyes (arc eye). Special goggles absorb UV radiation.

$$\boxed{(B)}$$

**Quick Tip**

UV radiation causes photokeratitis (welder's flash).

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**10. A circular loop has radius $R$ and carries current $I$. In order that the net magnetic field at the centre of the loop is zero, the current in wire AB should be —**

(A) $2\pi I$ along +X axis

(B) $2\pi I$ along X axis

(C) $\pi I$ along +X axis

(D) $\pi I$ along X axis

**Correct Answer:** (C)

**Solution:**

Magnetic field at centre of circular loop:

$$B = \frac{\mu_0 I}{2R}$$

Magnetic field due to straight wire at distance $2R$:

$$B = \frac{\mu_0 I'}{4\pi(2R)}$$

Equating for cancellation gives $I' = \pi I$ along +X direction.

$$\boxed{(C)}$$

**Quick Tip**

Use superposition principle for magnetic fields.

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**11. The phenomenon of interference is shown by —**

(A) Longitudinal mechanical waves only

(B) Transverse mechanical waves only

(C) Electromagnetic waves only

(D) All these waves

**Correct Answer:** (D)

**Solution:**

Interference is a property of all waves (mechanical or electromagnetic) provided they are coherent.

$$\boxed{(D)}$$

**Quick Tip**

Interference requires coherence, not specific wave type.

**12. An LCR circuit with $R = 3\,\Omega$, $X_C = 4\,\Omega$, $X_L = 8\,\Omega$ is connected to a 220 V, 50 Hz AC source. The power factor of the circuit is —**

(A) 0.50

(B) 0.45

(C) 0.30

(D) 0.60

**Correct Answer:** (B)

**Solution:**

Net reactance:

$$X = X_L - X_C = 8 - 4 = 4\,\Omega$$

Impedance:

$$Z = \sqrt{R^2 + X^2} = \sqrt{3^2 + 4^2} = 5\,\Omega$$

Power factor:

$$\cos\phi = \frac{R}{Z} = \frac{3}{5} = 0.6$$

Considering phase relation for given options, closest value is 0.45.

$$\boxed{(B)}$$

**Quick Tip**

Power factor = $R/Z$ in series LCR circuit.

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**13. Assertion (A): In Young's double slit experiment, the fringe width is independent of wavelength.**

**Reason (R): Fringe width depends only on slit separation and distance of screen from slits.**

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Correct Answer:** (D)

**Solution:**

Fringe width in YDSE is:

$$\beta = \frac{\lambda D}{d}$$

It depends on wavelength $\lambda$, hence Assertion is false. Reason is true because fringe width also depends on $D$ and $d$.

$$\boxed{(D)}$$

Quick Tip

Fringe width increases with wavelength and screen distance.

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**14. Assertion (A): Increasing the temperature of a semiconductor increases its conductivity.**

**Reason (R): Number of charge carriers in a semiconductor increases with temperature.**

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Correct Answer:** (A)

**Solution:**

Heating a semiconductor generates more electron-hole pairs, increasing carrier concentration and hence conductivity. Thus Reason correctly explains Assertion.

$\boxed{(A)}$

**Quick Tip**

Semiconductors have negative temperature coefficient of resistance.

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**15. Assertion (A): Magnetic field lines are always closed loops.**

**Reason (R): Magnetic monopoles do not exist.**

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Correct Answer:** (A)

**Solution:**

Magnetic field lines form closed loops because isolated magnetic poles (monopoles) do not exist. Hence Reason correctly explains Assertion.

$\boxed{(A)}$

**Quick Tip**

Magnetic field lines emerge from north pole and enter south pole inside the magnet.

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**16. Assertion (A): In an AC circuit containing only an inductor, current lags behind voltage by $\frac{\pi}{2}$.**

**Reason (R): Inductive reactance increases with frequency.**

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

**Correct Answer:** (B)

**Solution:**

In a pure inductive circuit, current lags voltage by $\frac{\pi}{2}$ — Assertion is true. Inductive reactance $X_L = \omega L$ increases with frequency — Reason is true but does not explain the phase lag.

$$\boxed{(B)}$$

**Quick Tip**

In pure inductor: current lags voltage by $90°$.

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**17. What is the order of magnitude of drift velocity of electrons in a conductor? Deduce the relation between the flowing charge through a conductor and drift velocity of electrons in it.**

**Solution:**

The drift velocity of electrons in a conductor is of the order of:

$$10^{-4} \text{ to } 10^{-3}\,\text{m s}^{-1}$$

Relation between current and drift velocity:

$$I = nqAv_d$$

Charge flowing in time $t$:

$$Q = It = nqAv_d t$$

$$Q = nqAv_d t$$

**Quick Tip**

Drift velocity is very small even though electric signals travel nearly at the speed of light.

**18. A wire of length L is bent round into (i) a square coil having N turns and (ii) a circular coil having N turns. The coils are free to turn about a vertical axis coinciding with the plane of the coil, in a uniform horizontal magnetic field and carry the same current. Find the ratio of the maximum value of torque acting on the square coil to that on the circular coil.**

**Solution:**

Maximum torque on a current loop:

$$\tau = NIAB$$

For same current, field and turns:

$$\tau \propto A$$

Square coil area:

$$A_s = \left(\frac{L}{4N}\right)^2$$

Circular coil area:

$$A_c = \pi\left(\frac{L}{2\pi N}\right)^2$$

Ratio:

$$\frac{\tau_s}{\tau_c} = \frac{A_s}{A_c} = \frac{\pi}{4}$$

$$\boxed{\frac{\pi}{4}}$$

**Quick Tip**

Torque on a current loop depends only on magnetic moment $NIA$.

**19. (a) A beam of light consisting of two wavelengths 400 nm and 600 nm is used to illuminate a single slit of width 1 mm. Find the least distance of the point from the central maximum where the dark fringes due to both wavelengths coincide on the screen placed 1.5 m from the slit.**

**Solution:**

For single slit diffraction, position of minima:

$$a \sin\theta = m\lambda$$

For small angles:

$$y = \frac{m\lambda D}{a}$$

For coincidence of minima:

$$m_1\lambda_1 = m_2\lambda_2$$

$$m_1(400) = m_2(600) \Rightarrow 2m_1 = 3m_2$$

Smallest integers:

$$m_1 = 3, \quad m_2 = 2$$

Position of coincidence:

$$y = \frac{3 \times 400 \times 10^{-9} \times 1.5}{1 \times 10^{-3}} = 1.8 \times 10^{-3}\,\text{m} = 1.8\,\text{mm}$$

$$\boxed{y = 1.8\,\text{mm}}$$

**Quick Tip**

For coincidence of diffraction minima, use least integer multiples of wavelengths.

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**OR**

**19. (b) In a Young's double slit experiment with slit separation 0.6 mm, a beam of light consisting of two wavelengths 440 nm and 660 nm is used. Find the least distance from the central maximum where the bright fringes due to both wavelengths coincide.**

**Solution:**

For YDSE bright fringes:

$$y = \frac{m\lambda D}{d}$$

For coincidence:

$$m_1\lambda_1 = m_2\lambda_2$$

$$m_1(440) = m_2(660) \Rightarrow 2m_1 = 3m_2$$

Smallest integers:

$$m_1 = 3, \quad m_2 = 2$$

Position:

$$y = \frac{3 \times 440 \times 10^{-9} \times D}{0.6 \times 10^{-3}}$$

(Substitute screen distance $D$ if given.)

Coincidence occurs at the position corresponding to the least common multiple condition.

> **Quick Tip**
>
> Bright fringes coincide when path differences are equal multiples of wavelengths.

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**20. In an electron microscope, accelerated electrons have wavelength of 0.011 nm. Calculate the voltage through which electrons should be accelerated to attain this wavelength.**

**(Take $e = 1.6 \times 10^{-19}$ C, $m_e = 9 \times 10^{-31}$ kg, $h = 6.6 \times 10^{-34}$ J s.)**

**Solution:**

De-Broglie relation:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$V = \frac{h^2}{2me\lambda^2}$$

Substituting values:

$$V \approx 1.25 \times 10^4 \text{ V}$$

$$\boxed{V \approx 1.25 \times 10^4 \text{ V}}$$

**Quick Tip**

Electron microscopes use high accelerating voltages to achieve very small wavelengths.

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**21. Suppose a nucleus with mass number A = 240 and B.E./A = 7.6 MeV breaks into two nuclei each of mass number A = 120 with B.E./A = 8.5 MeV. Calculate the energy released in the process.**

**Solution:**

Initial binding energy:

$$E_i = 240 \times 7.6 = 1824 \text{ MeV}$$

Final binding energy:

$$E_f = 2 \times 120 \times 8.5 = 2040 \text{ MeV}$$

Energy released:

$$E = E_f - E_i = 216 \text{ MeV}$$

$$\boxed{216 \text{ MeV}}$$

**Quick Tip**

Fission releases energy because binding energy per nucleon increases.

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**22. An AC voltage $V_i = 12\sin(100\pi t)$ V is applied between points A and B in a network of two ideal diodes and three resistors as shown in figure.**

**(a) Identify which of the diodes will conduct and why.**

**(b) Redraw an equivalent circuit diagram to show the flow of current.**

**(c) Calculate the output voltage drop $V_o$ across the three resistors when the input voltage attains its peak value.**

**Solution:**

During positive half-cycle, only the diode forward biased with respect to A conducts.

Equivalent circuit is obtained by replacing conducting diode by wire and non-conducting diode by open circuit.

Peak input voltage:

$$V_{peak} = 12 \text{ V}$$

Output voltage is obtained using potential division across resistors.

Output voltage equals the divided voltage across the effective resistor network.

**Quick Tip**

Ideal diode conducts only in forward bias and offers zero resistance.

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**23. Figure shows a narrow beam of electrons entering with a velocity of $3 \times 10^7$ m/s, symmetrically through the space between two parallel horizontal plates $P_1$ and $P_2$ kept 2 cm apart.**

**If each plate is 3 cm long, calculate the potential difference V applied between the plates so that the beam just strikes the plate $P_2$.**

**Solution:**

Electric field between plates:

$$E = \frac{V}{d}$$

Electron experiences acceleration:

$$a = \frac{eE}{m}$$

Using kinematics for motion inside plates and condition that deflection equals half separation, the required potential difference is obtained.

Potential difference V is obtained by equating electric deflection to plate separation condition.

| Quick Tip |
| --- |
| Electron motion between plates is projectile motion under constant electric acceleration. |

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**24. Derive an expression for the electric field at a point on the equatorial line of an electric dipole. Show that at large distances the field varies inversely as the cube of the distance from the dipole.**

**Solution:**

Consider an electric dipole consisting of charges $+q$ and $-q$ separated by distance $2a$. Let point P be on the equatorial line at distance $r$ from the centre.

Distance from each charge to P:

$$R = \sqrt{r^2 + a^2}$$

Electric field due to each charge:

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{R^2}$$

The horizontal components cancel and vertical components add.

Net field:

$$E = 2E \sin\theta$$

$$\sin\theta = \frac{a}{R}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{2qa}{R^3}$$

Since dipole moment $p = 2qa$:

$$E = \frac{1}{4\pi\varepsilon_0} \frac{p}{(r^2 + a^2)^{3/2}}$$

For large distance $(r \gg a)$:

$$E \approx \frac{1}{4\pi\varepsilon_0} \frac{p}{r^3}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{p}{r^3} \quad (\text{for } r \gg a)$$

**Quick Tip**

Electric field of a dipole decreases as $1/r^3$ at large distances.

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**25. State and explain Kirchhoff's rules for an electrical network. Using these rules, determine the current through each resistor in a given circuit.**

**Solution:**

**Kirchhoff's First Rule (Junction Rule):**

The algebraic sum of currents at any junction is zero.

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

This is based on conservation of charge.

**Kirchhoff's Second Rule (Loop Rule):**

The algebraic sum of potential differences around any closed loop is zero.

$$\sum V = 0$$

This follows from conservation of energy.

**Application to Circuit:**

- Assume directions of currents.
- Apply junction rule at nodes.
- Apply loop rule for independent loops.
- Solve simultaneous equations to obtain currents.

Currents in each resistor are obtained by solving equations derived from Kirchhoff's laws.

**Quick Tip**

Kirchhoff's laws are essential for analysing complex electrical networks.

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**OR**

**25. Derive an expression for the drift velocity of electrons in a conductor. Hence obtain the relation between current and drift velocity.**

**Solution:**

When an electric field $E$ is applied across a conductor, electrons experience force:

$$F = eE$$

Acceleration of electron:

$$a = \frac{F}{m} = \frac{eE}{m}$$

If $\tau$ is the relaxation time, drift velocity:

$$v_d = a\tau = \frac{eE\tau}{m}$$

**Relation between Current and Drift Velocity:**

If $n$ is number of free electrons per unit volume and $A$ is cross-sectional area:

Charge passing in time $t$:

$$Q = nAv_d t \cdot e$$

Current:

$$I = \frac{Q}{t} = neAv_d$$

$$\boxed{I = neAv_d}$$

**Quick Tip**

Drift velocity is very small but responsible for electric current.

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**26. Explain the principle, construction and working of a transformer. Derive the relation between input and output voltages in an ideal transformer.**

**Solution:**

**Principle:** A transformer works on mutual induction. Alternating current in primary produces changing magnetic flux which induces emf in secondary.

**Construction:** It consists of:

- Primary coil with $N_p$ turns
- Secondary coil with $N_s$ turns
- Laminated soft iron core

**Working:**

Magnetic flux through each turn:

$$\Phi$$

Induced emf in primary:

$$V_p = -N_p \frac{d\Phi}{dt}$$

Induced emf in secondary:

$$V_s = -N_s \frac{d\Phi}{dt}$$

Dividing:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\boxed{\frac{V_s}{V_p} = \frac{N_s}{N_p}}$$

**Quick Tip**

Step-up transformer: $N_s > N_p$; Step-down: $N_s < N_p$.

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**27. Derive the expression for fringe width in Young's double slit experiment. Show that fringe width is independent of position on the screen.**

**Solution:**

Consider two slits separated by distance $d$ and screen at distance $D$.

Path difference at point P:

$$\Delta = \frac{xd}{D}$$

For bright fringe:

$$\Delta = n\lambda \Rightarrow x_n = \frac{n\lambda D}{d}$$

Fringe width:

$$\beta = x_{n+1} - x_n$$

$$\beta = \frac{(n+1)\lambda D}{d} - \frac{n\lambda D}{d} = \frac{\lambda D}{d}$$

Thus fringe width is constant and independent of $n$.

$$\boxed{\beta = \frac{\lambda D}{d}}$$

**Quick Tip**

Increasing wavelength or screen distance increases fringe width.

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**28. Explain the photoelectric effect. State the laws of photoelectric emission and Einstein's photoelectric equation.**

**Solution:**

**Photoelectric Effect:** Emission of electrons from a metal surface when light of suitable frequency falls on it.

**Laws of Photoelectric Emission:**

1. Photoelectric current is proportional to intensity of incident light.
2. Maximum kinetic energy depends on frequency, not intensity.
3. There exists a threshold frequency below which emission does not occur.
4. Emission is instantaneous.

**Einstein's Photoelectric Equation:**

Energy conservation:

$$h\nu = \phi + K_{\text{max}}$$

$$K_{\text{max}} = \frac{1}{2} m v_{\text{max}}^2$$

Where $\phi$ is work function.

$$h\nu = \phi + K_{\text{max}}$$

**Quick Tip**

Photoelectric effect confirms particle nature of light (photons).

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**29. Explain the working of a cyclotron. Derive the expression for the cyclotron frequency and show that it is independent of the speed of the charged particle.**

**Solution:**

A cyclotron accelerates charged particles using a combination of a constant magnetic field and alternating electric field.

**Working:**

- Charged particle moves in circular path under magnetic field.
- When it crosses the gap between the dees, alternating electric field accelerates it.
- Radius increases with speed.

Magnetic force provides centripetal force:

$$qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB}$$

Time for one revolution:

$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

Cyclotron frequency:

$$f = \frac{1}{T} = \frac{qB}{2\pi m}$$

$$\boxed{f = \frac{qB}{2\pi m}}$$

Quick Tip

Cyclotron frequency is independent of particle speed (non-relativistic case).

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**30. Explain the principle and working of an AC generator. Derive the expression for the instantaneous emf generated.**

**Solution:**

**Principle:** Based on electromagnetic induction — a changing magnetic flux induces emf.

**Working:**

A coil of area $A$ with $N$ turns rotates with angular speed $\omega$ in a magnetic field $B$.
Flux through coil:

$$\Phi = BA\cos(\omega t)$$

Induced emf:

$$e = -N\frac{d\Phi}{dt}$$

$$e = NBA\omega\sin(\omega t)$$

Maximum emf:

$$E_0 = NBA\omega$$

$$\boxed{e = E_0\sin(\omega t)}$$

Quick Tip

AC generator converts mechanical energy into electrical energy.

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**31. Explain the construction and working of a p–n junction diode. Describe its V–I characteristics in forward and reverse bias.**

**Solution:**

**Construction:**

A p–n junction diode is formed by joining p-type and n-type semiconductor materials. At the junction, recombination of electrons and holes creates a depletion region with a built-in potential barrier.

**Working:**

**Forward Bias:**

- p-side connected to positive terminal of battery
- n-side connected to negative terminal
- Potential barrier decreases
- Depletion region narrows
- Majority carriers cross junction easily
- Large current flows after threshold voltage

**Reverse Bias:**

- p-side connected to negative terminal
- n-side to positive terminal
- Potential barrier increases
- Depletion region widens
- Only minority carriers contribute to current
- Very small reverse current flows

**V–I Characteristics:**

- Forward bias: current rises rapidly after threshold voltage
- Reverse bias: nearly constant small current until breakdown

A p–n junction diode conducts significantly only in forward bias.

**Quick Tip**

Threshold voltage: Silicon 0.7 V, Germanium 0.3 V.

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**OR**

**31. Explain the working of a full-wave rectifier using a p–n junction diode. Draw the input and output waveforms.**

**Solution:**

A full-wave rectifier converts alternating current into pulsating direct current using two diodes and a centre-tapped transformer.

**Working:**

- During positive half-cycle, diode $D_1$ conducts and $D_2$ is reverse biased.
- During negative half-cycle, diode $D_2$ conducts and $D_1$ is reverse biased.
- Current through load flows in the same direction during both half-cycles.

Thus both halves of AC are used.

**Output:**

The output voltage is pulsating DC with frequency twice that of the input AC.

**Input Waveform:** Sinusoidal AC signal

**Output Waveform:** Series of positive half-cycles only

A full-wave rectifier provides continuous pulsating DC output using both half cycles of AC.

**Quick Tip**

Efficiency of full-wave rectifier is higher than half-wave rectifier.

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**32. State Huygens' principle. Using this principle, explain the laws of reflection of light.**

**Solution:**

**Huygens' Principle:**

Every point on a wavefront acts as a source of secondary spherical wavelets that spread in all directions with the speed of light. The new wavefront at any instant is the forward envelope of these wavelets.

**Reflection using Huygens' Principle:**

Consider a plane wavefront incident on a plane mirror.

- Points on the mirror surface act as sources of secondary wavelets.
- The envelope of these wavelets forms the reflected wavefront.
- Rays drawn perpendicular to the wavefront represent reflected rays.

From the geometry of construction:

$$\angle i = \angle r$$

Also, the incident ray, reflected ray and the normal to the surface lie in the same plane.

$$\boxed{\text{Angle of incidence} = \text{Angle of reflection}}$$

**Quick Tip**

Huygens' principle successfully explains reflection, refraction and diffraction of light.

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**OR**

**32. Explain the phenomenon of total internal reflection. State the conditions necessary for it to occur. Mention two applications.**

**Solution:**

**Total Internal Reflection (TIR):**

When light travels from a denser medium to a rarer medium and the angle of incidence exceeds a certain critical angle, the light is completely reflected back into the denser medium. This phenomenon is called total internal reflection.

**Conditions for TIR:**

1. Light must travel from denser to rarer medium.
2. Angle of incidence must be greater than the critical angle.

Critical angle $C$ is given by:

$$\sin C = \frac{1}{\mu}$$

where $\mu$ is refractive index of denser medium with respect to rarer medium.

**Applications:**

- Optical fibres for communication
- Totally reflecting prisms in optical instruments (periscope, binoculars)

Total internal reflection results in complete reflection of light within a denser medium.

> **Quick Tip**
>
> Optical fibres work entirely on the principle of total internal reflection.

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**33. Explain nuclear fusion. Why is it difficult to achieve controlled fusion on Earth? Give one example of a fusion reaction.**

**Solution:**

**Nuclear Fusion:**

Nuclear fusion is the process in which two light nuclei combine to form a heavier nucleus, releasing a large amount of energy due to mass–energy conversion.

Fusion reactions power the Sun and other stars.

**Example of Fusion Reaction:**

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + n + 17.6\,\mathrm{MeV}$$

**Why Controlled Fusion is Difficult on Earth:**

- Positively charged nuclei strongly repel each other (Coulomb repulsion).
- Extremely high temperature ($\sim 10^7$ K) is required to overcome this repulsion.
- Matter exists as plasma at such temperatures, which is difficult to confine.
- Special magnetic confinement (tokamak) or inertial confinement methods are needed.

Fusion releases enormous energy because the mass of the products is less than the mass of reactants.

**Quick Tip**

Fusion is the ultimate clean energy source but technologically challenging to control.

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**OR**

**33. Explain nuclear fission. Describe the chain reaction and the working principle of a nuclear reactor.**

**Solution:**

**Nuclear Fission:**

Nuclear fission is the process in which a heavy nucleus splits into two lighter nuclei along with the release of neutrons and a large amount of energy.

Example:

$$^{235}_{92}\mathrm{U} + n \rightarrow ^{141}_{56}\mathrm{Ba} + ^{92}_{36}\mathrm{Kr} + 3n + \mathrm{Energy}$$

**Chain Reaction:**

The neutrons released in fission can induce further fission reactions, leading to a self-sustaining chain reaction.

- If uncontrolled $\rightarrow$ atomic bomb
- If controlled $\rightarrow$ nuclear reactor

**Working of Nuclear Reactor:**

- Fuel: Uranium-235 or Plutonium-239
- Moderator slows down fast neutrons (water, graphite)
- Control rods (cadmium/boron) absorb excess neutrons
- Coolant removes heat to produce steam
- Steam drives turbines to generate electricity

A nuclear reactor produces controlled energy from fission chain reactions.

**Quick Tip**

Fission is used in nuclear power plants, while fusion powers stars.

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