CBSE Sample Paper 10

Class XII Exam 2022-23

Physics

Time: 3 Hours **Max. Marks: 70**

General Instructions:

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

SECTION - A

18 Marks

1. Which material moves from a higher magnetic field to a lower magnetic field in a non-uniform magnetic field?

(a) Paramagnetic
(b) Diamagnetic
(c) Ferromagnetic
(d) None of these 1

2. A hemisphere is uniformly charged positively. The electric field at a point on a diameter away from the centre is directed:

(a) at an angle tilted away from the diameter.
(b) at an angle tilted towards the diameter.
(c) parallel to the diameter.
(d) perpendicular to the diameter. 1

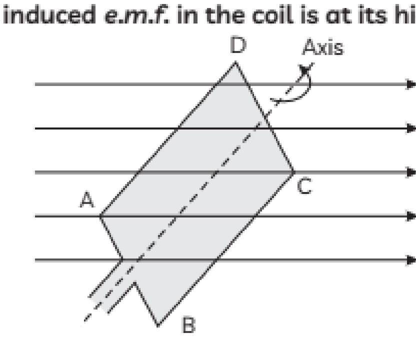
3. Consider an area where several forms of charges exist but the overall charge is zero. At areas outside of the region:

(a) The electric field is always zero.
(b) The electric field is caused only by the dipole moment of the charge distribution.
(c) For large r, the dominant electric field is inversely proportional to r^3 (distance from origin).
(d) The effort required to carry a charged particle away from the area through a closed path will not be zero. 1

4. Fringes are created on a screen positioned at some distance from the plane of the slits in a two slit experiment using monochromatic light. If the screen is moved 5×10^{-2} m towards the slits, the fringe width changes by 3×10^{-5} m. The wavelength of light, if the distance between the slits is 10^{-3} m, will be:

(a) 3000 Å (b) 4000 Å
(c) 6000 Å (d) 7000 Å 1

5. A rectangular coil ABCD is turned anticlockwise with a consistent angular velocity about the axis depicted in the diagram. The coil's axis of rotation and the magnetic field B are both horizontal. When the induced *e.m.f.* in the coil is at its highest,



(a) The coil's plane is horizontal.
(b) The coil's plane forms a 45° angle with the magnetic field.
(c) The coil's plane is perpendicular to the magnetic field.
(d) The plane of the coil forms a 30° angle with the magnetic field. 1

6. The wavefront of a wave moves in the same direction as the wave's direction is:

(a) Opposite (b) Perpendicular
(c) Parallel (d) At an angle of θ 1

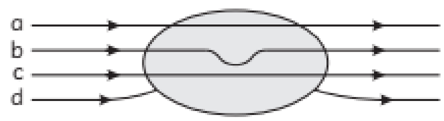
7. We can identify the direction of magnetic field lines caused by a current carrying loop by:

(a) Fleming's left hand rule
(b) Fleming's left hand rule
(c) Right hand thumb rule
(d) Left hand thumb rule 1

8. The deflecting torque acting on the coil of a galvanometer is:

(a) inversely proportional to area of the coil.
(b) inversely proportional to number of turns.
(c) inversely proportional to current flowing.
(d) directly proportional to the magnetic field strength. 1

9. As represented in the picture, a metallic sphere is positioned in a constant electric field. Which path should electric field lines pursue?



(a) Path b (b) Path a
(c) Path d (d) Path c 1

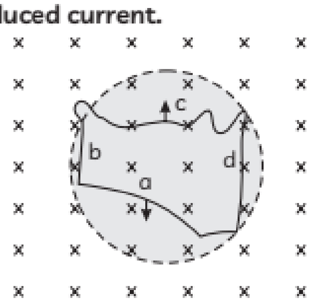
10. In vacuum, what physical quantity remains constant for microwaves of 1 mm wavelength and UV-radiation of 1600 Å?

(a) wavelength (b) path
(c) intensity (d) speed 1

11. Two nuclei have mass numbers in the ratio 64:125. What is the ratio of their nuclear radii?

(a) 5:4 (b) 4:5
(c) 1:2 (d) 2:1 1

12. When put in an area field oriented normal to the plane of the loop away from the reader, a flexible wire of irregular shape, as illustrated in the image, transforms into a circular shape. Predict the direction of the wire's induced current.



(a) Clockwise direction
(b) Anti-clockwise direction
(c) Zig-zag direction
(d) No movement shown 1

13. A dipole of dipole moment *p* is present in a uniform electric field E. The value of the angle between *p* and E for which the torque experienced by the dipole, is minimum is:

(a) 90°, 180° (b) 180°, 360°
(c) 0°, 270° (d) 0°, 180° 1

14. A current I is carried by a circular coil with N turns and radius R. It is unwound and rewound to form another coil of radius $\frac{R}{2}$, while current I remains constant. Calculate the ratio of making another coil of radius $\frac{R}{2}$ with the same current I. Calculate the magnetic moment ratio between the new and original coils.

(a) 1:2 (b) 4:1
(c) 2:1 (d) 1:4 1

15. In a circular orbit, an electron in the ground state of a hydrogen atom rotates anticlockwise. When the atom is oriented normal to the electron orbit, it forms a 30° angle in the magnetic field. What is the torque felt by the circling electron?

(a) 0 (b) $\frac{ehB}{8\pi m_e}$
(c) $\frac{ehB}{4\pi m_e}$ (d) 1 1

Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

16. Assertion (A): Huygen's principle states that no reverse wave-front is attainable.

Reason (R): Secondary wavelet amplitude is proportional to $(1 + \cos\theta)$. Where, θ is the angle between the ray at the place of consideration and the secondary wavelet direction. 1

17. Assertion (A): Even when the switch is turned off, a current flows through the superconducting coil.

Reason (R): The Meissner effect can be seen in superconducting coils. 1

18. Assertion (A): Magnet poles cannot be separated by separating them into two parts.

Reason (R): When a magnet is broken into two equal parts, the magnetic moment is decreased to half. 1

SECTION - B 14 Marks

19. Show how one is needed Magnetic Field Laws and their Applications to generalise Ampere's circuital law to include the term due to displacement current in the case of a parallel plate capacitor being charged. 2

20. What form of wave front will develop from a;

(i) point source

(ii) distant light source, according to the Huygens Principle? 2

21. The hydrogen atom's ground state energy is - 13.6 eV. What are the electron's kinetic and potential energies in this state?

OR

If Bohr's quantisation postulate (angular momentum = $\frac{nh}{2\pi}$) is a fundamental rule of nature, it should also apply to planetary motion. Why, therefore, do we never discuss quantification of planet orbits around the sun? 2

22. A solenoid is linked to a battery and receives a continuous current. Will the current rise or decrease if an iron core is introduced into the solenoid? Explain.

OR

A circular copper disc with a radius of 10 cm rotates at a rate of 2π rad/s about an axis running through its centre and perpendicular to the disc. A 0.2T uniform magnetic field acts perpendicular to the disc.

(A) Determine the potential difference that has arisen between the disc's axis and the rim.

(B) What is the induced current if the disc's resistance is 2Ω? 2

23. Display the fluctuation of photocurrent with collector plate potential for different frequencies but the same incoming radiation intensity. 2

24. Can two equipotential surfaces intersect? Justify your response. 2

25. How does the power of a convex lens vary when red light is replaced with violet light? 2

SECTION - C 15 Marks

26. An observer in a laboratory starts with N, nuclei of a radioactive sample and keep on observing the number (N) of left over nuclei at regular intervals of 10 min each. She prepares the following table on the basis of her observation.

Time t (in min)	$\log_e\left(\frac{N_0}{N}\right)$
0	0
10	3,465
20	6,930
30	10,395
40	13,860

Use this data to plot a graph of $\log_e\left(\frac{N_0}{N}\right)$ *vs* time (t) and calculate the:

(A) decay constant and

(B) half-life of the given sample. 3

27. The oscillating electric field with a frequency of 3×10^{10} Hz and an amplitude of 30 $\frac{V}{m}$ propagates in the positive x-direction as an electromagnetic wave. What is the electromagnetic wave's wavelength? Make a note of the expression that represents the relevant magnetic field.

OR

The electric field in a planar electromagnetic wave oscillates sinusoidally at a frequency of 2×10^{10} Hz and an amplitude of 48 $\frac{V}{m}$.

(A) What is the wavelength of the electromagnetic wave?

(B) Determine the amplitude of the fluctuating magnetic field.

(C) What is the average energy density of the wave's electromagnetic field? 3

28. Calculate Einstein's photoelectric equation. Explain how you got this equation using the photon image of electromagnetic radiation. Write out the three most noticeable elements of the photon image of electromagnetic radiation. Write down the three most noticeable features of the photoelectric effect that can be explained using this equation. 3

29. Mention the critical aspects necessary while building a p-n junction diode to be employed as a Light Emitting Diode. If an must emit light in the visible range, what should the order of its band gap be?

OR

The energy gap E_g in an intrinsic semiconductor is 1.2 eV. Its hole mobility is substantially less than electron mobility and is temperature independent. What is the ratio of conductivity at 600K to conductivity at 300K? Assume that:

$$n_{t-} n_0 \exp\left[-\frac{E_g}{2k_B T}\right]$$

represents the temperature dependence of intrinsic carrier concentration n_i.

Where, n_0 is constant. 3

30. What is Brewster law? Prove, using this law, that the reflected and transmitted rays are perpendicular to each other at the polarising angle of incidence. 3

SECTION - D

15 Marks

31. (A) Six lead-acid type secondary cells, each with an emf of 2.0 V and an internal resistance of 0.015Ω, are connected in series to offer a supply to an 8.5Ω resistance current obtained from the supply and its terminal voltage?

(B) After prolonged usage, a secondary cell has an emf of 1.9 V and a high internal resistance of 380. What is the maximum current that the cell can produce? Could the cell power a car's starter motor?

OR

Respond to the following questions:

(A) A constant current passes through a metallic conductor with a non-uniform cross section. Which of the following parameters, current, current density, electric field, or drift speed, is constant along the conductor?

(B) Is Ohm's law applicable to all conducting elements? If not, describe instances of components that violate Ohm's law.

(C) A low voltage supply from which high currents are required must have very low resistance. Why?

(D) A 6 kV high tension (HT) supply must have a very high internal resistance. 5

32. A series LCR circuit with L = 0.12 H, C = 480 nF, R = 23 variable frequency supply, is connected to a 230 V.

(A) What is the source frequency for which current amplitude is maximum. Obtain this maximum value.

(B) What is the source frequency for which average power absorbed by the circuit is maximum. Obtainthe value of this maximum power.

(C) For which frequencies of the source is the power transferred to the circuit half the power at resonant frequency? What is the current amplitude at these frequencies?

(D) What is the Q-factor of the given circuit?

OR

Respond to the following questions:

(A) In every alternating current circuit, is the applied instantaneous voltage equal to the algebraic sum of the instantaneous voltages across the circuit's series elements? Is this true for RMS voltage as well?

(B) A capacitor is utilised in the primary circuit of an induction coil.

(C) An applied voltage signal is a high-frequency AC voltage superimposed on a DC voltage. The circuit is made up of a series inductor and a capacitor. Demonstrate that the DC signal will appear across C and the AC signal will emerge across L.

(D) A DC line is connected to a choke coil in series with a bulb. The lamp appears to be shining brilliantly. Inserting an iron core into the choke has no effect on the lamp's brightness. If the connection is to an alternating current line, predict the related observations.

(E) Why is a choke coil required when using fluorescent bulbs with alternating current mains? Why can't we just use a regular resistor in place of the choke coil? 5

33. Use the mirror equation to deduce that:

(A) an object placed between *f* and 2*f* of a concave mirror produces a real image beyond 2*f*.

(B) a convex mirror always produces a virtual image independent of the location of the object.

(C) the virtual image produced by a convex mirror is always diminished in size and is located between the focus and the pole.

(D) an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

OR

(A) When observing at a mesh of crossed wires, a man can see the vertical lines more clearly than the horizontal wires. What is the cause of the effect? How is an eyesight defect corrected?

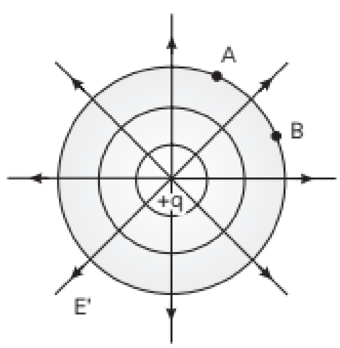
(B) A individual with a normal near point (25 cm) uses a magnifying glass: a narrow convex lens with a focal length of 5cm to read a book with small type:

(i) What is the closest and furthest distance he can read the book while using the magnifying glass?

(ii) What is the highest and least angular magnifying power achievable with the aforementioned basic microscope? 5

SECTION - E **8 Marks**

34. *Equipotential surfaces are represented by curves for the various charge systems, while lines of force are represented by full line curves. We assume a constant potential difference between any two adjacent equipotential surfaces. The equipotential surfaces of a single point charge are concentric spherical shells with their centres at the point charge. Because the lines of force radiate outward, they are always perpendicular to the equipotential surfaces.*



(A) Calculate the work needed to transfer a unit charge from P to Q along an equipotential surface. 1

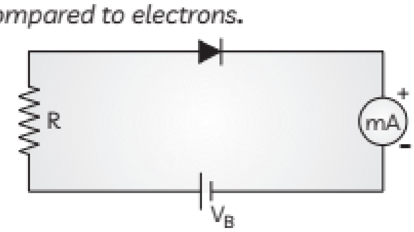
(B) What is the work done in transmitting a charge q once around a radius a circle with a charge Q at its center? 1

(C) Prove that an equipotential volume must be enclosed by a closed equipotential surface with no change inside itself.

OR

Can there be a potential difference between two adjacent conductors carrying the same charge? 2

35. *A silicon p-n junction diode is connected to a resistor R and a battery of voltage V_B through milliammeter (mA) as shown in figure. The knee voltage for this junction diode is $V_N = 0.7$ V. The p-n junction diode requires a minimum current of 1 mA to attain a value higher than the knee point on the I-V characteristics of this junction diode. Assuming that the voltage V across the junction is independent of the current above the knee point. A p-n junction is the basic building block of many semiconductor devices like diodes. Important process occurring during the formation of a p-n junction are diffusion and drift. In an n-type semiconductor concentration of electrons is more as compared to holes. In a p-type semiconductor concentration of holes is more as compared to electrons.*



(A) If V_B = 5V, the maximum value of R. So what is the volatage V above the knee point voltage? 1

(B) When the diode is reverse biased with a voltage of 6V and V_{bi} = 0.63V. Calculate the total potential. 1

(C) Why are elemental dopants for silicon or germanium typically selected from groups XIII or XV?

OR

Is it possible to detect the potential barrier across a p-n junction by simply attaching a voltmeter across the junction? 2

SOLUTION

SECTION - A

1. *(b) Diamagnetic*

Explanation: Diamagnetic materials are magnetized in the opposite direction as the magnetic field. As a result, they prefer to migrate away from the stronger section of the field and toward the weaker half.

2. *(d) perpendicular to the diameter.*

Explanation: As the side or diameter of hemisphere is plane surface, and whole hemisphere is charged with positive charge so, the electric field line of forces emerging outward will be perpendicular to the plane surface or diameter.

3. *(c) For large r, the dominant electric field is inversely proportional to r^3 (distance from origin).*

Explanation: When a region has multiple forms of charges but the overall charge is zero, the region is said to have a number of electric dipoles. Therefore, at the points of outside the region,

The electric field, E is inversely proportional to cube of distance from origin.

4. *(c) 6000Å*

Explanation: We know that,

Fringe width, $$\beta = \frac{\lambda D}{d}$$

where, λ is the wavelength of light, D is the distance between screen and the slits and *d* is the distance between two slits

$$\therefore \quad \Delta\beta = \frac{\lambda}{d}\Delta D$$

(As λ and *d* are constants)

$$\text{or} \quad \lambda = \frac{\Delta\beta d}{\Delta D}$$

Substituting the given values, we get

$$\lambda = \frac{(3\times10^{-5}m)(10^{-3}m)}{(5\times10^{-2}m)}$$

$$= 6\times10^{-7}\,m$$

$$= 6000\text{Å}$$

5. *(d) The plane of the coil forms a 30° angle with the magnetic field.*

Explanation: Let θ be the angle formed between the magnetic field and the line perpendicular to the surface of the rectangular coil.

Hence, the flux through the coil is,

$$\phi = \vec{B}.\overline{A} = BA\cos\theta$$

So, the induced *emf* = rate of change of flux

$$-\frac{d\phi}{dt} = BA\sin\theta\,\frac{d\phi}{dt}$$

$$= BA\,\omega\sin\theta$$

Hence, it is minimum at

$$\theta = 0°, 180°.$$

That is, the plane of the coil is perpendicular to the magnetic field.

Caution

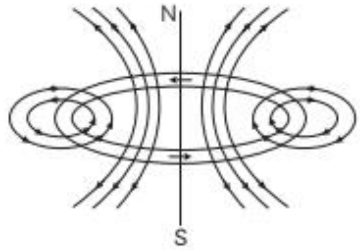
➥ *Students must know that when the emf is induced, students frequently become confused. It is caused by any change in magnetic flux.*

6. *(b) Perpendicular*

Explanation: The wave's direction is perpendicular to the wavefront.

7. *(c) Right hand thumb rule*

Explanation: Magnetic field lines due to a current carrying loop is as shown below:



8. *(d) directly proportional to the magnetic field strength.*

Explanation: We know that,

$$\tau = nBIA.$$

So, Torque is proportional to the magnetic field intensity, coil area, number of turns, and current flowing.

9. *(c) Path d*

Explanation: Electric field lines follow path d. Because the electric field intensity within the metallic sphere is zero, no electric lines of force exist within the sphere, and lines fall naturally on the surface. Electric field lines are always perpendicular to the conductor's surface.

10. *(d) speed*

Explanation: Microwaves and ultraviolet waves are both part of the electromagnetic spectrum. As a result, the physical quantity remaining for both forms of radiation is their speeds which is equal to c.

Where, $c = 3 \times 10^8$ m/s

Related Theory

The relationship $v = \lambda \times f$, describes the velocity of a wave. When a light beam travels from one medium to another, its frequency remains constant. Hence, $v \propto \lambda$ or greater the wavelength, the greater the speed.

11. *(b) 4:5*

Explanation: We know that,

Radius of nucleus,

$$R = R_0 A^{1/3}$$

Where, A = mass number

R_0 = constant

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$$

$$= \left(\frac{64}{125}\right)^{\frac{1}{3}}$$

$$R_1 : R_2 = 4:5$$

12. *(b) Anti-clockwise direction*

Explanation: The wire is increasing from a circle, showing that the magnetic field is imposing force on each section of the wire (acting in the downwards direction). The induced current's direction should be such that it induces an upward magnetic field (towards the reader). As a result, the force on the wire will be inward, showing that induced current is flowing through the loop from *cbadc* in an anti-clockwise direction.

Related Theory

Magnetic flux is defined as the total number of magnetic lines of force flowing naturally through a region surrounded by a magnetic field, which is equal to the magnetic flux associated with that area.

13. *(d) 0°, 180°*

Explanation: Since, torque (τ) on the dipole in electric field E is,

$$\tau = p \times E$$

$$\Rightarrow \quad |\tau| = pE \sin\theta$$

For minimum torque,

$$|\tau| = 0$$

$$\Rightarrow \quad pE \sin\theta = 0$$

$$\sin\theta = 0$$

$$\Rightarrow \quad \theta = 0°, 180°$$

14. *(c) 2 : 1*

Explanation: The length of wire is same

$$N_1 \times (2\pi R) = N_2 \times 2\pi\left(\frac{R}{2}\right)$$

Where, N_1 and N_2 are the number of turns in the coil.

$$N_2 = 2N_1$$

The ratio of magnetic moment is given by,

$$\frac{M_1}{M_2} = \frac{N_1 I A_1}{N_2 I A_2} = \frac{N_1 \times \pi R_1^2}{N_2 \times \pi R_2^2}$$

$$\frac{M_1}{M_2} = \left(\frac{N_1}{2N_2}\right) \times \left(\frac{R}{\frac{R}{2}}\right)^2$$

$$M_1 : M_2 = 2 : 1$$

15. *(b)* $\frac{ehB}{8\pi m_e}$

Explanation: A Magnetic moment associated with electron,

$$M = \frac{eh}{4\pi m_e}$$

$$\theta = 30°$$

and $\quad \tau = MB \sin\theta$

$$\tau = \frac{eh}{4\pi m_e} B \times \sin 30°$$

$$= \frac{eh}{4\pi m_e} B \times \frac{1}{2}$$

$$\tau = \frac{ehB}{8\pi m_e}$$

16. *(b) Both A and R are true and R is NOT the correct explanation of A.*

Explanation: According to the Stoke's law,

The intensity at each point of the secondary wave is proportional to $(1 + \cos\theta)$

Here, θ is the angle between normal and central line,

For backward wave-front,

$$\theta = \pi$$

So, $\cos\theta = \cos\pi$

Thus, intensity at any point on backward wave

$$= k(1 + \cos\pi)$$
$$= k(1 - 1) = 0$$

Therefore, Back wave-front does not exist.

17. *(b) Both A and R are true and R is NOT the correct explanation of A.*

Explanation: The assertion is true. Even when the *emf* is switched off, the current continues to flow because its resistance becomes zero. The Meissner effect is another property of the superconductor and not the reason for the assertion. Meissner effect repels the magnetic field lines from the interior of the superconductor.

Related Theory

➥ *Students should be aware that superconductors are ideal diamagnets, as they totally reject magnetic field lines. The Meissner effect is a phenomena of perfect diamagnetism.*

18. *(b) Both A and R are true and R is NOT the correct explanation of A.*

Explanation: Poles cannot be separated because, as we know, every atom in a magnet behaves as a dipole. When a magnet is divided into two equal halves, the magnetic moment of each portion is half that of the original magnet.

SECTION - B

19. The gap between the capacitors is made up of an insulator. As a result, no actual charge transfer takes place in this location. During the charging of a capacitor, current flows in the circuit. This necessitates the presence of a displacement current in the capacitor, resulting in a magnetic field.

$$\oint B.dl = \mu_0 I$$

Here, I is the sum of conduction and displacement currents.

20. (i) From a point source, the wavefront is diverging spherical wavefront.

(ii) From a distant light source, the wavefront is plane wavefront.

21. Ground state energy of hydrogen atom,

$$E = -13.6 \text{ eV}$$

This is the total energy of a hydrogen atom. Kinetic energy is equal to the negative of the total energy.

$$\text{Kinetic energy} = -E = -(-13.6)$$
$$= 13.6 \text{ eV}$$

Potential energy is equal to the negative of two times of kinetic energy,

$$\text{Potential energy} = -2 \times (13.6) = -27.2 \text{ eV}$$

OR

We never discuss quantization of planet orbits around the Sun because the angular momentum associated with planetary motion is highly dependent on the magnitude of Planck's constant (*h*). The Earth's orbital angular momentum is in the order of 1070h. This results in an extremely high quantum level n of the order of 1070. For big n values, consecutive energies and angular momenta are exceedingly tiny. As a result, the quantum levels for planetary motion are thought to be continuous.

22. The current will be reduced. This is because adding an iron core into the solenoid increases the magnetic field and hence the magnetic flux associated with the solenoid. According to Lenz's law, the induced emf in the solenoid will resist this rise, which may be done by decreasing the current. The current will drop. This is due to the fact that adding an iron core into the solenoid increases the magnetic field and hence the magnetic flux associated with the solenoid. According to Lenz's law, the induced emf in the solenoid will resist this rise, which may be done by decreasing current.

OR

(A) Radius, $r = 10$ cm,

$B = 0.2T$

$\omega = 2\pi$ rad/s

$$\epsilon = \frac{1}{2} B w r^2$$

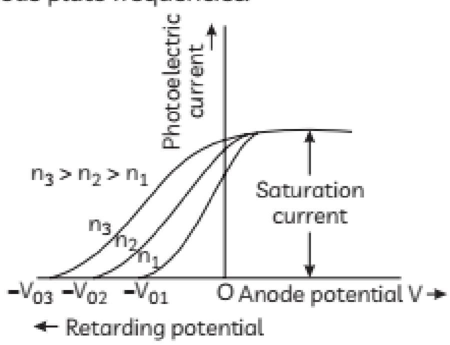
$$\epsilon = \frac{1}{2} \times 0.2 \times 2\pi \times (0.1)^2$$

$$\epsilon = 0.00628 \text{ volts}$$

(B) $$I = \frac{\epsilon}{R} = \frac{0.0628}{2}$$

$$I = 0.0314 \text{ A}$$

23. The following graph depicts the fluctuation of photocurrent with collector plate potential for various plate frequencies:



24. (i) No, two equipotential surfaces cannot cross since two normals may be drawn at an intersecting point on two surfaces, giving two E directions at the same place, which is impossible.

(ii) It is also impossible to have two potential values at the same place.

25. From lens maker's formula,

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

We can write,

$$P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For same lens when only medium is changed

$\Rightarrow$ $P \propto (\mu - 1)$

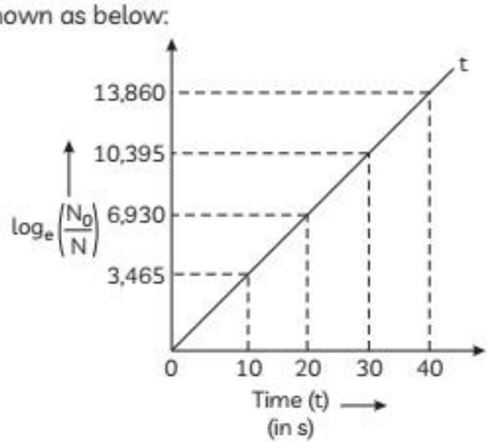
Also, $$\mu \propto \frac{1}{\lambda \text{ (wavelength)}}$$

$$P \propto \frac{1}{\lambda}$$

The refractive index of glass increases as the wavelength decreases (from red to violet), and so the power of the lens increases.

SECTION - C

26. The graph between $\log_e\left(\frac{N_0}{N}\right)$ and time is shown as below:



(A) $\because$ $\log_e\left(\frac{N_0}{N}\right) = \lambda t$

$\Rightarrow$ Slope of $\log_e\left(\frac{N_0}{N}\right)$ vs time t graph gives decay constant λ.

$\therefore$ $$\lambda = \frac{3.465}{10} \ s^{-1}$$

[using observation given in table]

$$= \frac{6.930}{20}$$

$$= 0.3465$$

(B) $\because$ Half-life, $$T_{1/2} = \frac{0.693}{\lambda}$$

$$T_{1/2} = \frac{0.693}{0.3465} = 2\ s$$

Half-life, $T_{1/2} = 2\ s$

27. Given,

$$\nu = 3 \times 10^{10} \text{ Hz},$$

$$E_0 = 30 \ \frac{V}{m}$$

$\therefore$ $$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{3 \times 10^{10}} = 10^{-2}\ m$$

$\because \quad c = \frac{E_0}{B_0}$

$\Rightarrow \quad B_0 = \frac{E_0}{c} = 1 \times 10^{-7}$ T

$B = B_0 \sin(\omega t - kx)\ \hat{k}$

$\omega = 2\pi v = 6\pi \times 10^{10}$ rad/s

$k = \frac{2\pi}{\lambda} = \frac{2\pi}{10^{-2}} = 200\ \pi$

$\Rightarrow \quad B = (10^{-7}\text{ T}) \sin(6\pi \times 10^{10} t - 200\ \pi x)\ \hat{k}$

OR

(A) $\nu = 2 \times 10^{10}$ Hz

$E_0 = 48\ \frac{\text{v}}{m}$

$\lambda = \frac{C}{\nu}$

$\lambda = \frac{3 \times 10^8}{2 \times 10^{10}}$

$\lambda = 1.5 \times 10^{-2}$ m

(B) $E_0 = cB_0$

$B_0 = \frac{E_0}{c}$

$= \frac{48}{3 \times 10^8}$

$B_0 = 16 \times 10^{-8}$ Tesla

(C) Energy Density,

$U = \frac{1}{2}\ \epsilon_0 E^2$

$U = \frac{1}{2} \times 8.85 \times 10^{-12} \times 48 \times 48$

$U = 1 \times 10^{-8}$ J/m^3

28. Einstein's photoelectric equation,

$KE_{max} = h\nu - W_0$ ...(i)

where, ν = frequency of incident light beam

W_0 = work-function of metal

KE_{max} = maximum kinetic energy

$\because \quad W_0 = h\nu_0$

where, v_0 is threshold frequency.

$\Rightarrow \quad KE_{max} = h\nu - h\nu_0$

$KE_{max} = h(\nu - \nu_0)$ ...(ii)

This equation is obtained by considering the particle nature of electromagnetic radiation. Three salient features observed in photoelectric effect and their explanation on the basis of Einstein's photoelectric equation is given as below:

(1) Threshold frequency: For $KE_{max} \geq 0$.

$\Rightarrow \quad \nu \geq \nu_0$ [From Eq. (ii)]

i.e., the phenomenon of photoelectric effect takes place when incident frequency is greater or equal to a minimum frequency (threshold frequency) ν_0 fixed for given metal.

(2) KE_{max} of photoelectron: When incident frequency is greater than threshold frequency, then KE_{max} of photoelectron is directly proportional o $(\nu - \nu_0)$ as

$KE_{max} = h(\nu - \nu_0)$ [From Eq. (ii)]

$\Rightarrow \quad KE_{max} \propto (\nu - \nu_0)$

(3) Effect of intensity of incident light: The number of photon incident per unit time per unit area increases with the increase of intensity of incident light. More number of photons facilitates ejection of more number of photoelectrons from metal surface leads to further increase of photocurrent till its saturation value is reached.

29. The threshold voltages for LEDS are substantially higher and slightly varied for different colours. LED reverse breakdown voltages are typically about 5v. as a result, effort is taken to ensure that excessive reverse voltages do not develop across LEDS. LEDS have very little resistance to limit current flow. to avoid damage to the LED, a resistor must be placed in series with it.

The semiconductor utilised in the manufacturing of visible LEDs must have a band gap of at least 1.80V. (spectral range of visible light is from about 0.4 um to 0.7 um *i.e.*, from about 3 *eV* to 1.8 *eV*).

OR

Energy gap of the given intrinsic semiconductor,

$E_g = 1.2\ eV$

The temperature dependence of the intrinsic carrier-concentration is written as:

$n_{t-}\ n_0 \exp\left[-\frac{E_g}{2k_B T}\right]$

Where, k_B = Boltzmann constant

$= 8.62 \times 10^{-5}$ eV/K

T = Temperature

n_0 = Constant

Initial temperature,

$T_1 = 300$ K

The intrinsic carrier-concentration at this temperature can be written as:

$$n_{t_1} = n_0 \exp\left[-\frac{E_g}{-2k_B \times 300}\right] \quad ...(1)$$

Final temperature,

$$T_2 = 600 \text{ K}$$

The intrinsic carrier-concentration at this temperature can be written as:

$$n_{t_2} = n_0 \exp\left[-\frac{E_g}{-2k_B \times 600}\right] \quad ...(2)$$

The ratio between the conductivities at 600 K and at 300 K is equal to the ratio between the respective intrinsic carrier-concentrations at these temperatures.

$$\frac{n_{t_2}}{n_{t_1}} = \frac{n_0 \exp\left[-\frac{E_g}{2k_B 600}\right]}{n_0 \exp\left[-\frac{E_g}{2k_B 300}\right]}$$

$$= \exp \frac{E_g}{2k_B}\left[\frac{1}{300} - \frac{1}{600}\right]$$

$$= \exp\left[\frac{1.2}{2 \times 8.62 \times 10^{-5}} \times \frac{2-1}{600}\right]$$

$$= \exp[11.6] = 1.09 \times 10^5$$

Therefore, the ratio between the conductivities is 1.09×10^5.

30. According to Brewster's law, the longest angle of polarisation for a thin medium is equal to the medium's refractive index.

i.e., $\mu = \tan i_p$

Proof: Using Snell's law

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

When, $i = i_p$

$$\mu = \frac{\sin i_p}{\sin r_p} \quad ...(1)$$

Also $= \tan i_p = \frac{\sin i_p}{\sin r_p} \quad ...(2)$

from (1) and (2)

$$\frac{\sin i_p}{\sin r_p} = \frac{\sin i_p}{\cos i_p}$$

$$\sin r_p = \cos i_p$$

$$\sin r_p = \sin(90° - i_p)$$

$$\Rightarrow \quad r_p + i_p = 90°$$

SECTION - D

31. (A) Number of secondary cells,

$$n = 6$$

Emf of each secondary cell,

$$E = 2.0 \text{ V}$$

Internal resistance of each cell,

$$r = 0.015\ \Omega$$

series resistor is connected to the combination of cells.

Resistance of the resistor,

$$R = 8.5\ \Omega$$

Current drawn from the supply = I, which is given by the relation,

$$I = \frac{nE}{R + nr}$$

$$= \frac{6 \times 2}{8.5 + 6 \times 0.015}$$

$$= \frac{12}{8.59} = 1.39 \text{ amp}$$

Terminal voltage,

$$V = IR = 1.39 \times 8.5 = 11.87 \text{ A}$$

Therefore, the current drawn from the supply is 1.39 amp and terminal voltage is 11.87 amp.

(B) After a long use, emf of the secondary cell,

$$E = 1.9 \text{ V}$$

Internal resistance of the cell,

$$r = 380\ \Omega$$

Hence, maximum current

$$I = \frac{E}{r} = \frac{1.9}{380} = 0.005 \text{ amp}$$

Therefore, the maximum current drawn from the cell is 0.005 A. Since a large current is required to start the motor of a car, the cell cannot be used to start a motor.

OR

(A) When a steady current travels through a non-uniform cross-sectional metallic conductor, the current flowing through the conductor is constant. Current density, electric field, and drift speed are all inversely related to cross-sectional area. As a result, they are not consistent.

(B) No, Ohm's law does not apply uniformly to all conducting components. A non-ohmic conductor is a vacuum diode semi-conductor. Ohm's law does not apply to it.

(C) Ohm's law states that the relationship between potential, current, and resistance is V=IR. Voltage (V) is proportional to current (I). R denotes the source's internal resistance.

$$I = \frac{V}{R}$$

If V is low, R must be very low in order to draw a high current from the source.

(D) A high tension supply must have a very high internal resistance to prevent the current from exceeding the safety limit. If the internal resistance is low, the current drawn may exceed the permissible limits in the event of a short circuit.

32. Inductance,

$$L = 0.12 \text{ H.}$$

Capacitance, $C = 480\ nF$

$$= 480 \times 10^{-9} \text{ F}$$

Resistance, $R = 23\Omega$

Supply voltage, $V = 230$ V

Peak voltage is given as:

$$V_0 = \sqrt{2} \times 230 = 325.22 \text{ V}$$

(A) Current flowing in the circuit is given by the relation,

$$I_0 = \frac{V_0}{\sqrt{R^2 + \left((\omega)L - \frac{1}{(\omega)C}\right)^2}}$$

Where, I_0 = maximum at resonance

At resonance, we have

$$(\omega)_R L - \frac{1}{(\omega)_R C} = 0$$

ω_R = Resonance angular frequency

$$\omega_R = \frac{1}{\sqrt{LC}}$$

$$= \frac{1}{\sqrt{0.12 \times 480 \times 10^{-9}}} = 4166.67 \text{ rad/s}$$

Resonant frequency,

$$\nu_R = \frac{(i)_R}{2\pi} = \frac{4166.67}{2 \times 3.14}$$

$$= 663.48 \text{ Hz}$$

And, maximum current

$$(I_0)_{max} = \frac{V_0}{R} = \frac{325.22}{23}$$

$$= 14.14 \text{ A}$$

(B) Maximum average power absorbed by the circuit is given as:

$$(P_\omega)_{max} = \frac{1}{2} (I_0)_{max}{}^2 R$$

$$= \frac{1}{2} \times (14.14)^2 \times 23$$

$$= 2299.3\text{W}$$

Hence, resonant frequency (ν_R) is 663.48 Hz.

(C) The power transferred to the circuit is half the power at resonant frequency. Frequencies at which power transferred is half,

$$= (1)_R \pm \Delta (1)$$

$$= 2\pi (\nu_R \pm \Delta\nu)$$

Where, $\Delta(i) = \frac{R}{2L}$

$$= \frac{23}{2 \times 0.12} = 95.83 \text{ rad/s}$$

Hence, change in frequency,

$$\Delta\nu = \frac{1}{2\pi} \Delta(1)$$

$$= \frac{95.83}{2\pi} = 15.26 \text{ Hz}$$

$\therefore\ \nu R + \Delta\nu = 66348 + 15.26$

$$= 678.74 \text{ Hz}$$

And $\nu_R - \Delta\nu = 663.48 - 15.26$

$$\nu_R = 648.22 \text{ Hz}$$

Hence, at 648.22 Hz and 678.74 Hz frequencies, the power transferred is half.

At these frequencies, current amplitude can be given as:

$$I' = \frac{1}{\sqrt{2}} \times (I_0)_{max}$$

$$= \frac{14.14}{\sqrt{2}} = 10 \text{ A}$$

(D) Q-factor of the given circuit can be obtained using the relation,

$$Q = \frac{(i)_R L}{R}$$

$$= \frac{4166.67 \times 0.12}{23}$$

$$= 21.74\text{s}$$

Hence, the Q-factor of the given circuit is 21.74.

OR

(A) The statement is false for rms voltage.

The applied voltage in any alternating current circuit is equal to the average sum of the instantaneous voltages across the circuit's series components. This is not the case for *rms* voltage since voltages across distinct components may be out of phase.

(B) The capacitor is charged using a high induced voltage. In the main circuit of an induction coil, a capacitor is employed. This is due to the fact that when the circuit is disrupted, a high induced voltage is utilised to charge the capacitor in order to prevent sparks.

(C) The *dc* signal will flow across capacitor C because the impedance of an inductor (L) is insignificant for dc signals but the impedance of a capacitor (C) is quite large (almost infinite). As a result, a *dc* signal develops over C. For a high-frequency alternating current signal, L has a large impedance while C has a very low impedance. As a result, a high-frequency alternating current signal develops over L.

(D) Inserting an iron core into the choke coil (which is in series with a lamp attached to the alternating current line) causes the light to shine weakly. This is due to the choke coil and iron core increasing the circuit's resistance.

(E) When using fluorescent tubes with alternating current, a choke coil is required because it decreases the voltage across the tube without losing much power. A regular resistor cannot be used in place of a choke coil for this purpose since it loses power as heat.

33. (A) For a concave mirror, the focal length (f) is negative.

$$f < 0$$

When the object is placed on the left side of the mirror, the object distance (u) is negative.

$$u < 0$$

For image distance v, we can write the lens formula as:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} \quad \text{...(i)}$$

The object lies between f and $2f$.

$\therefore \quad 2f < u < f$

($\because$ u and f are negative)

$$\frac{1}{2f} > \frac{1}{u} > \frac{1}{f}$$

$$-\frac{1}{2f} < -\frac{1}{u} < -\frac{1}{f}$$

$$\frac{1}{f} - \frac{1}{2f} < \frac{1}{f} - \frac{1}{u} < 0 \quad \text{...(ii)}$$

Using equation (1), we get:

$$\frac{1}{2f} < \frac{1}{v} < 0$$

$\frac{1}{v}$ is negative, *i.e.*, v is negative.

$$\frac{1}{2f} < \frac{1}{v}$$

$$2f > v$$

$$-v > -2f$$

Therefore, the image lies beyond $2f$.

(B) For a convex mirror, the focal length (f) is positive.

$\therefore \quad f > 0$

When the object is placed on the left side of the mirror, the object distance (u) is negative.

$\therefore \quad u < 0$

For image distance v, we have the mirror formula:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

Using equation (2), we can conclude that:

$$\frac{1}{v} < 0$$

$$v > 0$$

Thus, the image is formed on the back side of the mirror.

Hence, a convex mirror always produces a virtual image, regardless of the object distance.

(C) For a convex mirror, the focal length (f) is positive.

$\therefore \quad f > 0$

When the object is placed on the left side of the mirror, the object distance (u) is negative,

$\therefore \quad u < 0$

For image distance v, we have the mirror formula:

$$\frac{1}{v}+\frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f}-\frac{1}{u}$$

But we have $u < 0$

$$\therefore \quad \frac{1}{v} > \frac{1}{f}$$

$$v < f$$

Hence, the image formed is diminished and is located between the focus (f) and the pole.

(D) For a concave mirror, the focal length (f) is negative.

$$f < 0$$

When the object is placed on the left side of the mirror, the object distance (u) is negative.

$$u < 0$$

It is placed between the focus (f) and the pole.

$$\therefore \quad f > u > 0$$

$$\frac{1}{f} < \frac{1}{u} < 0$$

$$\frac{1}{f}-\frac{1}{u} < 0$$

For image distance v, we have the mirror formula:

$$\frac{1}{v}+\frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f}-\frac{1}{u}$$

$$\therefore \quad \frac{1}{v} < 0$$

$$v > 0$$

The image is formed on the right side of the mirror. Hence, it is a virtual image.

For $u < 0$ and $v > 0$, we can write:

$$\frac{1}{u} > \frac{1}{v}$$

$$v > u$$

OR

(A) It is caused by an astigmatism, which is created by an uneven surface of the cornea and a varied curvature of the eye lens in various planes. A cylindrical lens can be used to fix this sort of defect.

(B) (i) Here

$$f = 5\text{cm},$$

$$v = -2.5 \text{ cm}$$

For closest point,

$$\frac{1}{f} = \frac{1}{v}-\frac{1}{u}$$

$$\frac{1}{5} = \frac{1}{-2.5}-\frac{1}{v} \text{ and}$$

Thus,

$$\frac{1}{u} = \frac{1}{5}+\frac{1}{-2.5}$$

$$-\frac{1}{u} = \frac{6}{25}$$

$$u = 4.2 \text{ cm}$$

A for farthest point,

$$f = 5 \text{ cm},$$

$$v = -\infty$$

Using,

$$\frac{1}{5} = \frac{1}{-\infty}-\frac{1}{v}$$

$$u = -5 \text{ cm}$$

(ii) Angular magnification,

$$m = \frac{D}{|v|}$$

Maximum angular magnification,

$$m = \frac{25}{4.2} = 6$$

Minimum angular magnification,

$$m = \frac{25}{5} = 5$$

SECTION - E

34. (A) Work done to move a unit charge along an equipotential surface from P to Q,

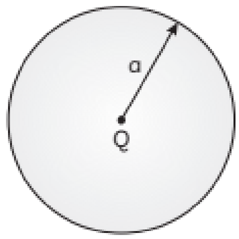
$$W = -\int_P^Q \vec{E}.\vec{dl}$$

On equipotential surface $\vec{E} \perp \vec{dl}$

$$W = -\int_P^Q E(dl) \cos 90° = 0$$

(B) The electrical potential at any point on circle of radius a due to charge Q at its center,

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a}$$



It is an equipotential surface. Hence, work done in carrying a charge q round the circle is zero.

Related Theory

Students should know that the electrostatic field varies as $\frac{1}{r^2}$, whereas the electrostatic potential varies as $\frac{1}{r}$. This requirement must be kept in mind when trying tasks, both conceptual and numerical.

(C) Let's assume contradicting statement that the potential is not same inside, the closed equipotential surface. Let the potential. just inside the surface be different to that on the surface having a potential gradient $\left(\frac{dV}{dr}\right)$.

Consequently, electric field comes into existence, which is given by,

$$E = -\frac{dV}{dr}$$

Consequently, field lines point inwards or outwards from the surface. These lines cannot be formed on the surface, as the surface is equipotential. It is possible only when the other end of the field lines are originated from the charges inside.

This contradicts the original assumption. Hence, the entire volume inside must be equipotential.

OR

If in two conductors flowing current is same then both may be considered in series. So Ohm's law becomes $V \propto R$. *i.e.*, if the resistances (which depends on ρ,1 and A) are different then potential difference will be different.

So there can be potential difference between two adjacent conductors carrying the same charge or current if either their length or area of cross-section (A) and resistivity are different.

35. (A) Voltage drop across, R

$$V_R = V_B - V_N$$
$$= 5 - 0.7 = 4.3V$$

Here, $I_{min} = 1 \times 10^{-3}$ A

$$R_{max} = \frac{V_R}{I_{min}} = \frac{4.3}{1\times10^{-3}}$$
$$= 4.3 \times 10^3\ \Omega = 4.3\ k\Omega$$

(B) $V_t = V_{bi} + V_R = 0.63 + 6 = 6.63V$

(C) Because the size of the dopant must be compatible with the semiconductor and they must form covalent bonds. The elemental dopants for silicon or germanium are usually chosen from groups XIII or XV.

Related Theory

The dopant atom's size should be comparable to that of Si or Ge. So that the symmetry of pure Si or Ge is not disrupted. And dopants can contribute charge carriers to the formation of covalent bonds between Si or Germanium atoms. Because silicon and germanium belong to the XIV group, the XIII and XV groups of the contemporary periodic table will have identical atom sizes.

OR

We can't use a voltmeter to detect the potential barrier across a p-n junction because the voltmeter's resistance must be very high in comparison to the junction resistance, which is almost infinite.