CBSE 12th 2024 Compartment Physics Set-1 (55/S/1) Solutions

SECTION A

Q.1. Two particles A and B of the same mass but having charges q and 4q respectively, are accelerated from rest through different potential differences V_A and V_B such that they attain the same kinetic energies. The value of is:
V_A/V_B

(A)1/ 4
(B)1/ 2
(c) 2
(D) 4

To solve this problem, we need to use the concept of kinetic energy and the relationship between potential difference and kinetic energy for charged particles.

Given:

- Two particles A and B with the same mass but different charges: q and $4q$, respectively.
- Both particles are accelerated from rest through different potential differences V_A and V_B, and they attain the same kinetic energy.

We need to find the ratio $\frac{V_A}{V_B}$.

Steps to Solve:

1. **Kinetic Energy of a Charged Particle:**

   The kinetic energy K of a charged particle accelerated through a potential difference V is given by:

$$K = \frac{1}{2}mv^2 = qV$$

1. **Kinetic Energy of a Charged Particle:**

   The kinetic energy K of a charged particle accelerated through a potential difference V is given by:

$$K = \frac{1}{2}mv^2 = qV$$

   where q is the charge, m is the mass, and v is the velocity of the particle.

2. **For Particle A:**

$$K_A = qV_A$$

3. **For Particle B:**

$$K_B = 4qV_B$$

4. **Since both particles have the same kinetic energy:**

$$K_A = K_B$$

   Therefore:

$$qV_A = 4qV_B$$

5. **Simplify the equation:**

$$V_A = 4V_B$$

6. **Find the ratio $\frac{V_A}{V_B}$:**

$$\frac{V_A}{V_B} = 4$$

Thus, the value of $\frac{V_A}{V_B}$ is:

(D) 4

Q.2. A coil of resistance 20 Ω and self-inductance 10 mH is connected to an ac source of frequency 1000/π Hz. The phase difference between current in the circuit and the source voltage is:

(A) 30°

(B) 60°

© 75°

(D) 45°

Solution. (D) 45°

To find the phase difference between the current in the circuit and the source voltage for an AC circuit with a coil (inductor) and a resistor, we can use the following steps:

Given:

- Resistance, $R = 20\ \Omega$
- Self-inductance, $L = 10$ mH $= 0.01$ H
- Frequency, $f = \frac{1000}{\pi}$ Hz

Steps to Solve:

1. **Calculate the Inductive Reactance (X_L):**

   The formula for inductive reactance is:

   $$X_L = 2\pi f L$$

   Substitute the given values:

   $$X_L = 2\pi \left(\frac{1000}{\pi}\right) \times 0.01$$

   $$X_L = 2 \times 1000 \times 0.01$$

   $$X_L = 20\,\Omega$$

2. **Calculate the Phase Difference (ϕ):**

   The phase difference between the current and voltage in an RL circuit is given by:

   $$\tan\phi = \frac{X_L}{R}$$

   Substitute X_L and R:

   $$\tan\phi = \frac{20}{20} = 1$$

   To find ϕ, take the inverse tangent (arctan) of 1:

   $$\phi = \tan^{-1}(1) = 45^\circ$$

Q 3. Isotones are nuclides having :

(A) same number of neutrons but different number of protons

(B) same number of protons but different number of neutrons

(C) same number of protons and also same number of neutrons

(D) different number of protons and also different number of neutrons

Solution. (A) same number of neutrons but different number of protons

Isotones are nuclides that share the same number of neutrons but have different numbers of protons.

Explanation:

- Isotones: Nuclides with the same number of neutrons but different numbers of protons. For example, 24He^4_2\text{He}24He (with 2 protons and 2 neutrons) and 36 Li^6_3\text{Li}36Li (with 3 protons and 3 neutrons) are isotones because they both have 2 neutrons.

Given this, the correct answer is:

(A) same number of neutrons but different number of protons

Q.4. A bulb is rated (100 W, 110 V). It is operated by a current of 1.0 A supplied by a step down transformer. If the input voltage and efficiency of the transformer are 220 V and 0.9 respectively, the input current drawn from the mains is:

(A) ½ A

(B) 3/8 A

© 5/9 A

(D) 4/ 7 A

Solution. (A) ½ A

To find the input current drawn from the mains, we need to follow these steps:

1. **Determine the Power Consumed by the Bulb:**
   The power rating of the bulb is given as 100 W. This is the power it consumes when operated at its rated voltage of 110 V.
2. **Calculate the Power Output of the Transformer:**
   The power consumed by the bulb (100 W) is the output power of the transformer. To find the input power of the transformer, we use the efficiency formula:

$$\text{Efficiency}(\eta) = \frac{\text{Output Power}}{\text{Input Power}}$$

   Rearranging for input power:

$$\text{Input Power} = \frac{\text{Output Power}}{\text{Efficiency}}$$

   Substituting the given values:

$$\text{Input Power} = \frac{100 \text{ W}}{0.9} \approx 111.11 \text{ W}$$

3. **Calculate the Input Current:**
   The input voltage to the transformer is 220 V. Using the formula for power:

$$\text{Power} = \text{Voltage} \times \text{Current}$$

   Rearranging for current:

$$\text{Current} = \frac{\text{Power}}{\text{Voltage}}$$

   Substituting the input power and voltage:

$$\text{Input Current} = \frac{111.11 \text{ W}}{220 \text{ V}} \approx 0.505 \text{ A}$$

   Therefore, the closest option to 0.505 A is:

   (A) ½ A

Q.5. Which of the following substances has relative magnetic permeability μ >> 1?

(A) Aluminum

(C) Nickel

(B) Copper chloride

(D) Sodium chloride

Solution. (C) Nickel, In human terms, the substance among the options with a relative magnetic permeability (μ) much greater than 1 is Nickel (C)

Nickel is a ferromagnetic material, meaning it has a high relative magnetic permeability and can be strongly magnetized. In simple terms, it's like Nickel is very good at attracting and holding onto magnetic forces.

Aluminum (A) and Copper chloride (B) are not significantly magnetic. Aluminum is paramagnetic, which means it has a small and weak magnetic response, and Copper chloride is generally not magnetic.

Sodium chloride (D), commonly known as table salt, is non-magnetic.

So, in everyday terms, if you think of Nickel as having a magnetic "superpower" compared to the others, that's a good way to understand its high relative magnetic permeability.

Q.6. Which of the following statements is correct for an alpha particle scattering experiment?

(A) For angle of scattering 0 ≈ 0, the impact parameter is small.

(B) For angle of scattering 0 = π, the impact parameter is large.

(C) The number of alpha particles undergoing head-on collision is small.

(D) The experiment provides an estimate of the upper limit to the size of the target atom.

Solution.**(D) The experiment provides an estimate of the upper limit to the size of the target atom.** In human terms, the correct statement about an alpha particle scattering experiment is (D) The experiment provides an estimate of the upper limit to the size of the target atom.

Alpha particle scattering involves firing alpha particles (which are positively charged) at a target material, usually a thin foil. By observing how these particles scatter, scientists can infer properties about the target atoms.

Statement (D) is correct because the way alpha particles scatter off atoms gives us clues about the size of the target atoms. If the alpha particles scatter at large angles, it suggests that they are encountering something substantial—this helps estimate the upper limit of the atom's size.

The other statements are not quite right:

Statement (A) is not accurate because a scattering angle of 0 degrees (straight through) would mean the impact parameter (the closest approach) is actually large, not small.

Statement (B) is incorrect because a scattering angle of π (180 degrees, or head-on) implies a very small impact parameter, indicating a close approach.

Statement (C) is misleading because, in general, the number of head-on collisions (where alpha particles come very close to the nucleus) is actually quite small compared to those at larger angles.

So, thinking of it like trying to understand how big a target is by seeing how much it affects the path of the objects hitting it Statement (D) is the right way to view the results of the experiment.

Q.7 A straight wire of length 1.0 m is placed along x-axis, in a region with magnetic field B = (31+2) T. A current of 2.0 A flows in the wire along +x direction. The magnetic force acting on the wire is : ←

(A) 2.0 N, along z-axis

(B) 2.0 N, along -z-axis

(C) 4.0 N, along z-axis

(D) 4.0 N, along -z-axis

Solution. (C) 4.0 N, along z-axis,

To find the magnetic force acting on the wire, we use the formula for the magnetic force on a current-carrying wire:

$$\mathbf{F} = I\mathbf{L} \times \mathbf{B}$$

where:

- I is the current (2.0 A)
- $\mathbf{L}$ is the length vector of the wire (1.0 m along the x-axis, so $\mathbf{L} = 1.0\hat{x}$ m)
- $\mathbf{B}$ is the magnetic field vector $\mathbf{B} = (3\hat{i} + 2\hat{j})$ T

Let's compute the cross product:

1. **Current (I):** 2.0 A
2. **Length vector ($\mathbf{L}$):** 1.0 m along x-axis, so $\mathbf{L} = 1.0\hat{x}$
3. **Magnetic field ($\mathbf{B}$):** $\mathbf{B} = 3\hat{i} + 2\hat{j}$

The cross product $\mathbf{L} \times \mathbf{B}$ can be calculated as:

The cross product $\mathbf{L} \times \mathbf{B}$ can be calculated as:

$$\mathbf{L} \times \mathbf{B} = (1.0\hat{x}) \times (3\hat{x} + 2\hat{y})$$

Since $\hat{x} \times \hat{x} = 0$ and $\hat{x} \times \hat{y} = \hat{z}$, we have:

$$(1.0\hat{x}) \times (2\hat{y}) = 1.0 \times 2\,\hat{z} = 2\hat{z}$$

Thus:

$$\mathbf{F} = I\mathbf{L} \times \mathbf{B} = 2.0 \times 2\hat{z} = 4.0\hat{z}$$

So, the magnetic force is 4.0 N in the +z direction.

Therefore, the correct answer is:

(C) 4.0 N, along z-axis

Q.8. The electric field E associated with an electromagnetic wave is represented by Ey = Eo sin (kx - wt)

Which of the following statements is correct?

(A) The wave is propagating along +x-axis.

(B) The wave is propagating along +z-axis.

(C) The magnetic field B of the wave is acting along +y-axis.

(D) The magnetic field B of the wave is acting along -x-axis.

Solution.(A) The wave is propagating along +x-axis.

To determine the correct statement, we need to analyze the given electric field and its implications for the direction of propagation and the orientation of the magnetic field in an electromagnetic wave.

The electric field is given by:

$Ey=E0\sin(kx-\omega t)$

where:

Ey indicates that the electric field oscillates in the y-direction.

$(kx-\omega t)$represents the phase of the wave, indicating its propagation direction.

Here’s how to interpret this:

1. Propagation Direction:

The argument of the sine function$(kx-\omega t)$ suggests that the wave is travelling in the positive x-direction. For a wave of the form$(kx-\omega t)$, the direction of propagation is along the x-axis.

So, (A) The wave propagating along the x-axis is correct.

2. Magnetic Field Direction: In an electromagnetic wave, the electric field, magnetic field, and the direction of propagation are mutually perpendicular to each other. The right-hand rule helps us determine the direction of the magnetic field.

Given the electric field is along the y-axis (Ey), and the wave propagates along the x-axis, the magnetic field $\mathbf{B}$ must be perpendicular to both the x and y directions. The only remaining direction for $\mathbf{B}$ is the z-axis.

Using the right-hand rule:

Point your fingers in the direction of $\mathbf{E}$ (y-direction).

Curl them in the direction of propagation (x-direction).

Your thumb will point in the direction of the magnetic field.

Thus, if $\mathbf{E}$ is along the y-axis and the wave propagates along the x-axis, the magnetic field $\mathbf{B}$ will be along the z-axis. Specifically, if you follow the right-hand rule, $\mathbf{B}$ will be in the negative z-direction.

So, none of the options stating $\mathbf{B}$ along the x-axis are correct. The correct magnetic field direction is along the z-axis, and in this context, it would be more accurate to say the field is in the negative z-direction.

Given the options, the closest correct statements are:

(A) The wave propagating along +x-axis is correct.

None of the other statements correctly describe the magnetic field direction based on the provided information.

Q.9. A point object is placed in air at a distance of 4R on the principal axis of a convex spherical surface of radius of curvature R separating two mediums, air and glass. As the object is moved towards the surface, the image formed is:

(A) always real

(B) always virtual

(C) first virtual and then real

(D) first real and then virtual

Solution.(D) first real and then virtual

To understand how the image changes as the object moves towards the convex spherical surface, let's break down the situation step by step.

1. Convex Spherical Surface:

The surface separates two media: air (on the object side) and glass (on the other side).

The convex surface has a radius of curvature (R).

2. Object Placement:

Initially, the object is placed at a distance of (4R) from the convex surface.

3.Movement of Object:

We need to determine how the image formed changes as the object moves towards the surface.

Image Formation by Convex Surface

For a convex spherical surface, we use the mirror formula:

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

Where:

(f) is the focal length.

(u) is the object distance (distance from the surface to the object, with sign convention considered).

(v) is the image distance (distance from the surface to the image, with sign convention considered).

The focal length (f) of the convex surface is related to the radius of curvature (R) by:

$$f = \frac{R}{2}$$

Sign Conventions:

For a convex surface, the focal length is positive (because it’s a converging surface).

Object distance u is positive when the object is in air and in front of the surface.

Initial Position:

When the object is at $4R$ from the convex surface:

Object distance $u = 4R$.

Substitute into the mirror formula:

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

$$\frac{2}{R} = \frac{1}{4R} + \frac{1}{v}$$

Solving this:

$$\frac{2}{R} - \frac{1}{4R} = \frac{1}{v}$$

$$\frac{8 - 1}{4R} = \frac{1}{v}$$

$$\frac{7}{4R} = \frac{1}{v}$$

$$v = \frac{4R}{7}$$

Here, the image distance (v) is positive, meaning the image is formed on the side opposite to the object (real image).

As the Object Moves Towards the Surface:

1.When the Object is Moved Closer:

The object distance (u) decreases.

As (u) decreases, solving the mirror formula shows that v also decreases.

The nature of the image will change as the object gets closer to the surface.

2.At Certain Points:

When the object is very close to the surface (closer than the focal length f, the image can become virtual.

Initially, when the object is far from the surface (at \(4R \)), the image is real and formed on the opposite side of the surface.

As the object approaches the surface, there will be a point where the image switches from real to virtual.

Therefore, the correct statement is:

(D) first real and then virtual.

Q.10. An electron makes a transition from orbit n = 2 to orbit n = 1, in Bohr's model of hydrogen atom. Consider the change in magnitudes of its kinetic energy (K) and potential energy (U).

(A) K increases and U decreases

(B) K decreases and U increases

(C) Both K and U decrease

(D) Both K and U increase

In Bohr's model of the hydrogen atom, when an electron transitions from a higher energy orbit to a lower energy orbit, there are clear changes in both its kinetic energy (K) and potential energy (U). Let's break down what happens during this transition:

Bohr's Model Basics

1. Energy Levels:

The electron in a hydrogen atom can occupy discrete energy levels, denoted by the principal quantum number (n).

Higher (n) values correspond to higher energy levels.

2. Energy Change During Transition:

When an electron moves from an orbit with a higher (n) (e.g., (n = 2) to an orbit with a lower n (e.g., $n = 1$), it releases energy in the form of electromagnetic radiation (a photon).

Kinetic and Potential Energy Changes

1. **Kinetic Energy (K):**

   - The kinetic energy of an electron in the Bohr model is given by $K = \frac{1}{2} m_e v^2$ where m_e is the electron mass and v is its velocity.

   - For an electron in a higher orbit (e.g., $n = 2$), it is farther from the nucleus and moving more slowly compared to an electron in a lower orbit (e.g., $n = 1$). The velocity increases as the electron moves to a lower orbit.

   - Therefore, as the electron transitions from $n = 2$ to $n = 1$, its kinetic energy **increases** because it is moving faster in the lower orbit.

2. **Potential Energy (U):**

   - The potential energy of the electron is given by $U = - \frac{k e^2}{r}$ where k is Coulomb's constant, e is the electron charge, and r is the radius of the orbit.

   - For the Bohr model, the radius of the orbit is smaller for lower n values, meaning the electron is closer to the nucleus in lower orbits.

   - The potential energy is negative and becomes more negative as the electron gets closer to the nucleus.

- As the electron moves from \(n = 2 \) to \(n = 1 \), it gets closer to the nucleus, so the magnitude of the potential energy increases (i.e., becomes more negative).

Summary

- **Kinetic Energy (K):** Increases because the electron moves to a lower orbit and its speed increases.

- **Potential Energy (U):** Decreases in magnitude (becomes more negative) because the electron is closer to the nucleus.

Thus, during the transition from \(n = 2 \) to \(n = 1 \):

- **Kinetic Energy increases.**

- **Potential Energy becomes more negative, which means it decreases.**

Therefore, the correct answer is:

(A) K increases and U decreases.

Q.11. Which of the following statements is not true for a p-n junction diode under reverse bias ?

(A) The current is almost independent of the applied voltage.

(B) Holes flow from p-side to n-side.

(C) Electric field in the depletion region increases.

(D) n-side of the junction is connected to +ve terminal and p-side to -ve terminal of the battery.

To identify the statement that is not true for a p-n junction diode under reverse bias, let's analyze each statement:

1.Statement (A): "The current is almost independent of the applied voltage."

True.In reverse bias, the current through the diode is very small (reverse saturation current) and remains almost constant despite increases in reverse voltage, until breakdown occurs.

2.Statement (B): "Holes flow from p-side to n-side."

Not true. In reverse bias, the flow of holes from the p-side to the n-side does not occur. Instead, the reverse bias widens the depletion region and the flow of carriers is minimal. The holes in the p-side are pulled away from the junction by the negative voltage, and the electrons in the n-side are pulled away from the junction by the positive voltage.

3. Statement (C): "Electric field in the depletion region increases."True. As reverse bias is applied, the electric field in the depletion region increases because the depletion region widens due to the increased separation of charges.

4.Statement (D): "n-side of the junction is connected to +ve terminal and p-side to -ve terminal of the battery."

True. In reverse bias, the n-side is connected to the positive terminal of the battery and the p-side to the negative terminal.

Summary

The statement that is not true for a p-n junction diode under reverse bias is:

(B) Holes flow from p-side to n-side.

Q.12. A parallel plate capacitor is charged by a battery. The battery is then disconnected and the plates of the charged capacitor are then moved farther apart. In the process:

(A) the charge on the capacitor increases.

(B) the potential difference across the plates decreases.

(C) the capacitance of the capacitor increases.

(D) the electrostatic energy stored in the capacitor increases.

Let's analyze what happens to a parallel plate capacitor when it is charged by a battery, then disconnected, and the plates are moved farther apart.

Initial Conditions:

The capacitor is initially connected to a battery, which means it gets charged to a certain voltage (V) and stores a charge (Q). The capacitance of the capacitor is (C).

The relationship between charge, capacitance, and voltage is (Q = C.V)

After Disconnection and Plate Separation:

1. Charge on the Capacitor:When the capacitor is disconnected from the battery, the charge (Q) on the capacitor plates remains constant because no charge can flow in or out of the capacitor once it is disconnected.

So, the charge on the capacitor does not change.

2.Potential Difference Across the Plates:

The capacitance (C) of a parallel plate capacitor is given by (C = \frac{\epsilon_0 A}{d} \), where \(\epsilon_0 \) is the permittivity of free space, \(A \) is the area of the plates, and \(d \) is the distance between the plates.

When the plates are moved farther apart, the distance \(d \) increases, so the capacitance \(C \) decreases.

Since the charge \(Q \) is constant and the capacitance \(C \) decreases, the potential difference \(V \) across the plates increases according to the formula \(Q = C \cdot V \).

3.Capacitance of the Capacitor:

As mentioned, the capacitance \(C \) is inversely proportional to the distance \(d) between the plates. Moving the plates farther apart increases \(d), which decreases the capacitance.

So, the capacitance decreases, not increases.

4. Electrostatic Energy Stored in the Capacitor:

The energy \(E \) stored in the capacitor is given by \(E = \frac{1}{2} \frac{Q^2}{C} \).

Since \(Q \) remains constant and \(C \) decreases, the energy \(E \) stored in the capacitor increases.

Therefore, the electrostatic energy stored in the capacitor increases.

Summary

(A) The charge on the capacitor remains constant (not true).

(B) The potential difference across the plates increases (not true).

(C) The capacitance decreases (not true).

(D) The electrostatic energy stored in the capacitor increases (true).

The correct answer is:

(D) the electrostatic energy stored in the capacitor increases.

Questions number 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given one labelled Assertion (A) and

the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.

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

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

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

Q.13. Assertion (A): The current density (J) at a point in a conducting wire is in the E direction of electric field (E) at that point. ←

Reason (R): A conducting wire obeys Ohm's law.

Solution. Let’s evaluate the given Assertion (A) and Reason (R) to determine their truthfulness and their relationship to each other.

Assertion (A):"The current density (J) at a point in a conducting wire is in the direction of the electric field (E) at that point."

True. In a conductor, current density $\mathbf{J}$ is directly related to the electric field $\mathbf{E}$ through the equation $\mathbf{J} = \sigma \mathbf{E}$, where σ is the electrical conductivity of the material. This implies that the direction of the current density $\mathbf{J}$ is the same as the direction of the electric field $\mathbf{E}$.

Reason (R):"A conducting wire obeys Ohm's law."

True. Ohm's law states that $V = IR$, which means that the current I through a conductor is proportional to the voltage V across it, with resistance R being the proportionality constant. This law applies to many conductors under steady-state conditions and in the linear region of their operation.

Relationship Between Assertion (A) and Reason (R):

The fact that a conductor obeys Ohm's law (Reason R) means that the current density $\mathbf{J}$ is proportional to the electric field $\mathbf{E}$ (i.e., $\mathbf{J} = \sigma \mathbf{E}$). Therefore, the direction of $\mathbf{J}$ is indeed in the same direction as $\mathbf{E}$ in a conductor that obeys Ohm's law.

So, the Reason (R) correctly explains why Assertion (A) is true.

Conclusion:

The correct option is:

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

Q.14. Assertion (A): The torque acting on a current carrying coil is maximum when it is suspended in a radial magnetic field.

Reason (R): The torque tends to rotate the coil on its own axis.

Let's evaluate the given Assertion (A) and Reason (R) to determine their truthfulness and relationship:

Assertion (A):The torque acting on a current-carrying coil is maximum when it is suspended in a radial magnetic field."

False. The torque τ on a current-carrying coil in a magnetic field is given by the formula:

[tau = nIBA \sin(\theta)\]

where:(n \) is the number of turns in the coil,

(I) is the current,

(B) is the magnetic field strength,

(A) is the area of the coil,

(theta) is the angle between the normal to the plane of the coil and the magnetic field. For the torque to be maximum, \(\sin(\theta) \) should be 1, which occurs when the plane of the coil is perpendicular to the magnetic field lines. In a radial magnetic field (one that points towards or away from a center point), the field lines are not uniform across the plane of the coil and do not provide the optimal orientation for maximum torque. The maximum torque is achieved in a uniform magnetic field when the plane of the coil is perpendicular to the field lines, not in a radial field.

Reason (R):

"The torque tends to rotate the coil on its own axis."

True.The torque on a current-carrying coil in a magnetic field indeed tends to rotate the coil about its axis. This rotation is due to the force exerted by the magnetic field on the current in the coil, which creates a torque that tries to align the plane of the coil with the magnetic field.

Relationship Between Assertion (A) and Reason (R):

Although Reason (R) is true and describes the effect of torque, Assertion (A) is incorrect because the torque is not maximised in a radial magnetic field. Instead, it is maximised in a uniform magnetic field when the plane of the coil is perpendicular to the field lines.

Conclusion:

The correct option is:(C) Assertion (A) is true, but Reason (R) is false.

Q.15. Assertion (A): Although the surfaces of a goggle lens are curved, it does not have any power.

Reason (R): In case of goggles, both the curved surfaces are curved on the same side and have equal radii of curvature.

Let's analyse the Assertion (A) and Reason (R) about the power of goggle lenses and their curvature.

Assertion (A):

"Although the surfaces of a goggle lens are curved, it does not have any power."

True. The power of a lens depends on its ability to converge or diverge light, which is determined by the curvature of its surfaces and the refractive index of the lens material. If the lens surfaces are curved in such a way that they are equally curved on both sides, and the lens is designed with equal radii of curvature on both sides, it essentially acts as a neutral lens or has minimal power. This means it does not significantly alter the path of light passing through it.

Reason (R):

"In the case of goggles, both the curved surfaces are curved on the same side and have equal radii of curvature."

True.In many goggles, especially those designed for protection rather than vision correction, the lenses have a symmetric curvature, meaning both surfaces are curved in the same direction (either both convex or both concave) and often have equal radii of curvature. This design minimises any optical power change introduced by the lenses, making them effectively neutral in terms of optical power.

Relationship Between Assertion (A) and Reason (R):

Assertion (A) is correct because lenses with equal and symmetric curvatures on both sides will not have significant optical power.

Reason (R) correctly explains why the goggles' lenses have no significant power: the equal curvature on both sides results in negligible optical power.

Conclusion:

The correct option is:

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

Q.16. Assertion (A): Nuclear fission reactions are responsible for energy generation in the Sun.

Reason (R): Light nuclei fuse together in the nuclear fission reactions.

Let's analyse the Assertion (A) and Reason (R) regarding nuclear reactions and energy generation in the Sun:

Assertion (A):

"Nuclear fission reactions are responsible for energy generation in the Sun."

False.The energy generation in the Sun is due to nuclear fusion, not fission. In the Sun, light nuclei, primarily hydrogen atoms, fuse together to form heavier elements, releasing a significant amount of energy in the process. This process is called nuclear fusion, and it's the primary source of the Sun's energy.

Reason (R):"Light nuclei fuse together in the nuclear fission reactions."

False. In nuclear fission, heavy atomic nuclei split into lighter nuclei, releasing energy. For example, uranium or plutonium nuclei are split into smaller nuclei. The process described in the Reason, where light nuclei fuse together, actually describes nuclear fusion, not fission.

Between Assertion (A) and Reason (R):

Both Assertion (A) and Reason (R) are incorrect. The Sun generates energy through nuclear fusion, not fission, and fusion involves light nuclei coming together, not fission.

Conclusion:

The correct option is: (D) Both Assertion (A) and Reason (R) are false.

Section B

Q.18. A long straight horizontal wire is carrying a current I. At an instant, an alpha particle at a distance r from it, is travelling with speed v parallel to the wire in a direction opposite to the current. Find the magnitude and direction of the force experienced by the particle at this instant.

Solution.

To find the magnitude and direction of the force experienced by an alpha particle moving near a long straight current-carrying wire, we need to use the concepts of the magnetic field produced by the wire and the Lorentz force acting on the moving charge. Here's a step-by-step explanation:

1. Magnetic Field Due to the Wire

A long straight wire carrying a current I generates a magnetic field around it. The magnetic field B at a distance r from the wire is given by:

$B = \frac{\mu_0 I}{2\pi r}$

where:

- μ_0 is the permeability of free space ($\mu_0 \approx 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$).

2. Lorentz Force on the Moving Particle

The alpha particle (which is positively charged) is moving with speed v parallel to the wire, but in the direction opposite to the current. The force F on a charged particle moving in a magnetic field is given by the Lorentz force law:

$$F = qvB\sin(\theta)$$

where:

- q is the charge of the alpha particle,
- v is the velocity of the particle,
- B is the magnetic field strength,
- θ is the angle between the velocity vector and the magnetic field direction.

Since the alpha particle is moving parallel to the wire and the magnetic field circles around the wire, the angle θ between the velocity vector of the particle and the magnetic field is 90° (since the magnetic field lines are perpendicular to the direction of the particle's motion). Thus, $\sin(90^\circ) = 1$.

3. Charge of the Alpha Particle

An alpha particle consists of 2 protons and 2 neutrons, so it has a charge of $2e$, where $e \approx 1.6 \times 10^{-19}$ C. Therefore:

$$q = 2e$$

4. Calculating the Force

Substitute the values into the force equation:

$$F = qvB$$

$$F = 2ev\left(\frac{\mu_0 I}{2\pi r}\right)$$

5. Direction of the Force

To determine the direction of the force, use the right-hand rule for the magnetic force on a moving charge:

- Point your thumb in the direction of the current in the wire.
- Point your fingers in the direction of the velocity of the particle.
- Your palm will face in the direction of the force experienced by a positive charge (for an alpha particle).

For an alpha particle moving in the direction opposite to the current, the force will be perpendicular to both the current direction and the direction of motion. Given the current direction and the particle's opposite motion, the force will act in a direction perpendicular to the plane formed by the current and the particle's velocity, which can be determined using the right-hand rule.

Q.19. A point light source rests on the bottom of a bucket filled with a liquid of refractive index μ = 1.25 up to height of 10 cm. Calculate :

(a) the critical angle for liquid-air interface

(b) radius of circular light patch formed on the surface by light emerging from the source.

Solution.

To solve the problem, we need to address two parts: finding the critical angle for the liquid-air interface and calculating the radius of the circular light patch formed on the surface. Let's tackle each part step-by-step.

(a) Critical Angle for the Liquid-Air Interface

The critical angle is the angle of incidence beyond which light cannot pass through the interface and is entirely reflected. For a light ray traveling from a medium with refractive index μ_1 (liquid) to a medium with refractive index μ_2 (air), the critical angle θ_c can be found using Snell's Law:

$\sin\theta_c = \frac{\mu_2}{\mu_1}$

where:

- μ_1 is the refractive index of the liquid ($\mu = 1.25$),
- μ_2 is the refractive index of air ($\mu_{air} \approx 1.00$).

Substitute these values into the equation:

$\sin\theta_c = \frac{1.00}{1.25} = 0.80$

Now, find θ_c by taking the inverse sine:

$\theta_c = \sin^{-1}(0.80) \approx 53.13^\circ$

(b) Radius of the Circular Light Patch

To find the radius of the circular light patch formed on the surface of the liquid, we need to understand that this patch is formed by light emerging from the source at the critical angle. The circle of light on the surface is determined by the light rays that are just grazing the critical angle at the surface of the liquid.

Let's denote:

- The height of the liquid in the bucket as $h = 10\,\text{cm}$,
- The radius of the circular patch as R,
- The critical angle as θ_c.

In the right-angled triangle formed by the height of the liquid, the radius of the circular patch, and the line of sight from the source to the edge of the patch, we have:

$\tan\theta_c = \frac{R}{h}$

Rearrange to solve for R:

$R = h \cdot \tan\theta_c$

We have already found $\theta_c \approx 53.13^\circ$, so:

$R = 10\,\text{cm} \cdot \tan(53.13^\circ) \approx 10\,\text{cm} \cdot 1.33 \approx 13.3\,\text{cm}$

Q.20. State Huygens principle. Using it draw a diagram showing the details of passage of a plane wave from a denser into a rarer medium.

Huygens' Principle states that:

"Every point on a wavefront can be considered as a source of secondary wavelets. The new wavefront at any later time is the envelope of these secondary wavelets."

This principle helps in understanding how wavefronts propagate and how waves change direction when they encounter different media.

Application of Huygens' Principle:

To illustrate the passage of a plane wave from a denser medium to a rarer medium, let's break down the process:

1. Plane Wavefront in Denser Medium:
    - Imagine a plane wavefront traveling in a denser medium (e.g., water).
2. Wavefront at the Boundary:
    - When the wavefront reaches the boundary between the denser medium (e.g., water) and the rarer medium (e.g., air), each point on the wavefront in the denser medium acts as a new source of secondary wavelets.
3. Formation of New Wavefront:
    - These secondary wavelets spread out in the rarer medium. The new wavefront in the rarer medium is the envelope of these secondary wavelets.
4. Refraction and Change in Direction:
    - The wave changes direction as it passes from the denser to the rarer medium due to a change in speed, according to Snell's Law.

Q.21.(a) A cell is connected across an external resistance 12 Ω and supplies 0.25 A current. When the external resistance is increased by

4 Ω, the current reduces to 0.2 A. Calculate (i) the emf, and (ii) the internal resistance, of the cell.

To find the electromotive force (emf) and the internal resistance of the cell, we can use the given information about how the current changes with different external resistances. Here's how to approach the problem:

Given Data:

1. When the external resistance $R_1 = 12\,\Omega$, the current $I_1 = 0.25\,\text{A}$.
2. When the external resistance is increased by $4\,\Omega$, i.e., $R_2 = 12\,\Omega + 4\,\Omega = 16\,\Omega$, the current $I_2 = 0.2\,\text{A}$.

Step-by-Step Solution:

1. Find the emf (E) and internal resistance (r) of the cell:

Ohm's Law and Kirchoff's Law:

For a cell with emf E and internal resistance r, the current I through an external resistance R is given by:

$I = \frac{E}{R+r}$

We can write two equations based on the given data:

- For $R_1 = 12\,\Omega$ and $I_1 = 0.25\,\text{A}$:

$$0.25 = \frac{E}{12 + r} \quad (1)$$

- For $R_2 = 16\,\Omega$ and $I_2 = 0.2\,\text{A}$:

$$0.2 = \frac{E}{16 + r} \quad (2)$$

Solving these equations:

From Equation (1):

$$E = 0.25 \times (12 + r)$$

From Equation (2):

$$E = 0.2 \times (16 + r)$$

Set the two expressions for E equal to each other:

$$0.25 \times (12 + r) = 0.2 \times (16 + r)$$

Expanding and solving for r:

$$3 + 0.25r = 3.2 + 0.2r$$

Rearrange to solve for r:

$$0.25r - 0.2r = 3.2 - 3$$

$$0.05r = 0.2$$

$$r = \frac{0.2}{0.05} = 4\,\Omega$$

Calculate the emf (E):

Substitute $r = 4\,\Omega$ back into either Equation (1) or (2). Using Equation (1):

$$0.25 = \frac{E}{12 + 4}$$

$$0.25 = \frac{E}{16}$$

$$E = 0.25 \times 16 = 4\,\text{V}$$

OR

(b) Two point charges of 3 μC and 4 μC are kept in air at (0-3 m, 0) and (0, 0.3 m) in x-y plane. Find the magnitude and direction of the net electric field produced at the origin (0, 0).

To find the magnitude and direction of the net electric field at the origin (0, 0) due to two point charges located in the x-y plane, follow these steps:

Given Data:

- Charge $Q_1 = 3\,\mu\text{C}$ located at $(0, -0.3\,\text{m})$.
- Charge $Q_2 = 4\,\mu\text{C}$ located at $(0, 0.3\,\text{m})$.

Calculate the Electric Field Due to Each Charge:

The electric field E due to a point charge Q at a distance r from the charge is given by:

$E = \frac{k \cdot Q}{r^2}$

where:

- k is Coulomb's constant ($k \approx 8.99 \times 10^9\,\text{N} \cdot \text{m}^2/\text{C}^2$),
- Q is the charge,
- r is the distance from the charge to the point where the electric field is being calculated.

1. Electric Field Due to Charge Q_1:

- **Position of Q_1:** $(0, -0.3\,\text{m})$
- **Distance from origin:** $r_1 = 0.3\,\text{m}$

The electric field E_1 due to Q_1 at the origin is:

$$E_1 = \frac{k \cdot Q_1}{r_1^2} = \frac{8.99 \times 10^9 \times 3 \times 10^{-6}}{(0.3)^2}$$

$$E_1 = \frac{8.99 \times 10^9 \times 3 \times 10^{-6}}{0.09}$$

$$E_1 \approx \frac{2.697 \times 10^4}{0.09}$$

$$E_1 \approx 2.997 \times 10^5\,\text{N/C}$$

Direction of E_1:

- Since Q_1 is positive and located below the origin, the electric field vector E_1 points upward along the y-axis (toward the origin).

2. Electric Field Due to Charge Q_2:

- **Position of Q_2:** $(0, 0.3\,\text{m})$
- **Distance from origin:** $r_2 = 0.3\,\text{m}$

The electric field E_2 due to Q_2 at the origin is:

$$E_2 = \frac{k \cdot Q_2}{r_2^2} = \frac{8.99 \times 10^9 \times 4 \times 10^{-6}}{(0.3)^2}$$

$$E_2 = \frac{8.99 \times 10^9 \times 4 \times 10^{-6}}{0.09}$$

Direction of E_2:

- Since Q_2 is positive and located above the origin, the electric field vector E_2 points downward along the y-axis (toward the origin).

Net Electric Field at the Origin:

The electric fields E_1 and E_2 are in opposite directions along the y-axis:

$$E_{net} = E_2 - E_1$$

$$E_{net} = 3.995 \times 10^5\,\text{N/C} - 2.997 \times 10^5\,\text{N/C}$$

$$E_{net} \approx 1.998 \times 10^5\,\text{N/C}$$

Direction of Net Electric Field:

- Since E_2 (downward) is larger than E_1 (upward), the net electric field points downward along the y-axis.