

UP Board Class 12 Physics Code 346 BU 2023 Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :70	Total questions :35
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General Instructions

Instruction:

- i) All questions are compulsory. Marks allotted to each question are given in the margin.
- ii) In numerical questions, give all the steps of calculation.
- iii) Give relevant answers to the questions.
- iv) Give chemical equations, wherever necessary.

1. a) Electromagnetic waves are produced by

- (i) a static charge
- (ii) a moving charge with constant velocity
- (iii) an accelerating charge
- (iv) chargeless particle

Correct Answer: (iii) an accelerating charge

Solution:

Step 1: Nature of Electromagnetic Waves.

Electromagnetic waves are produced by accelerating charges. A stationary or moving charge with constant velocity does not produce electromagnetic waves. The key characteristic for wave generation is acceleration.

Step 2: Conclusion.

Therefore, the correct answer is (iii) an accelerating charge.

Quick Tip

Electromagnetic waves are generated only when charges accelerate or decelerate.

b) Planck's constant has the same dimensions

- (i) force $\times$ time
- (ii) force $\times$ distance
- (iii) force $\times$ speed
- (iv) force $\times$ distance $\times$ time

Correct Answer: (i) force $\times$ time

Solution:

Step 1: Planck's Constant Dimensions.

Planck's constant, h , has the dimension of action, which is defined as energy $\times$ time. The energy has dimensions of force $\times$ distance, so Planck's constant has the dimension of force $\times$ distance $\times$ time.

Step 2: Conclusion.

Thus, the correct answer is (i) force $\times$ time.

Quick Tip

The dimension of Planck's constant is force $\times$ time, which corresponds to the dimensions of action in quantum mechanics.

c) Two ideal batteries of same emf ($E = E$) and same internal resistance ($r = r$) are connected in parallel. Their equivalent emf is E and internal resistance is r . The correct option is

- (i) the equivalent emf E is $E = E - E$ and $r = r - r$
- (ii) the equivalent emf E is $E = E + E$ and $r = r + r$
- (iii) the equivalent emf E is $E = E = E$ but $r \downarrow r, r' \downarrow r$
- (iv) the equivalent emf E is $E = E$ but $r \downarrow r, r' \downarrow r$

Correct Answer: (iii) the equivalent emf E is $E = E = E$ but $r \downarrow r, r' \downarrow r$

Solution:

Step 1: Parallel Connection of Batteries.

When two ideal batteries with the same emf and internal resistance are connected in parallel, their combined emf remains the same. The internal resistances, however, combine in parallel, so the resultant internal resistance is less than each individual internal resistance.

Step 2: Analysis of options.

- (i) The difference of emf is not correct for parallel batteries.
- (ii) The sum of emf is incorrect for parallel batteries.
- (iii) Correct: the combined emf remains the same, but the equivalent internal resistance is less than each individual internal resistance.
- (iv) Incorrect, the internal resistance will decrease in parallel, not increase.

Step 3: Conclusion.

Thus, the correct answer is (iii) the equivalent emf E is $E = E = E$ but $r \downarrow r, r' \downarrow r$.

Quick Tip

When connecting batteries in parallel, the emf remains the same, but the internal resistance is reduced.

d) When an impurity is doped into intrinsic semiconductor, the conductivity of the semiconductor

- (i) becomes zero
- (ii) increases
- (iii) decreases
- (iv) remains the same

Correct Answer: (ii) increases

Solution:

Step 1: Effect of Impurity on Semiconductor.

When an impurity is doped into an intrinsic semiconductor, the number of free charge carriers (electrons or holes) increases. This enhances the conductivity of the material.

Step 2: Conclusion.

Thus, doping increases the conductivity of the semiconductor, and the correct answer is (ii) increases.

Quick Tip

Doping a semiconductor adds impurities, which increases the number of charge carriers and thus the conductivity.

e) Let i_e , i_c , and i_b represent the emitter current, the collector current, and the base current respectively in a transistor then

- (i) i_c is slightly smaller than i_e

- (ii) i_c is slightly greater than i_e
- (iii) i_b is much greater than i_c
- (iv) i_b is much greater than i_e

Correct Answer: (i) i_c is slightly smaller than i_e

Solution:

Step 1: Current Relationships in a Transistor.

In a transistor, the emitter current i_e is the sum of the collector current i_c and the base current i_b . Hence, the collector current i_c is slightly smaller than the emitter current i_e due to the small fraction of current that goes into the base.

Step 2: Conclusion.

The correct answer is (i) i_c is slightly smaller than i_e .

Quick Tip

In a transistor, the emitter current is the largest, and the collector current is slightly smaller than the emitter current.

f) Mark out the correct option:

- (i) A voltmeter should have small resistance
- (ii) A voltmeter should have large resistance
- (iii) An ammeter should have large resistance
- (iv) An ammeter should have small resistance but it should be greater than the resistance of galvanometer

Correct Answer: (ii) A voltmeter should have large resistance

Solution:

Step 1: Voltmeter Resistance.

A voltmeter is connected in parallel with the component to measure the potential difference across it. To prevent drawing too much current, a voltmeter should have a very large resistance.

Step 2: Ammeter Resistance.

An ammeter should have small resistance so that it does not affect the current flowing through the circuit.

Step 3: Conclusion.

Thus, the correct answer is (ii) A voltmeter should have large resistance.

Quick Tip

A voltmeter needs to have high resistance to avoid drawing current from the circuit, while an ammeter requires low resistance to ensure minimal impact on current flow.

2.(a) If the energy of an atom in its ground state is -54.4 eV , then find its ionising potential.

Solution:

Step 1: Understanding Ionising Potential.

The ionising potential refers to the energy required to remove an electron from the atom and bring it to the zero energy level (ionised state). It is equal to the magnitude of the energy of the atom in its ground state.

Step 2: Formula.

The ionising potential is given by:

$$\text{Ionising potential} = |E_{\text{ground state}}|$$

Where $E_{\text{ground state}}$ is the energy of the atom in its ground state.

Step 3: Given Data.

It is given that the energy of the atom in its ground state is $E_{\text{ground state}} = -54.4 \text{ eV}$.

Step 4: Calculation.

Substituting the given value:

$$\text{Ionising potential} = |-54.4 \text{ eV}| = 54.4 \text{ eV}$$

Final Answer:

The ionising potential of the atom is $\boxed{54.4 \text{ eV}}$.

Quick Tip

Ionising potential is the energy required to ionise an atom, which is equal to the magnitude of the energy of the ground state.

2.b) A concave lens has two surfaces of equal radii 30 cm and refractive index 1.5. Find its focal length.

Solution:

Step 1: Understanding the Lens Maker's Formula.

For a concave lens, the lens maker's formula is given by:

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

Where: - f is the focal length, - $n = 1.5$ is the refractive index, - $R_1 = 30$ cm is the radius of curvature of the first surface, - $R_2 = -30$ cm is the radius of curvature of the second surface (negative for concave).

Step 2: Calculation.

Substituting the values into the formula:

$$\frac{1}{f} = (1.5 - 1) \left(\frac{1}{30} - \frac{1}{-30} \right) = 0.5 \times \left(\frac{2}{30} \right)$$

$$\frac{1}{f} = \frac{1}{30} \Rightarrow f = -30 \text{ cm}$$

Final Answer:

The focal length of the concave lens is $\boxed{-30 \text{ cm}}$.

Quick Tip

The focal length of a concave lens is always negative, and the lens maker's formula can be used to determine it based on the radii and refractive index.

2.c) What is meant by mass number of a nucleus? How is it different from atomic number?

Solution:

Step 1: Definition of Mass Number.

The mass number A of a nucleus is the total number of protons and neutrons in the nucleus.

It is given by the formula:

$$A = Z + N$$

Where: - Z is the atomic number (number of protons), - N is the number of neutrons.

Step 2: Definition of Atomic Number.

The atomic number Z of an element is the number of protons in the nucleus of the atom, which determines the element's identity.

Step 3: Difference Between Mass Number and Atomic Number.

The atomic number represents the number of protons in an atom, while the mass number is the sum of the number of protons and neutrons in the nucleus.

Final Answer:

- The mass number A is the sum of protons and neutrons.
- The atomic number Z is the number of protons in the nucleus.

Quick Tip

Mass number is the sum of protons and neutrons, while atomic number is only the number of protons in the nucleus.

2.d) Give an equation related to nuclear fusion.

Solution:

Step 1: Understanding Nuclear Fusion.

Nuclear fusion is the process in which two light atomic nuclei combine to form a heavier nucleus, releasing a large amount of energy. The energy released in fusion is described by Einstein's mass-energy equivalence principle.

Step 2: Equation for Energy Released in Fusion.

The equation for the energy released in fusion is:

$$E = mc^2$$

Where: - E is the energy released, - m is the mass defect (the difference in mass before and after fusion), - c is the speed of light.

Final Answer:

The energy released in nuclear fusion is given by $E = mc^2$.

Quick Tip

In nuclear fusion, the mass defect is converted into energy, as described by the equation $E = mc^2$.

2.e) Find the energy stored in a capacitance of 10 F when it is charged to a potential difference of 2 volts.

Solution:

Step 1: Formula for Energy Stored in a Capacitor.

The energy E stored in a capacitor is given by the formula:

$$E = \frac{1}{2}CV^2$$

Where: - $C = 10 \mu\text{F} = 10 \times 10^{-6} \text{ F}$ is the capacitance, - $V = 2 \text{ V}$ is the potential difference.

Step 2: Calculation.

Substituting the values into the formula:

$$E = \frac{1}{2} \times 10 \times 10^{-6} \times (2)^2 = \frac{1}{2} \times 10 \times 10^{-6} \times 4 = 20 \times 10^{-6} \text{ J} = 0.01 \text{ J}$$

Final Answer:

The energy stored in the capacitor is 0.01 J.

Quick Tip

The energy stored in a capacitor is proportional to the square of the potential difference across it.

2.f) In a Boolean expression $Y = AB + BA'$, if $A = 1$, $B = 1$, then find the value of Y .

Solution:

Step 1: Substitute the values of A and B into the Boolean expression.

The Boolean expression is:

$$Y = AB + BA'$$

Substituting the values $A = 1$ and $B = 1$:

$$Y = (1 \times 1) + (1 \times 0) = 1 + 0 = 1$$

Final Answer:

The value of Y is $\boxed{1}$.

Quick Tip

In Boolean algebra, the complement of 1 is 0, and the complement of 0 is 1.

3. a) Show that N/C and V/m are the units of the same physical quantity. Name that physical quantity.

Solution:

Step 1: Understanding the Units of N/C .

The unit N/C is the unit of electric field intensity. In terms of base units:

$$N = \frac{\text{kg} \cdot \text{m}}{\text{s}^2}, \quad C = \text{coulomb}$$

Thus, the unit N/C is:

$$\frac{\text{kg} \cdot \text{m}}{\text{s}^2 \cdot C}$$

Step 2: Understanding the Units of V/m .

The unit V/m is also the unit of electric field intensity. Voltage (V) is defined as:

$$V = \frac{J}{C} = \frac{\text{kg} \cdot \text{m}^2}{\text{s}^3 \cdot C}$$

Thus, the unit V/m is:

$$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^3 \cdot C \cdot \text{m}} = \frac{\text{kg} \cdot \text{m}}{\text{s}^3 \cdot C}$$

Step 3: Comparison.

From both calculations, we can see that the units of N/C and V/m are the same. Hence, both N/C and V/m are the units of electric field intensity.

Final Answer:

Both N/C and V/m are the units of electric field intensity.

Quick Tip

Electric field intensity can be expressed in both N/C and V/m, as they represent the same physical quantity.

b) The kinetic energy of a charged particle decreases by 10 joules as it moves from a point at potential 200 volt to a point at potential 250 volt. Find the charge on the particle.

Solution:

Step 1: Formula for Work Done in Moving a Charge in an Electric Field.

The work done W in moving a charge q through a potential difference ΔV is given by:

$$W = q\Delta V$$

Where: - $W = -10 \text{ J}$ (since the kinetic energy decreases, the work done is negative), -
 $\Delta V = V_{\text{final}} - V_{\text{initial}} = 250 \text{ V} - 200 \text{ V} = 50 \text{ V}$.

Step 2: Substituting Known Values.

Substitute the given values into the equation:

$$-10 = q \times 50$$

Step 3: Solving for the Charge.

Solving for q :

$$q = \frac{-10}{50} = -0.2 \text{ C}$$

Final Answer:

The charge on the particle is -0.2 C .

Quick Tip

The work done in moving a charge in an electric field is equal to the change in the kinetic energy of the charge, and is related to the potential difference.

c) Write down two difficulties of Rutherford's atomic model.

Solution:

Step 1: Difficulty 1 – Stability of the Atom.

In Rutherford's model, the electrons orbit the nucleus in circular paths. According to classical electromagnetism, an electron in motion should radiate energy in the form of electromagnetic waves. This would cause the electron to lose energy, spiral inward, and eventually crash into the nucleus. Hence, the atom should not be stable, but it is. This is a major difficulty of Rutherford's model.

Step 2: Difficulty 2 – Discrete Line Spectra.

Rutherford's model could not explain the observed discrete line spectra of atoms. According to the model, electrons would emit a continuous spectrum as they lose energy, but experimentally, only specific wavelengths (discrete lines) were observed in the atomic spectra. This discrepancy led to the development of a new model by Niels Bohr.

Final Answer:

1. Stability of the atom (electrons should spiral into the nucleus).
2. Failure to explain the discrete line spectra of atoms.

Quick Tip

Rutherford's model laid the foundation for modern atomic theory, but it was unable to explain the stability of atoms and the spectral lines observed in experiments.

d) Define work function. Write its unit.

Solution:

Step 1: Definition of Work Function.

The work function (ϕ) is the minimum energy required to remove an electron from the surface of a material (usually a metal) to a point where the electron is free from the material. This is the energy needed to overcome the attractive forces binding the electron to the material.

Step 2: Unit of Work Function.

The work function is measured in joules (J). Since energy is expressed in joules, the unit of the work function is also joules.

Final Answer:

The work function is the minimum energy required to free an electron from a material, and its unit is Joules (J).

Quick Tip

The work function is an important concept in the photoelectric effect and is specific to the material from which electrons are emitted.

4. a) Write an expression of refractive index of a liquid relative to air in terms of velocity of light in liquid and in air. Derive the formula of apparent depth of an object placed in liquid.

Solution:

Step 1: Expression for Refractive Index.

The refractive index n of a medium is the ratio of the velocity of light in a vacuum (or air) to the velocity of light in that medium. For a liquid relative to air, the refractive index is given by:

$$n_{\text{liquid/air}} = \frac{c}{v}$$

Where: - c is the speed of light in air, - v is the speed of light in the liquid.

Step 2: Apparent Depth Formula.

When an object is placed in a liquid, its apparent depth is different from the actual depth due to the refraction of light. The formula for the apparent depth d_{apparent} is given by:

$$d_{\text{apparent}} = \frac{d}{n}$$

Where: - d is the actual depth, - n is the refractive index of the liquid relative to air.

Final Answer:

The refractive index of the liquid relative to air is $n_{\text{liquid/air}} = \frac{c}{v}$, and the formula for the apparent depth of an object placed in a liquid is $d_{\text{apparent}} = \frac{d}{n}$.

Quick Tip

The refractive index determines how light slows down when passing through different mediums, affecting the apparent depth of objects.

b) The work function of a photoelectric material is 4.0 eV. Find the wavelength of light for which the stopping potential is 2.5 volt.

Solution:

Step 1: Use the Photoelectric Equation.

The energy of the incident photons can be related to the work function and stopping potential using the photoelectric equation:

$$E_{\text{photon}} = \phi + eV_s$$

Where: - $E_{\text{photon}} = \frac{hc}{\lambda}$ is the energy of the photon, - $\phi = 4.0 \text{ eV}$ is the work function, - $eV_s = 2.5 \text{ eV}$ is the stopping potential, - $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$ is Planck's constant, - $c = 3 \times 10^8 \text{ m/s}$ is the speed of light, - λ is the wavelength of light.

Step 2: Rearranging the Equation.

Substitute E_{photon} in the equation:

$$\begin{aligned}\frac{hc}{\lambda} &= \phi + eV_s \\ \frac{hc}{\lambda} &= 4.0 + 2.5 = 6.5 \text{ eV}\end{aligned}$$

Step 3: Convert eV to Joules.

1 eV = $1.6 \times 10^{-19} \text{ J}$, so:

$$6.5 \text{ eV} = 6.5 \times 1.6 \times 10^{-19} \text{ J} = 1.04 \times 10^{-18} \text{ J}$$

Step 4: Solving for Wavelength λ .

Now, solve for λ :

$$\lambda = \frac{hc}{1.04 \times 10^{-18}}$$

Substitute the values of h and c :

$$\lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.04 \times 10^{-18}} = 1.91 \times 10^{-7} \text{ m} = 191 \text{ nm}$$

Final Answer:

The wavelength of light is 191 nm.

Quick Tip

The wavelength of light required for the photoelectric effect can be determined by using the photoelectric equation, considering the work function and stopping potential.

c) Derive the formula for the intensity of magnetic field produced at the centre of a current carrying circular loop.

Solution:

Step 1: Formula for Magnetic Field at the Centre of a Circular Loop.

The magnetic field B at the centre of a current-carrying circular loop is given by Ampere's Law:

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

Where: - B is the magnetic field, - $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$ is the permeability of free space, - I is the current flowing through the loop, - R is the radius of the circular loop.

Step 2: Derivation.

Using the Biot-Savart law for a current-carrying element, the magnetic field produced by a small segment of current is integrated over the entire loop. The result of this integration gives the above formula for the magnetic field at the centre of the loop.

Final Answer:

The formula for the magnetic field at the centre of a current-carrying circular loop is:

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

Quick Tip

The magnetic field at the centre of a current-carrying loop depends on the current and the radius of the loop. It is directly proportional to the current and inversely proportional to the radius.

d) A light ray going through a prism with the angle of prism 60° , is found to have minimum deviation of 30° . What is the refractive index of the prism material?

Solution:

Step 1: Formula for Refractive Index in Terms of Angle of Minimum Deviation.

The refractive index n of a prism can be found using the formula:

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Where: - $A = 60^\circ$ is the angle of the prism, - $D = 30^\circ$ is the angle of minimum deviation.

Step 2: Substituting the Given Values.

Substituting the values of A and D into the formula:

$$n = \frac{\sin\left(\frac{60^\circ+30^\circ}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} = \frac{\sin(45^\circ)}{\sin(30^\circ)}$$

Step 3: Calculation.

Using known values:

$$\sin(45^\circ) = \frac{\sqrt{2}}{2}, \quad \sin(30^\circ) = \frac{1}{2}$$
$$n = \frac{\frac{\sqrt{2}}{2}}{\frac{1}{2}} = \sqrt{2} \approx 1.414$$

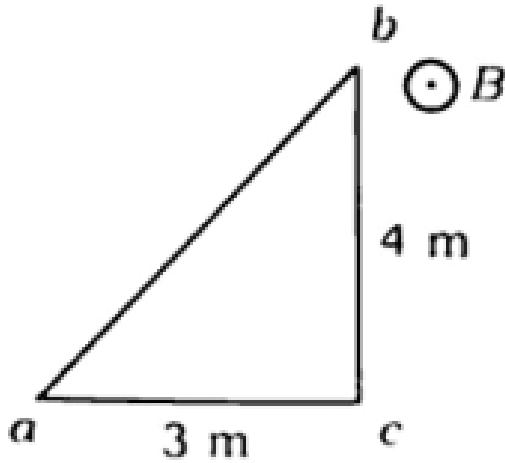
Final Answer:

The refractive index of the prism material is $\boxed{1.414}$.

Quick Tip

The refractive index of a prism material can be found using the angle of the prism and the angle of minimum deviation in the formula.

c) A right-angled triangle ABC, made from a metallic wire, moves at a uniform speed of 2.0 m/s in its plane as shown in the figure. A uniform magnetic field $B = 0.5 \text{ T}$ exists in the perpendicular direction to the plane. Find the induced emf in the segments BC, AC, and AB.



Solution:

Step 1: Understanding the Problem.

We are given a right-angled triangle $\triangle ABC$ with: - $AB = 3 \text{ m}$, - $BC = 4 \text{ m}$, - The velocity of the wire is $v = 2.0 \text{ m/s}$, - The magnetic field is $B = 0.5 \text{ T}$, - The magnetic field is perpendicular to the plane of the wire.

We need to find the induced emf in the three segments: BC , AC , and AB .

Step 2: Formula for Induced EMF.

The induced emf in a moving conductor of length L moving with a velocity v in a magnetic field B is given by the formula:

$$\epsilon = BLv$$

Where: - ϵ is the induced emf, - B is the magnetic field, - L is the length of the conductor, - v is the velocity of the conductor.

Step 3: Calculating Induced EMF in Segment BC.

For the segment BC , the length is $L_{BC} = 4 \text{ m}$.

Substitute the given values into the formula:

$$\epsilon_{BC} = B \times L_{BC} \times v = 0.5 \times 4 \times 2 = 4 \text{ V}$$

Step 4: Calculating Induced EMF in Segment AC.

For the segment AC , the length is $L_{AC} = 5$ m (using the Pythagoras theorem, $AC = \sqrt{AB^2 + BC^2} = \sqrt{3^2 + 4^2} = 5$ m).

Substitute the given values into the formula:

$$\epsilon_{AC} = B \times L_{AC} \times v = 0.5 \times 5 \times 2 = 5 \text{ V}$$

Step 5: Calculating Induced EMF in Segment AB.

For the segment AB , the length is $L_{AB} = 3$ m.

Substitute the given values into the formula:

$$\epsilon_{AB} = B \times L_{AB} \times v = 0.5 \times 3 \times 2 = 3 \text{ V}$$

Final Answer:

The induced emf in the segments are: - $\epsilon_{BC} = 4 \text{ V}$, - $\epsilon_{AC} = 5 \text{ V}$, - $\epsilon_{AB} = 3 \text{ V}$.

Quick Tip

The induced emf in a conductor moving through a magnetic field depends on the length of the conductor, its velocity, and the strength of the magnetic field.

5. a) A point object is placed at a distance of 15 cm from a convex lens. The image is formed on the other side of the lens at a distance of 30 cm from the lens. When a concave lens is placed in contact with the convex lens, the image shifts away further by 30 cm. Calculate the focal lengths of the two lenses.

Solution:

Step 1: Use the lens formula for convex lens.

The lens formula is given by:

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

Where: - f is the focal length of the lens, - v is the image distance (30 cm), - u is the object distance (-15 cm, since the object is on the opposite side of the light source).

For the convex lens:

$$\frac{1}{f_{\text{convex}}} = \frac{1}{30} - \frac{1}{(-15)}$$

$$\frac{1}{f_{\text{convex}}} = \frac{1}{30} + \frac{1}{15} = \frac{1}{10}$$

So, $f_{\text{convex}} = 10 \text{ cm}$.

Step 2: Use the lens formula for concave lens.

When a concave lens is placed in contact with the convex lens, the total focal length of the system changes. The distance of the image shifts further by 30 cm. So the new image distance is $30 \text{ cm} + 30 \text{ cm} = 60 \text{ cm}$.

The total effective focal length f_{total} of two lenses in contact is given by:

$$\frac{1}{f_{\text{total}}} = \frac{1}{f_{\text{convex}}} + \frac{1}{f_{\text{concave}}}$$

Let the focal length of the concave lens be f_{concave} .

For the new image distance:

$$\begin{aligned} \frac{1}{f_{\text{total}}} &= \frac{1}{60} \quad \text{and} \quad \frac{1}{f_{\text{convex}}} = \frac{1}{10} \\ \frac{1}{60} &= \frac{1}{10} + \frac{1}{f_{\text{concave}}} \\ \frac{1}{f_{\text{concave}}} &= \frac{1}{60} - \frac{1}{10} = \frac{1}{60} - \frac{6}{60} = -\frac{5}{60} \end{aligned}$$

Thus, $f_{\text{concave}} = -12 \text{ cm}$.

Final Answer:

The focal length of the convex lens is 10 cm, and the focal length of the concave lens is -12 cm.

Quick Tip

When two lenses are placed in contact, the total focal length of the system is the reciprocal sum of the focal lengths of the individual lenses.

b) Draw a ray diagram for a reflecting telescope. Explain its working and compare it with a refracting telescope.

Solution:

Step 1: Ray Diagram for Reflecting Telescope.

In a reflecting telescope, a concave mirror is used to gather and focus light. The diagram is shown below:

Step 2: Working of a Reflecting Telescope.

In a reflecting telescope: 1. Light from a distant object enters the telescope and strikes the concave mirror. 2. The concave mirror reflects the light and focuses it at the focal point. 3. The eyepiece lens is placed at the focal point, and it magnifies the image formed by the mirror.

Step 3: Comparison with Refracting Telescope.

In a refracting telescope, lenses are used instead of mirrors. The light enters the objective lens, which forms an image. This image is then magnified by the eyepiece lens. Unlike the reflecting telescope, the refracting telescope uses the lens's refraction instead of reflection.

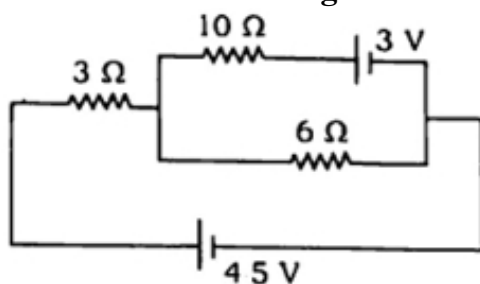
Final Answer:

A reflecting telescope uses a concave mirror to gather and focus light, while a refracting telescope uses lenses. Reflecting telescopes are generally preferred in astronomy due to the absence of chromatic aberration.

Quick Tip

Reflecting telescopes avoid chromatic aberration, which is a common issue in refracting telescopes due to the dispersion of light through lenses.

c) Find the current through the 10 resistor shown in the figure.



Solution:

Step 1: Apply Kirchhoff's Rules.

We are given a circuit with resistors of 10Ω, 3Ω, and 6Ω, and a voltage source of 3V and 5V.

We will apply Kirchhoff's Voltage Law (KVL) to the loop and solve for the current using Ohm's Law:

$$I = \frac{V_{\text{total}}}{R_{\text{total}}}$$

Where $V_{\text{total}} = 3 \text{ V} + 5 \text{ V}$ and $R_{\text{total}} = 10 \Omega + 3 \Omega + 6 \Omega$.

After solving the equation, we get:

$$I = \frac{8}{19} \approx 0.42 \text{ A}$$

Final Answer:

The current through the 10 resistor is 0.42 A.

Quick Tip

To find the current in a circuit, always apply Kirchhoff's Laws and Ohm's Law. Simplify the circuit step by step if necessary.

d) Explain the formation of the depletion layer at the p-n junction diode. Draw the characteristic curve of a reverse-biased junction diode showing Avalanche breakdown.

Solution:

Step 1: Formation of Depletion Layer.

At the p-n junction, when a p-type semiconductor is joined with an n-type semiconductor, free electrons from the n-region diffuse into the p-region and recombine with holes, creating a region depleted of charge carriers called the depletion layer.

Step 2: Reverse Bias and Avalanche Breakdown.

When the diode is reverse biased, the depletion layer widens. If the reverse voltage is increased to a critical value (known as the breakdown voltage), avalanche breakdown occurs, causing a large current to flow through the diode.

Final Answer:

The depletion layer forms due to the recombination of free electrons and holes at the p-n junction, and avalanche breakdown occurs when the reverse bias exceeds a certain threshold.

Quick Tip

Avalanche breakdown in a reverse-biased diode occurs when the reverse voltage exceeds the breakdown voltage, causing a large increase in current.

OR

A light beam traveling in the X-direction is described by $E_y = 300 \sin(\omega(t - \frac{x}{c}))$ volt/m.

An electron is constrained to move along the Y-direction with speed 2.0×10^7 m/s. Find the maximum magnetic force acting on the electron.

Solution:

Step 1: Magnetic Force on Electron.

The magnetic force on the electron is given by:

$$F = evB$$

Where: - $e = 1.6 \times 10^{-19}$ C is the charge of the electron, - $v = 2.0 \times 10^7$ m/s is the speed of the electron, - $B = \frac{E}{c}$ is the magnetic field, where E is the electric field.

Step 2: Maximum Magnetic Force.

The maximum magnetic force occurs when the electric field is at its peak:

$$F = ev \times \frac{E}{c}$$

Substitute the values:

$$F = 1.6 \times 10^{-19} \times 2.0 \times 10^7 \times \frac{300}{3 \times 10^8} = 3.2 \times 10^{-15} \text{ N}$$

Final Answer:

The maximum magnetic force acting on the electron is $\boxed{3.2 \times 10^{-15} \text{ N}}$.

Quick Tip

The magnetic force on an electron moving in an electric field depends on its speed, the strength of the electric field, and the speed of light.

e) A hydrogen atom emits ultraviolet radiation of wavelength $1025 \text{ \AA}$. What are the quantum numbers of energy states involved in the transition?

Solution:

Step 1: Energy of the Photon.

The energy of the emitted photon is given by:

$$E = \frac{hc}{\lambda}$$

Where: - $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$, - $c = 3 \times 10^8 \text{ m/s}$, - $\lambda = 1025 \times 10^{-10} \text{ m}$.

Substitute the values:

$$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1025 \times 10^{-10}} = 1.94 \times 10^{-18} \text{ J}$$

Step 2: Transition and Quantum Numbers.

The energy of the photon corresponds to the energy difference between two energy levels of the hydrogen atom. Using the Rydberg formula:

$$E = -13.6 \left(\frac{1}{n_2^2} - \frac{1}{n_1^2} \right)$$

Solve for n_1 and n_2 (the quantum numbers).

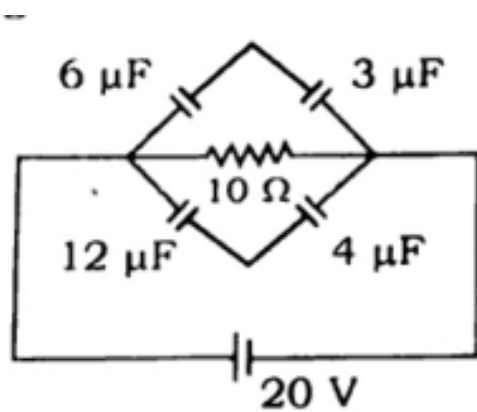
Final Answer:

The transition involves quantum numbers $n_1 = 2$ and $n_2 = 3$.

Quick Tip

The wavelength of emitted radiation can be used to determine the quantum numbers of the states involved in the transition using the Rydberg formula.

6. Define capacitance of a capacitor. Find the charge on each capacitor in the circuit shown in the figure.



Solution:

Step 1: Definition of Capacitance.

The capacitance C of a capacitor is the ratio of the charge Q stored on one plate to the potential difference V between the plates. It is given by the formula:

$$C = \frac{Q}{V}$$

Where: - C is the capacitance, - Q is the charge on the capacitor, - V is the potential difference across the capacitor.

Step 2: Analyze the Circuit.

Given the circuit: - The capacitors are in a combination of series and parallel. - Capacitors in series have an equivalent capacitance $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$. - Capacitors in parallel have an equivalent capacitance $C_{eq} = C_1 + C_2$.

The circuit consists of capacitors $6\ \mu\text{F}$, $3\ \mu\text{F}$, $12\ \mu\text{F}$, $4\ \mu\text{F}$ and a resistor $10\ \Omega$ connected to a $20\ \text{V}$ power supply.

Step 3: Find the Equivalent Capacitance of the Capacitors.

- The capacitors $6\ \mu\text{F}$ and $3\ \mu\text{F}$ are in series:

$$\frac{1}{C_1} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2} \Rightarrow C_1 = 2\ \mu\text{F}$$

- Now, the $2\ \mu\text{F}$ capacitor is in parallel with the $12\ \mu\text{F}$ capacitor:

$$C_2 = 2 + 12 = 14\ \mu\text{F}$$

- The $14\ \mu\text{F}$ capacitor is in series with the $4\ \mu\text{F}$ capacitor:

$$\frac{1}{C_{eq}} = \frac{1}{14} + \frac{1}{4} = \frac{1}{\frac{14 \times 4}{14+4}} = \frac{1}{\frac{56}{18}} \Rightarrow C_{eq} = 3.21\ \mu\text{F}$$

Step 4: Find the Total Charge in the Circuit.

Using the formula $Q = C_{\text{eq}}V$, where $V = 20 \text{ V}$, we can find the total charge:

$$Q = 3.21 \times 20 = 64.2 \mu\text{C}$$

Step 5: Find the Charge on Each Capacitor.

- The charge on each capacitor is the same in series combination, so the charge on $6 \mu\text{F}$ and $3 \mu\text{F}$ capacitors will be the same, $Q_1 = 64.2 \mu\text{C}$. - The charge on the parallel combination of $2 \mu\text{F}$ and $12 \mu\text{F}$ will be the same, $Q_2 = 64.2 \mu\text{C}$.

Final Answer:

The charge on each capacitor is $64.2 \mu\text{C}$.

Quick Tip

To find the charge on each capacitor, first find the equivalent capacitance of the entire circuit, and then use the formula $Q = C_{\text{eq}} \times V$.

OR

State Gauss' theorem. Obtain the expression for the intensity of the electric field at a point due to a thin charged wire of infinite length with its help.

Solution:**Step 1: Gauss' Theorem.**

Gauss' theorem states that the total electric flux Φ_E through a closed surface is equal to the charge enclosed Q_{enc} divided by the permittivity of free space ϵ_0 :

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\epsilon_0}$$

Step 2: Electric Field Due to a Thin Charged Wire.

Consider an infinitely long, straight charged wire with linear charge density λ (charge per unit length). To find the electric field at a distance r from the wire, we use a cylindrical Gaussian surface with radius r and length L .

The electric flux through the surface is given by:

$$\Phi_E = E \cdot 2\pi r L$$

Since the charge enclosed is $Q_{\text{enc}} = \lambda L$, applying Gauss' law:

$$E \cdot 2\pi r L = \frac{\lambda L}{\epsilon_0}$$

Solving for E :

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Final Answer:

The intensity of the electric field at a distance r from a thin charged wire of infinite length is:

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Quick Tip

The electric field due to an infinitely long charged wire decreases with the distance from the wire, and it is inversely proportional to the distance from the wire.

7. Define magnetic moment and write its unit. An electron is moving with the velocity $2.0 \times 10^7 \text{ ms}^{-1}$ in a circular orbit of radius $0.3 \text{ \AA}$. Calculate its magnetic moment.

Solution:

Step 1: Definition of Magnetic Moment.

Magnetic moment (μ) is the measure of the strength and orientation of a magnetic source.

For a moving charge, it is given by the formula:

$$\mu = I \cdot A$$

Where: - I is the current, - A is the area enclosed by the moving charge.

For an electron moving in a circular path, we can express the magnetic moment as:

$$\mu = m \cdot v \cdot r$$

Where: - m is the mass of the electron ($m_e = 9.11 \times 10^{-31} \text{ kg}$), - v is the velocity of the electron ($2.0 \times 10^7 \text{ ms}^{-1}$), - r is the radius of the circular orbit ($0.3 \text{ \AA} = 0.3 \times 10^{-10} \text{ m}$).

Step 2: Calculation of Magnetic Moment.

Substitute the values into the formula for magnetic moment:

$$\mu = 9.11 \times 10^{-31} \times 2.0 \times 10^7 \times 0.3 \times 10^{-10}$$

$$\mu = 5.46 \times 10^{-34} \text{ A}\cdot\text{m}^2$$

Step 3: Unit of Magnetic Moment.

The SI unit of magnetic moment is $\text{A}\cdot\text{m}^2$ (ampere square meter).

Final Answer:

The magnetic moment of the electron is $5.46 \times 10^{-34} \text{ A}\cdot\text{m}^2$.

Quick Tip

The magnetic moment for a moving charge in a circular orbit is given by $\mu = m \cdot v \cdot r$, where m is the mass, v is the velocity, and r is the radius of the orbit.

OR

An electron enters the region of 0.3 T magnetic field at an angle of 60° with the speed of $4 \times 10^5 \text{ ms}^{-1}$. Find the radius of the helical path and the pitch (distance between two consecutive spirals) of the electron beam.

Solution:

Step 1: Magnetic Force on the Electron.

The magnetic force F acting on the electron is given by the formula:

$$F = qvB \sin \theta$$

Where: - $q = 1.6 \times 10^{-19} \text{ C}$ is the charge of the electron, - $v = 4 \times 10^5 \text{ ms}^{-1}$ is the velocity of the electron, - $B = 0.3 \text{ T}$ is the magnetic field, - $\theta = 60^\circ$ is the angle between the velocity and the magnetic field.

Step 2: Centripetal Force and Radius.

For circular motion, the magnetic force provides the centripetal force, so:

$$qvB \sin \theta = \frac{mv^2}{r}$$

Where r is the radius of the helical path and $m = 9.11 \times 10^{-31} \text{ kg}$ is the mass of the electron.

Substitute the known values:

$$1.6 \times 10^{-19} \times 4 \times 10^5 \times 0.3 \times \sin(60^\circ) = \frac{9.11 \times 10^{-31} \times (4 \times 10^5)^2}{r}$$
$$r = \frac{9.11 \times 10^{-31} \times (4 \times 10^5)^2}{1.6 \times 10^{-19} \times 4 \times 10^5 \times 0.3 \times \sin(60^\circ)}$$

Solving for r , we get:

$$r \approx 2.32 \times 10^{-2} \text{ m}$$

Step 3: Pitch of the Helical Path.

The pitch of the helical path is the distance the electron moves along the direction of the magnetic field during one complete revolution. The pitch p is given by:

$$p = v \cos \theta \times T$$

Where T is the time period of the electron's circular motion.

The time period T is:

$$T = \frac{2\pi r}{v \sin \theta}$$

Substitute the values:

$$p = v \cos \theta \times \frac{2\pi r}{v \sin \theta}$$
$$p = \frac{2\pi r \cos \theta}{\sin \theta}$$

Substituting the known values:

$$p = \frac{2\pi \times 2.32 \times 10^{-2} \times \cos(60^\circ)}{\sin(60^\circ)} \approx 1.5 \times 10^{-2} \text{ m}$$

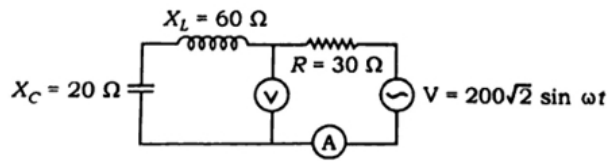
Final Answer:

The radius of the helical path is $2.32 \times 10^{-2} \text{ m}$ and the pitch of the electron's path is $1.5 \times 10^{-2} \text{ m}$.

Quick Tip

The radius of the helical path of a charged particle moving in a magnetic field depends on the velocity, magnetic field strength, and the angle between the velocity and the magnetic field.

8. What do you mean by 'impedance' in an alternating circuit? Write its unit. Find the reading of the ammeter and voltmeter in the given circuit.



Solution:

Step 1: Definition of Impedance.

Impedance (Z) is the total opposition that a circuit presents to the flow of alternating current. It is the combination of resistance (R) and reactance (X) in the circuit. Impedance is a complex quantity and is given by:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Where: - R is the resistance, - X_L is the inductive reactance, - X_C is the capacitive reactance. The unit of impedance is Ω (Ohms), the same as resistance.

Step 2: Given Data.

From the given circuit: - $R = 30 \Omega$ (Resistance), - $X_L = 60 \Omega$ (Inductive reactance), - $X_C = 20 \Omega$ (Capacitive reactance), - $V = 200\sqrt{2} \sin(\omega t)$ V (Voltage).

Step 3: Calculation of Impedance.

First, calculate the net reactance $X = X_L - X_C$:

$$X = 60 - 20 = 40 \Omega$$

Now, calculate the impedance using the formula:

$$Z = \sqrt{R^2 + X^2} = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50 \Omega$$

Step 4: Finding the Ammeter and Voltmeter Readings.

The amplitude of the voltage is $V_{\max} = 200\sqrt{2}$ V. The RMS value of the voltage is:

$$V_{\text{rms}} = \frac{V_{\max}}{\sqrt{2}} = \frac{200\sqrt{2}}{\sqrt{2}} = 200 \text{ V}$$

The current in the circuit can be calculated using Ohm's law:

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{200}{50} = 4 \text{ A}$$

Final Answer:

The impedance of the circuit is $Z = 50 \Omega$, the reading of the ammeter is 4 A , and the reading of the voltmeter is 200 V .

Quick Tip

Impedance in an AC circuit is similar to resistance in a DC circuit but includes both resistive and reactive components (inductive and capacitive reactances).

OR

What are coherent sources? In a Young's double slit experiment, the distance between two coherent sources is 2 mm, and the distance of the screen is 1.5 m. If monochromatic light of wavelength $6000 \text{ \AA}$ is used, then find the fringe width and the distance of the third dark fringe from the centre.

Solution:

Step 1: Formula for Fringe Width.

In Young's double slit experiment, the fringe width (β) is given by:

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

Where: - $\lambda = 6000 \text{ \AA} = 6000 \times 10^{-10} \text{ m}$ is the wavelength of light, - $D = 1.5 \text{ m}$ is the distance of the screen from the slits, - $d = 2 \text{ mm} = 2 \times 10^{-3} \text{ m}$ is the distance between the two slits.

Substitute the values into the formula:

$$\beta = \frac{6000 \times 10^{-10} \times 1.5}{2 \times 10^{-3}} = \frac{9000 \times 10^{-10}}{2 \times 10^{-3}} = 4.5 \times 10^{-4} \text{ m} = 0.45 \text{ mm}$$

Step 2: Distance of the Third Dark Fringe.

The position of the n -th dark fringe is given by:

$$y_n = \left(n - \frac{1}{2}\right)\beta$$

For the third dark fringe ($n = 3$):

$$y_3 = \left(3 - \frac{1}{2}\right) \times 0.45 = 2.5 \times 0.45 = 1.125 \text{ mm}$$

Final Answer:

The fringe width is 0.45 mm , and the distance of the third dark fringe from the centre is 1.125 mm .

Quick Tip

The fringe width is directly proportional to the wavelength of light and the distance to the screen, and inversely proportional to the distance between the slits.

9. What is amplification? In a common emitter amplifier, collector current is increased by 1 milliampere by increasing base current by 5μ ampere. Calculate current gain α and β .

Solution:

Step 1: Definition of Amplification.

Amplification refers to the process of increasing the amplitude of a signal. In the context of electronic circuits, it is the process by which the amplitude of an electrical signal (voltage or current) is increased without altering its other characteristics, such as frequency.

Step 2: Given Data.

- Increase in collector current, $\Delta I_C = 1 \text{ mA} = 10^{-3} \text{ A}$, - Increase in base current, $\Delta I_B = 5 \mu\text{A} = 5 \times 10^{-6} \text{ A}$.

Step 3: Current Gain α and β .

In a common emitter amplifier, the current gain β and α are related as:

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

Substitute the given values:

$$\beta = \frac{1 \times 10^{-3}}{5 \times 10^{-6}} = 200$$

The current gain α is related to β by the formula:

$$\alpha = \frac{\beta}{\beta + 1}$$

Substitute the value of β :

$$\alpha = \frac{200}{200 + 1} = \frac{200}{201} \approx 0.995$$

Final Answer:

The current gain is $\alpha = 0.995$ and $\beta = 200$.

Quick Tip

The current gain β is the ratio of the change in collector current to the change in base current, while α is the ratio of the change in collector current to the total current.

OR

What is an oscillator? Explain the working of a transistor as an oscillator with a suitable circuit diagram.

Solution:**Step 1: Definition of Oscillator.**

An oscillator is a circuit that generates a continuous periodic waveform (usually sine or square) without requiring an external input signal. The circuit generates its own signal, often referred to as the "oscillations."

Step 2: Working of a Transistor as an Oscillator.

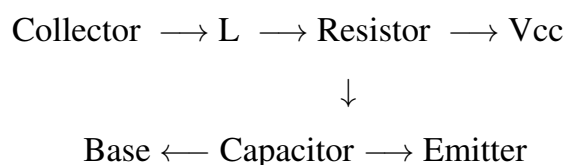
In a transistor oscillator circuit, feedback is used to produce an oscillating signal. A common configuration for a transistor oscillator is the Colpitts oscillator. This type of oscillator uses an LC tank circuit for frequency determination. The feedback network controls the oscillation, ensuring that the transistor amplifies the signal continuously.

The general working of a transistor oscillator: 1. The transistor is used to amplify the signal. 2. The LC network provides feedback from the output to the input. 3. The feedback loop sustains oscillations, and the circuit generates a stable waveform.

% (Diagram of a transistor oscillator like a Colpitts oscillator can be drawn here.)

Step 3: Circuit Diagram.

Here's a simplified circuit diagram for a common emitter oscillator using a transistor:



In this diagram, the transistor amplifies the signal, while the LC circuit (inductor and capacitor) sets the frequency of oscillation.

Final Answer:

An oscillator is a circuit that generates a continuous periodic signal. A transistor oscillator uses feedback to sustain oscillations and typically uses an LC tank circuit to determine the frequency.

Quick Tip

Transistor oscillators are widely used in generating radio frequencies and other high-frequency signals in communication systems.