CLASS: XII
SUBJECT PHYSICS (THEORY)
SOLUTIONS WITH STEP MARKING

1. **Solution:**
c) Newton per Coulomb 1
The unit of electric field intensity is Newton per Coulomb (N/C).
2. **Solution:**
c) Same 1
In a parallel circuit, the voltage across each component is the same.
3. **Solution:** 1
b) 90°
The force on a moving charge in a magnetic field is maximum when the angle between the velocity and the magnetic field is 90°.
4. **Solution:**
c) The effective value for power calculation 1
The RMS value is the effective value that produces the same power as a DC current.
5. **Solution:**
b) Directly proportional to the number of turns 1
Self-inductance is directly proportional to the square of the number of turns in the coil.
6. **Solution:**
b) Diffraction 1
Diffraction refers to the bending of light around obstacles and edges.
7. **Solution:**
b) Myopia 1
A concave lens is used to correct myopia (nearsightedness).
8. **Solution:** 1
c) Momentum
The de Broglie wavelength of an electron is inversely proportional to its momentum.
9. **Solution:**
b) Less 1
In nuclear fission, some mass is converted into energy according to $E=mc^2$ so the mass of the products is less than that of the reactants.
10. **Solution:** 1
b) Depletion region
The depletion region is where no current flows in a P-N junction diode.
11. **Solution:** 1
a) Both Assertion and Reason are true, and Reason is the correct explanation.
12. **Solution:** 1
a) Both Assertion and Reason are true, and Reason is the correct explanation..
13. **Solution**

Drift Velocity: Drift velocity (V_d) is the average velocity of charged particles, such as electrons, in a conducting medium (like a metal) due to an applied electric field. It represents the slow, net flow of charge carriers in the direction of the electric field when an electric field is applied to the conductor. 1/2 (2)

Continue....

To derive the formula $I = neAv_d$, where I is the current, n is the number density of charge carriers, e is the charge of each carrier, A is the cross-sectional area of the conductor, and v_d is the drift velocity, follow these steps:

. Consider a Conductor:

Let the conductor have a cross-sectional area A.

Suppose it contains n charge carriers per unit volume, where n is the number density of the charge carriers. Each charge carrier has a charge e. The drift velocity of the carriers is v_d.

Number of Charge Carriers in a Volume:

In a small volume of the conductor of thickness d and cross-sectional area A, the number of charge carriers is $n \cdot A \cdot d$.

Charge Flow Per Unit Time:

The total charge Q passing through the cross-sectional area A in time t is given by the product of the number of charge carriers and the charge of each carrier: $Q = (n \cdot A \cdot d) \cdot e$

Since the thickness d of the volume is the drift velocity v_d multiplied by time t (i.e., $d = v_d \cdot t$): $Q = (n \cdot A \cdot v_d \cdot t) \cdot e$

Current Definition:

The current I is the rate of flow of charge, given by: $I = \frac{Q}{t}$

Substituting the expression for Q: $I = \frac{n \cdot A \cdot v_d \cdot t \cdot e}{t}$

Simplifying, we get: $I = n \cdot A \cdot v_d \cdot e$

14.

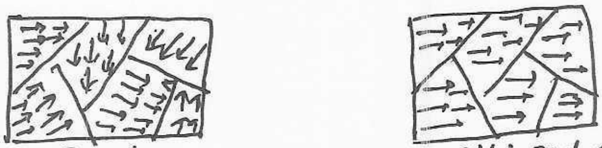
Solution:

Domain Theory of Ferromagnetism:

Domain theory explains ferromagnetism by describing how magnetic domains form and align within a material. A magnetic domain is a region within a ferromagnetic material where the magnetic moments of atoms are aligned in the same direction.

1. **Formation of Domains:**
   In an unmagnetized ferromagnetic material, the magnetic moments of atoms are randomly oriented due to thermal motion. However, these moments tend to align in regions called domains, each with a uniform magnetic direction.
2. **Alignment of Domains:**
   When an external magnetic field is applied, the domains aligned with the field grow in size while those opposed to the field shrink. This process increases the material's overall magnetization.
3. **Magnetization:**
   The net magnetization of the material is the result of the alignment of these domains. In a fully magnetized material, most of the domains are aligned with the external field.
4. **Domain Wall:**
   The boundary between two different domains, known as the domain wall, separates regions of different magnetic orientations.

Diagram of Domains:



Before Magnetization: Domains are randomly oriented, leading to zero net magnetization.

During Magnetization: Domains align with an applied external magnetic field, causing the overall magnetic moment of the material to increase.

This theory helps in understanding how ferromagnetic materials like iron can be magnetized and demagnetized, as well as the microscopic mechanism behind their magnetic properties.

15.Answer:

Explanation of the Photoelectric Effect: Def- $\frac{1}{2}$, Derivation $1\frac{1}{2}$

The photoelectric effect is a phenomenon where electrons are emitted from a material when it is exposed to electromagnetic radiation, such as light. This effect demonstrates the particle nature of light and is crucial in understanding quantum mechanics. When light of a certain frequency (or wavelength) strikes a material (typically a metal), electrons are emitted from the surface of the material. The emission of electrons occurs only if the frequency of the incident light is above a certain threshold frequency, which is specific to the material.

Einstein's Photoelectric Equation: The photoelectric effect by proposing that light is quantized and consists of photons. Each photon carries an energy E proportional to its frequency ν, given by:

$$E=h\nu$$

where h is Planck's constant.

The energy of the incident photons is used to overcome the work function (ϕ) of the material, which is the minimum energy required to liberate an electron from the surface.

The energy of the incoming photon is used to overcome the work function of the material and the remaining energy is converted into the kinetic energy (K.E. of the emitted electron.

If hν is the energy of the photon, and ϕ is the work function of the material, then the kinetic energy of the emitted electron is given by:

$$K.E.=h\nu-\phi$$

According to the photoelectric effect equation:

$$K.E.=h\nu-\phi$$

where:

K.E.is the kinetic energy of the emitted photoelectron,
h is Planck's constant (6.626×10^{-34} Js)
ν is the frequency of the incident light,
ϕ is the work function of the material (the minimum energy needed to remove an electron).

If the frequency of the incident light is less than the threshold frequency (ν_0), no photoelectrons are emitted because the photon energy hνh \nuhν is insufficient to overcome the work function.

The threshold frequency is related to the work function by:

$$\phi=h\nu_0$$

$$K.E.=h(\nu-\nu_0)$$

16.

To find the magnitude of the magnetic field B at the center of a circular coil of wire, you can use the formula for the magnetic field at the center of a circular coil with N turns:

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

where

- μ_0 is the permeability of free space ($\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T \cdot m/A}$)
- N is the number of turns
- I is the current
- R is the radius of the coil

Given:

- Number of turns $N = 100$
- Radius $R = 8.0\,\mathrm{cm} = 0.08\,\mathrm{m}$
- Current $I = 0.40\,\mathrm{A}$

Plugging these values into the formula:

$$B = \frac{4\pi \times 10^{-7} \times 100 \times 0.40}{2 \times 0.08}$$

First calculate the numerator:

$$4\pi \times 10^{-7} \times 100 \times 0.40 = 1.6\pi \times 10^{-5}$$

Then calculate the denominator:

$$2 \times 0.08 = 0.16$$

So:

$$B = \frac{1.6\pi \times 10^{-5}}{0.16} = \pi \times 10^{-4} \approx 3.14 \times 10^{-4}\,\mathrm{T}$$

Thus, the magnitude of the magnetic field B at the center of the coil is approximately

$$B \approx 3.14 \times 10^{-4}\,\mathrm{T}$$

OR

The power factor is given by
Power Factor=cosϕ
where ϕ is the phase angle between voltage and current.
It measures how effectively the current is being converted into useful work.

17. Answer:

Concept of Mutual Induction:

Mutual induction is a fundamental principle in electromagnetism where a change in electric current in one coil induces an electromotive force (emf) in a nearby coil. This phenomenon occurs because the changing current in the first coil generates a varying magnetic field, which then influences the second coil through this magnetic field.

Physical Basis:

1. **Changing Magnetic Field:**

   When current flows through a coil (let's call it Coil 1), it generates a magnetic field around it. If the current in Coil 1 changes with time, the magnetic field associated with Coil 1 also changes.

   This changing magnetic field extends to any nearby coil (Coil 2) and induces a voltage in Coil 2 due to Faraday's Law of Induction, which states that a change in magnetic flux through a coil induces an emf.

2. **Faraday's Law of Induction:**

   According to Faraday's Law, the induced emf (E2\mathcal{E}_2E2) in Coil 2 is proportional to the rate of change of magnetic flux through it.

Derivation of the Induced emf:

1. **Definition of Mutual Inductance:**
2. **Magnetic Flux**
3. **Magnetic Field**
4. **Expression for Mutual Inductance**
5. **Induced emf in Coil 2**

18.

Diffraction of Light:

Definition: Diffraction is the bending of light waves around the edges of an obstacle or through an aperture, causing the spreading of light. It occurs when the size of the obstacle or aperture is comparable to the wavelength of the light. 1

Principle: When light passes through a narrow slit or around an edge, the waves spread out rather than continuing in straight lines. This spreading creates a pattern of alternating light and dark regions, known as a diffraction pattern.

Examples: The spreading of light after passing through a small slit, the pattern observed when light passes through a small hole, or the colorful patterns seen in a CD or DVD.

Difference Between Diffraction and Interference:

1. **Nature of Phenomenon:** 2

   Diffraction: Involves the bending and spreading of light waves as they encounter an obstacle or slit. It is a single wave phenomenon where the pattern depends on the shape and size of the aperture or obstacle.

   Interference: Involves the superposition of two or more coherent light waves, which can be from different sources or the same source split into multiple beams. Interference results in a pattern of alternating constructive (bright) and destructive (dark) regions due to the overlapping of the waves.

2. **Conditions Required:**

   Diffraction: Occurs when light waves pass through an aperture or around an obstacle whose dimensions are on the order of the wavelength of the light. The aperture or obstacle needs to be of comparable size to the wavelength of light.

   Interference: Requires coherent light sources, meaning the light waves must have a constant phase difference and the same frequency. It typically occurs in experiments like Young's double-slit experiment where two coherent sources produce overlapping waves.

3. **Pattern Formation:**

   Diffraction: Results in a broad spreading of light and the formation of a diffraction pattern consisting of a central bright region (central maximum) with diminishing brightness towards the edges (diffraction fringes). The pattern is influenced by the shape and size of the aperture or obstacle.

   Interference: Results in a series of evenly spaced bright and dark fringes (interference fringes) on a screen. The fringe pattern is determined by the path difference between the overlapping waves and is usually seen in setups like the double-slit experiment.

19.

Binding energy is the energy required to disassemble a nucleus into its individual protons and neutrons. It reflects the stability of the nucleus; a higher binding energy means a more stable nucleus. 1

To derive the expression for mass defect: 2

1. Mass Defect (Δm) is the difference between the mass of the fully assembled nucleus and the sum of the individual masses of its constituent protons and neutrons.
2. For a nucleus with Z protons and N neutrons:

$$\text{Mass defect } (\Delta m) - [Z \cdot m_p - N \cdot m_n - m_{\text{nucleus}}]$$

   where m_p is the mass of a proton, m_n is the mass of a neutron, and m_{nucleus} is the mass of the nucleus.

3. The Binding Energy (E_b) can be found using Einstein's mass-energy equivalence principle $E - \Delta m \cdot c^2$:

$$E_b - \Delta m \cdot c^2$$

   where c is the speed of light.

20. Solution:

Rearrange Coulomb's Law to solve for q_2:

$$q_2 = \frac{F \cdot r^2}{k \cdot |q_1|}$$

Substitute the given values into the formula:

$$q_2 = \frac{(5 \times 10^{-2}) \cdot (12)^2}{8.99 \times 10^9 \cdot 4 \times 10^{-6}}$$

$$q_2 = \frac{7.2}{3.596 \times 10^4}$$

$$q_2 \approx 2.002 \times 10^{-4}\,C$$

21.

Displacement current is a term added by James Clerk Maxwell to Ampère's law to account for the changing electric field in a capacitor or in situations with time-varying electric fields. It allows the law to be applicable in such cases, ensuring consistency with the continuity equation.

The displacement current density J_d is given by:

$$J_d = \epsilon_0 \frac{\partial E}{\partial t}$$

where ϵ_0 is the permittivity of free space and $\frac{\partial E}{\partial t}$ is the time rate of change of the electric field E.

In terms of the total displacement current I_d through a surface area A, it is:

$$I_d = \epsilon_0 A \frac{\partial E}{\partial t}$$

22.

Answer:

Explanation of Ohm's Law:

Ohm's Law is a fundamental principle in electrical engineering and physics that relates the voltage across a conductor, the current flowing through it, and its resistance. The law is expressed mathematically as:

V=I·R

where:

- V is the voltage across the conductor (in volts, V),
- I is the current flowing through the conductor (in amperes, A),
- R is the resistance of the conductor (in ohms, Ω).

Ohm's Law states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance. This relationship holds true as long as the temperature and material properties of the conductor remain constant.

Derivation of the Expression for Power Dissipated in a Resistor:

The power P dissipated in a resistor due to the flow of current can be derived from Ohm's Law.

1. **Expression for Power Using Ohm's Law:**
   Power P in an electrical circuit is defined as the rate at which energy is consumed or converted. It can be calculated using the formula:
   P=V·I
2. **Substitute Ohm's Law into the Power Formula:**
   From Ohm's Law, we have V=I·R
   Substituting this into the power formula:
   P=(I·R)·I
   This shows that power dissipated in a resistor is proportional to the square of the current and the resistance.
3. **Alternate Expression for Power:**
   Similarly, the power can also be expressed in terms of voltage and resistance.
   Rearranging Ohm's Law to express current I:
   I=V/R

Substituting this into the power formula P=V·I
P=V·(V/R)
This expression shows that power dissipated in a resistor is proportional to the square of the voltage across it and inversely proportional to its resistance.

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Solution:

Bohr's Postulates of the Hydrogen Atom:

1. Quantized Orbits:

   Electrons in a hydrogen atom orbit the nucleus in specific, quantized orbits or energy levels. These orbits are stable and do not emit radiation.

   The angular momentum of the electron in these orbits is quantized and is given by:

   $$L = n\hbar$$

   where L is the angular momentum, n is a positive integer (quantum number), and $\hbar$ is the reduced Planck's constant ($\hbar = \frac{h}{2\pi}$).

2. Energy Quantization:

   Electrons in these quantized orbits have specific energy levels. The energy of these levels is given by:

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

   where E_n is the energy of the nth orbit, and n is the principal quantum number (n = 1, 2, 3, ...). The negative sign indicates that the energy is bound (the electron is bound to the nucleus

3. Emission and Absorption of Energy:

   An electron can move between these quantized orbits by absorbing or emitting a photon of energy equal to the difference between the initial and final energy levels:

   $$\Delta E = E_i - E_f = h\nu$$

   where ΔE is the change in energy, h is Planck's constant, and ν is the frequency of the emitted or absorbed photon.

How Bohr's Postulates Help in Determining Energy Levels:

1. Quantization of Energy Levels:

   Bohr's postulates establish that only certain discrete energy levels are allowed for electrons in an atom. This quantization explains the discrete line spectra observed for hydrogen, as each spectral line corresponds to a transition between these quantized energy levels.

2. Calculation of Energy Levels:

   The energy levels of the hydrogen atom can be calculated using the formula $E_n = -\frac{13.6 \text{ eV}}{n^2}$. This helps in determining the energy associated with each orbit and in predicting the wavelengths of spectral lines emitted during transitions.

3. Spectral Lines:

   The difference in energy between the quantized levels determines the wavelengths of light absorbed or emitted by the atom. This leads to the observed spectral lines in the emission or absorption spectra of hydrogen.

24

1. **(d) Both (a) and (b)** if points 1 and 2 both show flat regions in the potential graph.
2. (a) positive and negative
3. (d) Can't determine
4. True, False, True

25.
Solution:

Given:

- Focal length of the convex lens, $f = 20$ cm
- Object distance, $u = -30$ cm (Note: The object distance is taken as negative in lens formula convention)

(a) Position of the Image:

To find the image distance, v, we use the lens formula: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Substitute the given values: $\frac{1}{20} = \frac{1}{v} - \frac{1}{-30}$

Simplify: $\frac{1}{20} = \frac{1}{v} + \frac{1}{30}$

Combine the fractions on the right side: $\frac{1}{v} = \frac{1}{20} - \frac{1}{30}$

To find a common denominator: $\frac{1}{v} = \frac{3-2}{60} = \frac{1}{60}$

Therefore: $v = 60\text{ cm}$

(b) Magnification of the Lens:

Magnification, m, is given by: $m = \frac{v}{u}$

Substitute the values of v and u: $m = \frac{60}{-30} = -2$

The negative sign indicates that the image is inverted relative to the object.

(c) Distance for a Sharp Image Projection:

To project a sharp image onto a screen, the screen should be placed at the position of the image formed. Therefore, the screen should be placed 60 cm away from the lens.

OR

1. Lens Formula and Magnification Formula:

The formation of images by a convex lens (or converging lens) can be analyzed using two fundamental formulas:

Lens Formula:

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

where f is the focal length of the lens, v is the image distance from the lens, and u is the object distance from the lens. For a convex lens, the focal length is positive.

Magnification Formula:

$$m = \frac{v}{u}$$

Object at Infinity:

i. When an object is at an infinite distance from the lens, parallel rays of light converge at the focal point of the lens.
ii. **Image Position:** At the focal point F.
iii. **Image Nature:** Real, inverted, and highly diminished (practically a point).

Object at 2F:

i. When the object is placed exactly at twice the focal length from the lens.
ii. **Image Position:** Also at 2F on the opposite side of the lens.
iii. **Image Nature:** Real, inverted, and of the same size as the object.

Object Between F and 2F:

i. When the object is placed between the focal point FFF and twice the focal length 2F2F2F.
ii. **Image Position:** Beyond 2F on the opposite side of the lens.
iii. **Image Nature:** Real, inverted, and magnified (larger than the object).

26
Solution:
1. Concept of Energy Bands and the Band Gap in Semiconductors:
In solid-state physics, the concept of energy bands helps explain the electrical properties of materials. Here's a detailed explanation:

Energy Bands: In a solid, atoms are closely packed together, and their discrete energy levels overlap and form continuous energy bands. The highest range of these bands that are filled with electrons is called the **valence band**, and the next higher range, which can accept electrons, is called the **conduction band**.

Band Gap: The energy difference between the top of the valence band and the bottom of the conduction band is known as the **band gap (E_g)**. This gap determines the electrical conductivity of the material:

- **Conductors:** Have overlapping valence and conduction bands, so there is no band gap. Electrons flow freely, resulting in high conductivity.
- **Insulators:** Have a large band gap (typically > 3 eV). The energy required to move electrons from the valence band to the conduction band is large, making them poor conductors.
- **Semiconductors:** Have a moderate band gap (typically between 0.1 eV and 3 eV). At room temperature, some electrons can gain enough energy to jump from the valence band to the conduction band, allowing moderate electrical conductivity.

27. Diff. b/w extrinsic & Intrinsic semiconductor 2

Solution:

Resonance in an LCR Circuit:

Definition of Resonance: Resonance in an LCR series circuit occurs when the inductive reactance X_L and the capacitive reactance X_C are equal in magnitude. At this frequency, the circuit behaves as if it were purely resistive, and the impedance is minimized to the value of the resistance R alone.

Condition for Resonance: The resonance condition is met when:

$$X_L = X_C$$

where: $X_L = 2\pi f L$

$$X_C = \frac{1}{2\pi f C}$$

At resonance: $2\pi f L = \frac{1}{2\pi f C}$

Solving for the resonant frequency f_0:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Effect of Resonance on Impedance and Current: At resonance, the impedance Z of the circuit is purely resistive and equals R:

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

This is because $X_L - X_C = 0$ at resonance. Consequently, the current I through the circuit reaches its maximum value:

$$I_{max} = \frac{V}{R}$$

where V is the amplitude of the applied AC voltage. The circuit shows maximum power transfer and energy exchange at this frequency.

OR

(a) Average Current Over One Complete Cycle: For a sinusoidal AC current, the average value over one complete cycle is zero. This is because the positive and negative halves of the cycle cancel each other out. Thus, the average current is:

$2\frac{1}{2}$

$$\text{Average current} = 0\,\text{A}$$

(b) RMS Value of the Current: The RMS (Root Mean Square) value of a sinusoidal current is given by:

$$I_{\text{RMS}} = \frac{I_0}{\sqrt{2}}$$

$2\frac{1}{2}$

where I_0 is the peak amplitude of the current. Given $I_0 = 5\,\text{A}$:

$$I_{\text{RMS}} = \frac{5\,\text{A}}{\sqrt{2}} \approx 3.54\,\text{A}$$