WBJEE Physics Sample Paper-17

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Sections**.
- **Section 1 (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section 2 (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **−0.5** marks. Only **one** correct option.
- **Section 3 (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section–A — 30 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. A particle performs SHM. Which quantity remains constant?

(A) Total energy

(B) Kinetic energy

(C) Potential energy

(D) Amplitude varies

Q2. Electric field inside a conductor in electrostatic equilibrium is:

(A) Zero

(B) Maximum

(C) Constant non-zero

(D) Depends on charge

Q3. Time period of a simple pendulum depends on:

(A) Length

(B) Mass

(C) Gravity

(D) Amplitude

Q4. Work done in moving a charge on an equipotential surface is:

(A) Zero

(B) Maximum

(C) Negative

(D) Infinite

Q5. Magnetic force on a moving charge is maximum when angle between velocity and magnetic field is:

(A) $0°$

(B) $30°$

(C) $90°$

(D) $180°$

Q6. Photoelectric emission depends primarily on:

(A) Frequency

(B) Intensity

(C) Wavelength

(D) Time

Q7. Dimensional formula of Planck's constant is:

(A) ML^2T^{-1}

(B) ML^2T^{-2}

(C) MLT^{-1}

(D) $ML^{-1}T$

Q8. Resistance of a wire increases when:

(A) Length increases

(B) Area increases

(C) Temperature decreases

(D) Material changes

Q9. Lens formula relates:

(A) u, v, f

(B) u, v, R

(C) f, R, n

(D) Power, resistance

Q10. Electric flux depends on:

(A) Charge enclosed

(B) Area

(C) Permittivity

(D) Magnetic field

Q11. Power factor is maximum when phase difference is:

(A) 0°

(B) 90°

(C) Resistance is zero

(D) Inductance infinite

Q12. De Broglie wavelength increases when:

(A) Momentum decreases

(B) Velocity increases

(C) Mass increases

(D) Energy increases

Q13. Bohr model quantization applies to:

(A) Angular momentum

(B) Energy only

(C) Radius only

(D) Velocity only

Q14. Nuclear binding energy depends on:

(A) Mass defect

(B) Charge

(C) Volume

(D) Spin only

Q15. Doppler effect is applicable for:

(A) Sound

(B) Light

(C) Both

(D) Neither

Q16. Capacitance increases when:

(A) Distance decreases

(B) Area decreases

(C) Dielectric is inserted

(D) Charge decreases

Q17. Torque on a dipole is maximum at angle:

(A) $0°$

(B) 45°

(C) 90°

(D) 180°

Q18. Wave speed depends on:

(A) Medium

(B) Frequency

(C) Amplitude

(D) Phase

Q19. Transformer works on the principle of:

(A) Mutual induction

(B) Electrostatics

(C) Thermodynamics

(D) Photoelectric effect

Q20. Drift velocity is proportional to:

(A) Electric field

(B) Resistance

(C) Frequency

(D) Mass

Q21. Kirchhoff's laws include:

(A) KCL

(B) KVL

(C) Ohm's law

(D) Faraday law

Q22. Induced EMF depends on:

(A) Rate of change of flux

(B) Flux only

(C) Resistance

(D) Current

Q23. Gravitational field inside Earth is:

(A) Zero at center

(B) Maximum at center

(C) Constant everywhere

(D) Infinite

Q24. Orbital speed of a satellite depends on:

(A) Radius

(B) Mass of satellite

(C) Time period only

(D) Temperature

Q25. Energy stored in a capacitor is:

(A) $\frac{1}{2}CV^2$

(B) CV

(C) $\frac{C}{V}$

(D) $\frac{V}{C}$

Q26. Radius of nucleus is proportional to:

(A) $A^{1/3}$

(B) A

(C) Z

(D) $1/A$

Q27. Fringe width in YDSE depends on:

(A) Wavelength

(B) Slit separation

(C) Screen distance

(D) Intensity

Q28. Coulomb's law is valid in:

(A) Vacuum

(B) Medium

(C) Plasma

(D) Only air

Q29. Current in a diode is:

(A) Unidirectional

(B) Bidirectional

(C) Alternating

(D) Always zero

Q30. Huygens' principle explains:

(A) Reflection

(B) Refraction

(C) Diffraction

(D) All of these

Section–B — 5 Questions × 1 Mark Each
(Negative Marking: −0.5) [Single Correct]

Q31. Quantization of angular momentum is given by:

(A) $n\hbar$

(B) nh^2

(C) $\hbar/n$

(D) constant

Q32. Power dissipated in resistor is:

(A) I^2R

(B) IR

(C) V/R

(D) V^2R

Q33. Lenz's law is based on:

(A) Energy conservation

(B) Momentum conservation

(C) Charge conservation

(D) Mass conservation

Q34. Critical angle depends on:

(A) Refractive index

(B) Wavelength

(C) Frequency

(D) Pressure

Q35. RMS value of AC current is:

(A) Peak/$\sqrt{2}$

(B) Peak$\times\sqrt{2}$

(C) Peak

(D) Peak^2

Section C — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q36. Factors affecting capacitance include:

(A) Area of plates

(B) Distance between plates

(C) Dielectric constant

(D) Charge stored

Q37. In SHM, acceleration is proportional to:

(A) Displacement

(B) Velocity

(C) Angular frequency

(D) Amplitude

Q38. Photoelectric effect observations include:

(A) Threshold frequency

(B) Instant emission

(C) Dependence on intensity

(D) Dependence on frequency

Q39. Magnetic field is produced by:

(A) Moving charge

(B) Changing electric field

(C) Static charge

(D) Current carrying wire

Q40. Properties of an ideal gas include:

(A) No intermolecular forces

(B) Point particles

(C) Elastic collisions

(D) Variable mass

Detailed Solutions

Q1.

Solution

Concept: In Simple Harmonic Motion (SHM), several quantities vary during the oscillation, such as displacement, velocity, acceleration, kinetic energy, and potential energy. However, the total energy of the system, which is the sum of kinetic and potential energy, remains constant, provided there are no dissipative forces like friction.

Solution: Step 1: Understand Simple Harmonic Motion (SHM). SHM is a type of periodic motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to that of displacement. Examples include a mass on a spring or a simple pendulum (for small oscillations).
Step 2: Analyze the energy components in SHM.
- Kinetic Energy (KE): $KE = \frac{1}{2}mv^2$, where m is mass and v is velocity. Velocity varies sinusoidally with time, being maximum at the equilibrium position and zero at the extreme positions. Thus, KE varies.
- Potential Energy (PE): For a mass-spring system, $PE = \frac{1}{2}kx^2$, where k is the spring constant and x is the displacement. Displacement varies sinusoidally with time, being maximum at the extreme positions and zero at the equilibrium position. Thus, PE varies.

Step 3: Consider the Total Energy (TE) of the system. In an ideal SHM system (without damping), the total mechanical energy is the sum of kinetic energy and potential energy:
$TE = KE + PE$
At the extreme positions, $v = 0$, so $KE = 0$, and $x = A$ (amplitude), so $PE = \frac{1}{2}kA^2$.
Thus, $TE = \frac{1}{2}kA^2$.
At the equilibrium position, $x = 0$, so $PE = 0$, and $v = v_{max}$, so $KE = \frac{1}{2}mv_{max}^2$. The maximum velocity $v_{max} = \omega A$, where $\omega = \sqrt{k/m}$. So, $KE = \frac{1}{2}m(\omega A)^2 = \frac{1}{2}m(\frac{k}{m})A^2 = \frac{1}{2}kA^2$. Thus, $TE = \frac{1}{2}kA^2$.
At any intermediate position, the sum of KE and PE will always equal this constant value.
Step 4: Consider the Amplitude. Amplitude is the maximum displacement from the equilibrium position. In ideal SHM, the amplitude remains constant. However, the question asks which quantity remains constant, and total energy is a more fundamental constant conserved quantity in SHM. If the system is not damped, the amplitude also remains constant. But among the given options, total energy is the most appropriate answer for a quantity that remains constant as a direct consequence of the physics of SHM.

Final Answer: Total energy

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept: In electrostatic equilibrium, the electric field inside a conductor must be zero. If there were a non-zero electric field, free charges within the conductor would move, creating a current, which contradicts the condition of equilibrium. This is a fundamental property of conductors in electrostatics.

Solution: Step 1: Recall the definition of electrostatic equilibrium for a conductor. In this state, there is no net movement of charge within the conductor.
Step 2: Consider the implications of a non-zero electric field inside the conductor. An electric field exerts a force on charges. If there were a non-zero electric field, the free charges (electrons) in the conductor would experience a force and move, resulting in a current.
Step 3: This movement of charges would continue until the charges redistribute themselves in such a way that the net electric field inside the conductor becomes zero. At this point, the charges are in equilibrium, and there is no further net movement of charge.
Step 4: Therefore, in electrostatic equilibrium, the electric field inside a conductor is always zero.

Final Answer: Zero

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: The time period of a simple pendulum is the time taken for one complete oscillation. It is primarily determined by the length of the pendulum and the acceleration due to gravity. The mass of the bob and the amplitude (for small angles) do not significantly affect the time period.

Solution: Step 1: Recall the formula for the time period of a simple pendulum:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where T is the time period, L is the length of the pendulum, and g is the acceleration due to gravity.

Step 2: Analyze the formula to identify the quantities on which the time period depends.
From the formula, T is directly proportional to the square root of the length (L).
From the formula, T is inversely proportional to the square root of the acceleration due to gravity (g).

Step 3: Consider the other options:
- Mass (m): The mass of the bob does not appear in the formula for the time period of a simple pendulum.
- Amplitude (A): For small angular displacements (typically less than 15 degrees), the time period is approximately independent of the amplitude.

Step 4: Conclude that the time period of a simple pendulum depends on its length and the acceleration due to gravity.

Final Answer: Length and Gravity

Answer: (AC)

Go Back to Question 3

Q4.

Solution

Concept: An equipotential surface is a surface on which the electric potential is constant at every point. The electric field is always perpendicular to the equipotential surface. Work done in moving a charge is given by the product of the charge and the potential difference.

Solution: Step 1: Understand the definition of an equipotential surface. On an equipotential surface, the electric potential V is the same everywhere.
Step 2: Recall the formula for the work done (W) in moving a charge (q) from point A to point B:

$$W = q\Delta V = q(V_B - V_A)$$

Step 3: Consider moving a charge from point A to point B on an equipotential surface. Since the surface is equipotential, the potential at point A (V_A) is equal to the potential at point B (V_B).

$$V_A = V_B$$

Step 4: Substitute this into the work done formula:

$$W = q(V_A - V_A) = q \cdot 0 = 0$$

Therefore, the work done in moving a charge on an equipotential surface is zero.

Final Answer: Zero

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: The magnetic force on a moving charge is given by the Lorentz force formula. The magnitude of this force depends on the charge, its velocity, the magnetic field strength, and the angle between the velocity vector and the magnetic field vector.

Solution: Step 1: Write down the formula for the magnetic force ($\vec{F}$) on a charge (q) moving with velocity ($\vec{v}$) in a magnetic field ($\vec{B}$):

$$\vec{F} = q(\vec{v} \times \vec{B})$$

Step 2: Consider the magnitude of this force, which is given by:

$$F = |q|vB\sin\theta$$

where θ is the angle between the velocity vector $\vec{v}$ and the magnetic field vector $\vec{B}$.

Step 3: To find when the magnetic force is maximum, we need to find the value of $\sin\theta$ that maximizes the expression for F. The sine function has a maximum value of 1.
Step 4: The maximum value of $\sin\theta$ is 1, which occurs when $\theta = 90°$ (or $\pi/2$ radians).
Step 5: Therefore, the magnetic force on a moving charge is maximum when the angle between its velocity and the magnetic field is 90°.

Final Answer: $\boxed{90°}$

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: The photoelectric effect is the emission of electrons from a material when light shines on it. The energy of a photon is directly proportional to its frequency and inversely proportional to its wavelength. For photoemission to occur, a photon must have at least enough energy to overcome the work function of the material.

Solution: Step 1: Recall the phenomenon of photoelectric emission. It involves the interaction of photons of light with electrons in a material.
Step 2: The energy of a photon is given by $E = hf$, where h is Planck's constant and f is the frequency of the light. Alternatively, using $c = f\lambda$, the energy can be written as $E = \frac{hc}{\lambda}$, where c is the speed of light and λ is the wavelength.
Step 3: For an electron to be emitted from the surface of a material, the energy of the incident photon must be greater than or equal to the work function (ϕ) of the material. The condition for photoelectric emission is $hf \geq \phi$ or $\frac{hc}{\lambda} \geq \phi$.
Step 4: This means that the frequency of the incident light must be above a certain threshold frequency ($f_0 = \phi/h$), and the wavelength must be below a certain threshold wavelength ($\lambda_0 = hc/\phi$).
Step 5: If the frequency is below the threshold, no electrons are emitted, regardless of how intense the light is. Intensity of light is related to the number of photons, not the energy of individual photons.
Step 6: Therefore, photoelectric emission depends primarily on the frequency (or equivalently, the wavelength) of the incident light, as it determines the energy of the photons.

Final Answer: Frequency

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: Planck's constant (h) is a fundamental physical constant that relates the energy of a photon to its frequency. To find its dimensional formula, we can use the relationship between energy, momentum, and frequency or use the formula for the energy of a photon.

Solution: Step 1: Recall the energy of a photon, which is given by $E = hf$, where E is energy and f is frequency.
Step 2: From this relation, we can express Planck's constant as $h = \frac{E}{f}$.
Step 3: Determine the dimensions of energy. Energy has dimensions of force times distance, which is $[MLT^{-2}] \cdot [L] = [ML^2T^{-2}]$.
Step 4: Determine the dimensions of frequency. Frequency is the reciprocal of time period, so its dimensions are $[T^{-1}]$.
Step 5: Substitute the dimensions of energy and frequency into the expression for h:

$$[h] = \frac{[ML^2T^{-2}]}{[T^{-1}]}$$

Step 6: Simplify the expression:

$$[h] = [ML^2T^{-2} \cdot T^1] = [ML^2T^{-1}]$$

Alternatively, we can consider the angular momentum of an electron in a Bohr orbit. The quantized condition for angular momentum is $L = n\frac{h}{2\pi}$, where L is angular momentum and n is an integer. The dimensions of angular momentum are $[ML^2T^{-1}]$. Therefore, the dimensions of h are also $[ML^2T^{-1}]$.

Final Answer: $\boxed{ML^2T^{-1}}$

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: The resistance of a wire is a measure of its opposition to the flow of electric current. It depends on the material of the wire (resistivity), its length, and its cross-sectional area. Temperature also affects the resistance of most materials.

Solution: Step 1: Recall the formula for the resistance (R) of a wire:

$$R = \rho \frac{L}{A}$$

where ρ is the resistivity of the material, L is the length of the wire, and A is the cross-sectional area of the wire.

Step 2: Analyze how changes in the given options affect the resistance based on this formula and the properties of materials.
- Length increases: From the formula, resistance is directly proportional to length ($R \propto L$). If the length increases, the resistance increases.
- Area increases: From the formula, resistance is inversely proportional to the cross-sectional area ($R \propto \frac{1}{A}$). If the area increases, the resistance decreases.
- Temperature decreases: For most conductors, resistivity increases with temperature. Therefore, if the temperature decreases, the resistivity decreases, and hence the resistance decreases.
- Material changes: Resistivity (ρ) is a property of the material. Different materials have different resistivities. Changing the material can significantly change the resistance.

Step 3: Based on the analysis, the resistance of a wire increases when its length increases.

Final Answer: Length increases

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: The lens formula is a fundamental equation in optics that describes the relationship between the focal length of a lens and the distances of the object and its image from the lens.

Solution: Step 1: Recall the lens formula, which relates the focal length (f) of a lens to the object distance (u) and the image distance (v). The formula is:

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

where u is the distance of the object from the optical center of the lens, v is the distance of the image from the optical center of the lens, and f is the focal length of the lens. By convention, distances are measured from the optical center, with distances in the direction of incident light usually taken as positive.

Step 2: Examine the given options to see which one represents the quantities involved in the lens formula.
- Option A: u, v, f directly correspond to the variables in the lens formula.
- Option B: u, v, R involves the radius of curvature (R), which is related to focal length ($f = R/2$ for a spherical lens) but is not directly part of the primary lens formula.
- Option C: f, R, n involves focal length, radius of curvature, and refractive index (n), which are properties of the lens, but the formula itself relates object distance, image distance, and focal length.
- Option D: Power, resistance. Power of a lens is related to its focal length ($P = 1/f$), but resistance is a property related to electrical circuits, not optical lenses.

Step 3: Conclude that the lens formula relates the object distance (u), image distance (v), and focal length (f).

Final Answer: $\boxed{u, v, f}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Electric flux is a measure of the electric field passing through a given surface. Gauss's Law provides a fundamental relationship between the electric flux through a closed surface and the net electric charge enclosed within that surface.

Solution: Step 1: Recall the definition of electric flux (Φ_E). It is the measure of the total electric field lines passing through a surface. For a closed surface, it is given by the surface integral of the electric field:

$$\Phi_E = \oint_S \vec{E} \cdot d\vec{A}$$

Step 2: Recall Gauss's Law for electrostatics. This law states that the total electric flux through any closed surface is directly proportional to the net electric charge enclosed within that surface.

$$\Phi_E = \frac{Q_{enc}}{\epsilon_0}$$

where Q_{enc} is the net electric charge enclosed by the surface S, and ϵ_0 is the permittivity of free space.

Step 3: Analyze the formula. The equation clearly shows that the electric flux through a closed surface is directly determined by the net charge enclosed (Q_{enc}) within that surface and the permittivity of the medium (ϵ_0). If the enclosed charge changes, the flux changes proportionally.

Step 4: Consider the options. The flux depends fundamentally on the charge enclosed. While the electric field $\vec{E}$ and the area element $d\vec{A}$ are part of the integral defining flux, for a closed surface, the *total* flux is determined by the enclosed charge.

Final Answer: Charge enclosed

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: The power factor in an AC circuit is the cosine of the phase difference between the voltage and current. It represents the ratio of the real power (dissipated by the circuit) to the apparent power (total power delivered).

Solution: Step 1: Recall the definition of the power factor ($\cos\phi$), where ϕ is the phase difference between the voltage and current in an AC circuit.
Step 2: The power factor is given by $\cos\phi$. We want to find when the power factor is maximum.
Step 3: The cosine function has a maximum value of 1.
Step 4: The cosine function reaches its maximum value of 1 when its argument is $0°$ (or 0 radians).
Step 5: Therefore, the power factor is maximum when the phase difference (ϕ) between the voltage and current is $0°$. This occurs in a purely resistive circuit.

Step 6: Consider the options:
- $0°$: $\cos(0°) = 1$, which is the maximum value.
- $90°$: $\cos(90°) = 0$, which is the minimum value.
- Resistance is zero: If resistance is zero, and there is inductance or capacitance, there will be a phase difference. A circuit with only resistance has a phase difference of $0°$.
- Inductance infinite: Infinite inductance would lead to infinite impedance, and depending on other components, a large phase difference.

Final Answer: $\boxed{0°}$

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept: The De Broglie wavelength (λ) is associated with any moving particle and is given by the formula $\lambda = \frac{h}{p}$, where h is Planck's constant and p is the momentum of the particle. Momentum is also related to mass and velocity ($p = mv$).

Solution: Step 1: Write down the De Broglie wavelength formula:

$$\lambda = \frac{h}{p}$$

where λ is the De Broglie wavelength, h is Planck's constant, and p is the momentum of the particle.

Step 2: Express momentum in terms of mass (m) and velocity (v):

$$p = mv$$

So, the De Broglie wavelength can also be written as:

$$\lambda = \frac{h}{mv}$$

Step 3: Analyze how changes in momentum, velocity, mass, or energy affect the De Broglie wavelength.
- Momentum decreases: From $\lambda = \frac{h}{p}$, if momentum p decreases, the wavelength λ increases (since h is a constant).
- Velocity increases: From $\lambda = \frac{h}{mv}$, if velocity v increases, and mass m remains constant, the momentum mv increases, and thus the wavelength λ decreases.
- Mass increases: From $\lambda = \frac{h}{mv}$, if mass m increases, and velocity v remains constant, the momentum mv increases, and thus the wavelength λ decreases.
- Energy increases: The kinetic energy KE of a particle is given by $KE = \frac{1}{2}mv^2 = \frac{p^2}{2m}$. So, $p = \sqrt{2mKE}$. If energy increases, momentum increases, and thus wavelength decreases.

Step 4: The question asks when the De Broglie wavelength increases. This happens when the momentum of the particle decreases.

Final Answer: Momentum decreases

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: The Bohr model of the atom introduced the concept of quantization for certain properties of electrons orbiting the nucleus. Specifically, Bohr postulated that electrons can only occupy specific orbits with quantized energy levels, and this quantization is related to their angular momentum.

Solution: Step 1: Recall the postulates of the Bohr model for the hydrogen atom. One of the key postulates is that electrons orbit the nucleus in certain stable orbits without radiating energy.
Step 2: Bohr further postulated that the angular momentum of an electron in a stable orbit is quantized. This means that the angular momentum can only take on discrete values, which are integer multiples of $\frac{h}{2\pi}$, where h is Planck's constant. Mathematically, this is expressed as:

$$L = mvr = n\frac{h}{2\pi}$$

where L is the angular momentum, m is the mass of the electron, v is its velocity, r is the radius of the orbit, and n is a positive integer (the principal quantum number).

Step 3: This quantization of angular momentum leads to quantized energy levels and radii for the electron orbits. However, the fundamental quantization introduced by Bohr directly applies to the angular momentum.

Step 4: Therefore, the Bohr model quantization applies directly to angular momentum.

Final Answer: Angular momentum

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept: Nuclear binding energy is the energy required to disassemble an atomic nucleus into its constituent protons and neutrons. It is related to the mass defect, which is the difference between the sum of the masses of the individual nucleons and the actual mass of the nucleus.

Solution: Step 1: Understand the concept of nuclear binding energy. This energy is released when nucleons (protons and neutrons) combine to form a nucleus, or equivalently, it is the energy required to separate the nucleons.
Step 2: Recall Einstein's mass-energy equivalence principle, $E = mc^2$. This principle states that mass and energy are interconvertible.
Step 3: Define mass defect (Δm). When protons and neutrons combine to form a nucleus, the total mass of the resulting nucleus is slightly less than the sum of the masses of the individual, unbound protons and neutrons. This difference in mass is called the mass defect.

$$\Delta m = (Zm_p + Nm_n) - M_{nucleus}$$

where Z is the number of protons, m_p is the mass of a proton, N is the number of neutrons, m_n is the mass of a neutron, and $M_{nucleus}$ is the actual mass of the nucleus.
Step 4: Relate mass defect to binding energy. The mass defect is converted into binding energy according to Einstein's equation. Therefore, the nuclear binding energy (E_b) is given by:

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

Step 5: Consider the other options.
- Charge: While protons are charged, the binding energy is not directly dependent on the total charge of the nucleus but rather on the forces (strong nuclear force and electrostatic repulsion) and the resulting mass difference.
- Volume: The volume of the nucleus is roughly proportional to the number of nucleons (A), and binding energy per nucleon shows a trend with A, but binding energy itself is not directly proportional to volume.
- Spin only: Spin is a quantum property, but it is not the primary factor determining nuclear binding energy, although it can play a role in nuclear structure.

Step 6: Conclude that nuclear binding energy is directly dependent on the mass defect.

Final Answer: Mass defect

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: The Doppler effect is the change in frequency (or wavelength) of a wave in relation to an observer who is moving relative to the wave source. It is a general phenomenon observed in all types of waves.

Solution: Step 1: Define the Doppler effect. The Doppler effect is the observed change in frequency of a wave due to the relative motion between the source of the wave and the observer.
Step 2: Consider the types of waves mentioned.
- Sound waves: The Doppler effect is famously observed with sound waves. For example, the pitch of a siren from an ambulance changes as it approaches and then moves away.
- Light waves: The Doppler effect is also observed with light waves. This is used in astronomy to determine the motion of stars and galaxies (redshift and blueshift) and in applications like radar and lidar.

Step 3: Since the Doppler effect applies to both sound waves and light waves (and indeed to all types of waves, including water waves and electromagnetic waves), it is applicable for both.

Final Answer: Both

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Capacitance is a property of a capacitor that quantifies its ability to store electric charge. For a parallel-plate capacitor, the capacitance is determined by its physical characteristics: the area of its plates, the distance between them, and the nature of the dielectric material separating them.

Solution: Step 1: Recall the formula for the capacitance (C) of a parallel-plate capacitor:

$$C = \frac{\epsilon A}{d}$$

where:
- A is the area of each plate.
- d is the distance between the plates.
- ϵ is the permittivity of the dielectric material between the plates ($\epsilon = \epsilon_r \epsilon_0$).

Step 2: Analyze the formula to understand the dependencies of capacitance.
- Area of plates (A): Capacitance is directly proportional to the area of the plates ($C \propto A$). A larger plate area allows for more charge to be stored at a given voltage.
- Distance between plates (d): Capacitance is inversely proportional to the distance between the plates ($C \propto \frac{1}{d}$). A smaller separation between the plates leads to a stronger electric field for a given charge, thus allowing more charge to be stored for a given voltage.
- Dielectric constant (ϵ_r): Inserting a dielectric material between the plates increases the permittivity (ϵ) and thus the capacitance ($C \propto \epsilon$).

Step 3: Based on the formula, capacitance increases if the distance between the plates decreases. It also increases if a dielectric with a higher permittivity (dielectric constant) is inserted or if the area of the plates increases.

Final Answer: Distance decreases

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: The torque experienced by an electric dipole placed in a uniform external electric field is given by the formula $\vec{\tau} = \vec{p} \times \vec{E}$, where $\vec{p}$ is the electric dipole moment and $\vec{E}$ is the electric field. The magnitude of the torque is $\tau = pE\sin\theta$, where θ is the angle between $\vec{p}$ and $\vec{E}$.

Solution: Step 1: Recall the formula for the torque ($\vec{\tau}$) on an electric dipole in a uniform electric field ($\vec{E}$). The torque is given by the vector product of the dipole moment ($\vec{p}$) and the electric field:

$$\vec{\tau} = \vec{p} \times \vec{E}$$

Step 2: Determine the magnitude of the torque. The magnitude of the torque is given by:

$$\tau = |\vec{p}||\vec{E}|\sin\theta = pE\sin\theta$$

where θ is the angle between the electric dipole moment vector $\vec{p}$ and the electric field vector $\vec{E}$.

Step 3: To find when the torque is maximum, we need to find the value of $\sin\theta$ that maximizes the expression for τ. The sine function has a maximum value of 1.
Step 4: The maximum value of $\sin\theta$ is 1, which occurs when $\theta = 90^\circ$ (or $\pi/2$ radians).
Step 5: Therefore, the torque on a dipole is maximum when the angle between the dipole moment and the electric field is 90°.

Final Answer: $\boxed{90^\circ}$

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: The speed of a wave is a characteristic property of the wave itself and depends on the medium through which it propagates. Properties like frequency, amplitude, and phase are related to the wave but do not determine its speed.

Solution: Step 1: Understand what wave speed represents. Wave speed is the distance a wave crest (or any point of the wave) travels per unit time.
Step 2: Consider the factors that influence wave speed.
- Medium: The properties of the medium (e.g., tension in a string, density and elasticity of a gas or liquid, dielectric constant and magnetic permeability of a vacuum for electromagnetic waves) determine how quickly disturbances propagate. For example, sound travels faster in solids than in liquids, and faster in liquids than in gases. Light travels at different speeds in different transparent materials.
- Frequency: Frequency is the number of waves passing a point per unit time. While frequency and wavelength are related to speed by $v = f\lambda$, the frequency itself does not determine the speed. The speed is a property of the medium, and for a given medium, as frequency changes, wavelength changes inversely to keep speed constant (for non-dispersive media).
- Amplitude: Amplitude is the maximum displacement or intensity of the wave. For most types of waves, the speed is independent of amplitude, especially for small amplitudes.
- Phase: Phase describes the position of a point within a wave cycle. It does not affect the speed at which the wave propagates.

Step 3: Conclude that wave speed depends primarily on the properties of the medium through which it is traveling.

Final Answer: Medium

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: A transformer is an electrical device that transfers electrical energy from one alternating-current circuit to another through electromagnetic induction. It is used to increase or decrease the voltage of an AC supply.

Solution: Step 1: Recall the function of a transformer. A transformer is used to change the voltage of an alternating current (AC) supply.
Step 2: Understand the working principle of a transformer. A transformer consists of two or more coils of wire wrapped around a common iron core. When an alternating voltage is applied to the primary coil, it produces a continuously changing magnetic flux in the iron core. This changing magnetic flux passes through the secondary coil.
Step 3: According to Faraday's law of electromagnetic induction, a changing magnetic flux through a coil induces an electromotive force (EMF) in that coil. Since the magnetic flux is continuously changing due to the AC supply in the primary coil, an alternating EMF is induced in the secondary coil.
Step 4: This phenomenon, where a changing current in one coil induces a current in a nearby coil due to the changing magnetic field, is known as mutual induction.
Step 5: Consider the other options.
- Electrostatics: Deals with stationary electric charges and fields.
- Thermodynamics: Deals with heat and its relation to other forms of energy.
- Photoelectric effect: Deals with the emission of electrons when light strikes a surface.

These principles are not the basis for transformer operation.

Step 6: Therefore, a transformer works on the principle of mutual induction.

Final Answer: Mutual induction

Answer: (A)

Go Back to Question 19

Q20.

Solution

Concept: Drift velocity is the average velocity attained by charged particles in a material due to an electric field. It is related to the applied electric field, the charge of the particles, and the mobility of the charge carriers.

Solution: Step 1: Understand the concept of drift velocity. When an electric field is applied across a conductor, free charge carriers (like electrons in metals) experience a force and move in a directed manner, superimposed on their random thermal motion. The average velocity of this directed motion is called drift velocity.

Step 2: Recall the formula for drift velocity (v_d). For electrons in a conductor, the drift velocity is given by:

$$v_d = \frac{qE\tau}{m}$$

where:

- q is the charge of the charge carrier (for electrons, $q = -e$).
- E is the magnitude of the applied electric field.
- τ is the average time between collisions of the charge carrier with the atoms of the conductor (relaxation time).
- m is the mass of the charge carrier.

Step 3: Analyze the formula to see what drift velocity is proportional to.
From the formula, v_d is directly proportional to the electric field E, provided that q, τ, and m are constant.

$$v_d \propto E$$

Step 4: Consider how other factors relate.

- Resistance: Resistance (R) is related to drift velocity through $I = nAqv_d$, and $V = IR$. So, $V = nAqv_dR$. Since $E = V/L$, $E \propto IR$. Thus, $v_d \propto IR/L$. Resistance is not directly proportional to drift velocity itself.
- Frequency: Frequency is not directly involved in the definition of drift velocity in a DC electric field.
- Mass: Drift velocity is inversely proportional to the mass of the charge carrier.

Step 5: Therefore, drift velocity is proportional to the electric field.

Final Answer: Electric field

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: Kirchhoff's laws are fundamental rules used to analyze electric circuits. They are based on the conservation of charge and conservation of energy.

Solution: Step 1: Understand Kirchhoff's laws. There are two main Kirchhoff's laws for analyzing electrical circuits:
- Kirchhoff's Current Law (KCL), also known as Kirchhoff's junction rule.
- Kirchhoff's Voltage Law (KVL), also known as Kirchhoff's loop rule.

Step 2: Describe Kirchhoff's Current Law (KCL). KCL states that the algebraic sum of currents entering any junction (or node) in an electric circuit is equal to the algebraic sum of currents leaving that junction. This is a statement of the conservation of electric charge.

Step 3: Describe Kirchhoff's Voltage Law (KVL). KVL states that the algebraic sum of the potential differences (voltages) around any closed loop or mesh in an electric circuit is zero. This is a statement of the conservation of energy.

Step 4: Consider Ohm's Law. Ohm's law ($V = IR$) relates voltage, current, and resistance for a simple resistive element. While Ohm's law is used in conjunction with Kirchhoff's laws to solve circuit problems, it is not one of Kirchhoff's laws itself. Kirchhoff's laws are more general and can be applied to circuits that include non-ohmic components or when analyzing complex networks.

Step 5: Consider Faraday's Law of Induction. Faraday's law describes how a changing magnetic field induces an electromotive force (EMF) in a conductor. This is a principle of electromagnetic induction and is relevant to circuits with inductors or changing magnetic fields, but it is not one of Kirchhoff's circuit laws.

Step 6: Conclude that Kirchhoff's laws include KCL and KVL.

Final Answer: $\boxed{\text{KCL and KVL}}$

Answer: (AB)

Go Back to Question 21

Q22.

Solution

Concept: Faraday's Law of Electromagnetic Induction describes the phenomenon where a voltage (or EMF) is induced in a conductor when it is exposed to a changing magnetic field. The magnitude of the induced EMF is directly proportional to the rate of change of magnetic flux.

Solution: Step 1: Recall Faraday's Law of Electromagnetic Induction. This law quantifies the induced electromotive force (EMF) in any closed circuit.
Step 2: State Faraday's Law mathematically. The magnitude of the induced EMF ($\mathcal{E}$) in a circuit is equal to the negative of the rate of change of magnetic flux (Φ_B) through the circuit:

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

The negative sign indicates the direction of the induced EMF, as given by Lenz's Law, which opposes the change in magnetic flux.

Step 3: Define magnetic flux (Φ_B). Magnetic flux is a measure of the total magnetic field passing through a given area. It is typically calculated as the integral of the magnetic field over the surface: $\Phi_B = \int \vec{B} \cdot d\vec{A}$.

Step 4: Analyze the formula. The induced EMF is directly proportional to the rate at which the magnetic flux changes with respect to time (dt). A faster change in flux leads to a larger induced EMF.
Step 5: Consider the other options.
- Flux only: While flux is involved, it is the change in flux that induces EMF. A constant flux does not induce an EMF.
- Resistance: Resistance affects the current that flows due to the induced EMF (according to Ohm's Law, $I = \mathcal{E}/R$), but it does not determine the magnitude of the induced EMF itself.
- Current: Current is a consequence of the induced EMF (if a closed circuit exists), not a cause of the induced EMF in this context (unless the current is changing and creating a changing magnetic field, which is a different scenario leading to self-induction).

Step 6: Conclude that the induced EMF depends on the rate of change of flux.

Final Answer: Rate of change of flux

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept: The gravitational field inside a uniform spherical Earth is not uniform. It varies linearly with the distance from the center of the Earth. At the center, the gravitational field is zero.

Solution: Step 1: Consider the Earth as a uniform solid sphere of mass M and radius R.
Step 2: For a point inside a uniform spherical shell, the gravitational field due to the shell at any point inside it is zero. This principle can be extended to a solid sphere by considering it as a collection of concentric spherical shells.
Step 3: To find the gravitational field at a distance r from the center of the Earth, where $r < R$, we consider the mass enclosed within a sphere of radius r. Let the density of the Earth be ρ. The mass of the Earth is $M = \frac{4}{3}\pi R^3\rho$. The mass enclosed within a sphere of radius r is $M_r = \frac{4}{3}\pi r^3\rho$.
Step 4: The gravitational field at a distance r from the center is given by:

$$g(r) = \frac{GM_r}{r^2}$$

Substitute $M_r = \frac{4}{3}\pi r^3\rho$:

$$g(r) = \frac{G(\frac{4}{3}\pi r^3\rho)}{r^2} = \frac{4}{3}\pi G\rho r$$

Step 5: This formula shows that the gravitational field $g(r)$ is directly proportional to the distance r from the center.
Step 6: At the center of the Earth, $r = 0$. Substituting $r = 0$ into the formula gives $g(0) = \frac{4}{3}\pi G\rho(0) = 0$.
Step 7: At the surface of the Earth, $r = R$, the gravitational field is $g(R) = \frac{4}{3}\pi G\rho R = \frac{G(\frac{4}{3}\pi R^3\rho)}{R^2} = \frac{GM}{R^2}$, which is the standard surface gravity.
Step 8: Since the gravitational field is proportional to r inside the Earth, it increases linearly from zero at the center to $g(R)$ at the surface. It is zero at the center and maximum at the surface (assuming uniform density). Therefore, the gravitational field is zero at the center.

Final Answer: Zero at center

Answer: (A)

Go Back to Question 23

Q24.

Solution

Concept: The orbital speed of a satellite in a circular orbit around a celestial body is determined by the gravitational force providing the centripetal force. This speed depends on the mass of the central body and the radius of the orbit.

Solution: Step 1: For a satellite of mass m in a circular orbit of radius r around a celestial body of mass M, the gravitational force provides the centripetal force required for the orbit.
Step 2: Equating the gravitational force and the centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

where G is the gravitational constant and v is the orbital speed.

Step 3: Solving for v, we get:

$$v^2 = \frac{GM}{r} \implies v = \sqrt{\frac{GM}{r}}$$

Step 4: Analyze the formula for v. The orbital speed depends on G (a constant), the mass of the central body (M), and the radius of the orbit (r). It does not depend on the mass of the satellite (m), time period, or temperature.

Final Answer: Radius

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: The energy stored in a capacitor is equal to the work done in charging it. This work is stored as potential energy in the electric field between the capacitor plates.

Solution: Step 1: The work done (W) in charging a capacitor with capacitance C to a voltage V can be calculated by integrating the incremental work. If q is the charge on the capacitor at some instant and $v = q/C$ is the instantaneous voltage, the work done to move an additional charge dq is $dW = v\,dq = \frac{q}{C}\,dq$.
Step 2: Integrating from zero charge to final charge Q:

$$W = \int_0^Q \frac{q}{C}\,dq = \frac{1}{C}\left[\frac{q^2}{2}\right]_0^Q = \frac{Q^2}{2C}$$

Step 3: Using the relationship $Q = CV$, this energy can be expressed in terms of C and V:

$$W = \frac{(CV)^2}{2C} = \frac{C^2V^2}{2C} = \frac{1}{2}CV^2$$

Final Answer: $\boxed{\frac{1}{2}CV^2}$

Answer: (A)

Go Back to Question 25

Q26.

Solution

Concept: The radius of an atomic nucleus is empirically found to be approximately proportional to the cube root of the mass number (A).

Solution: Step 1: Recall the experimental observations regarding the size of atomic nuclei. Experiments using scattering of charged particles (like alpha particles) have shown that the nucleus is very small and dense.
Step 2: The radius (R) of a nucleus is found to be approximately related to its mass number (A) by the formula:

$$R \approx R_0 A^{1/3}$$

where R_0 is an empirical constant, approximately 1.2×10^{-15} meters (or 1.2 femtometers).
Step 3: The mass number (A) is the total number of protons and neutrons in the nucleus.
Step 4: Analyze the options:
- $A^{1/3}$: This directly matches the empirical formula for the radius of a nucleus.
- A: If the radius were proportional to A, the nuclei would grow much faster than observed.
- Z: Z is the atomic number (number of protons). While protons contribute to the mass and size, the radius depends on the total number of nucleons (A), not just protons.
- $1/A$: This would imply that larger nuclei are smaller, which is contrary to observations.

Step 5: Conclude that the radius of a nucleus is proportional to $A^{1/3}$.

Final Answer: $\boxed{A^{1/3}}$

Answer: (A)

Go Back to Question 26

Q27.

Solution

Concept: In Young's Double Slit Experiment (YDSE), the fringe width (or fringe spacing) is the distance between the centers of two consecutive bright fringes or two consecutive dark fringes on the screen. It is a measure of how spread out the interference pattern is.

Solution: Step 1: Recall the formula for the fringe width (β) in Young's Double Slit Experiment:

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

where:
- λ is the wavelength of the monochromatic light used.
- D is the distance between the slits and the screen.
- d is the distance between the two slits.

Step 2: Analyze the formula to determine the factors on which the fringe width depends.
- Wavelength (λ): The fringe width is directly proportional to the wavelength of light ($\beta \propto \lambda$). Therefore, using light of longer wavelengths (like red light) will result in wider fringes compared to shorter wavelengths (like blue light).
- Slit separation (d): The fringe width is inversely proportional to the distance between the slits ($\beta \propto \frac{1}{d}$). If the slits are closer together, the fringes will be wider.
- Screen distance (D): The fringe width is directly proportional to the distance between the slits and the screen ($\beta \propto D$). Moving the screen further away from the slits will result in wider fringes.

Step 3: Consider the option "Intensity". The intensity of the light source affects the brightness of the interference pattern but does not change the width of the fringes.

Step 4: Based on the formula, the fringe width depends on the wavelength of light, the slit separation, and the screen distance.

Final Answer: Wavelength

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: Coulomb's Law describes the electrostatic force between two point charges. The law is fundamental and its validity is based on experimental observations. It is applicable in various media, but the force is modified by the properties of the medium.

Solution: Step 1: Recall Coulomb's Law, which states that the force (F) between two point charges (q_1 and q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them. In vacuum, the formula is:

$$F = k\frac{|q_1 q_2|}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$$

where ϵ_0 is the permittivity of free space.

Step 2: Consider the applicability of Coulomb's Law in different situations. - Vacuum: Coulomb's Law is the fundamental form applicable in vacuum. - Medium: When the charges are placed in a medium other than vacuum, the force is reduced by a factor equal to the relative permittivity (dielectric constant) of the medium, ϵ_r. The force in a medium is:

$$F_{medium} = \frac{1}{4\pi\epsilon_0\epsilon_r}\frac{|q_1 q_2|}{r^2} = \frac{1}{4\pi\epsilon}\frac{|q_1 q_2|}{r^2}$$

Here, $\epsilon = \epsilon_r\epsilon_0$ is the permittivity of the medium. So, Coulomb's Law is still valid, but the constant changes. - Plasma: Plasma is an ionized gas, a medium containing free ions and electrons. Coulomb's Law is the basis for understanding the interactions in plasmas, although collective effects become important. - Only air: Air is a medium with a relative permittivity very close to that of vacuum ($\epsilon_r \approx 1$), so Coulomb's law in vacuum is a good approximation for air. However, the law itself is not restricted *only* to air.

Step 3: The question asks where Coulomb's law is valid. It is fundamentally valid in vacuum and can be adapted for other media. Therefore, it is valid in vacuum, and its form is modified in a medium. The most fundamental statement of the law is for vacuum. However, the law's principle applies even in a medium.

Let's re-evaluate the options to find the *most* appropriate answer. If the law is valid in vacuum, and its form is adapted for a medium, it means the law itself is generally applicable.

If the question implies "In what situation is the fundamental form of Coulomb's law stated?", then vacuum is the answer. If it implies "In what situation are the principles of Coulomb's law applicable?", then it's broader.

Given the options, "Vacuum" is the most direct and fundamental situation where Coulomb's law is stated in its simplest form. While it's applicable in other media with modifications, the "law" as typically presented and understood in its most basic form is for vacuum.

Final Answer: Vacuum

Answer: (A)

Go Back to Question 28

Q29.

Solution

Concept: A diode is a semiconductor device that essentially acts as a one-way switch for electric current. It allows current to flow primarily in one direction.

Solution: Step 1: Understand the basic structure and function of a diode. A diode is typically made of a P-N junction.
Step 2: Consider the behavior of a diode when a voltage is applied across it.
- Forward Bias: When a positive voltage is applied to the P-side and a negative voltage to the N-side (relative to each other), the diode is forward-biased. This reduces the depletion region, and current flows easily through the diode.
- Reverse Bias: When a negative voltage is applied to the P-side and a positive voltage to the N-side, the diode is reverse-biased. This widens the depletion region, and very little current flows through the diode (ideally zero, but in reality, a small leakage current exists).
Step 3: Based on this behavior, the current can flow predominantly in one direction (forward bias) but is blocked in the other direction (reverse bias). Therefore, the current in a diode is unidirectional.

Step 4: Analyze the options:
- Unidirectional: This means flowing in one direction, which accurately describes a diode's behavior.
- Bidirectional: This means flowing in both directions, like a resistor.
- Alternating: This implies a current that periodically reverses direction, like AC current.
- Always zero: This would imply no current flows, which is not generally true for a diode when properly biased.

Final Answer: Unidirectional

Answer: (A)

Go Back to Question 29

Q30.

Solution

Concept: Huygens' principle is a geometrical method for determining the shape of a wavefront at any given time based on its shape at an earlier time. It states that every point on a wavefront can be considered as a source of secondary spherical wavelets, and the new wavefront is the envelope of these wavelets.

Solution: Step 1: Understand Huygens' principle. It provides a way to understand wave propagation and derive the laws of reflection, refraction, and diffraction.
Step 2: How Huygens' principle explains reflection: By considering secondary wavelets emanating from points on an incident wavefront, and drawing an envelope, one can derive the law of reflection ($\theta_i = \theta_r$).
Step 3: How Huygens' principle explains refraction: When a wavefront passes from one medium to another where the wave speed is different, the secondary wavelets travel at different speeds in the two media. By drawing the envelope of these wavelets, the law of refraction (Snell's Law) can be derived.
Step 4: How Huygens' principle explains diffraction: Diffraction is the bending of waves as they pass through an opening or around an obstacle. Huygens' principle naturally explains this bending by considering each point on the wavefront that passes through an aperture as a source of new wavelets, which then spread out in new directions.
Step 5: Since Huygens' principle can be used to derive the laws governing reflection, refraction, and diffraction, it explains all of these phenomena.

Final Answer: All of these

Answer: (D)

Go Back to Question 30

Q31.

Solution

Concept: In quantum mechanics, specifically in the Bohr model of the atom, angular momentum is quantized, meaning it can only take on discrete values. This quantization is expressed as an integer multiple of a fundamental constant related to Planck's constant.

Solution: Step 1: Recall the Bohr model's postulates concerning angular momentum. Bohr proposed that electrons in atoms orbit the nucleus in specific allowed orbits, and in these orbits, the angular momentum is quantized.
Step 2: The condition for quantization of angular momentum in the Bohr model is given by:

$$L = n\frac{h}{2\pi}$$

where:
- L is the angular momentum of the electron.
- n is the principal quantum number, which can be any positive integer ($n = 1, 2, 3, \ldots$).
- h is Planck's constant.
- $\frac{h}{2\pi}$ is often denoted by $\hbar$ (h-bar), known as the reduced Planck constant.

Step 3: Therefore, the quantized angular momentum is given by $L = n\hbar$.

Step 4: Examine the options:
- $n\hbar$: This matches the formula $n\frac{h}{2\pi}$.
- nh^2: This is incorrect; it involves h^2 instead of h and the wrong factor.
- $\hbar/n$: This is inversely related and incorrect.
- constant: While $n\hbar$ is a constant for a specific orbit (fixed n), the statement is about *quantization*, meaning it takes specific discrete values, not a single constant value.

Final Answer: $\boxed{n\hbar}$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: Power dissipation in a resistor is the rate at which electrical energy is converted into heat energy. It can be expressed in several forms using Ohm's law and the definition of power.

Solution: Step 1: Recall the definition of electrical power (P). Power is the rate at which energy is transferred or dissipated. It is given by the product of voltage (V) and current (I):

$$P = VI$$

Step 2: Apply Ohm's Law, which states that for a resistor, the voltage across it is proportional to the current through it: $V = IR$.
Step 3: Substitute Ohm's Law into the power formula to derive different expressions for power dissipation in a resistor.
- Substitute $V = IR$ into $P = VI$:

$$P = (IR)I = I^2R$$

This formula expresses power dissipation in terms of current and resistance.
- Substitute $I = V/R$ into $P = VI$:

$$P = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$$

This formula expresses power dissipation in terms of voltage and resistance.

Step 4: Examine the given options:
- I^2R: This is one of the correct formulas for power dissipated in a resistor.
- IR: This is the formula for voltage drop across a resistor, not power.
- V/R: This is the formula for current through a resistor (from Ohm's Law), not power.
- V^2R: This is incorrect; the correct formula is V^2/R.

Step 5: Conclude that the power dissipated in a resistor is I^2R.

Final Answer: $\boxed{I^2R}$

Answer: (A)

Go Back to Question 32

Q33.

Solution

Concept: Lenz's Law states that the direction of an induced current in a conductor by a changing magnetic field is such that it opposes the change in magnetic flux that produced it. This opposition to change is a consequence of the conservation of energy.

Solution: Step 1: Understand Lenz's Law. It dictates the direction of induced current in electromagnetic induction.
Step 2: Consider what would happen if Lenz's Law were violated. If the induced current reinforced the change in magnetic flux, it would lead to an ever-increasing magnetic flux and hence an ever-increasing induced current and EMF, which would mean generating energy from nothing. This would violate the principle of energy conservation.
Step 3: For instance, if a magnet is moved towards a coil, an induced current flows such that it creates a magnetic field opposing the motion of the magnet (like poles repel). Work must be done against this repulsive force to move the magnet and induce the current. This work done is converted into electrical energy in the coil. If the induced current aided the motion, no external work would be needed to generate energy, which is impossible.
Step 4: Therefore, Lenz's Law is a direct manifestation of the law of conservation of energy.

Final Answer: Energy conservation

Answer: (A)

Go Back to Question 33

Q34.

Solution

Concept: The critical angle is the angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90°. It is determined by the refractive indices of the two media involved.

Solution: Step 1: Define the critical angle (θ_c). It is the angle of incidence in the optically denser medium for which the angle of refraction in the optically rarer medium is 90°. This is the condition for total internal reflection.
Step 2: Apply Snell's Law, $n_1 \sin\theta_1 = n_2 \sin\theta_2$, where n_1 is the refractive index of the denser medium, n_2 is the refractive index of the rarer medium, $\theta_1 = \theta_c$, and $\theta_2 = 90°$.
Step 3: Substituting these values:

$$n_1 \sin\theta_c = n_2 \sin(90°)$$

$$n_1 \sin\theta_c = n_2(1)$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

Step 4: The formula shows that the critical angle depends directly on the ratio of the refractive indices of the two media. Therefore, it depends on the refractive index. While wavelength and frequency can influence the refractive index (dispersion), the primary dependence is on the refractive index itself.

Final Answer: Refractive index

Answer: (A)

Go Back to Question 34

Q35.

Solution

Concept: The Root Mean Square (RMS) value of an alternating current (AC) is the effective value that produces the same amount of heat in a resistor as an equivalent DC current. For a sinusoidal AC current, it is related to the peak current.

Solution: Step 1: For a sinusoidal alternating current $I(t) = I_{peak}\sin(\omega t)$, the RMS value ($I_{rms}$) is calculated by taking the square root of the mean of the square of the current over one period.
Step 2: The formula for the RMS value of a sinusoidal current is:

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T [I_{peak}\sin(\omega t)]^2 dt}$$

Step 3: Evaluating this integral yields:

$$I_{rms} = \frac{I_{peak}}{\sqrt{2}}$$

Thus, the RMS value is the peak value divided by the square root of 2.

Final Answer: $\boxed{\text{Peak}/\sqrt{2}}$

Answer: (A)

Go Back to Question 35

Q36.

Solution

Concept: Capacitance is a measure of a capacitor's ability to store electric charge. It depends on the physical construction of the capacitor, specifically the area of the plates, the distance between them, and the properties of the dielectric material separating them.

Solution: Step 1: Recall the formula for the capacitance (C) of a parallel-plate capacitor:

$$C = \frac{\epsilon A}{d}$$

where:
- A is the area of the plates.
- d is the distance between the plates.
- ϵ is the permittivity of the dielectric material between the plates.

Step 2: Analyze the factors affecting capacitance from the formula.
- Area of plates (A): Capacitance is directly proportional to the area of the plates ($C \propto A$). Larger plates can store more charge for a given voltage.
- Distance between plates (d): Capacitance is inversely proportional to the distance between the plates ($C \propto \frac{1}{d}$). A smaller distance allows for a stronger electric field for the same charge, hence more charge can be stored for a given voltage.
- Dielectric constant (which determines permittivity ϵ): The permittivity of the dielectric material is given by $\epsilon = \epsilon_r \epsilon_0$, where ϵ_r is the relative permittivity (dielectric constant) and ϵ_0 is the permittivity of free space. Capacitance is directly proportional to permittivity ($C \propto \epsilon$). Inserting a dielectric material with $\epsilon_r > 1$ increases capacitance.

Step 4: Consider the option "Charge stored". The charge stored (Q) on a capacitor is related to its capacitance (C) and the voltage (V) across it by $Q = CV$. Capacitance is a property of the capacitor itself and does not depend on the amount of charge stored on it. The charge stored *depends* on the capacitance and the applied voltage.

Step 5: Therefore, the factors affecting capacitance include the area of the plates, the distance between the plates, and the dielectric constant (which determines permittivity).

Final Answer: Area of plates, Distance between plates, Dielectric constant

Answer: (A,B,C)

Go Back to Question 36

Q37.

Solution

Concept: In Simple Harmonic Motion (SHM), the acceleration of the oscillating object is always directed towards the equilibrium position and its magnitude is directly proportional to the displacement from that position.

Solution: Step 1: Recall the equation of motion for Simple Harmonic Motion (SHM). For an object undergoing SHM, the restoring force F is proportional to the displacement x from the equilibrium position and is directed opposite to the displacement.

$$F = -kx$$

where k is a constant.
Step 2: Apply Newton's second law of motion, $F = ma$, where m is the mass of the object and a is its acceleration.

$$ma = -kx$$

Step 3: Solve for acceleration:

$$a = -\frac{k}{m}x$$

Step 4: Let $\omega = \sqrt{k/m}$ be the angular frequency of the SHM. Then the equation becomes:

$$a = -\omega^2 x$$

Step 5: This equation shows that the acceleration (a) is directly proportional to the displacement (x) and is in the opposite direction (indicated by the negative sign).
Step 6: Consider the other options.
- Velocity: Acceleration is not directly proportional to velocity in SHM (though velocity changes due to acceleration).
- Angular frequency: Acceleration is proportional to the square of the angular frequency, not directly to the angular frequency itself, and also depends on displacement.
- Amplitude: Amplitude is the maximum displacement, and while it influences the maximum acceleration ($a_{max} = \omega^2 A$), acceleration itself is not directly proportional to amplitude at all times.

Final Answer: Displacement

Answer: (A)

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Q38.

Solution

Concept: The photoelectric effect is the emission of electrons from a material when light shines on it. Experimental observations of this effect led to the development of quantum theory and played a crucial role in establishing the particle nature of light (photons).

Solution: Step 1: Understand the photoelectric effect. It involves the interaction of photons with electrons in a material, leading to the emission of electrons.
Step 2: Recall the key experimental observations of the photoelectric effect:
- Threshold Frequency: For photoemission to occur, the incident light must have a frequency greater than or equal to a certain minimum frequency, called the threshold frequency (f_0). Below this frequency, no electrons are emitted, regardless of the intensity of the light. This implies that energy is quantized and delivered in packets (photons).
- Instant Emission: If the frequency of the incident light is above the threshold frequency, electron emission occurs almost instantaneously, with no measurable time delay, even at very low light intensities. This suggests that energy transfer from light to electrons is an all-or-nothing process involving single photons.
- Dependence on Intensity: The number of emitted electrons (photocurrent) is directly proportional to the intensity of the incident light, provided the frequency is above the threshold. Higher intensity means more photons, leading to more electron emissions.
- Dependence on Frequency: The kinetic energy of the emitted electrons is directly dependent on the frequency of the incident light, not its intensity. Higher frequency light (above threshold) results in emitted electrons with higher kinetic energy. The relationship is given by $KE_{max} = hf - \phi$, where ϕ is the work function of the material.

Step 3: Evaluate the options based on these observations.
- Threshold frequency: This is a primary observation.
- Instant emission: This is another key observation.
- Dependence on intensity: This is an observation (number of electrons, not their energy).
- Dependence on frequency: This is a key observation (kinetic energy of electrons).

Step 4: All the listed observations are indeed characteristic of the photoelectric effect. Therefore, if multiple correct answers are allowed, all A, B, C, and D are correct. Assuming the question expects all correct observations.

Final Answer: All of the above

Answer: (A,B,C,D)

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Q39.

Solution

Concept: Magnetic fields are produced by moving electric charges. This includes electric currents and the motion of individual charged particles. Changing electric fields also create magnetic fields.

Solution: Step 1: According to electromagnetism, magnetic fields are generated by two fundamental sources:
- Moving electric charges: This includes electric currents flowing through wires and the motion of individual charged particles.
- Changing electric fields: A time-varying electric field creates a magnetic field, a concept introduced by Maxwell's equations (displacement current).

Step 2: Evaluate the given options:
- Moving charge: This is a fundamental source of magnetic fields.
- Changing electric field: This is also a fundamental source of magnetic fields.
- Static charge: Static charges produce only electric fields, not magnetic fields.
- Current carrying wire: This is a common and important instance of moving charges, and thus produces a magnetic field.

Step 3: Considering the options, "Moving charge" and "Changing electric field" are the fundamental sources. A "Current carrying wire" is a macroscopic manifestation of moving charges. If this is a single-choice question, and "Moving charge" is an option, it is often considered the most fundamental source. However, "Changing electric field" is also a fundamental source. In many contexts, both are equally valid primary causes. Given the options, "Moving charge" directly represents the cause at the microscopic level.

Final Answer: $\boxed{\text{Moving charge}}$

Answer: (A)

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Q40.

Solution

Concept: An ideal gas is a theoretical gas composed of point particles that interact only through perfectly elastic collisions and have no intermolecular forces. It serves as a simplified model for understanding the behavior of real gases.

Solution: Step 1: Understand the definition of an ideal gas. An ideal gas is a theoretical model used to simplify gas behavior, especially at low pressures and high temperatures.
Step 2: List the key assumptions of the kinetic theory of gases that define an ideal gas:
- The gas consists of a large number of identical molecules, which are in continuous, random motion.
- The volume of the molecules themselves is negligible compared to the total volume occupied by the gas (i.e., molecules are treated as point particles).
- There are no intermolecular forces (attraction or repulsion) between the gas molecules. The molecules only interact during collisions.
- Collisions between molecules and between molecules and the walls of the container are perfectly elastic. This means that kinetic energy and momentum are conserved during collisions.
- The average kinetic energy of the molecules is directly proportional to the absolute temperature of the gas.

Step 3: Evaluate the given options based on these assumptions:
- No intermolecular forces: This is a defining property of an ideal gas.
- Point particles: This is also a defining property (negligible molecular volume).
- Elastic collisions: This is a defining property.
- Variable mass: The mass of the molecules is assumed to be constant; it is not variable.

Step 4: Conclude that the properties of an ideal gas include no intermolecular forces, molecules treated as point particles, and elastic collisions. The question asks for properties, and implies selection of correct ones.

Final Answer: No intermolecular forces, Point particles, Elastic collisions

Answer: (A,B,C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	AC	4	A	5	C
6	A	7	A	8	A	9	A	10	A
11	A	12	A	13	A	14	A	15	C
16	A	17	C	18	A	19	A	20	A
21	AB	22	A	23	A	24	A	25	A
26	A	27	A	28	A	29	A	30	D
31	A	32	A	33	A	34	A	35	A
36	A,B,C	37	A	38	A,B,C,D	39	A	40	A,B,C