MHT-CET Physics Sample Paper-16

Duration: 45 Minutes **Maximum Marks: 50**

Instructions

- This paper contains a total of **50** Multiple Choice Questions.
- Each correct answer carries **+1 marks**.
- No negative marking for incorrect questions.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.
- No marks will be deducted for questions that are left unattempted.

Q1. A body of mass m is rotating in a vertical circle of radius r. The minimum velocity at the lowest point so that it just completes the circle is:

(A) $\sqrt{gr}$

(B) $\sqrt{2gr}$

(C) $\sqrt{3gr}$

(D) $\sqrt{5gr}$

Q2. In a Young's double-slit experiment, the intensity at a point where the path difference is $\lambda/6$ (λ being the wavelength of light) is I. If I_0 denotes the maximum intensity, then I/I_0 is equal to:

(A) $3/4$

(B) $1/2$

(C) $\sqrt{3}/2$

(D) $1/4$

Q3. The ratio of the angular momentum of an electron in the 2^{nd} orbit to that in the 3^{rd} orbit of a hydrogen atom is:

(A) 2 : 3

(B) 3 : 2

(C) 4 : 9

(D) 9 : 4

Q4. A capacitor of capacitance C is charged to a potential V. The flux of the electric field through a closed surface enclosing the capacitor is:

(A) CV/ϵ_0

(B) $2CV/\epsilon_0$

(C) $CV/2\epsilon_0$

(D) Zero

Q5. If the length of a potentiometer wire is increased, then the length of the balancing point for the same cell will:

(A) Increase

(B) Decrease

(C) Remain unchanged

(D) Depend on the internal resistance

Q6. A particle performs S.H.M. with amplitude A. At what distance from the mean position is the kinetic energy equal to the potential energy?

(A) $A/2$

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

(C) $A/\sqrt{3}$

(D) $A/4$

Q7. Which of the following series of transition in the spectrum of hydrogen atom falls in the visible region?

(A) Lyman series

(B) Balmer series

(C) Paschen series

(D) Brackett series

Q8. The efficiency of a Carnot engine working between 227°C and 27°C is:

(A) 40%

(B) 50%

(C) 60%

(D) 30%

Q9. When a p-n junction diode is reverse biased, the thickness of the depletion layer:

(A) Decreases

(B) Increases

(C) Remains the same

(D) Becomes zero

Q10. The wavelength of the first line of the Lyman series is λ. The wavelength of the first line of the Balmer series will be:

(A) $\frac{27}{5}\lambda$

(B) $\frac{5}{27}\lambda$

(C) $\frac{32}{27}\lambda$

(D) $\frac{27}{32}\lambda$

Q11. A thin uniform rod of mass M and length L has a moment of inertia I_1 about an axis passing through its center and perpendicular to its length. Its moment of inertia about an axis passing through one end and perpendicular to its length is I_2. The ratio I_2/I_1 is:

(A) 2

(B) 3

(C) 4

(D) 6

Q12. The magnetic flux linked with a coil is given by $\phi = 5t^2 + 3t + 16$. The induced emf in the coil at $t = 2$ seconds is:

(A) 23 V

(B) 20 V

(C) 10 V

(D) 16 V

Q13. In a transition from state $n = 4$ to $n = 1$ in a Hydrogen atom, the number of spectral lines possible is:

(A) 3

(B) 4

(C) 6

(D) 10

Q14. Two coherent sources of intensity ratio 81 : 1 produce interference fringes. The ratio of maximum to minimum intensity in the interference pattern is:

(A) 9:1

(B) 81:1

(C) 25:16

(D) 100:64

Q15. The work done in blowing a soap bubble of radius R is W. The work done in blowing a bubble of radius $2R$ from the same solution is:

(A) $2W$

(B) $4W$

(C) $8W$

(D) $\sqrt{2}W$

Q16. A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates are now moved farther apart by means of insulating handles:

(A) The capacitance increases

(B) The charge on the capacitor increases

(C) The voltage across the plates increases

(D) The electrostatic energy stored decreases

Q17. If the speed of light in vacuum is c, then the velocity of light in a medium of refractive index 1.5 is:

(A) $1.5c$

(B) $c/1.5$

(C) c

(D) $0.5c$

Q18. In an AC circuit, V and I are given by $V = 100\sin(100t)$ volts and $I = 100\sin(100t + \pi/3)$ mA. The power dissipated in the circuit is:

(A) 10^4 W

(B) 10 W

(C) 2.5 W

(D) 5.0 W

Q19. The threshold wavelength for a metal is 4000 Å. The maximum kinetic energy of photoelectrons emitted by light of 2000 Å will be:

(A) 3.1 eV

(B) 4.2 eV

(C) 6.2 eV

(D) 1.5 eV

Q20. A torque of 100 N-m acting on a wheel at rest produces an angular acceleration of 2 rad/s^2 in 5 seconds. The angular momentum at the end of 5 seconds is:

(A) 500 kg m^2/s

(B) 1000 kg m^2/s

(C) 250 kg m^2/s

(D) 2000 kg m^2/s

Q21. The escape velocity of a body from the earth's surface is v_e. The escape velocity from a planet having twice the radius and same mean density as the earth is:

(A) v_e

(B) $2v_e$

(C) $v_e/2$

(D) $4v_e$

Q22. A wire of resistance R is stretched to twice its original length. Its new resistance will be:

(A) $4R$

(B) $2R$

(C) $R/2$

(D) $R/4$

Q23. The angle of minimum deviation for a prism of refractive index $\sqrt{3}$ is equal to the angle of the prism. The angle of the prism is:

(A) 30°

(B) 45°

(C) 60°

(D) 90°

Q24. Two charges $+q$ and $-q$ are kept at a distance d apart. At a point exactly midway between them:

(A) Electric field is zero

(B) Electric potential is zero

(C) Both field and potential are zero

(D) Neither field nor potential is zero

Q25. In a radioactive sample, the fraction of nuclei left after 5 half-lives is:

(A) $1/5$

(B) $1/10$

(C) $1/32$

(D) $1/25$

Q26. A simple pendulum has a period T_1 on the surface of earth and T_2 when taken to a height R above the earth's surface (R = radius of earth). The ratio T_2/T_1 is:

(A) 1

(B) 2

(C) 4

(D) $\sqrt{2}$

Q27. The molar specific heat of an ideal gas at constant pressure is $C_p = \frac{7}{2}R$. The gas is:

(A) Monatomic

(B) Diatomic

(C) Triatomic

(D) Polyatomic

Q28. The logic gate that provides an output of '1' only when both inputs are '1' is:

(A) OR gate

(B) AND gate

(C) NOR gate

(D) NAND gate

Q29. An electron enters a uniform magnetic field B moving perpendicular to it with velocity v. The radius of its circular path is:

(A) mv/Be

(B) Be/mv

(C) mB/ve

(D) mvB/e

Q30. In a step-up transformer, the turn ratio is $1:20$. If the primary voltage is 110 V, the secondary voltage is:

(A) 2200 V

(B) 5.5 V

(C) 110 V

(D) 440 V

Q31. If the error in the measurement of the radius of a sphere is 2%, the error in the determination of its volume is:

(A) 2%

(B) 4%

(C) 6%

(D) 8%

Q32. The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and eyepiece is 20 cm. The focal length of the objective is:

(A) 18 cm

(B) 15 cm

(C) 10 cm

(D) 2 cm

Q33. A liquid rises to a height of 5 cm in a capillary tube. If the area of cross-section of the tube is reduced to $1/4$ of its original value, the liquid will rise to a height of:

(A) 5 cm

(B) 10 cm

(C) 20 cm

(D) 2.5 cm

Q34. The displacement of a particle is given by $x = 3\sin(2t) + 4\cos(2t)$. The amplitude of the particle is:

(A) 3

(B) 4

(C) 5

(D) 7

Q35. The energy equivalent of 1 amu is approximately:

(A) 931 MeV

(B) 931 keV

(C) 9.31 MeV

(D) 1.6×10^{-19} J

Q36. An ideal gas undergoes isothermal expansion. The change in internal energy is:

(A) Positive

(B) Negative

(C) Zero

(D) Depends on the pressure

Q37. The de Broglie wavelength of an electron accelerated through a potential difference of 100 V is nearly:

(A) 12.27 Å

(B) 1.227 Å

(C) 0.1227 Å

(D) 122.7 Å

Q38. The magnetic moment of a current-carrying loop of area A and current I is:

(A) I/A

(B) IA

(C) I^2A

(D) IA^2

Q39. In a semiconductor, the movement of holes is due to:

(A) Movement of free electrons

(B) Movement of valence electrons

(C) Movement of protons

(D) Movement of ions

Q40. Two sources of sound produce 4 beats per second. If the frequency of one source is 256 Hz, the frequency of the other source could be:

(A) 252 Hz

(B) 260 Hz

(C) Both (A) and (B)

(D) 256 Hz

Q41. A projectile is thrown with an initial velocity of $(\hat{i} + 2\hat{j})$ m/s. The equation of its path is ($g = 10$ m/s^2):

(A) $y = 2x - 5x^2$

(B) $y = x - 5x^2$

(C) $y = 2x - 10x^2$

(D) $y = x - 10x^2$

Q42. The SI unit of luminous intensity is:

(A) Watt

(B) Lux

(C) Candela

(D) Lumen

Q43. A stone is dropped from a height h. It hits the ground with a certain momentum P. If the same stone is dropped from a height 100% more than the previous height, the momentum when it hits the ground will change by:

(A) 68%

(B) 41%

(C) 200%

(D) 100%

Q44. Polarization of light proves the:

(A) Corpuscular nature of light

(B) Quantum nature of light

(C) Transverse wave nature of light

(D) Longitudinal wave nature of light

Q45. The half-life of a radioactive substance is 10 years. Its mean life is:

(A) 14.4 years

(B) 7.2 years

(C) 20 years

(D) 6.93 years

Q46. Which of the following has the highest frequency?

(A) Radio waves

(B) X-rays

(C) Gamma rays

(D) Microwaves

Q47. In a series LCR circuit at resonance, the phase difference between voltage and current is:

(A) 0

(B) $\pi/2$

(C) π

(D) $\pi/4$

Q48. The focal length of a convex lens is 20 cm in air. Its focal length in water ($\mu = 4/3$) will be:

(A) 20 cm

(B) 40 cm

(C) 80 cm

(D) 10 cm

Q49. Surface tension of a liquid decreases with:

(A) Increase in area

(B) Decrease in temperature

(C) Increase in temperature

(D) Increase in density

Q50. The electric potential at a point on the axis of an electric dipole depends on the distance r as:

(A) $1/r$

(B) $1/r^2$

(C) $1/r^3$

(D) r

Detailed Solutions

Q1.

Solution

Concept:
When a body performs vertical circular motion, it must maintain a certain minimum velocity at various points to keep the string taut or maintain contact. At the highest point, the minimum velocity required is $\sqrt{gr}$. By applying the principle of Conservation of Mechanical Energy between the highest point and the lowest point, we can determine the required velocity at the bottom.

Solution:
1. Let v_L be the velocity at the lowest point and v_H be the velocity at the highest point. 2. At the highest point, for the body to just complete the circle, the tension in the string becomes zero ($T = 0$). The centripetal force is provided entirely by weight:

$$\frac{mv_H^2}{r} = mg \implies v_H = \sqrt{gr}$$

3. According to the Law of Conservation of Energy: Total Energy at Lowest Point = Total Energy at Highest Point 4. Taking the lowest point as the reference level for potential energy ($h = 0$):

$$\frac{1}{2}mv_L^2 + 0 = \frac{1}{2}mv_H^2 + mg(2r)$$

5. Substitute $v_H^2 = gr$:

$$\frac{1}{2}mv_L^2 = \frac{1}{2}m(gr) + 2mgr$$

6. Multiplying the entire equation by $2/m$:

$$v_L^2 = gr + 4gr = 5gr$$

7. Therefore, the minimum velocity at the lowest point is:

$$v_L = \sqrt{5gr}$$

Final Answer: The minimum velocity at the lowest point is $\sqrt{5gr}$.

Answer: (D)

Q2.

Solution

Concept:

The resultant intensity I at a point where two waves of equal intensity $I_{max}/4$ interfere is determined by the phase difference ϕ. The relationship between intensity and phase difference is:

$$I = I_0 \cos^2\left(\frac{\phi}{2}\right)$$

where I_0 is the maximum intensity. The phase difference ϕ is related to the path difference Δx by the relation:

$$\phi = \frac{2\pi}{\lambda}\Delta x$$

Solution:

1. Given the path difference $\Delta x = \frac{\lambda}{6}$. 2. Calculate the phase difference ϕ:

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{2\pi}{6} = \frac{\pi}{3}$$

3. Convert $\pi/3$ to degrees: $\phi = 60^\circ$. 4. Use the intensity formula:

$$I = I_0 \cos^2\left(\frac{\phi}{2}\right)$$

5. Substitute the value of ϕ:

$$I = I_0 \cos^2\left(\frac{60^\circ}{2}\right) = I_0 \cos^2(30^\circ)$$

6. Since $\cos(30^\circ) = \frac{\sqrt{3}}{2}$:

$$I = I_0 \left(\frac{\sqrt{3}}{2}\right)^2 = I_0\left(\frac{3}{4}\right)$$

7. Find the ratio I/I_0:

$$\frac{I}{I_0} = \frac{3}{4}$$

Final Answer: The ratio I/I_0 is $3/4$.

Answer: (A)

Q3.

Solution

Concept:

According to Bohr's second postulate of the atomic model, the angular momentum (L) of an electron orbiting the nucleus is quantized. It is given by the integral multiple of $h/2\pi$:

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

where n is the principal quantum number (orbit number) and h is Planck's constant.

Solution:

1. The angular momentum for the n^{th} orbit is:

$$L_n = n\left(\frac{h}{2\pi}\right)$$

2. For the 2^{nd} orbit ($n_1 = 2$):

$$L_2 = 2\left(\frac{h}{2\pi}\right)$$

3. For the 3^{rd} orbit ($n_2 = 3$):

$$L_3 = 3\left(\frac{h}{2\pi}\right)$$

4. To find the ratio of angular momentum:

$$\frac{L_2}{L_3} = \frac{2(h/2\pi)}{3(h/2\pi)}$$

5. The constants h and 2π cancel out:

$$\frac{L_2}{L_3} = \frac{2}{3}$$

Final Answer: The ratio of the angular momentum is 2 : 3.

Answer: (A)

Q4.

Solution

Concept:

Gauss's Law states that the total electric flux Φ through any closed surface is equal to the net charge $Q_{enclosed}$ inside the surface divided by the permittivity of free space ϵ_0:

$$\Phi = \frac{Q_{net}}{\epsilon_0}$$

A capacitor consists of two plates with equal and opposite charges, $+Q$ and $-Q$.

Solution:

1. A capacitor has a charge $+Q$ on one plate and $-Q$ on the other plate. 2. The magnitude of charge is given by $Q = CV$. 3. When a closed surface (Gaussian surface) encloses the entire capacitor, it encloses both the positive and the negative plates. 4. Calculate the net charge Q_{net} inside the closed surface:

$$Q_{net} = (+Q) + (-Q) = 0$$

5. Applying Gauss's Law:

$$\Phi = \frac{Q_{net}}{\epsilon_0} = \frac{0}{\epsilon_0} = 0$$

6. Therefore, the total flux through the closed surface is zero.

Final Answer: The flux of the electric field through the closed surface is Zero.

Answer: (D)

Q5.

Solution

Concept:

A potentiometer works on the principle that the potential drop (V) across any portion of the wire is directly proportional to its length (l), provided the current and cross-sectional area are constant.

$$V = kl \implies k = \frac{V_{total}}{L}$$

where k is the potential gradient and L is the total length of the potentiometer wire. For a balancing cell of emf E, we have $E = kl$.

Solution:

1. The potential gradient k is defined as the potential drop per unit length:

$$k = \frac{V}{L}$$

2. If the length of the potentiometer wire L is increased (while keeping the driving voltage V constant), the potential gradient k decreases. 3. The balancing condition for a cell of emf E is:

$$E = k \times l_{balancing}$$

4. Since the emf E of the cell being measured remains constant, and the potential gradient k has decreased:

$$l_{balancing} = \frac{E}{k}$$

5. As k is in the denominator, a decrease in k results in an increase in the balancing length $l_{balancing}$.

Final Answer: The length of the balancing point will Increase.

Answer: (A)

Q6.

Solution

Concept:

In Simple Harmonic Motion (SHM), the total energy is the sum of kinetic energy (KE) and potential energy (PE). For a particle with amplitude A and displacement x from the mean position, these are given by:

$$KE = \frac{1}{2}k(A^2 - x^2)$$

$$PE = \frac{1}{2}kx^2$$

where k is the force constant ($m\omega^2$).

Solution:

1. We are given the condition that kinetic energy is equal to potential energy:

$$KE = PE$$

2. Substitute the expressions for KE and PE:

$$\frac{1}{2}k(A^2 - x^2) = \frac{1}{2}kx^2$$

3. Canceling the constant $\frac{1}{2}k$ from both sides:

$$A^2 - x^2 = x^2$$

4. Rearrange the equation to solve for x:

$$A^2 = 2x^2$$

$$x^2 = \frac{A^2}{2}$$

5. Taking the square root of both sides:

$$x = \frac{A}{\sqrt{2}}$$

Final Answer: The distance from the mean position is $A/\sqrt{2}$.

Answer: (B)

Q7.

Solution

Concept:
The hydrogen spectrum consists of several series of spectral lines corresponding to transitions of electrons between different energy levels. These are governed by the Rydberg formula. Each series falls into a specific region of the electromagnetic spectrum:

- Lyman: Ultraviolet (UV)
- Balmer: Visible
- Paschen, Brackett, Pfund: Infrared (IR)

Solution:
1. Spectral lines are produced when an electron jumps from a higher energy orbit (n_2) to a lower energy orbit (n_1). 2. For the Lyman series, $n_1 = 1$. The energy differences are large, placing the emissions in the Ultraviolet region. 3. For the Balmer series, $n_1 = 2$. The transitions from $n_2 = 3, 4, 5, 6$ result in photons with wavelengths between approximately 400 nm and 700 nm. 4. This specific range corresponds to the Visible light region of the electromagnetic spectrum. 5. Other series like Paschen ($n_1 = 3$) involve smaller energy changes and fall into the Infrared region.
Final Answer: The series that falls in the visible region is the Balmer series.

Answer: (B)

Q8.

Solution

Concept:

The efficiency (η) of a Carnot engine is the ratio of the work done to the heat absorbed from the source. It is determined solely by the absolute temperatures of the source (T_1) and the sink (T_2). The formula is:

$$\eta = 1 - \frac{T_2}{T_1}$$

Note: Temperatures must be converted from Celsius to Kelvin ($T_K = T_C + 273$).

Solution:

1. Identify the given temperatures: Source temperature: $t_1 = 227°C$ Sink temperature: $t_2 = 27°C$
2. Convert temperatures to Kelvin:

$$T_1 = 227 + 273 = 500 \text{ K}$$

$$T_2 = 27 + 273 = 300 \text{ K}$$

3. Apply the efficiency formula:

$$\eta = 1 - \frac{300}{500}$$

$$\eta = 1 - \frac{3}{5} = \frac{2}{5}$$

4. Convert to percentage:

$$\text{Efficiency in \%} = \frac{2}{5} \times 100 = 40\%$$

Final Answer: The efficiency of the Carnot engine is 40%.

Answer: (A)

Q9.

Solution

Concept:
A p-n junction diode consists of a depletion layer where there are no free charge carriers. When a diode is reverse biased, the positive terminal of the battery is connected to the n-region and the negative terminal to the p-region. This setup pulls majority carriers (holes in p and electrons in n) away from the junction.

Solution:
1. In reverse bias, the holes in the p-type material are attracted toward the negative terminal of the external source. 2. Similarly, the free electrons in the n-type material are attracted toward the positive terminal. 3. As the majority carriers move away from the junction, the region devoid of mobile charge carriers (the depletion layer) expands. 4. This increase in width increases the barrier potential and the resistance of the diode, preventing current flow. 5. Therefore, the thickness of the depletion layer increases in reverse bias.

Final Answer: The thickness of the depletion layer Increases.

Answer: (B)

Q10.

Solution

Concept:

The wavelength λ of the emitted radiation in a hydrogen atom is given by the Rydberg formula:

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

where R is the Rydberg constant, n_1 is the lower energy level, and n_2 is the higher energy level.

Solution:

1. For the first line of the Lyman series, $n_1 = 1$ and $n_2 = 2$:

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(1 - \frac{1}{4}\right) = \frac{3R}{4} \implies R = \frac{4}{3\lambda_L}$$

2. For the first line of the Balmer series, $n_1 = 2$ and $n_2 = 3$:

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = R\left(\frac{5}{36}\right)$$

3. Substitute the value of R from the first step:

$$\frac{1}{\lambda_B} = \left(\frac{4}{3\lambda_L}\right) \times \frac{5}{36}$$

4. Simplify the expression:

$$\frac{1}{\lambda_B} = \frac{5}{27\lambda_L}$$

5. Taking the reciprocal to find λ_B:

$$\lambda_B = \frac{27}{5}\lambda_L$$

Final Answer: The wavelength of the first line of the Balmer series is $\frac{27}{5}\lambda$.

Answer: (A)

Q11.

Solution

Concept:
The Moment of Inertia (I) of a uniform rod depends on the axis of rotation. For a rod of mass M and length L: 1. About an axis passing through its center and perpendicular to its length: $I_c = \frac{ML^2}{12}$. 2. About an axis passing through one end and perpendicular to its length: $I_{end} = \frac{ML^2}{3}$. These can be related using the Parallel Axis Theorem: $I = I_c + Mh^2$, where h is the distance between the two axes.

Solution:
1. Given I_1 is the moment of inertia about the center:

$$I_1 = \frac{ML^2}{12}$$

2. Given I_2 is the moment of inertia about one end:

$$I_2 = \frac{ML^2}{3}$$

3. To find the ratio I_2/I_1, divide the two expressions:

$$\frac{I_2}{I_1} = \frac{ML^2/3}{ML^2/12}$$

4. Simplify the fraction by multiplying by the reciprocal:

$$\frac{I_2}{I_1} = \frac{12}{3} = 4$$

5. Thus, the moment of inertia about the end is four times that about the center.
Final Answer: The ratio I_2/I_1 is 4.

Answer: (C)

Q12.

Solution

Concept:

According to Faraday's Law of Electromagnetic Induction, the induced electromotive force (emf) in a circuit is equal to the negative rate of change of magnetic flux (ϕ) through the circuit:

$$e = -\frac{d\phi}{dt}$$

In this problem, we are interested in the magnitude of the induced emf.

Solution:

1. The given equation for magnetic flux is:

$$\phi = 5t^2 + 3t + 16$$

2. Differentiate the flux with respect to time t to find the expression for induced emf:

$$e = \frac{d}{dt}(5t^2 + 3t + 16)$$

3. Applying basic differentiation rules ($\frac{d}{dt}t^n = nt^{n-1}$):

$$e = 10t + 3$$

4. We need to find the emf at the specific time $t = 2$ seconds. Substitute $t = 2$ into the expression:

$$e = 10(2) + 3$$

$$e = 20 + 3 = 23 \text{ V}$$

Final Answer: The induced emf at $t = 2$ seconds is 23 V.

Answer: (A)

Q13.

Solution

Concept:
When an electron in a hydrogen atom transitions from a higher energy level (n) to a lower energy level, it can follow various paths, emitting photons of different frequencies. The total number of possible spectral lines (different wavelengths) emitted when an electron jumps from level n to the ground state ($n = 1$) is given by the formula:

$$N = \frac{n(n-1)}{2}$$

Solution:
1. The electron is in the higher energy state $n = 4$. 2. The destination state is the ground state $n = 1$. 3. Using the formula for the number of spectral lines:

$$N = \frac{4(4-1)}{2}$$

4. Calculate the value:

$$N = \frac{4 \times 3}{2} = \frac{12}{2} = 6$$

5. The six possible transitions are: (4 to 1), (4 to 2), (4 to 3), (3 to 1), (3 to 2), and (2 to 1).
Final Answer: The number of spectral lines possible is 6.

Answer: (C)

Q14.

Solution

Concept:

In wave interference, the intensity (I) is proportional to the square of the amplitude (A). The maximum and minimum intensities in an interference pattern are given by:

$$I_{max} = (A_1 + A_2)^2 \quad \text{and} \quad I_{min} = (A_1 - A_2)^2$$

The ratio of intensities of the sources is $I_1/I_2 = (A_1/A_2)^2$.

Solution:

1. Given the ratio of intensities of the two sources:

$$\frac{I_1}{I_2} = \frac{81}{1}$$

2. Find the ratio of their amplitudes (A_1/A_2):

$$\frac{A_1}{A_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{81}{1}} = \frac{9}{1}$$

3. Let $A_1 = 9x$ and $A_2 = 1x$. 4. Calculate maximum and minimum resultant amplitudes:

$$A_{max} = A_1 + A_2 = 9x + 1x = 10x$$

$$A_{min} = A_1 - A_2 = 9x - 1x = 8x$$

5. The ratio of maximum to minimum intensity is:

$$\frac{I_{max}}{I_{min}} = \left(\frac{A_{max}}{A_{min}}\right)^2 = \left(\frac{10x}{8x}\right)^2$$

6. Simplify the fraction and square it:

$$\frac{I_{max}}{I_{min}} = \left(\frac{5}{4}\right)^2 = \frac{25}{16}$$

Final Answer: The ratio of maximum to minimum intensity is 25:16.

Answer: (C)

Q15.

Solution

Concept:
The work done (W) in blowing a soap bubble is stored as surface energy. A soap bubble has two free surfaces (inside and outside). If T is the surface tension and R is the radius, the surface area is $2 \times 4\pi R^2$. The work done is:

$$W = T \times \Delta A = T \times (8\pi R^2)$$

This shows that $W \propto R^2$.

Solution:

1. The work done for a bubble of radius R is:

$$W_1 = 8\pi R^2 T = W$$

2. For a bubble of radius $2R$, the new work done W_2 is:

$$W_2 = 8\pi (2R)^2 T$$

3. Expand the square:

$$W_2 = 8\pi (4R^2) T$$

4. Rearrange to relate it to W_1:

$$W_2 = 4 \times (8\pi R^2 T)$$

5. Substitute W for the term in the brackets:

$$W_2 = 4W$$

Final Answer: The work done in blowing a bubble of radius $2R$ is $4W$.

Answer: (B)

Q16.

Solution

Concept:

The capacitance (C) of a parallel plate capacitor is given by $C = \frac{\epsilon_0 A}{d}$, where A is the area of the plates and d is the separation. The charge (Q) is related to capacitance and voltage (V) by $Q = CV$. When a battery is disconnected, the charge Q on the plates remains constant because it has no path to flow.

Solution:

1. The initial charge on the capacitor is Q. Since the battery is disconnected, Q stays constant. 2. The initial capacitance is $C = \frac{\epsilon_0 A}{d}$. 3. When the plates are moved farther apart, the distance d increases. 4. As d increases, the capacitance $C = \frac{\epsilon_0 A}{d}$ decreases. 5. The potential difference V is given by $V = \frac{Q}{C}$. 6. Since Q is constant and C decreases, the denominator becomes smaller, causing the voltage V to increase. 7. Therefore, moving the plates apart with the battery disconnected leads to an increase in the voltage across the plates.

Final Answer: The voltage across the plates increases.

Answer: (C)

Q17.

Solution

Concept:

The refractive index (μ) of a medium is defined as the ratio of the speed of light in a vacuum (c) to the speed of light in that medium (v). It is a dimensionless constant that indicates how much the light slows down upon entering the medium.

$$\mu = \frac{c}{v}$$

Solution:

1. We are given the refractive index of the medium, $\mu = 1.5$. 2. The speed of light in vacuum is c. 3. Using the formula for refractive index:

$$v = \frac{c}{\mu}$$

4. Substitute the given value of μ:

$$v = \frac{c}{1.5}$$

5. Note: 1.5 is equivalent to $3/2$. So, $v = \frac{c}{3/2} = \frac{2c}{3}$, which is approximately $0.67c$. 6. Comparing this with the given options, the expression is represented as $c/1.5$.

Final Answer: The velocity of light in the medium is $c/1.5$.

Answer: (B)

Q18.

Solution

Concept:

The average power (P) dissipated in an AC circuit is given by:

$$P = V_{rms} I_{rms} \cos(\phi)$$

where $V_{rms} = \frac{V_0}{\sqrt{2}}$, $I_{rms} = \frac{I_0}{\sqrt{2}}$, and ϕ is the phase difference between voltage and current. $\cos(\phi)$ is known as the power factor.

Solution:

1. From the given equations: $V = 100 \sin(100t) \implies V_0 = 100$ V $I = 100 \sin(100t + \pi/3)$ mA $\implies I_0 = 100$ mA $= 0.1$ A 2. The phase difference is $\phi = \pi/3 = 60°$. 3. The formula for power can be rewritten using peak values:

$$P = \left(\frac{V_0}{\sqrt{2}}\right)\left(\frac{I_0}{\sqrt{2}}\right)\cos(\phi) = \frac{V_0 I_0}{2}\cos(\phi)$$

4. Substitute the values into the formula:

$$P = \frac{100 \times 0.1}{2}\cos(60°)$$

5. Since $\cos(60°) = 0.5$:

$$P = \frac{10}{2} \times 0.5 = 5 \times 0.5 = 2.5 \text{ W}$$

Final Answer: The power dissipated in the circuit is 2.5 W.

Answer: (C)

Q19.

Solution

Concept:

Einstein's photoelectric equation relates the maximum kinetic energy (KE_{max}) of emitted photoelectrons to the energy of the incident photon (E) and the work function of the metal (Φ):

$$KE_{max} = E - \Phi = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

where λ is the incident wavelength and λ_0 is the threshold wavelength. In electron-volts, $E(\text{eV}) \approx \frac{12400}{\lambda(\text{Å})}$.

Solution:

1. Calculate the energy of the incident photon (E) for $\lambda = 2000$ Å:

$$E = \frac{12400}{2000} = 6.2 \text{ eV}$$

2. Calculate the work function (Φ) for the threshold wavelength $\lambda_0 = 4000$ Å:

$$\Phi = \frac{12400}{4000} = 3.1 \text{ eV}$$

3. Apply Einstein's equation:

$$KE_{max} = E - \Phi$$

$$KE_{max} = 6.2 \text{ eV} - 3.1 \text{ eV} = 3.1 \text{ eV}$$

Final Answer: The maximum kinetic energy will be 3.1 eV.

Answer: (A)

Q20.

Solution

Concept:

Angular momentum (L) can be found using the relationship between torque (τ) and time (t) when the torque is constant:

$$\tau = \frac{dL}{dt} \implies \Delta L = \tau \Delta t$$

Alternatively, $L = I\omega$, where $\omega = \omega_0 + \alpha t$. Since the wheel starts from rest, $\omega_0 = 0$.

Solution:

1. The torque τ applied to the wheel is 100 N-m. 2. The duration t for which the torque acts is 5 seconds. 3. The wheel starts from rest, so the initial angular momentum $L_i = 0$. 4. The change in angular momentum is:

$$\Delta L = \tau \times t$$

$$\Delta L = 100 \times 5 = 500 \text{ kg m}^2/\text{s}$$

5. Since $L_i = 0$, the final angular momentum L_f is equal to the change:

$$L_f = 500 \text{ kg m}^2/\text{s}$$

6. Note: The given angular acceleration α is redundant here because torque and time are directly given. If we used $I = \tau/\alpha = 100/2 = 50$, then $L = I\alpha t = 50 \times 2 \times 5 = 500$, which confirms the result.

Final Answer: The angular momentum at the end of 5 seconds is 500 kg m^2/s.

Answer: (A)

Q21.

Solution

Concept:

The escape velocity (v_e) from the surface of a planet depends on its mass (M) and radius (R):

$$v_e = \sqrt{\frac{2GM}{R}}$$

If we express mass in terms of density (ρ) and volume ($V = \frac{4}{3}\pi R^3$):

$$v_e = \sqrt{\frac{2G(\frac{4}{3}\pi R^3 \rho)}{R}} = R\sqrt{\frac{8\pi G\rho}{3}}$$

This shows that for a constant density, escape velocity is directly proportional to the radius ($v_e \propto R$).

Solution:

1. Let v_e be the escape velocity of the Earth with radius R and density ρ. 2. For the new planet, the radius $R' = 2R$ and the density $\rho' = \rho$. 3. Since $v_e \propto R$ when density is constant:

$$\frac{v'_e}{v_e} = \frac{R'}{R}$$

4. Substitute $R' = 2R$:

$$\frac{v'_e}{v_e} = \frac{2R}{R} = 2$$

5. Therefore, the new escape velocity $v'_e = 2v_e$.

Final Answer: The escape velocity from the planet is $2v_e$.

Answer: (B)

Q22.

Solution

Concept:
The resistance (R) of a wire is given by $R = \rho\frac{l}{A}$, where ρ is resistivity, l is length, and A is the area of cross-section. When a wire is stretched, its volume ($V = A \times l$) remains constant. If the length increases, the area must decrease proportionally.

Solution:
1. Initial resistance $R = \rho\frac{l}{A}$. 2. The wire is stretched to twice its length, so $l' = 2l$. 3. Since volume is constant ($A \times l = A' \times l'$):

$$A' = A \times \frac{l}{l'} = A \times \frac{l}{2l} = \frac{A}{2}$$

4. Calculate the new resistance R':

$$R' = \rho\frac{l'}{A'} = \rho\frac{2l}{A/2}$$

5. Simplify the expression:

$$R' = 4 \times \left(\rho\frac{l}{A}\right) = 4R$$

6. Stretching a wire by n times its length increases resistance by n^2 times. Here $n = 2$, so $2^2 = 4$.
Final Answer: Its new resistance will be $4R$.

Answer: (A)

Q23.

Solution

Concept:
For a prism, the refractive index (μ) is related to the angle of the prism (A) and the angle of minimum deviation (δ_m) by the formula:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Solution:
1. We are given $\mu = \sqrt{3}$ and the condition $\delta_m = A$. 2. Substitute $\delta_m = A$ into the prism formula:

$$\sqrt{3} = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin(A)}{\sin\left(\frac{A}{2}\right)}$$

3. Use the trigonometric identity $\sin(A) = 2\sin(A/2)\cos(A/2)$:

$$\sqrt{3} = \frac{2\sin(A/2)\cos(A/2)}{\sin(A/2)}$$

4. Cancel $\sin(A/2)$ from numerator and denominator:

$$\sqrt{3} = 2\cos(A/2) \implies \cos(A/2) = \frac{\sqrt{3}}{2}$$

5. We know that $\cos(30^\circ) = \frac{\sqrt{3}}{2}$, so:

$$\frac{A}{2} = 30^\circ \implies A = 60^\circ$$

Final Answer: The angle of the prism is 60°.

Answer: (C)

Q24.

Solution

Concept:
Electric field (E) is a vector quantity, while electric potential (V) is a scalar quantity. At a point midway between two equal and opposite charges (an electric dipole): 1. The electric field vectors due to both charges point in the same direction. 2. The electric potentials due to both charges have the same magnitude but opposite signs.

Solution:
1. Let the charges be $+q$ at position $-d/2$ and $-q$ at $+d/2$. The origin is the midpoint. 2. The potential at the midpoint ($r = 0$) is the algebraic sum of individual potentials:

$$V = V_{+q} + V_{-q} = \frac{1}{4\pi\epsilon_0}\frac{q}{(d/2)} + \frac{1}{4\pi\epsilon_0}\frac{-q}{(d/2)} = 0$$

3. The electric field at the midpoint is the vector sum. The field due to $+q$ points away from it (toward the right), and the field due to $-q$ points toward it (also toward the right). 4. Since both field vectors are in the same direction, they add up:

$$E_{net} = E_{+q} + E_{-q} \neq 0$$

5. Therefore, at the midway point, the electric potential is zero but the electric field is not.

Final Answer: Electric potential is zero.

Answer: (B)

Q25.

Solution

Concept:

Radioactive decay follows an exponential law. The number of nuclei remaining (N) after n half-lives is given by the formula:

$$N = N_0 \left(\frac{1}{2}\right)^n$$

where N_0 is the initial number of nuclei and n is the number of half-lives passed.

Solution:

1. We need to find the fraction of nuclei left, which is N/N_0. 2. The number of half-lives given is $n = 5$. 3. Substitute n into the decay formula:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^5$$

4. Calculate the value of $(1/2)^5$:

$$\left(\frac{1}{2}\right)^5 = \frac{1}{2 \times 2 \times 2 \times 2 \times 2} = \frac{1}{32}$$

5. Thus, $1/32$ of the original sample remains after 5 half-lives.

Final Answer: The fraction of nuclei left is $1/32$.

Answer: (C)

Q26.

Solution

Concept:

The time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$, where g is the acceleration due to gravity. The value of g varies with altitude according to the relation:

$$g_h = g\left(\frac{R}{R+h}\right)^2$$

where R is the radius of the Earth and h is the height above the surface.

Solution:

1. On the surface of the Earth ($h = 0$), the period is $T_1 = 2\pi\sqrt{\frac{l}{g}}$. 2. At a height $h = R$, the new acceleration due to gravity g' is:

$$g' = g\left(\frac{R}{R+R}\right)^2 = g\left(\frac{R}{2R}\right)^2 = \frac{g}{4}$$

3. The new time period T_2 is:

$$T_2 = 2\pi\sqrt{\frac{l}{g'}} = 2\pi\sqrt{\frac{l}{g/4}}$$

4. Simplify the expression for T_2:

$$T_2 = 2\pi\sqrt{\frac{4l}{g}} = 2 \times \left(2\pi\sqrt{\frac{l}{g}}\right)$$

5. Comparing T_2 with T_1:

$$T_2 = 2T_1 \implies \frac{T_2}{T_1} = 2$$

Final Answer: The ratio T_2/T_1 is 2.

Answer: (B)

Q27.

Solution

Concept:

Molar specific heat capacities are related by Mayer's relation: $C_p - C_v = R$. Also, the ratio of specific heats is $\gamma = C_p/C_v$. For an ideal gas, C_p can be expressed in terms of the degrees of freedom (f):

$$C_p = \left(\frac{f}{2} + 1\right) R$$

Solution:

1. We are given $C_p = \frac{7}{2}R$. 2. Using the formula $C_p = \left(\frac{f}{2} + 1\right) R$:

$$\frac{f}{2} + 1 = \frac{7}{2}$$

3. Solve for f:

$$\frac{f}{2} = \frac{7}{2} - 1 = \frac{5}{2} \implies f = 5$$

4. A gas with 5 degrees of freedom (3 translational + 2 rotational) is a diatomic gas (at moderate temperatures). 5. For a monatomic gas, $f = 3$ and $C_p = \frac{5}{2}R$. For a diatomic gas, $f = 5$ and $C_p = \frac{7}{2}R$.

Final Answer: The gas is Diatomic.

Answer: (B)

Q28.

Solution

Concept:

Logic gates are the basic building blocks of digital circuits. Each gate follows a truth table. 1. AND gate: Output is 1 only if all inputs are 1. 2. OR gate: Output is 1 if at least one input is 1. 3. NAND gate: Inverse of AND. 4. NOR gate: Inverse of OR.

Solution:

1. Consider two inputs A and B. 2. The logic for an AND gate is $Y = A \cdot B$. 3. Truth Table for AND: - $0 \cdot 0 = 0$ - $0 \cdot 1 = 0$ - $1 \cdot 0 = 0$ - $1 \cdot 1 = 1$ 4. From the truth table, it is clear that the output is high ('1') only when both inputs are high ('1').

Final Answer: The logic gate is the AND gate.

Answer: (B)

Q29.

Solution

Concept:
When a charged particle enters a magnetic field B with a velocity v perpendicular to the field lines, it experiences a Lorentz force $F = qvB$. This force acts as a centripetal force, causing the particle to move in a circular path.

$$F_{centripetal} = F_{magnetic} \implies \frac{mv^2}{r} = qvB$$

Solution:
1. For an electron, the charge q is denoted by e. 2. The equation for the circular motion is:

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

3. To find the radius r, rearrange the terms:

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

4. One v term cancels out:

$$r = \frac{mv}{eB}$$

5. This indicates that the radius is proportional to the momentum (mv) and inversely proportional to the magnetic field and charge.
Final Answer: The radius of its circular path is mv/Be.

Answer: (A)

Q30.

Solution

Concept:

A transformer works on the principle of mutual induction. The relationship between the primary voltage (V_p), secondary voltage (V_s), and the number of turns in the primary (N_p) and secondary (N_s) coils is given by the transformer ratio:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

1. Given the turn ratio for a step-up transformer is 1 : 20. This means:

$$\frac{N_s}{N_p} = \frac{20}{1}$$

2. The primary voltage $V_p = 110$ V. 3. Using the transformer formula:

$$V_s = V_p \times \left(\frac{N_s}{N_p}\right)$$

4. Substitute the values:

$$V_s = 110 \times 20$$

5. Calculate the final value:

$$V_s = 2200 \text{ V}$$

Final Answer: The secondary voltage is 2200 V.

Answer: (A)

Q31.

Solution

Concept:

When a physical quantity is calculated using a formula, the maximum fractional error is the sum of the fractional errors of the individual components, each multiplied by their respective powers. For the volume of a sphere ($V = \frac{4}{3}\pi r^3$), the relative error is:

$$\frac{\Delta V}{V} = 3\frac{\Delta r}{r}$$

Solution:

1. The volume of a sphere is given by:

$$V = \frac{4}{3}\pi r^3$$

2. Taking logs and differentiating, or using the power rule for errors:

$$\frac{\Delta V}{V} = 3 \times \frac{\Delta r}{r}$$

3. To find the percentage error, multiply both sides by 100:

$$\frac{\Delta V}{V} \times 100 = 3 \times \left(\frac{\Delta r}{r} \times 100\right)$$

4. We are given the percentage error in radius is 2%:

$$\% \text{ Error in } V = 3 \times 2\% = 6\%$$

Final Answer: The error in the determination of its volume is 6%.

Answer: (C)

Q32.

Solution

Concept:
For an astronomical telescope in normal adjustment (parallel rays), the magnifying power (M) and the length of the telescope (L) are given by:

$$M = \frac{f_o}{f_e} \quad \text{and} \quad L = f_o + f_e$$

where f_o is the focal length of the objective and f_e is the focal length of the eyepiece.
Solution:
1. Given $M = 9$ and $L = 20$ cm. 2. From the magnification formula:

$$9 = \frac{f_o}{f_e} \implies f_o = 9f_e$$

3. From the length formula:

$$f_o + f_e = 20$$

4. Substitute $f_o = 9f_e$ into the length equation:

$$9f_e + f_e = 20$$

$$10f_e = 20 \implies f_e = 2 \text{ cm}$$

5. Now, find f_o:

$$f_o = 9 \times 2 = 18 \text{ cm}$$

Final Answer: The focal length of the objective is 18 cm.

Answer: (A)

Q33.

Solution

Concept:

The height (h) to which a liquid rises in a capillary tube is given by Jurin's Law:

$$h = \frac{2T\cos\theta}{r\rho g}$$

This indicates that $h \propto \frac{1}{r}$, where r is the radius of the tube.

Solution:

1. Initial height $h_1 = 5$ cm with radius r_1. 2. The area of cross-section is $A = \pi r^2$. If the area is reduced to $1/4$:

$$A_2 = \frac{A_1}{4} \implies \pi r_2^2 = \frac{\pi r_1^2}{4}$$

3. Solving for r_2:

$$r_2^2 = \frac{r_1^2}{4} \implies r_2 = \frac{r_1}{2}$$

4. Using $h_1 r_1 = h_2 r_2$:

$$5 \times r_1 = h_2 \times \frac{r_1}{2}$$

5. Rearrange to solve for h_2:

$$h_2 = 5 \times 2 = 10 \text{ cm}$$

Final Answer: The liquid will rise to a height of 10 cm.

Answer: (B)

Q34.

Solution

Concept:

When a displacement is represented by the sum of two harmonic functions $x = A_1 \sin(\omega t) + A_2 \cos(\omega t)$, the motion is still simple harmonic. The resultant amplitude R is calculated using the vector addition of the two individual amplitudes:

$$R = \sqrt{A_1^2 + A_2^2}$$

Solution:

1. The given displacement is $x = 3\sin(2t) + 4\cos(2t)$. 2. Here, $A_1 = 3$ and $A_2 = 4$. 3. The resultant amplitude R is:

$$R = \sqrt{3^2 + 4^2}$$

4. Calculate the squares:

$$R = \sqrt{9 + 16} = \sqrt{25}$$

5. Therefore:

$$R = 5$$

Final Answer: The amplitude of the particle is 5.

Answer: (C)

Q35.

Solution

Concept:

Mass-energy equivalence ($E = mc^2$) allows us to calculate the energy stored in a specific amount of mass. 1 amu (atomic mass unit) is defined as $1/12^{th}$ of the mass of a Carbon-12 atom, approximately 1.66×10^{-27} kg.

Solution:

1. Using Einstein's equation $E = mc^2$ with $m = 1.66 \times 10^{-27}$ kg and $c = 3 \times 10^8$ m/s:

$$E = (1.66 \times 10^{-27}) \times (3 \times 10^8)^2 \text{ Joules}$$

2. To convert this energy into Electron Volts (eV), divide by 1.6×10^{-19}:

$$E(\text{eV}) = \frac{(1.66 \times 10^{-27}) \times (9 \times 10^{16})}{1.6 \times 10^{-19}}$$

3. The calculation yields approximately 931.5×10^6 eV. 4. Since 10^6 eV = 1 MeV:

$$E \approx 931 \text{ MeV}$$

Final Answer: The energy equivalent is approximately 931 MeV.

Answer: (A)

Q36.

Solution

Concept:

The internal energy (U) of an ideal gas depends solely on its absolute temperature (T). It is given by the relation:

$$U = \frac{f}{2}nRT$$

where f is the degrees of freedom. In an isothermal process, the temperature of the system remains constant throughout the expansion or compression ($\Delta T = 0$).

Solution:

1. For an ideal gas, the change in internal energy is:

$$\Delta U = nC_v\Delta T$$

2. In an isothermal expansion, by definition, the temperature T is constant. 3. Therefore, the change in temperature $\Delta T = T_{final} - T_{initial} = 0$. 4. Substituting $\Delta T = 0$ into the internal energy equation:

$$\Delta U = nC_v(0) = 0$$

5. This implies that all the heat absorbed by the gas is used to do external work, and no energy is stored as internal energy.

Final Answer: The change in internal energy is Zero.

Answer: (C)

Q37.

Solution

Concept:
The de Broglie wavelength (λ) of a particle is related to its momentum and, consequently, its kinetic energy. When an electron is accelerated through a potential difference V, its kinetic energy is eV. The formula for its wavelength is:

$$\lambda = \frac{h}{\sqrt{2m_e eV}}$$

For an electron, this simplifies to a very useful shortcut: $\lambda \approx \sqrt{\frac{150}{V}}$ Å or $\lambda \approx \frac{12.27}{\sqrt{V}}$ Å.
Solution:
1. We are given the accelerating potential $V = 100$ V. 2. Using the shortcut formula for the de Broglie wavelength of an electron:

$$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å}$$

3. Substitute $V = 100$:

$$\lambda = \frac{12.27}{\sqrt{100}} \text{ Å}$$

4. Since $\sqrt{100} = 10$:

$$\lambda = \frac{12.27}{10} = 1.227 \text{ Å}$$

Final Answer: The de Broglie wavelength is 1.227 Å.

Answer: (B)

Q38.

Solution

Concept:
The magnetic dipole moment (μ or M) of a current-carrying loop is a vector quantity that represents the strength and orientation of the magnetic field produced by the loop. It depends on the current (I) flowing through the loop and the area (A) enclosed by the loop.
Solution:
1. For a single turn loop, the magnitude of the magnetic moment is defined as the product of the current and the area:

$$M = I \times A$$

2. If the loop has N turns, the formula becomes $M = NIA$. 3. The direction of the magnetic moment is perpendicular to the plane of the loop, determined by the right-hand thumb rule. 4. The SI unit for magnetic moment is Ampere-meter^2 ($\text{A} \cdot \text{m}^2$). 5. Looking at the options, the direct relationship is IA.
Final Answer: The magnetic moment is IA.

Answer: (B)

Q39.

Solution

Concept:
In semiconductors, electrical conduction occurs through two types of charge carriers: free electrons in the conduction band and holes in the valence band. A "hole" is essentially a vacancy left behind when a valence electron gains enough energy to move, but "hole movement" is a specific physical phenomenon.

Solution:
1. A hole is created in the valence band when an electron moves to the conduction band. 2. When an electric field is applied, an electron from a neighboring covalent bond can move to fill this vacancy (hole). 3. As this neighbor electron moves into the hole, it leaves a new vacancy (hole) at its previous position. 4. This sequential shifting of valence electrons from one bond to another makes it appear as if the positive charge (the hole) is moving in the opposite direction. 5. Therefore, the effective movement of holes is actually due to the movement of valence electrons within the valence band.

Final Answer: The movement of holes is due to the movement of valence electrons.

Answer: (B)

Q40.

Solution

Concept:
Beats are produced when two sound waves of slightly different frequencies (f_1 and f_2) interfere with each other. The number of beats heard per second (beat frequency, f_b) is equal to the absolute difference between the frequencies of the two sources:

$$f_b = |f_1 - f_2|$$

Solution:
1. Given the frequency of the first source $f_1 = 256$ Hz. 2. Given the beat frequency $f_b = 4$ beats per second. 3. According to the beat formula:

$$|256 - f_2| = 4$$

4. This equation has two possible solutions for f_2: Case 1: $256 - f_2 = 4 \implies f_2 = 256 - 4 = 252$ Hz Case 2: $f_2 - 256 = 4 \implies f_2 = 256 + 4 = 260$ Hz 5. Both 252 Hz and 260 Hz will produce 4 beats per second when sounded with a 256 Hz source.

Final Answer: The frequency could be Both (A) and (B).

Answer: (C)

Q41.

Solution

Concept:

The trajectory of a projectile is determined by its initial velocity vector $\vec{v} = u_x\hat{i} + u_y\hat{j}$. The horizontal displacement is $x = u_x t$ and the vertical displacement is $y = u_y t - \frac{1}{2}gt^2$. By eliminating time t, we obtain the equation of the path (parabola).

Solution:

1. Given initial velocity $\vec{v} = \hat{i} + 2\hat{j}$. Thus, $u_x = 1$ m/s and $u_y = 2$ m/s. 2. From the horizontal motion:

$$x = u_x t = 1 \cdot t \implies t = x$$

3. From the vertical motion:

$$y = u_y t - \frac{1}{2}gt^2$$

4. Substitute $t = x$ and $g = 10$ m/s^2 into the vertical equation:

$$y = 2(x) - \frac{1}{2}(10)(x)^2$$

5. Simplify the expression:

$$y = 2x - 5x^2$$

6. This matches the standard form of a parabolic trajectory $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$.

Final Answer: The equation of its path is $y = 2x - 5x^2$.

Answer: (A)

Q42.

Solution

Concept:

Luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle. It is one of the seven base units in the International System of Units (SI).

Solution:

1. The SI unit of luminous intensity is the candela (cd). 2. One candela is defined as the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} Hz and that has a radiant intensity in that direction of $1/683$ watt per steradian. 3. Other related units include: - Lumen (lm) for luminous flux. - Lux (lx) for illuminance. - Watt (W) for power. 4. Therefore, the base SI unit for intensity of light as perceived by the human eye is the candela.

Final Answer: The SI unit of luminous intensity is Candela.

Answer: (C)

Q43.

Solution

Concept:
When a stone is dropped from a height h, its velocity v just before hitting the ground is $\sqrt{2gh}$. Momentum (P) is defined as the product of mass (m) and velocity (v):

$$P = m\sqrt{2gh}$$

This implies that $P \propto \sqrt{h}$.
Solution:
1. Initial momentum $P_1 = k\sqrt{h}$. 2. The new height h_2 is increased by 100%, so $h_2 = h + 100\%$ of $h = 2h$. 3. The new momentum P_2 is:

$$P_2 = k\sqrt{2h} = \sqrt{2} \times k\sqrt{h} = \sqrt{2}P_1$$

4. Since $\sqrt{2} \approx 1.414$, then $P_2 \approx 1.414P_1$. 5. The percentage change in momentum is:

$$\% \text{ Change} = \frac{P_2 - P_1}{P_1} \times 100$$

$$\% \text{ Change} = \frac{1.414P_1 - P_1}{P_1} \times 100 = 0.414 \times 100 = 41.4\%$$

6. Rounding to the nearest whole number, we get 41%.
Final Answer: The momentum will change by 41%.

Answer: (B)

Q44.

Solution

Concept:
Light is an electromagnetic wave. Interference and diffraction prove that light has wave-like properties. However, these phenomena can occur in both longitudinal and transverse waves. Polarization is a unique property that distinguishes these two.
Solution:
1. Polarization is the process of restricting the vibrations of a wave to a single plane perpendicular to the direction of propagation. 2. Longitudinal waves (like sound) cannot be polarized because their vibrations are already along the direction of travel. 3. Transverse waves (like light) vibrate perpendicular to the direction of propagation, allowing these vibrations to be filtered or "polarized" into a specific plane. 4. The fact that light can be polarized by filters (polaroids) or reflection confirms that light waves are transverse in nature. 5. While quantum nature and corpuscular nature relate to photons, polarization specifically identifies the wave type.
Final Answer: Polarization proves the transverse wave nature of light.

Answer: (C)

Q45.

Solution

Concept:

In radioactivity, the half-life ($T_{1/2}$) is the time taken for half of the nuclei to decay. The mean life (τ) is the average lifetime of all the nuclei in the sample. They are related to the decay constant (λ) as follows:

$$T_{1/2} = \frac{\ln(2)}{\lambda} = \frac{0.693}{\lambda} \quad \text{and} \quad \tau = \frac{1}{\lambda}$$

Solution:

1. From the relations above, we can see that:

$$T_{1/2} = 0.693 \times \tau$$

2. Rearranging to find the mean life τ:

$$\tau = \frac{T_{1/2}}{0.693} \approx 1.44 \times T_{1/2}$$

3. Given the half-life $T_{1/2} = 10$ years. 4. Calculate the mean life:

$$\tau = 1.44 \times 10 = 14.4 \text{ years}$$

5. This indicates that on average, a nucleus survives longer than the half-life of the sample.

Final Answer: Its mean life is 14.4 years.

Answer: (A)

Q46.

Solution

Concept:

The electromagnetic spectrum is organized by frequency and wavelength. The main regions, in order of increasing frequency (and decreasing wavelength), are: Radio waves, Microwaves, Infrared, Visible light, Ultraviolet, X-rays, and Gamma rays.

Solution:

1. Frequency (f) is inversely proportional to wavelength (λ) according to $c = f\lambda$. 2. Gamma rays (γ-rays) are produced by nuclear transitions and have the shortest wavelengths in the known spectrum. 3. Because they have the shortest wavelengths, they possess the highest frequencies and the highest photon energies ($E = hf$). 4. Comparing the given options: - Radio waves: Lowest frequency. - Microwaves: Low frequency. - X-rays: Very high frequency. - Gamma rays: Highest frequency. 5. Therefore, Gamma rays are at the top of the frequency scale among the choices.

Final Answer: Gamma rays have the highest frequency.

Answer: (C)

Q47.

Solution

Concept:

In a series LCR circuit, the impedance (Z) is given by $Z = \sqrt{R^2 + (X_L - X_C)^2}$. The phase difference ($\phi$) between the resultant voltage and current is given by:

$$\tan(\phi) = \frac{X_L - X_C}{R}$$

Resonance occurs when the inductive reactance equals the capacitive reactance ($X_L = X_C$).

Solution:

1. At the condition of resonance, $X_L = X_C$. 2. Substitute this into the phase angle formula:

$$\tan(\phi) = \frac{X_C - X_C}{R} = \frac{0}{R} = 0$$

3. The angle whose tangent is zero is $\phi = 0^\circ$ (or 0 radians). 4. This means that at resonance, the circuit behaves as a purely resistive circuit. 5. The current and voltage are in the same phase, reaching their maximum and minimum values at the same time.

Final Answer: The phase difference is 0.

Answer: (A)

Q48.

Solution

Concept:

The focal length (f) of a lens is determined by the Lens Maker's Formula:

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

where μ_{rel} is the refractive index of the lens material relative to the surrounding medium (μ_l/μ_m).

Solution:

1. Let $\mu_g = 1.5$ (glass) and $\mu_w = 1.33 = 4/3$ (water). 2. In air ($\mu_m = 1$):

$$\frac{1}{f_a} = (1.5 - 1)K = 0.5K \implies K = \frac{1}{0.5 \times 20} = \frac{1}{10}$$

3. In water ($\mu_m = 4/3$):

$$\frac{1}{f_w} = \left(\frac{1.5}{4/3} - 1\right)K = \left(\frac{4.5}{4} - 1\right)K = \left(\frac{1.125}{1} - 1\right)K = 0.125K$$

4. Substitute $K = 1/10$:

$$\frac{1}{f_w} = 0.125 \times \frac{1}{10} = \frac{1}{80}$$

5. Thus, $f_w = 80$ cm. 6. Generally, the focal length of a glass lens in water is approximately 4 times its focal length in air.

Final Answer: The focal length in water will be 80 cm.

Answer: (C)

Q49.

Solution

Concept:

Surface tension is a property of liquids arising from cohesive forces between molecules. It is defined as the force per unit length acting on the surface. Various factors influence the strength of these cohesive forces, most notably temperature and impurities.

Solution:

1. As the temperature of a liquid increases, the kinetic energy of its molecules also increases. 2. This increased molecular motion weakens the intermolecular cohesive forces that hold the surface molecules together. 3. Since surface tension is a direct result of these cohesive forces, a decrease in force leads to a decrease in surface tension. 4. Near the boiling point, the surface tension becomes very small, and at the critical temperature, it becomes zero. 5. Therefore, surface tension is inversely related to temperature.

Final Answer: Surface tension decreases with Increase in temperature.

Answer: (C)

Q50.

Solution

Concept:

An electric dipole consists of two equal and opposite charges separated by a small distance. The electric potential (V) at a point at distance r from the center of the dipole is given by the general formula:

$$V = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2}$$

where p is the dipole moment and θ is the angle with the dipole axis.

Solution:

1. For a point on the axis of the dipole, the angle θ is either $0°$ or $180°$. 2. Since $\cos(0°) = 1$ and $\cos(180°) = -1$, the formula becomes:

$$V_{axis} = \pm\frac{1}{4\pi\epsilon_0}\frac{p}{r^2}$$

3. From this expression, we can see that the magnitude of the potential is inversely proportional to the square of the distance:

$$V \propto \frac{1}{r^2}$$

4. This is different from a single point charge, where the potential $V \propto 1/r$.

Final Answer: The electric potential depends on the distance as $1/r^2$.

Answer: (B)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	A	3	A	4	D	5	A
6	B	7	B	8	A	9	B	10	A
11	C	12	A	13	C	14	C	15	B
16	C	17	B	18	C	19	A	20	A
21	B	22	A	23	C	24	B	25	C
26	B	27	B	28	B	29	A	30	A
31	C	32	A	33	B	34	C	35	A
36	C	37	B	38	B	39	B	40	C
41	A	42	C	43	B	44	C	45	A
46	C	47	A	48	C	49	C	50	B