BITSAT Physics Sample Paper-12

Duration: 40 Minutes **Maximum Marks: 90**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A diatomic ideal gas is heated at constant pressure. If its temperature increases from 300 K to 600 K, the ratio of final volume to initial volume is:

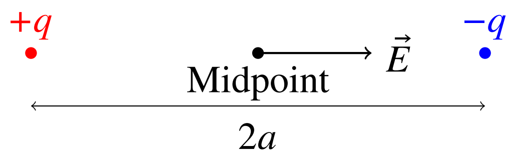
(A) 1

(B) 2

(C) 3

(D) 4

Q2. Two point charges $+q$ and $-q$ are separated by distance $2a$. The electric field at the midpoint is:



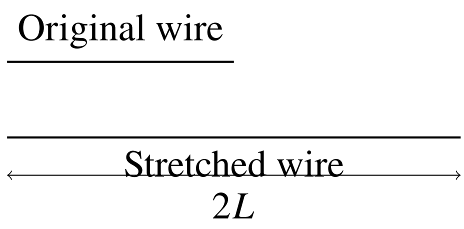
(A) Zero

(B) $\frac{1}{4\pi\varepsilon_0}\frac{q}{a^2}$

(C) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{a^2}$

(D) $\frac{1}{4\pi\varepsilon_0}\frac{4q}{a^2}$

Q3. A wire of resistance R is stretched to double its original length. Its new resistance becomes:



(A) R

(B) $2R$

(C) $3R$

(D) $4R$

Q4. The acceleration due to gravity at a height equal to Earth's radius above the surface is:

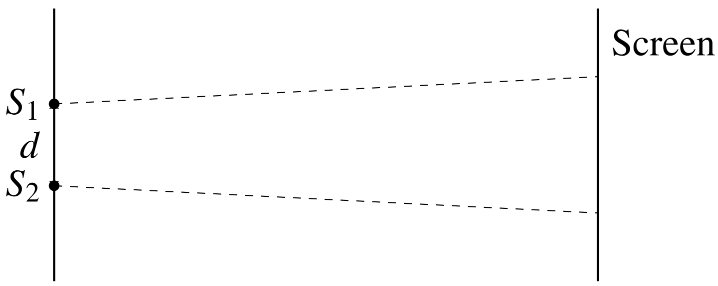
(A) $\frac{g}{2}$

(B) $\frac{g}{3}$

(C) $\frac{g}{4}$

(D) $\frac{g}{8}$

Q5. In Young's double slit experiment, the path difference corresponding to the third bright fringe is:



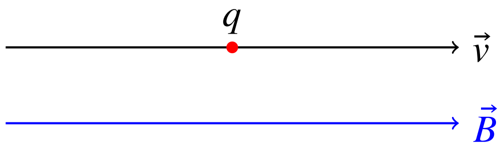
(A) λ

(B) 2λ

(C) 3λ

(D) $\frac{3\lambda}{2}$

Q6. The force on a charge moving parallel to a magnetic field is:



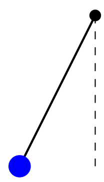
(A) Maximum

(B) Minimum

(C) Zero

(D) Infinite

Q7. The time period of a simple pendulum on the Moon is compared to that on Earth. If $g_{\text{moon}} = \frac{g}{6}$, then the time period becomes:



(A) $\frac{T}{6}$

(B) $\frac{T}{\sqrt{6}}$

(C) $\sqrt{6}T$

(D) $6T$

Q8. The stopping potential in the photoelectric effect depends upon:

(A) Intensity of light

(B) Frequency of light

(C) Area of metal surface

(D) Distance from source

Q9. The equivalent capacitance of two capacitors $3\mu F$ and $6\mu F$ connected in parallel is:

(A) $1\mu F$

(B) $2\mu F$

(C) $9\mu F$

(D) $18\mu F$

Q10. The RMS speed of gas molecules is directly proportional to:

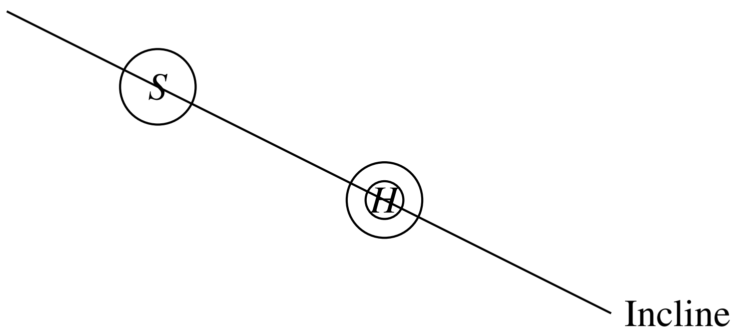
(A) Pressure

(B) Volume

(C) $\sqrt{T}$

(D) Density

Q11. A solid sphere and a hollow sphere of same mass and radius roll down the same incline. Which reaches first?



(A) Hollow sphere

(B) Solid sphere

(C) Both together

(D) Depends on angle

Q12. According to Lenz's law, the induced current always opposes the:

(A) Magnetic field

(B) Applied voltage

(C) Change producing it

(D) Resistance

Q13. In β^- decay, the atomic number of the nucleus:

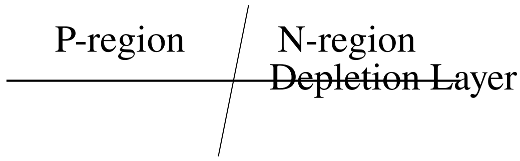
(A) Increases by 1

(B) Decreases by 1

(C) Remains same

(D) Doubles

Q14. A p-n junction diode conducts heavily when it is:



(A) Reverse biased

(B) Forward biased

(C) Unbiased

(D) Heated

Q15. The power of a machine is 500 W. The work done in 20 s is:

(A) 1000 J

(B) 5000 J

(C) 10000 J

(D) 25000 J

Q16. The SI unit of coefficient of viscosity is:

(A) N m

(B) $N\,s\,m^{-2}$

(C) $kg\,m^{-1}$

(D) Pa m

Q17. Two waves are said to be coherent if they have:

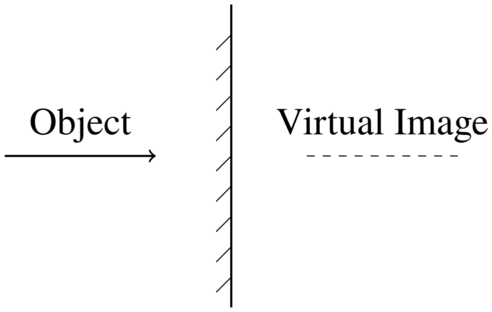
(A) Same amplitude

(B) Same wavelength

(C) Constant phase difference

(D) Same velocity

Q18. The image formed by a plane mirror is:



(A) Real and inverted

(B) Real and erect

(C) Virtual and erect

(D) Virtual and inverted

Q19. The electric potential inside a charged conducting sphere is:

(A) Zero

(B) Constant

(C) Infinite

(D) Variable

Q20. At resonance in a series LCR circuit, the impedance is equal to:

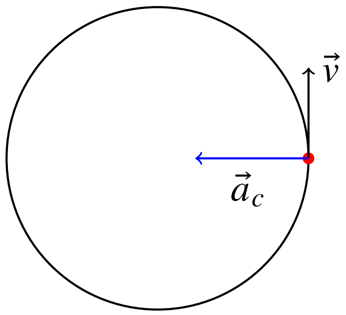
(A) X_L

(B) X_C

(C) R

(D) Zero

Q21. A body moving with constant speed in a circular path possesses:



(A) No acceleration

(B) Tangential acceleration only

(C) Centripetal acceleration

(D) Infinite acceleration

Q22. The coefficient of linear expansion has the unit:

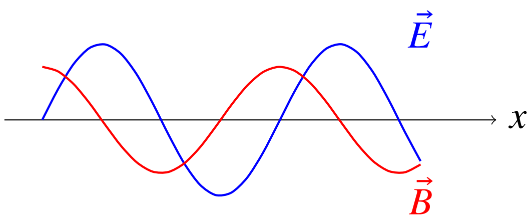
(A) K

(B) K^{-1}

(C) m/K

(D) Dimensionless

Q23. Electromagnetic waves are:



(A) Longitudinal

(B) Transverse

(C) Mechanical

(D) Stationary

Q24. The dimensional formula of Planck's constant is:

(A) $[ML^2T^{-1}]$

(B) $[MLT^{-1}]$

(C) $[ML^2T^{-2}]$

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

Q25. The SI unit of resistivity is:

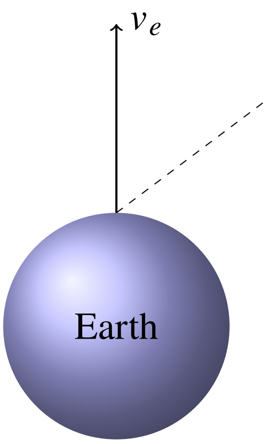
(A) Ω

(B) $\Omega\,\text{m}$

(C) Ω/m

(D) S/m

Q26. The escape velocity from Earth is approximately:



(A) 7.9 km/s

(B) 11.2 km/s

(C) 3×10^8 m/s

(D) 1 km/s

Q27. For an isothermal process of an ideal gas, the change in internal energy is:

(A) Positive

(B) Negative

(C) Zero

(D) Infinite

Q28. The SI unit of magnetic field is:

(A) Weber

(B) Henry

(C) Tesla

(D) Volt

Q29. The acceleration of a particle executing SHM is maximum at:

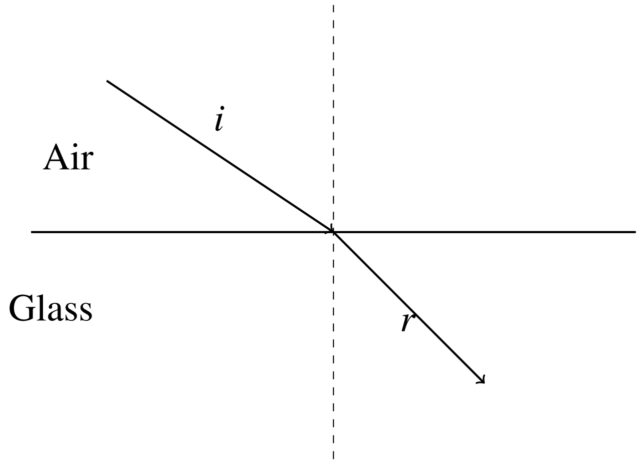
(A) Mean position

(B) Extreme position

(C) Midway position

(D) Every position

Q30. The refractive index of a medium is maximum for:



(A) Red light

(B) Yellow light

(C) Green light

(D) Violet light

Detailed Solutions

Q1.

Solution

Concept: For an ideal gas undergoing a process at constant pressure (isobaric process), Charles's Law states that the volume of the gas is directly proportional to its absolute temperature:

$$V \propto T$$

Thus, the ratio of the final volume to the initial volume is equal to the ratio of the final temperature to the initial temperature.

Solution: Step 1: Write down Charles's Law for the two states of the gas:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Step 2: Express the ratio of final volume V_2 to initial volume V_1:

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

Step 3: Substitute the given values of initial temperature $T_1 = 300\,\text{K}$ and final temperature $T_2 = 600\,\text{K}$ into the equation:

$$\frac{V_2}{V_1} = \frac{600\,\text{K}}{300\,\text{K}} = 2$$

Step 4: Conclude that the ratio of the final volume to the initial volume is 2.

Final Answer: $\boxed{2}$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The net electric field at any point due to a system of point charges is the vector sum of the electric fields produced by each individual charge (principle of superposition):

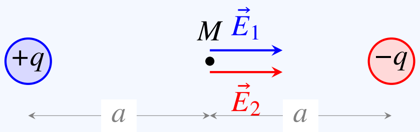
$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2$$

The magnitude of the electric field E at a distance r from a point charge q is:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

Solution: Step 1: Set up the geometry of the system. The distance between the charges $+q$ and $-q$ is $2a$. Therefore, the distance from each charge to the midpoint M is:

$$r = a$$



Step 2: Determine the electric field $\vec{E}_1$ due to $+q$ at the midpoint M:

$$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2} \quad \text{(directed away from } +q\text{, i.e., towards } -q\text{)}$$

Step 3: Determine the electric field $\vec{E}_2$ due to $-q$ at the midpoint M:

$$E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2} \quad \text{(directed towards } -q\text{)}$$

Step 4: Since both electric field vectors point in the same direction, add their magnitudes to find the total field:

$$E_{\text{net}} = E_1 + E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2} + \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2} = \frac{1}{4\pi\varepsilon_0}\frac{2q}{a^2}$$

Final Answer: $\boxed{\frac{1}{4\pi\varepsilon_0}\frac{2q}{a^2}}$

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: The resistance R of a wire of resistivity ρ, length L, and cross-sectional area A is given by:

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

When a wire is stretched, its total volume $V = A \cdot L$ remains constant.

Solution: Step 1: Write down the expression for the initial resistance of the wire:

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

Step 2: Use the conservation of volume to find the relationship between the initial and final cross-sectional areas. Since volume is constant:

$$A \cdot L = A' \cdot L'$$

Given that the length is doubled ($L' = 2L$), we substitute this in:

$$A \cdot L = A' \cdot (2L) \implies A' = \frac{A}{2}$$

Step 3: Express the new resistance R' in terms of the new length and area:

$$R' = \rho \frac{L'}{A'} = \rho \frac{2L}{A/2} = 4\left(\rho \frac{L}{A}\right)$$

Step 4: Substitute the initial resistance R into the equation:

$$R' = 4R$$

Final Answer: $\boxed{4R}$

Answer: (D)

Go Back to Question 3

Q4.

Solution

Concept: The acceleration due to gravity g' at a height h above the Earth's surface is given by the relation:

$$g' = g\left(\frac{R_e}{R_e + h}\right)^2$$

where g is the acceleration due to gravity on the Earth's surface and R_e is the radius of the Earth.

Solution: Step 1: Write down the formula for the variation of g with height:

$$g' = g\left(\frac{R_e}{R_e + h}\right)^2$$

Step 2: Substitute $h = R_e$ (height equal to the Earth's radius) into the formula:

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

Step 3: Simplify the expression:

$$g' = g\left(\frac{R_e}{2R_e}\right)^2 = g\left(\frac{1}{2}\right)^2 = \frac{g}{4}$$

Final Answer: $\boxed{\frac{g}{4}}$

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept: In Young's double slit experiment, constructive interference occurs when the path difference Δx is an integer multiple of the wavelength λ:

$$\Delta x = n\lambda, \quad \text{where } n = 0, 1, 2, 3, \ldots$$

The value of n represents the order of the bright fringe.

Solution: Step 1: Write down the condition for bright fringes (maxima) in interference:

$$\Delta x = n\lambda$$

where $n = 0$ corresponds to the central maximum, $n = 1$ to the first bright fringe, $n = 2$ to the second bright fringe, and so on.
Step 2: For the third bright fringe, we set $n = 3$:

$$\Delta x = 3\lambda$$

Final Answer: $\boxed{3\lambda}$

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: The magnetic force $\vec{F}$ acting on a charge q moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by the Lorentz force formula:

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

The magnitude of this force is:

$$F = qvB \sin\theta$$

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

Solution: Step 1: Identify the angle θ. Since the charge is moving parallel to the magnetic field:

$$\theta = 0^\circ \quad \text{(or } 180^\circ \text{ if antiparallel)}$$

Step 2: Calculate the sine of the angle:

$$\sin(0^\circ) = 0$$

Step 3: Substitute $\sin\theta = 0$ into the force magnitude equation:

$$F = qvB(0) = 0$$

Thus, the force acting on the charge is zero.

Final Answer: Zero

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: The time period T of a simple pendulum of length L is given by:

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

where g is the local acceleration due to gravity. The time period is inversely proportional to the square root of g:

$$T \propto \frac{1}{\sqrt{g}}$$

Solution: Step 1: State the formula for the time period on Earth (T):

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

Step 2: Set up the formula for the time period on the Moon (T'):

$$T' = 2\pi\sqrt{\frac{L}{g_{\text{moon}}}}$$

Step 3: Substitute the given condition $g_{\text{moon}} = \frac{g}{6}$ into the equation:

$$T' = 2\pi\sqrt{\frac{L}{g/6}} = 2\pi\sqrt{\frac{6L}{g}}$$

Step 4: Factor out the constant $\sqrt{6}$ to express T' in terms of T:

$$T' = \sqrt{6}\cdot\left(2\pi\sqrt{\frac{L}{g}}\right) = \sqrt{6}\,T$$

Final Answer: $\boxed{\sqrt{6}\,T}$

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: According to Einstein's photoelectric equation, the maximum kinetic energy K_{max} of emitted photoelectrons is related to the frequency of incident light ν and the work function ϕ of the metal:

$$K_{max} = h\nu - \phi$$

The maximum kinetic energy is also related to the stopping potential V_0 by:

$$K_{max} = eV_0$$

where e is the elementary charge.

Solution: Step 1: Write the expression for the stopping potential V_0 by combining the kinetic energy relationships:

$$eV_0 = h\nu - \phi \implies V_0 = \frac{h}{e}\nu - \frac{\phi}{e}$$

Step 2: Identify the variables in the equation: h and e are fundamental constants. ϕ is the work function, which is constant for a given metal. ν is the frequency of the incident light.

Step 3: Observe that the stopping potential V_0 is a linear function of the frequency of the incident light ν. It is independent of the light's intensity, distance from the source, and the area of the metal surface.

Final Answer: Frequency of light

Answer: (B)

Go Back to Question 8

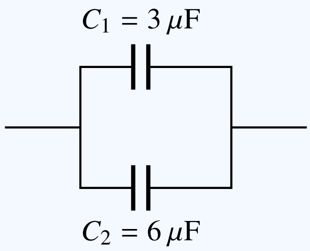
Q9.

Solution

Concept: When two or more capacitors are connected in parallel, the total equivalent capacitance C_{eq} is the sum of the individual capacitances:

$$C_{eq} = C_1 + C_2 + C_3 + \dots$$

Solution: Step 1: Identify the connection type of the two capacitors. They are in parallel.



Step 2: Use the formula for the parallel combination of capacitors:

$$C_{eq} = C_1 + C_2$$

Step 3: Substitute the values $C_1 = 3\,\mu$F and $C_2 = 6\,\mu$F:

$$C_{eq} = 3\,\mu\text{F} + 6\,\mu\text{F} = 9\,\mu\text{F}$$

Final Answer: $\boxed{9\,\mu\text{F}}$

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: The root-mean-square (RMS) speed v_{rms} of ideal gas molecules is given by the formula:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

where R is the universal gas constant, T is the absolute temperature, and M is the molar mass of the gas.

Solution: Step 1: Write down the expression for the RMS speed of gas molecules:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Step 2: Since R and M are constants for a specific ideal gas, determine the relationship between v_{rms} and the absolute temperature T:

$$v_{rms} \propto \sqrt{T}$$

Step 3: Conclude that the RMS speed of gas molecules is directly proportional to the square root of the absolute temperature ($\sqrt{T}$).

Final Answer: $\boxed{\sqrt{T}}$

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: When a body of mass M, radius R, and moment of inertia I rolls down an incline of angle θ without slipping, its acceleration a along the incline is given by:

$$a = \frac{g\sin\theta}{1 + \frac{I}{MR^2}}$$

The body with a greater acceleration will reach the bottom of the incline first.

Solution: Step 1: Write down the expression for the moment of inertia for both spheres:

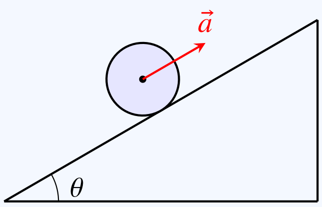
$$\text{For a solid sphere: } I_{\text{solid}} = \frac{2}{5}MR^2$$
$$\text{For a hollow sphere: } I_{\text{hollow}} = \frac{2}{3}MR^2$$

Step 2: Calculate the acceleration for both spheres using the rolling acceleration formula:

$$a_{\text{solid}} = \frac{g\sin\theta}{1 + \frac{2/5MR^2}{MR^2}} = \frac{g\sin\theta}{1+0.4} = \frac{g\sin\theta}{1.4} \approx 0.71g\sin\theta$$
$$a_{\text{hollow}} = \frac{g\sin\theta}{1 + \frac{2/3MR^2}{MR^2}} = \frac{g\sin\theta}{1+0.67} = \frac{g\sin\theta}{1.67} \approx 0.60g\sin\theta$$

Step 3: Compare the accelerations. Since $a_{\text{solid}} > a_{\text{hollow}}$, the solid sphere has a greater acceleration down the incline.

Step 4: Since both spheres cover the same distance starting from rest, the solid sphere will reach the bottom first.



Final Answer: Solid sphere

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Lenz's law is a fundamental law in electromagnetism based on the principle of conservation of energy. It states that the direction of an induced electromotive force (emf) or current is such that it will oppose the change in magnetic flux that produces it.

Solution: Step 1: Understand that Faraday's law of induction gives the magnitude of the induced emf as $\mathcal{E} = -\frac{d\Phi_B}{dt}$.
Step 2: The negative sign in Faraday's law represents Lenz's law, showing opposition.
Step 3: According to Lenz's law, when a magnetic flux through a loop changes, an induced current is generated. This induced current creates its own magnetic field, which acts in a direction to oppose the initial change in magnetic flux (i.e., the change producing it).
Final Answer: Change producing it

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: In beta-minus (β^-) decay, a neutron in the parent nucleus transforms into a proton, an electron (the beta particle, β^-), and an electron antineutrino ($\bar{\nu}_e$):

$$\mathrm{n} \longrightarrow \mathrm{p} + \mathrm{e}^- + \bar{\nu}_e$$

Solution: Step 1: Write down the general nuclear equation for β^- decay of a parent nucleus ${}^A_Z X$:

$${}^A_Z X \longrightarrow {}^{A}_{Z+1} Y + \mathrm{e}^- + \bar{\nu}_e$$

where: A is the mass number (total number of nucleons). Z is the atomic number (number of protons).
Step 2: Compare the parent and daughter nuclei: The mass number A remains unchanged because the total number of nucleons does not change (one neutron is lost, but one proton is gained). The atomic number Z increases by 1 because the number of protons increases by 1.
Final Answer: Increases by 1

Answer: (A)

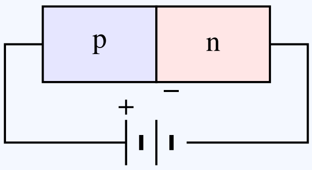
Go Back to Question 13

Q14.

Solution

Concept: A p-n junction diode's behavior depends on the external voltage applied across its terminals: Under **forward bias**, the positive terminal of the source is connected to the p-type side and the negative terminal to the n-type side. This reduces the width of the depletion layer and lowers the potential barrier, allowing majority carriers to cross the junction easily. Under **reverse bias**, the positive terminal is connected to the n-type side and the negative to the p-type side, which widens the depletion layer, creating high resistance and allowing almost no current to flow.

Solution: Step 1: Analyze forward bias. In forward bias, the external field opposes the internal barrier field, resulting in a very narrow depletion region and a low resistance path. Consequently, a large current flows through the junction.
Step 2: Analyze reverse bias. In reverse bias, the depletion layer becomes wider, resulting in very high resistance and only a negligible leakage current due to minority carriers.
Step 3: Conclude that the diode conducts heavily when it is forward biased.



Final Answer: Forward biased

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: Power P is defined as the rate at which work W is done over a time interval t:

$$P = \frac{W}{t}$$

From this, the work done is given by:

$$W = P \cdot t$$

Solution: Step 1: Identify the given values from the problem statement:

$$\text{Power } (P) = 500\,\text{W}$$
$$\text{Time } (t) = 20\,\text{s}$$

Step 2: Use the formula relating work, power, and time:

$$W = P \cdot t$$

Step 3: Substitute the given values into the formula:

$$W = 500\,\text{W} \cdot 20\,\text{s} = 10000\,\text{J}$$

Thus, the work done in 20 s is 10000 J.

Final Answer: $\boxed{10000\,\text{J}}$

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: According to Newton's law of viscosity, the viscous force F acting between two liquid layers of area A separated by a distance dy and having a velocity difference dv is:

$$F = -\eta A \frac{dv}{dy}$$

where η is the coefficient of viscosity.

Solution: Step 1: Rearrange the formula to express the coefficient of viscosity η:

$$\eta = \frac{F}{A\left(\frac{dv}{dy}\right)}$$

Step 2: Determine the SI units for each term in the expression: Force $F \rightarrow$ N (Newtons) Area $A \rightarrow \mathrm{m}^2$ (square meters) Velocity gradient $\frac{dv}{dy} \rightarrow \frac{\mathrm{m/s}}{\mathrm{m}} = \mathrm{s}^{-1}$ (per second)
Step 3: Substitute these units back into the formula for η:

$$\text{Unit of } \eta = \frac{\mathrm{N}}{\mathrm{m}^2 \cdot \mathrm{s}^{-1}} = \mathrm{N\,s\,m}^{-2}$$

Step 4: This unit is also equivalent to Pascal-seconds (Pa s) or Poiseuille (Pl). Looking at the options, $\mathrm{N\,s\,m}^{-2}$ is the correct unit.
Final Answer: $\boxed{\mathrm{N\,s\,m}^{-2}}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: In wave optics, two sources of waves are said to be coherent if they emit light waves of the same frequency (or wavelength) and have a constant phase difference that does not vary with time.

Solution: Step 1: Define coherence. Coherence is a property of waves that enables stationary (stable) interference patterns.
Step 2: State the criteria for two sources to be coherent: 1. They must emit waves of the same wavelength or frequency. 2. The phase difference between the waves must remain constant over time.
Step 3: Evaluate the given options. While having the same amplitude, wavelength, or velocity are properties of waves, the defining physical requirement for coherence is a constant phase difference.
Final Answer: $\boxed{\text{Constant phase difference}}$

Answer: (C)

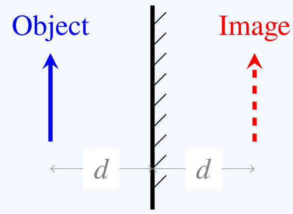
Go Back to Question 17

Q18.

Solution

Concept: A plane mirror forms an image of a real object through the reflection of light rays. The light rays from the object diverge upon reflection and appear to meet behind the mirror. Since the reflected rays do not actually intersect, the image is virtual.

Solution: Step 1: Recall the characteristics of the image formed by a plane mirror: 1. **Virtual:** The light rays do not actually pass through the image location, but only appear to diverge from it. 2. **Erect:** The image is oriented in the same upright direction as the object. 3. **Same size:** The size of the image is equal to the size of the object. 4. **Equal distance:** The image distance behind the mirror is equal to the object distance in front of the mirror.
Step 2: Combine these properties to match the options. The image is virtual and erect.



Final Answer: Virtual and erect

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: The electrostatic properties of a conductor state that the electric field inside a charged conductor is zero at all points in electrostatic equilibrium:

$$E = 0$$

The relationship between the electric field E and the electric potential V is given by:

$$E = -\frac{dV}{dr}$$

Solution: Step 1: Write down the expression for the relation between electric field and electric potential:

$$E = -\frac{dV}{dr}$$

Step 2: Since the electric field inside a charged conducting sphere is zero ($E = 0$), substitute this into the equation:

$$-\frac{dV}{dr} = 0$$

Step 3: A derivative of a variable with respect to distance being zero means that the variable itself is a constant:

$$V = \text{Constant}$$

Step 4: This constant potential is equal to the value of the potential at the surface of the sphere, which is:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$$

where q is the charge on the sphere and R is its radius.

Final Answer: $\boxed{\text{Constant}}$

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: The impedance Z of a series LCR (Inductor-Capacitor-Resistor) circuit is given by:

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

where:
R is the ohmic resistance.
$X_L = \omega L$ is the inductive reactance.
$X_C = \frac{1}{\omega C}$ is the capacitive reactance.

Solution: Step 1: Identify the condition for resonance in a series LCR circuit. Resonance occurs when the inductive reactance equals the capacitive reactance:

$$X_L = X_C$$

Step 2: Substitute this resonance condition ($X_L = X_C$) into the impedance formula:

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

$$Z = \sqrt{R^2 + 0^2}$$

$$Z = R$$

Step 3: At this point, the impedance of the circuit is minimum and purely resistive, meaning the total impedance is equal to R.

Final Answer: $\boxed{R}$

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept: For a body moving in a circular path, velocity is a vector quantity that has both magnitude (speed) and direction. Even if the speed is constant (uniform circular motion), the direction of the velocity vector changes continuously. A change in velocity direction causes an acceleration directed radially inward towards the center of the circle, which is known as **centripetal acceleration**:

$$a_c = \frac{v^2}{R}$$

Since the speed is constant, there is no tangential acceleration ($a_t = 0$).

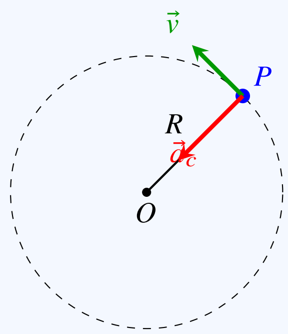
Solution: Step 1: Understand that velocity is a vector: $\vec{v} = v\hat{u}_t$, where v is the speed and $\hat{u}_t$ is the unit vector tangent to the path.
Step 2: Since the speed is constant, the tangential component of acceleration is zero:

$$a_t = \frac{dv}{dt} = 0$$

Step 3: Because the direction of motion is continuously changing along the circular path, there must be a radially inward acceleration. This is the centripetal acceleration:

$$a_c = \frac{v^2}{R}$$

Step 4: Conclude that the body possesses centripetal acceleration.



Final Answer: Centripetal acceleration

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept: The coefficient of linear expansion α measures the fractional change in length of a solid per degree change in temperature:

$$\alpha = \frac{\Delta L}{L_0 \Delta T}$$

where ΔL is the change in length, L_0 is the initial length, and ΔT is the change in temperature.

Solution: Step 1: Write down the formula for the coefficient of linear expansion:

$$\alpha = \frac{\Delta L}{L_0 \Delta T}$$

Step 2: Determine the SI units of each quantity in the formula: Change in length $(\Delta L) \rightarrow$ m Initial length $(L_0) \rightarrow$ m Change in temperature $(\Delta T) \rightarrow$ K (or °C)
Step 3: Substitute the units into the equation:

$$\text{Unit of } \alpha = \frac{\text{m}}{\text{m} \cdot \text{K}} = \text{K}^{-1}$$

Thus, the unit is K^{-1} (per Kelvin).
Final Answer: $\boxed{\text{K}^{-1}}$

Answer: (B)

Go Back to Question 22

Q23.

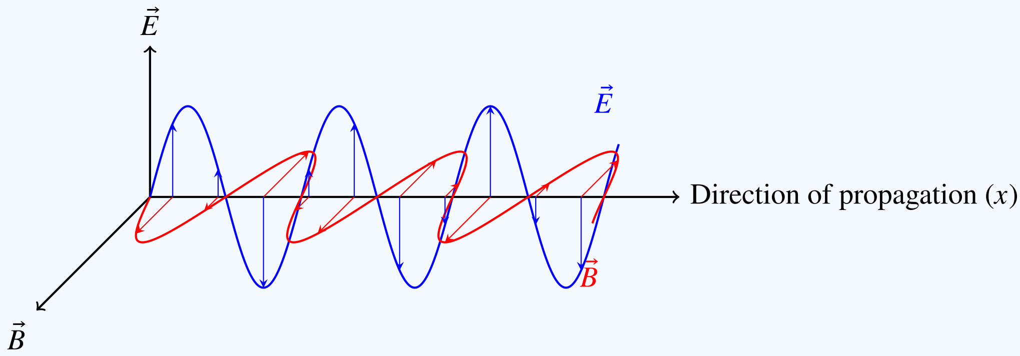
Solution

Concept: Electromagnetic waves consist of oscillating electric ($\vec{E}$) and magnetic ($\vec{B}$) field vectors. These fields oscillate perpendicular to each other and also perpendicular to the direction of wave propagation. Waves where the oscillations are perpendicular to the direction of propagation are classified as **transverse** waves.

Solution: Step 1: Identify the nature of oscillations in electromagnetic waves. The electric field vector $\vec{E}$ and magnetic field vector $\vec{B}$ both oscillate in planes perpendicular to the direction of propagation.

Step 2: Recall the definitions of wave types: **Longitudinal waves:** Oscillations are parallel to the direction of wave propagation. **Transverse waves:** Oscillations are perpendicular to the direction of wave propagation.

Step 3: Since the oscillations in electromagnetic waves are perpendicular to the direction of travel, they are transverse waves.



Final Answer: Transverse

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The relationship between the energy E of a photon and its frequency ν is given by Planck's equation:

$$E = h\nu$$

where h is Planck's constant.

Solution: Step 1: Write down the formula for Planck's constant h:

$$h = \frac{E}{\nu}$$

Step 2: Determine the dimensional formula for each component: Energy (E = Force × Distance):

$$[E] = [MLT^{-2}] \cdot [L] = [ML^2T^{-2}]$$

Frequency ($\nu = \frac{1}{\text{Time}}$):

$$[\nu] = [T^{-1}]$$

Step 3: Substitute these dimensional formulas back into the equation for h:

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

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

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: The electrical resistance R of a uniform conductor is directly proportional to its length L and inversely proportional to its cross-sectional area A:

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

where ρ is the electrical resistivity of the material.

Solution: Step 1: Rearrange the formula to express resistivity ρ:

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

Step 2: Identify the SI units for each term in the expression: Resistance $(R) \to \Omega$ (Ohms) Area $(A) \to \text{m}^2$ (square meters) Length $(L) \to$ m (meters)
Step 3: Substitute the units into the formula for ρ:

$$\text{Unit of } \rho = \Omega \cdot \frac{\text{m}^2}{\text{m}} = \Omega\,\text{m}$$

Thus, the SI unit of resistivity is Ohm-meter ($\Omega\,\text{m}$).
Final Answer: $\boxed{\Omega\,\text{m}}$

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: The escape velocity v_e from the surface of a spherical planet of mass M and radius R is given by:

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

where g is the acceleration due to gravity on the planet's surface.

Solution: Step 1: Write down the escape velocity formula:

$$v_e = \sqrt{2gR}$$

Step 2: Substitute the standard values for Earth: Acceleration due to gravity on Earth $(g) \approx 9.8\,\text{m/s}^2$
Mean radius of Earth $(R) \approx 6.4 \times 10^6$ m
Step 3: Calculate the numerical value:

$$v_e = \sqrt{2 \cdot 9.8 \cdot 6.4 \times 10^6} \approx \sqrt{1.2544 \times 10^8} \approx 11200\,\text{m/s} = 11.2\,\text{km/s}$$

Thus, the escape velocity from Earth is approximately 11.2 km/s.
Final Answer: $\boxed{11.2\,\text{km/s}}$

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept: For an ideal gas, internal energy U is a state function that depends only on its absolute temperature T:

$$U = nC_vT$$

where n is the number of moles and C_v is the molar specific heat capacity at constant volume.

Solution: Step 1: In an isothermal process, by definition, the temperature remains constant:

$$T = \text{constant} \implies \Delta T = 0$$

Step 2: Write down the expression for the change in internal energy (ΔU):

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

Step 3: Substitute $\Delta T = 0$ into the expression:

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

Thus, the change in internal energy during an isothermal process of an ideal gas is zero.
Final Answer: Zero

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: The magnetic field (or magnetic flux density) $\vec{B}$ is a vector quantity that represents the strength of a magnetic field. Its standard SI unit is the **Tesla (T)**.

Solution: Step 1: Recall the units of the physical quantities mentioned in the options: **Weber (Wb):*SI unit of magnetic flux ($\Phi_B = \vec{B} \cdot \vec{A}$). **Henry (H):*SI unit of inductance (L). **Tesla (T):*SI unit of magnetic field (B). **Volt (V):*SI unit of electric potential (V).
Step 2: Match the SI unit for the magnetic field, which is Tesla.
Final Answer: Tesla

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: The acceleration a of a particle executing simple harmonic motion (SHM) is directly proportional to its displacement x from the mean position and acts in the opposite direction:

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

where ω is the angular frequency of the motion.

Solution: Step 1: Write down the expression for the magnitude of acceleration:

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

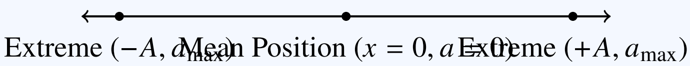
Step 2: Analyze the acceleration at the key positions of motion: **Mean position ($x = 0$):**

$$|a| = \omega^2(0) = 0 \quad \text{(Minimum)}$$

Extreme positions ($|x| = A$, where A is amplitude):

$$|a| = \omega^2 A \quad \text{(Maximum)}$$

Step 3: Conclude that the acceleration of a particle in SHM is maximum at the extreme positions.



Final Answer: Extreme position

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: According to Cauchy's dispersion formula, the refractive index n of a medium depends on the wavelength λ of the light passing through it:

$$n(\lambda) \approx A + \frac{B}{\lambda^2}$$

where A and B are constants. Since refractive index is inversely related to wavelength, a shorter wavelength of light results in a higher refractive index in a given medium.

Solution: Step 1: Arrange the colors of visible light in order of decreasing wavelength (and increasing frequency):

$$\lambda_{\text{red}} > \lambda_{\text{yellow}} > \lambda_{\text{green}} > \lambda_{\text{violet}}$$

Step 2: Using Cauchy's relationship ($n \propto \frac{1}{\lambda^2}$), establish the order of the refractive indices for these colors:

$$n_{\text{red}} < n_{\text{yellow}} < n_{\text{green}} < n_{\text{violet}}$$

Step 3: Conclude that the refractive index is maximum for violet light because it has the shortest wavelength among the given options.

Final Answer: Violet light

Answer: (D)

Go Back to Question 30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	D	4	C	5	C
6	C	7	C	8	B	9	C	10	C
11	B	12	C	13	A	14	B	15	C
16	B	17	C	18	C	19	B	20	C
21	C	22	B	23	B	24	A	25	B
26	B	27	C	28	C	29	B	30	D