

# JEE Main Physics Sample Paper-10

Duration: 1 Hour

Maximum Marks: 100

## Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

## Section A — Multiple Choice Questions

- Q1.** The de Broglie wavelength of an electron moving with a velocity of  $1.5 \times 10^6$  m/s is approximately [JEE Main 2024]
- (A)  $4.5 \times 10^{-12}$  m  
(B)  $4.5 \times 10^{-13}$  m  
(C)  $4.5 \times 10^{-14}$  m  
(D)  $4.5 \times 10^{-15}$  m
- Q2.** The radius of the first orbit of a hydrogen atom is  $0.529 \times 10^{-10}$  m. The radius of the  $n$ th orbit is given by  $r_n = n^2 r_1$ . What is the radius of the third orbit? [JEE Main 2023]
- (A)  $0.529 \times 10^{-10}$  m  
(B)  $1.587 \times 10^{-10}$  m  
(C)  $4.707 \times 10^{-10}$  m  
(D)  $1.058 \times 10^{-10}$  m
- Q3.** In a photoelectric effect experiment, the cutoff frequency of the material is  $5 \times 10^{14}$  Hz. If the frequency of the incident light is  $1.5 \times 10^{15}$  Hz, then the kinetic energy of the emitted photoelectron is [JEE Main 2022]



- (A) 1.5 eV
- (B) 2 eV
- (C) 3 eV
- (D) 4 eV

**Q4.** A proton and an  $\alpha$ -particle are accelerated through the same potential difference. The ratio of their de Broglie wavelengths is [\[JEE Main 2021\]](#)

- (A) 1:1
- (B) 1:2
- (C) 2:1
- (D) 4:1

**Q5.** The charge on the inner surface of a spherical shell due to a point charge at the center is [\[JEE Main 2024\]](#)

- (A) Zero
- (B) Equal to the charge at the center
- (C) Negative of the charge at the center
- (D) Dependent on the distance from the center

**Q6.** In a parallel-plate capacitor, if the distance between the plates is doubled and the dielectric constant is halved, the capacitance becomes [\[JEE Main 2023\]](#)

- (A) Doubled
- (B) Half
- (C) Quarter
- (D) Unchanged

**Q7.** A capacitor of capacitance  $10 \mu\text{F}$  is charged to 100 V. It is then disconnected from the battery and connected in parallel to another uncharged  $10 \mu\text{F}$  capacitor. The final potential difference across each capacitor is [\[JEE Main 2022\]](#)

- (A) 50 V
- (B) 100 V
- (C) 25 V



(D) 200 V

**Q8.** The current in an AC circuit is given by  $I = I_0 \sin(\omega t)$ . If the power delivered to the circuit is maximum, the phase angle between the voltage and current must be [JEE Main 2024]

(A)  $0^\circ$

(B)  $45^\circ$

(C)  $90^\circ$

(D)  $180^\circ$

**Q9.** The magnetic field at the center of a circular loop of radius  $R$  carrying a current  $I$  is  $B = \frac{\mu_0 I}{2R}$ . If the current is doubled and the radius is halved, the new magnetic field at the center is [JEE Main 2023]

(A)  $2B$

(B)  $4B$

(C)  $B$

(D)  $B/2$

**Q10.** In the case of diffraction, the angular width of the central maxima in single-slit diffraction is proportional to [JEE Main 2022]

(A)  $\lambda$

(B)  $\lambda/2$

(C)  $\lambda/d$

(D)  $1/\lambda$

**Q11.** A plane mirror and a concave mirror both form real images of an object. The magnification produced by the concave mirror is 2. What will be the magnification of the plane mirror? [JEE Main 2021]

(A) 1

(B) 2

(C) 4

(D) -1

**Q12.** The critical angle for a medium with a refractive index of 1.5 is [JEE Main 2024]



- (A)  $41.8^\circ$
- (B)  $45^\circ$
- (C)  $30^\circ$
- (D)  $60^\circ$

**Q13.** The time period of a simple pendulum is  $T$ . If the mass of the bob is doubled, the new time period is [JEE Main 2023]

- (A)  $T$
- (B)  $2T$
- (C)  $\sqrt{2}T$
- (D)  $T/\sqrt{2}$

**Q14.** The energy required to excite an electron in a hydrogen atom from  $n = 1$  to  $n = 2$  is [JEE Main 2022]

- (A) 13.6 eV
- (B) 10.2 eV
- (C) 1.6 eV
- (D) 3.4 eV

**Q15.** A block of mass 1 kg is moving on a frictionless surface with a velocity of 10 m/s. It collides with a spring of spring constant 500 N/m. The maximum compression in the spring will be [JEE Main 2021]

- (A) 1 m
- (B) 2 m
- (C) 5 m
- (D) 0.5 m

**Q16.** The work done by a force acting on a body in simple harmonic motion is maximum when the body is [JEE Main 2024]

- (A) At the mean position
- (B) At the amplitude position
- (C) At the equilibrium position
- (D) At the point of maximum displacement



- Q17.** A car moving with a velocity of 20 m/s is brought to rest in 5 seconds by applying brakes. The acceleration is [JEE Main 2022]
- (A)  $-4 \text{ m/s}^2$   
(B)  $-2 \text{ m/s}^2$   
(C)  $4 \text{ m/s}^2$   
(D)  $2 \text{ m/s}^2$
- Q18.** A satellite is moving in a circular orbit of radius  $R$  around Earth. If the radius of its orbit is doubled, its speed becomes [JEE Main 2023]
- (A)  $\sqrt{2}$  times  
(B) Half  
(C) Double  
(D)  $2\sqrt{2}$  times
- Q19.** The velocity of a particle in uniform circular motion is given by  $v = r\omega$ , where  $\omega$  is the angular velocity. The angular velocity is inversely proportional to [JEE Main 2021]
- (A) The mass of the particle  
(B) The radius of the circle  
(C) The square of the radius  
(D) The velocity of the particle
- Q20.** In the adiabatic expansion of an ideal gas, the temperature of the gas decreases. The relation between pressure and volume for this process is [JEE Main 2022]
- (A)  $P \propto V$   
(B)  $P \propto V^3$   
(C)  $P \propto V^\gamma$   
(D)  $P \propto V^2$



## Section B — Numerical Questions

- Q21.** A capacitor of  $20 \mu\text{F}$  is charged to  $50 \text{ V}$ . The energy stored in the capacitor is [JEE Main 2024]
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- Q22.** A ball of mass  $0.5 \text{ kg}$  is thrown vertically upwards with an initial velocity of  $20 \text{ m/s}$ . The maximum height reached by the ball is [JEE Main 2023]
- 
- Q23.** A charge of  $5 \mu\text{C}$  is placed at a point  $10 \text{ cm}$  away from a charge of  $10 \mu\text{C}$ . Find the force between the charges ( $k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$ ) [JEE Main 2022]
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- Q24.** A spring of force constant  $100 \text{ N/m}$  is stretched by  $0.2 \text{ m}$ . Find the work done in stretching the spring [JEE Main 2021]
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- Q25.** A block of mass  $0.5 \text{ kg}$  is attached to a spring and undergoes simple harmonic motion. The amplitude of the motion is  $5 \text{ cm}$ , and the spring constant is  $100 \text{ N/m}$ . Find the total mechanical energy of the system [JEE Main 2023]
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## Detailed Solutions

Q1.

## Solution

**Concept:** De-Broglie wavelength formula is given by:

$$\lambda = \frac{h}{p}, \quad p = mv$$

For the same potential difference, the energy gained by the particles will be the same, and the ratio of their de-Broglie wavelengths will depend on their masses. Since the proton is much lighter than the  $\alpha$ -particle, its de-Broglie wavelength will be larger.

$$\frac{\lambda_{\alpha}}{\lambda_{\text{proton}}} = \frac{m_{\text{proton}}}{m_{\alpha}} \Rightarrow \text{Ratio} = \frac{1}{2}$$

**Solution:** The ratio of the de-Broglie wavelengths of the proton and the  $\alpha$ -particle is approximately 1 : 2. This result comes from the difference in the masses of the two particles, where the proton is much lighter, resulting in a larger wavelength.

**Answer:** (A)

Q2.

## Solution

**Concept:** Energy band gap for LED is related to the wavelength of emitted light by:

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

where  $h = 6.626 \times 10^{-34}$  J.s is Planck's constant and  $c = 3 \times 10^8$  m/s is the speed of light. For violet LED ( $\lambda = 400$  nm =  $4 \times 10^{-7}$  m):

$$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{4 \times 10^{-7}} = 4.97 \times 10^{-19} \text{ J} \approx 3 \text{ eV}$$

**Solution:** The energy band gap required for a violet LED is closest to 3 eV, which is a common value for violet LEDs.

**Answer:** (C)



Q3.

**Solution**

**Concept:** The wavelength of the first line of the Lyman series is given by the formula:

$$\lambda = \frac{1.216 \times 10^{-9}}{1 - \frac{1}{n^2}}$$

For the first line (transition from  $n = 2$  to  $n = 1$ ), we use the value  $\lambda \approx 121.6$  nm, which is approximately 122 nm.

**Solution:** The wavelength of the first line of the Lyman series is around 122 nm, and this corresponds to the transition from  $n = 2$  to  $n = 1$ .

**Answer: (A)**

Q4.

**Solution**

**Concept:** The activity of a radioactive sample decays exponentially with time and is related to the number of half-lives by:

$$N(t) = N_0 \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$

Given that the activity drops to  $\frac{1}{4}$ , we know that two half-lives have passed. The decay process follows the rule that after each half-life, the amount of the substance halves.

**Solution:** Since the activity has dropped to  $\frac{1}{4}$ , it means that two half-lives have elapsed. Therefore, the number of half-lives is 2.

**Answer: (B)**

Q5.

**Solution**

**Concept:** The electric potential at a point due to point charges is the algebraic sum of potentials due to individual charges. The electric potential at the midpoint between two opposite charges (one positive and one negative) will cancel out, because the potentials due to each charge are equal in magnitude but opposite in sign.

**Solution:** At the midpoint, the electric potentials due to both the positive and negative charges cancel each other out, resulting in a net potential of zero.

**Answer: (A)**



Q6.

**Solution**

**Concept:** The capacitance of a parallel-plate capacitor with a dielectric inserted is given by:

$$C' = K \times C$$

where  $K$  is the dielectric constant. If the dielectric constant is  $K$ , the new capacitance is  $K \times C$ .

**Solution:** The new capacitance becomes  $K \times C$ .

**Answer:** (B)

Q7.

**Solution**

**Concept:** The electric field at any point between two equal charges will be zero at a point where the magnitudes of the fields due to each charge cancel each other out. This will occur closer to the smaller charge. For equal charges, the net electric field becomes zero at infinity.

**Solution:** The net electric field becomes zero at infinity.

**Answer:** (C)

Q8.

**Solution**

**Concept:** The current through a resistor in a parallel circuit is given by Ohm's Law. The total current splits in proportion to the inverse of the resistance. Given that  $V = IR$ , the current through the  $3 \Omega$  resistor is:

$$I_3 = \frac{V}{R_3} = \frac{9}{3} = 3 \text{ A}$$

**Solution:** The current through the  $3 \Omega$  resistor is 3 A.

**Answer:** (C)

Q9.

**Solution**

**Concept:** When the length of the wire is doubled, its resistance increases by a factor of 4, since resistance  $R \propto L$ . Thus, the new resistance is  $4 \times R$ .

**Solution:** The new resistance becomes  $16 \Omega$ .

**Answer:** (B)



Q10.

**Solution**

**Concept:** The equivalent resistance for a series and parallel combination can be calculated by the following formulas:

$$R_{\text{eq}} = R_1 + R_2 \quad (\text{for series}), \quad R_{\text{eq}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} \quad (\text{for parallel})$$

**Solution:** The equivalent resistance is  $5 \Omega$ .

**Answer:** (A)

Q11.

**Solution**

**Concept:** The critical angle for total internal reflection in a medium is given by:

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

where  $n_1$  is the refractive index of the denser medium (1.5 in this case), and  $n_2$  is the refractive index of the less dense medium (1 for air).

**Solution:** The critical angle is calculated as:

$$\sin \theta_c = \frac{1}{1.5} \Rightarrow \theta_c = \sin^{-1} \left( \frac{1}{1.5} \right) = 41.8^\circ$$

**Answer:** (A)

Q12.

**Solution**

**Concept:** The time period  $T$  of a simple pendulum is given by:

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

where  $L$  is the length of the pendulum and  $g = 9.8 \text{ m/s}^2$  is the acceleration due to gravity. The time period is independent of the mass of the bob.

**Solution:** Since doubling the mass of the bob does not affect the time period, the new time period remains the same:

$$T_{\text{new}} = T$$

**Answer:** (A)



Q13.

**Solution**

**Concept:** The energy required to excite an electron in a hydrogen atom from  $n = 1$  to  $n = 2$  is the difference in energy levels:

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

where  $n_1 = 1$  and  $n_2 = 2$ .

**Solution:** Substituting  $n_1 = 1$  and  $n_2 = 2$ :

$$E = -13.6 \left( \frac{1}{4} - 1 \right) = 10.2 \text{ eV}$$

**Answer: (B)**

Q14.

**Solution**

**Concept:** The maximum compression in a spring when a block is attached and moves towards the spring is given by:

$$E_{\text{kinetic}} = E_{\text{spring}}$$

where the spring potential energy is:

$$E_{\text{spring}} = \frac{1}{2} kx^2$$

and the kinetic energy is:

$$E_{\text{kinetic}} = \frac{1}{2} mv^2$$

**Solution:** Given:  $m = 1 \text{ kg}$ ,  $v = 10 \text{ m/s}$ , and  $k = 500 \text{ N/m}$ , we can equate the two energies:

$$\begin{aligned} \frac{1}{2} mv^2 &= \frac{1}{2} kx^2 \\ \Rightarrow x &= \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{1 \times (10)^2}{500}} = 0.447 \text{ m} \end{aligned}$$

**Answer: (0.447)**



Q15.

**Solution**

**Concept:** The work done by a force acting on a body in simple harmonic motion is maximum when the displacement is maximum, which is at the amplitude position. This is because the force is at its maximum at maximum displacement, and the body is moving the fastest at the amplitude position.

**Solution:** The work done is maximum when the body is at the amplitude position because the displacement is maximum and the restoring force is maximum.

**Answer: (B)**

Q16.

**Solution**

**Concept:** The acceleration in this scenario is calculated using the formula for uniform acceleration:

$$a = \frac{\Delta v}{\Delta t}$$

where  $\Delta v = 20 \text{ m/s}$  (initial velocity) and  $\Delta t = 5 \text{ s}$ .

**Solution:**

$$a = \frac{20 \text{ m/s}}{5 \text{ s}} = -4 \text{ m/s}^2$$

The negative sign indicates deceleration.

**Answer: (A)**

Q17.

**Solution**

**Concept:** The velocity of a satellite in circular orbit is given by:

$$v = \sqrt{\frac{GM}{R}}$$

where  $R$  is the radius of the orbit. If the radius is doubled, the new speed is:

$$v_{\text{new}} = \sqrt{\frac{GM}{2R}} = \frac{v}{\sqrt{2}}$$

**Solution:** When the radius is doubled, the speed decreases by a factor of  $\sqrt{2}$ .

**Answer: (B)**

Q18.

**Solution**

**Concept:** The angular velocity  $\omega$  is related to the radius  $r$  by the equation:

$$v = r\omega$$

Thus, angular velocity is inversely proportional to the radius of the circular path.

**Solution:** The angular velocity is inversely proportional to the radius of the circle.

**Answer:** (B)

Q19.

**Solution**

**Concept:** In an adiabatic process, the relation between pressure and volume is:

$$PV^\gamma = \text{constant}$$

where  $\gamma$  is the adiabatic index. For an ideal gas, this shows how pressure increases with volume as the gas expands adiabatically.

**Solution:** The correct relation for adiabatic expansion is  $P \propto V^\gamma$ , where  $\gamma$  is the adiabatic index.

**Answer:** (C)

Q20.

**Solution**

**Concept:** The energy required to excite an electron from one orbit to another in a hydrogen atom is related to the difference in energy levels. The energy for the transition from  $n = 1$  to  $n = 2$  can be calculated using the energy levels for the hydrogen atom.

**Solution:** The energy required to excite the electron from  $n = 1$  to  $n = 2$  is 10.2 eV, which is the energy difference between these two levels.

**Answer:** (B)



Q21.

**Solution****Concept:** The energy stored in a capacitor is given by:

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

where  $C = 20 \mu\text{F} = 20 \times 10^{-6} \text{ F}$  and  $V = 50 \text{ V}$ .**Solution:** Substitute the given values into the formula:

$$E = \frac{1}{2} \times 20 \times 10^{-6} \times (50)^2 = 0.025 \text{ J}$$

**Answer:** (0.025)

Q22.

**Solution****Concept:** The maximum height reached by a ball thrown vertically upwards can be found using the formula:

$$v^2 = u^2 - 2gh$$

where: -  $v = 0 \text{ m/s}$  (final velocity at maximum height), -  $u = 20 \text{ m/s}$  (initial velocity), -  $g = 9.8 \text{ m/s}^2$  (acceleration due to gravity), -  $h$  is the maximum height.**Solution:** Rearranging the formula to solve for height:

$$h = \frac{u^2}{2g} = \frac{(20)^2}{2 \times 9.8} = \frac{400}{19.6} = 20.41 \text{ m}$$

**Answer:** (20.41)

Q23.

**Solution****Concept:** The force between two charges is given by Coulomb's Law:

$$F = \frac{k|q_1q_2|}{r^2}$$

where: -  $k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$  is Coulomb's constant, -  $q_1 = 5 \mu\text{C} = 5 \times 10^{-6} \text{ C}$ , -  $q_2 = 10 \mu\text{C} = 10 \times 10^{-6} \text{ C}$ , -  $r = 10 \text{ cm} = 0.1 \text{ m}$ .**Solution:** Substituting the given values into Coulomb's law:

$$F = \frac{9 \times 10^9 \times (5 \times 10^{-6}) \times (10 \times 10^{-6})}{(0.1)^2} = \frac{9 \times 10^9 \times 50 \times 10^{-12}}{0.01}$$

$$F = 4.5 \times 10^{-2} \text{ N}$$

**Answer:** ( $4.5 \times 10^{-2}$ )

Q24.

**Solution****Concept:** The work done in stretching a spring is given by:

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

where: -  $k = 100 \text{ N/m}$  is the spring constant, -  $x = 0.2 \text{ m}$  is the extension in the spring.**Solution:** Substitute the given values into the formula:

$$W = \frac{1}{2} \times 100 \times (0.2)^2 = 2 \text{ J}$$

**Answer: (2)**

Q25.

**Solution****Concept:** The total mechanical energy in simple harmonic motion is given by:

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

where: -  $k = 100 \text{ N/m}$  is the spring constant, -  $A = 5 \text{ cm} = 0.05 \text{ m}$  is the amplitude of the motion.**Solution:** Substitute the given values into the formula:

$$E = \frac{1}{2} \times 100 \times (0.05)^2 = 0.125 \text{ J}$$

**Answer: (0.125)**

## Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	A	4	B	5	A
6	B	7	C	8	C	9	B	10	A
11	A	12	A	13	B	14	0.447	15	B
16	A	17	B	18	B	19	C	20	B

## Answer Key — Section B

Q	Ans	Q	Ans
21	0.025	22	20.41
23	$4.5 \times 10^{-2}$	24	2
25	0.125		

