JEE Main - 2023

Physics

Section A

This Section A contains 20 multiple choice questions from 1 to 20. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which only one is correct.

1. A material particle with a rest mass m_0 is moving with speed of light c. The de-Broglie wavelength associated is given by

(A) $\frac{h}{m_0 c}$

(B) $\frac{m_0 c}{h}$

(C) zero

(D) ∞

2. If the radius of hydrogen atom in its ground state is $5.3\times10^{-11}\text{m}$. After collision with an electron it is found to have a radius of $21.2\times10^{-11}\text{m}$. The principle quantum number of the final orbit is

(A) $n=4$

(B) $n=3$

(C) $n=2$

(D) $n=16$

3. In a common emitter (CE) amplifier having a voltage gain G, the transistor used has trans conductance 0.03 mho and current gain 25. If the above transistor is replaced with another one with trans conductance 0.02 mho and current gain 20, the voltage gain will be

(A) $1.5G$

(B) $\frac{1}{3}G$

(C) $\frac{5}{4}G$

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

4. For 100% modulation (AM), the useful part of the total power radiated is

(A) $\frac{1}{2}$ of the total power

(B) $\frac{1}{3}$ of the total power

(C) $\frac{1}{4}$ of the total power

(D) $\frac{2}{3}$ of the total power

5. A lead bullet strikes against a steel plate with a velocity $200\,\mathrm{m\,s^{-1}}$. If the impact is perfectly inelastic and the heat produced is equally shared between the bullet and the target, then the rise in temperature of the bullet is (specific heat capacity of lead $=125\,\mathrm{J\,kg^{-1}K^{-1}}$)

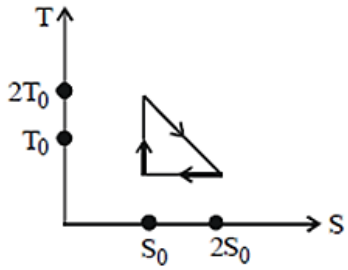
(A) $80°\mathrm{C}$

(B) $60°\mathrm{C}$

(C) $160°\mathrm{C}$

(D) $40°\mathrm{C}$

6. The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



(A) $\frac{1}{4}$

(B) $\frac{1}{2}$

(C) $\frac{2}{3}$

(D) $\frac{1}{3}$

7. A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is:

(A) $f_1 = f_2 < f$

(B) $f_1 > f$ and f_2 becomes negative

(C) $f_2 > f$ and f_1 becomes negative

(D) f_1 and f_2 both become negative

8. **Assertion**: Diffraction takes place for all types of waves mechanical or non-mechanical, transverse or longitudinal.

Reason: Diffraction's effect is perceptible only if wavelength of wave is comparable to dimensions of diffracting device.

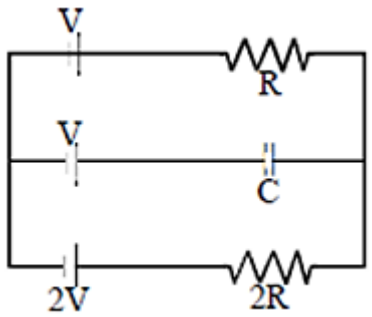
(A) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion

(B) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion

(C) If Assertion is correct but Reason is incorrect

(D) If Assertion is incorrect but Reason is correct

9. In the circuit shown in figure, with steady current, the potential drop across the capacitor must be



(A) V

(B) $\frac{V}{2}$

(C) $\frac{V}{3}$

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

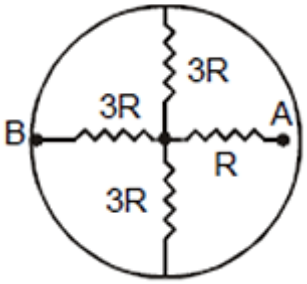
10. In the network shown below, the ring has zero resistance. The equivalent resistance between the point A and B is

(A) $2R$

(B) $4R$

(C) $7R$

(D) $10R$



11. Each of these questions contain two statements, Assertion and Reason. Each of these question also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c), and (d) given below.

Assertion: Drift speed v_d is the average speed between two successive collisions.

Reason: If $\Delta\ell$ is the average distance moved between two collision and Δt is the corresponding time, then

$$v_d = \lim_{\Delta t \to 0} \frac{\Delta \ell}{\Delta t}$$

(A) Assertion is correct. Reason is correct; reason is a correct explanation for assertion.

(B) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(C) Assertion is correct, reason is incorrect

(D) Assertion is incorrect, reason is correct.

12. Identical charges $(-q)$ are placed at each corners of a cube of side b, then the electrostatic potential energy of charge $(+q)$ placed at the centre of the cube will be:

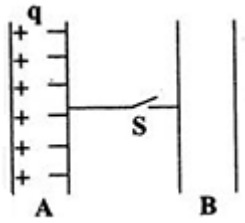
(A) $-\frac{4\sqrt{2}q^2}{\pi\varepsilon_0}$

(B) $\frac{8\sqrt{2}q^2}{\pi\varepsilon_0 b}$

(C) $-\left|\frac{4q^2}{\sqrt{3}\pi\varepsilon_0 b}\right|$

(D) $\left|\frac{8\sqrt{2}q^2}{4\pi\varepsilon_0 b}\right|$

13. Consider the situation shown in the figure. The capacitor A has a charge q on it whereas vB is uncharged. The charge appearing on the capacitor B a long time after the switch is closed is



(A) zero

(B) $\left|\frac{q}{2}\right|$

(C) $|q|$

(D) $|2q|$

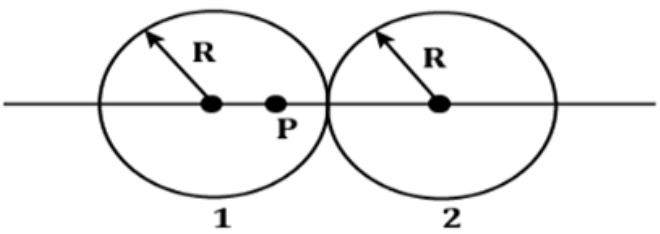
14. Figure shows, in cross section, two solid spheres with uniformly distributed charge throughout their volumes. Each has radius R, Point P lies on a line connecting the centres of the spheres, at radial distance $\frac{R}{2}$ from the centre of sphere 1. If the net electric field at point P is zero and Q_1 is $64\mu C$. What is Q_2 in μC ?

(A) $72\mu C$

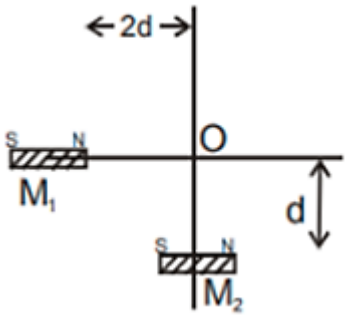
(B) $12\mu C$

(C) $36\mu C$

(D) $48\mu C$



15. Two short bar magnet of magnetic moments M_1 and M_2 are kept on X and Y axis as shown is figure. If resultant magnetic field at origin is zero, Then $\frac{M_1}{M_2}$



(A) $1:4$
(B) $4:1$
(C) $2:1$
(D) $8:1$

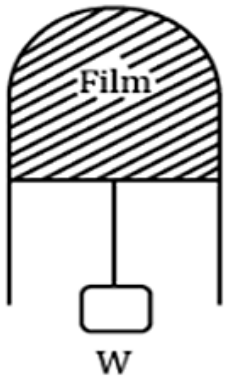
16. **Assertion**: Basic difference between an electric line and magnetic line of force is that former is discontinuous and the latter is continuous or endless.
Reason: No electric lines of forces exist inside a charged body but magnetic lines do exist inside a magnet.
(A) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(B) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(C) If assertion is true but reason is false.
(D) If the assertion is false and reason is true.

17. Let Q denote the charge on the plate of a capacitor of capacitance C. The dimensional formula for $\frac{Q^2}{C}$ is
(A) $\left[L^2M^2T\right]$
(B) $\left[LMT^2\right]$
(C) $\left[L^2MT^{-2}\right]$
(D) $\left[L^2M^2T^2\right]$

18. The minimum velocity (in ms^{-1}) with which a car driver must traverse a flat curve of radius $150\,\mathrm{m}$ and coefficient of friction 0.6 to avoid skidding is

(A) 15
(B) 30
(C) 25
(D) 60

19. A thin liquid film formed between a U - shaped wire and supports a light weight of $1.5\times10^{-2}\,\mathrm{N}$ (see figure). The length of the slider is $30\,\mathrm{cm}$ and its weight is negligible. The surface tension of the liquid film is



(A) $0.0125\,\mathrm{Nm}^{-1}$
(B) $0.1\,\mathrm{Nm}^{-1}$
(C) $0.05\,\mathrm{Nm}^{-1}$
(D) $0.025\,\mathrm{Nm}^{-1}$

20. A rod PQ of length L moves with a uniform velocity v parallel to a long straight wire carrying a current i, the end P remaining at a distance r from the wire. The emf induced across the rod is

(A) $\dfrac{\mu_0 iv^2}{2\pi}\ln\left(\dfrac{r+L}{R}\right)\Bigg|$
(B) Zero
(C) $\dfrac{\mu_0 iv}{2\pi}\ln\left(\dfrac{r+L}{R}\right)\Bigg|$
(D) $\dfrac{\mu_0 iv}{2\pi}\ln\left(\dfrac{r^2+L^2}{L^2}\right)\Bigg|$

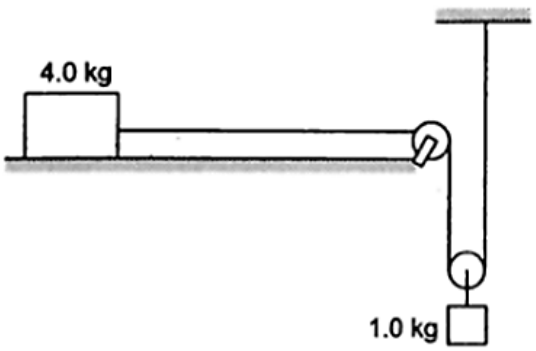
Section-B

This Section B contains 10 Integer Type Questions from 21 to 30. Attempt any 5 Questions.

21. The amplitude of a wave disturbance propagating in the positive x - direction is given by $y=\frac{1}{\left(1+x^2\right)}$ at time $t=0$ and $y=\frac{1}{\left[1+(x-1)^2\right]}$ at $t=1$ seconds where x and y are in metres. The shape of the wave disturbance does not change during the propagation. The velocity of the wave is ____ (in m/s)

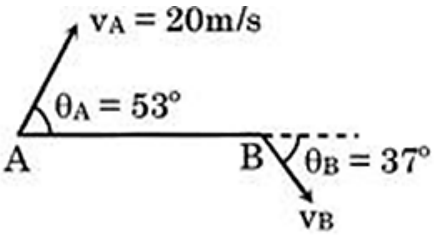
22. A particle is performing simple harmonic motion along x -axis with amplitude $4\,\text{cm}$ and time period $12\,\text{sec}$. The minimum time taken (in s) by the particle to move from $x=2\,\text{cm}$ to $x=+4\,\text{cm}$ and back again is ____ s

23. Consider the situation shown in figure, The system is released from rest and the block of mass $1.0\,\text{kg}$ is found to have a speed $0.3\,\text{m/s}$ after it has descended through a distance of $1\,\text{m}$. The coefficient of kinetic friction between the block and the table is $x\times10^{-2}$. The value of x is ____



24. A body of mass $5\,\text{kg}$ explodes at rest into three fragments with masses in the ratio $1:1:3$. The fragments with equal masses fly in mutually perpendicular directions with speeds of $21\,\text{m/s}$. The velocity (in m/s) up to nearest integer of the heaviest fragment will be ____.

25. The two ends A and B of a uniform rod of length $\ell=1\text{m}$ are moving with velocities V_A and V_B as shown. The velocity V_B (in m/s) is ____.



26. A wire is suspended vertically. One of its ends is stretched by attaching a weight of $200\,\mathrm{N}$ to the lower end. The weight stretches the wire by $1\mathrm{mm}$. Then the elastic energy stored in the wire is $m\times10^{-1}\,\mathrm{J}$. the value of m is ____.

27. The age of a rock containing lead and uranium is equal to 1.5×10^{9} yrs. The uranium is decaying into lead with half-life equal to 4.5×10^{9} yrs. If the ratio of lead to uranium present in the rock, assuming initially no lead was present in the rock s given by 259×10^{-k}. Then the value of k is ____ (Given $2^{\frac{1}{3}}=1.259$).

28. A uniform tube closed at one end, contains a pallet of mercury $10\,\mathrm{cm}$ long. When the tube is kept vertically with the closed end upward, the length of the air column trapped is $20\,\mathrm{cm}$. The length (up to nearest integer) in cm, of the air column trapped when the tube is inverted so that the closed end goes down (Atmospheric pressure $=75\,\mathrm{cm}$ of mercury) will be ____.

29. Two slits are separated by $0.320\,\mathrm{mm}$. A beam of $500\,\mathrm{mm}$ light strikes the slits, producing an interference pattern. Determine the number of maxima observed in the angular range $-30°<\theta<30°$

30. A particle moves from the point $\left(2.0\hat{i}+4.0\hat{j}\right)\mathrm{m},$ at $t=0$, with an initial velocity $\left(5.0\hat{i}+4.0\hat{j}\right)\mathrm{ms}^{-1}$. It is acted upon by a constant force which produces a constant acceleration $\left(4.0\hat{i}+4.0\hat{j}\right)\mathrm{ms}^{-2}$. The distance (up to nearest integer) in metre, of the particle from the origin at time $2\mathrm{s}$ is ____.