KCET PYQ 2021

PHYSICS

Q1 The physical quantity which is measure in the unit of wb A^{-1} is

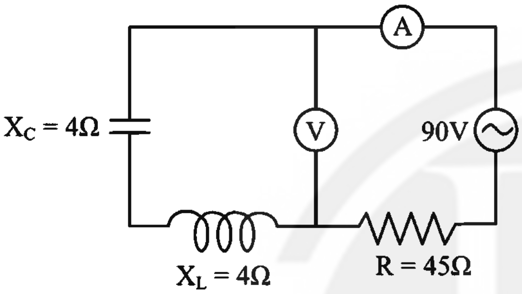
(A) self-inductance

(B) magnetic flux

(C) mutual inductance

(D) Both (A) and (C)

Q2 What will be the reading in the volmeter and ammeter of the circuit shown?



(A) 90V, 2A   (B) 0, 2A

(C) 90V, 1A   (D) 0, 1A

Q3 LC-oscillations are similr and analogous to the mechanical oscillations of a block attached to a spring. The electrical equivalent of the force constant of the spring is

(A) reciprocal of capacitive reactance

(B) capacitive reactance

(C) reciprocal of capacitance

(D) capacitance

Q4 In an oscillating *LC-circuit*, L = 3mH and C = 2.7 μF. At t = 0, the charge on the capacitor is zero and the current is 2A. The maximum charge that will appear on the capacitor will be

(A) 1.8×10^{-5} C

(B) 18×10^{-5} C

(C) 9×10^{-5} C

(D) 90×10^{-5} C

Q5 Suppose that the electric field amplitude of electromagnetic wave is E_0 = 120 NC^{-1} and its frequency f = 50 MHz. Then, which of the following value is incorrectly computed?

(A) Magnetic field amplitude is 400nT

(B) Angular frequency of EM wave is $\pi \times 10^8\, rad/s$

(C) Propagation constant (angular wave number) is 2.1 rad/m

(D) Wavelength of EM wave is 6m

Q6 The source of electromagnetic wave can be a charge

(A) moving with a constant velocity

(B) moving in a circular orbit

(C) at rest

(D) moving parallel to the magnetic field

Q7 In refraction, light waves are bent on passing from one medium to second medium because, in the second medium

(A) Frequency is different

(B) Speed is different

(C) Coefficient of elasticity is different

(D) Amplitude is smaller

Q8 If the refractive index from air to glass is $\frac{3}{2}$ and that from air to water is $\frac{4}{3}$, then the ratio of focal lengths of a glass lens in water and in air is

(A) 1:2   (B) 2:1

(C) 1:4   (D) 4:1

Q9 Two thin biconvex lenses have focal lengths f_1 and f_2. A third thin biconcave lens has focal length of f_3. If the two biconvex lenses are in contact, then the total power of the lenses is P_1. If the first convex lens is in contact with the third lens, then the total power is P_2. If the second lens is in contact with the third lens, the total power is P_3, then

(A) $P_1 = \frac{f_1 f_2}{f_1 - f_2}, P_2 = \frac{f_1 f_3}{f_3 - f_1}$ and $P_3 = \frac{f_2 f_3}{f_3 - f_2}$
(B) $P_1 = \frac{f_1 - f_2}{f_1 f_2}, P_2 = \frac{f_3 - f_1}{f_3 + f_1}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$
(C) $P_1 = \frac{f_1 - f_2}{f_1 f_2}, P_2 = \frac{f_3 - f_1}{f_1 f_3}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$
(D) $P_1 = \frac{f_1 + f_2}{f_1 f_2}, P_2 = \frac{f_3 - f_1}{f_1 f_3}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$

Q10 The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the lens, the new size of the image is

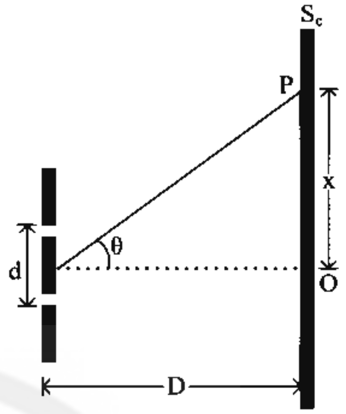
(A) 1.25 cm (B) 2.5 cm
(C) 1.05 cm (D) 2 cm

Q11 A slit of width a is illuminated by red light of wavelength $6500 \mathring{A}$. If the first diffraction minimum falls at 30°, then the value of a is

(A) 6.5×10^{-4} mm
(B) 1.3 micron
(C) $3250 \mathring{A}$
(D) 26×10^{-4} cm

Q12 Which of the following statements are correct with reference to single slit diffraction pattern?
(I) Fringes are of unequal width.
(II) Fringes are of equal width.
(III) Light energy is conserved.
(IV) Intensities of all bright fringes are equal.
(A) Both (I) and (III)
(B) Both (I) and (IV)
(C) Both (II) and (IV)
(D) Both (II) and (III)

Q13 In the Young's double slit experiment a monochromatic source of wavelength λ is used. The intensity of light passing through each slit is I_0. The intensity of light reaching the screen S_C at a point P, a distance x from O is given by (Take, $d << D$)



(A) $I_0 \cos^2\left(\frac{\pi D}{\lambda d} x\right)$
(B) $4I_0 \cos^2\left(\frac{\pi d}{\lambda D} x\right)$
(C) $I_0 \sin^2\left(\frac{\pi d}{2\lambda D} x\right)$
(D) $4I_0 \cos\left(\frac{\pi d}{2\lambda D} x\right)$

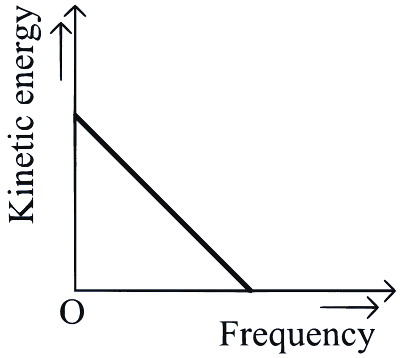
Q14 The work-function of a metal is 1 eV. Light of wavelength $3000 \mathring{A}$ is incident on this metal surface. The velocity of emitted photoelectrons will be

(A) 10 ms^{-1}
(B) 1×10^3 ms^{-1}
(C) 1×10^4 ms^{-1}
(D) 1×10^6 ms^{-1}

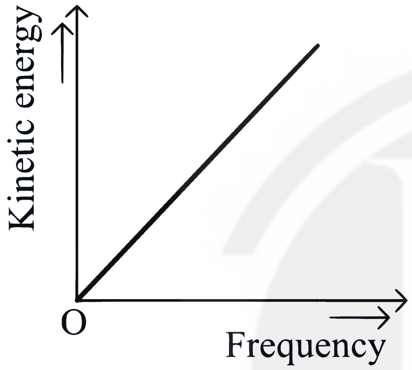
Q15 A proton moving with a momentum p_1 has a kinetic energy 1/8th of its rest mass-energy. Another light photon having energy equal to the kinetic energy of the proton possesses a momentum p_2. Then, the ratio $\frac{p_1 - p_2}{p_1}$ is equal to

(A) 1 (B) 1/4
(C) 1/2 (D) 3/4

Q16 According to Einstein's photoelectric equation to the graph between kinetic energy of photoelectrons ejected and the frequency of incident radiation is



(A)



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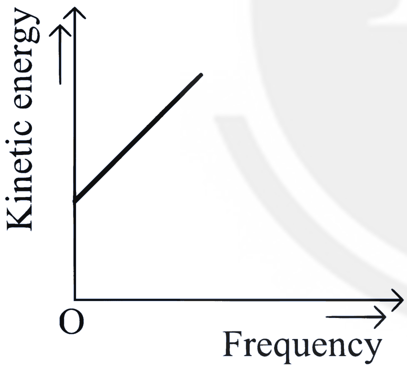

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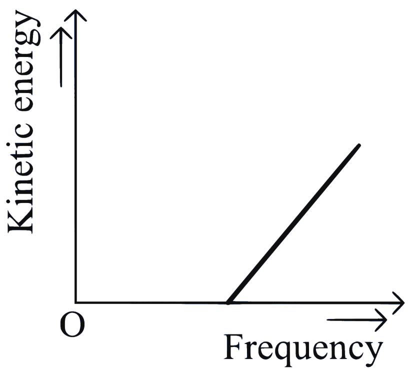


(D)

Q17 Energy of an electron in the second orbit of hydrogen atom is E_2. The energy of electron in the third orbit of He^+ will be

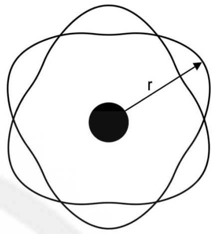
(A) $\frac{9}{16}E_2$

(B) $\frac{16}{9}E_2$

(C) $\frac{3}{16}E_2$

(D) $\frac{16}{3}E_2$

Q18 The figure shows standing de-Broglie waves due to the revolution of electron in a certain orbit of hydrogen atom. Then, the expression for the orbit radius is (All notations have their usual meanings)



(A) $\frac{36h^2\varepsilon_0}{\pi me^2}$

(B) $\frac{4h^2\varepsilon_0}{\pi me^2}$

(C) $\frac{9h^2\varepsilon_0}{\pi me^2}$

(D) $\frac{16h^2\varepsilon_0}{\pi me^2}$

Q19 An electron in an excited state of Li^{2+} ion has angular momentum $\frac{3h}{2\pi}$. The de-Broglie wavelength of electron in this state is $p\pi a_0$ (where, a_0 = Bohr radius). The value of p is

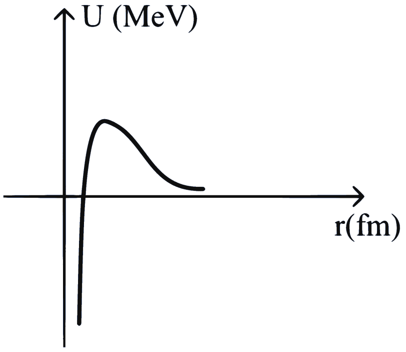
(A) 3

(B) 2

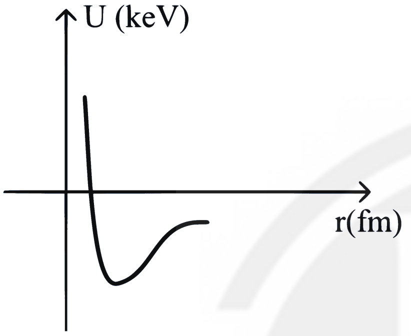
(C) 1

(D) 4

Q20 Which graph in the following diagram correctly represents the potential energy of a pair of nucleons as a function of their separation?



(A)



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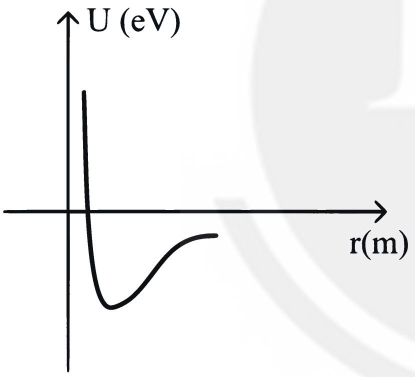

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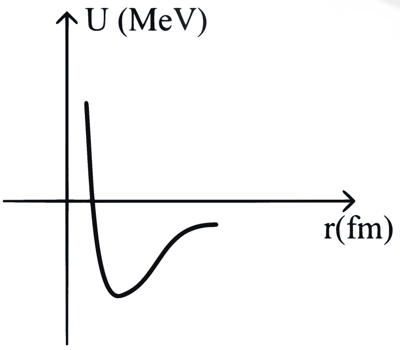


(D)

Q21 In a nuclear reactor heavy nuclei is not used as moderators because

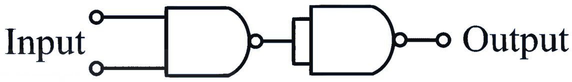
(A) they will break up

(B) elastic collision of neutrons with heavy nuclei will not slow them down

(C) the net weight of the reactor would be unbearably high

(D) substance with heavy nuclei do not occur in liquid or gaseous state at room temperature

Q22 The circuit given represents which of the logic operations?



(A) OR (B) AND

(C) NOT (D) NOR

Q23 Identify the incorrect statement.

(A) When a pn junction diode is forward biased, then the width of the depletion region decreases.

(B) When a pn junction diode is reverse biased, the barrier potential increases.

(C) A photodiode is operated in the reverse bias.

(D) An LED is a lightly doped p-n junction diode which emits spontaneous radiation of forward biasing.

Q24 Three photodiodes D_1, D_2, and D_3, are made of semiconductors having band gaps of 2.5 eV, 2eV and 3eV, respectively. Which one will be able to detect light of wavelength 600 nm ?

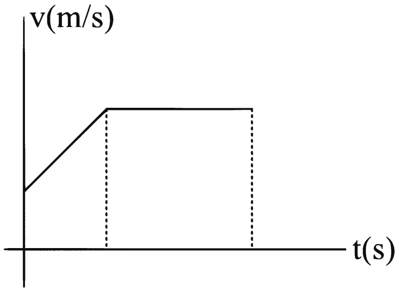
(A) D_1 only

(B) Both D_1 and D_2

(C) D_2 only

(D) All of these

Q25 For a body moving along a straight line, the following *v-t* graph is obtained.



According to the graph, the displacement during

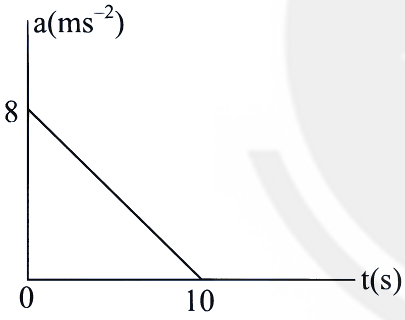
(A) uniform acceleration is greater than that during uniform motion

(B) uniform acceleration is less than that during uniform motion

(C) Cuniform acceleration is equal to that during uniform motion

(D) Duniform motion is zero

Q26 A particle starts from rest. Its acceleration *a* versus time *t* is shown in the figure. The maximum speed of the particle will be



(A) 80 ms^{-1} (B) 40 ms^{-1}

(C) 18 ms^{-1} (D) 2 ms^{-1}

Q27 The maximum range of a gun on horizontal plane is 16 km. If g = 10 ms^{-2}, then muzzle velocity of a shell is

(A) 160 ms^{-1} (B) $200\sqrt{2}$ ms^{-1}

(C) 400 ms^{-1} (D) 800 ms^{-1}

Q28 The trajectory of projectile is

(A) semicircle

(B) an ellipse

(C) parabola always

(D) a parabola in the absence of air resistance

Q29 For a projectile motion, the angle between the velocity and acceleration is minimum and acute at

(A) only one point (B) two points

(C) three points (D) four points

Q30 A particle starts from the origin at t = 0 with a velocity of $10\hat{\mathbf{j}}\ \text{ms}^{-1}$ and move in the *x-y* plane with a constant acceleration of $\left(8\hat{\mathbf{i}}+2\hat{\mathbf{j}}\right)\text{ms}^{-2}$. At an instant when the *x*-coordinate of the particle is 16 *m*, *y*-coordinate of the particle is

(A) 16 m (B) 28 m

(C) 36 m (D) 24 m

Q31 A coin placed on a rotating turn table just slips if it is placed at a distance of 4 cm from the centre. If the angular velocity of the turn table is doubled it will just slip at a distance of

(A) 1 cm (B) 2 cm

(C) 4 cm (D) 8 cm

Q32 A 1kg ball moving at 12 ms^{-1} collides with a 2 kg ball moving in opposite direction at 24 ms^{-1}. If the coefficient of restitution is 2/3, then their velocities after the collision are

(A) –4 ms^{-1}, –28 ms^{-1}

(B) –28 ms^{-1}, –4 ms^{-1}

(C) 4 ms^{-1}, 28 ms^{-1}

(D) 28 ms^{-1}, 4 ms^{-1}

Q33 A ball hits the floor and rebounds after an inelastic collision. In this case

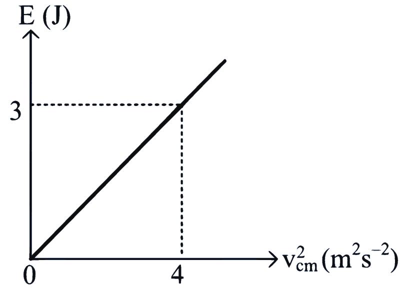
(A) the momentum of the ball is conserved

(B) the mechanical energy of the ball is conserved

(C) the total momentum of the ball and the earth is conserved

(D) the total mechanical energy of the ball and the earth is conserved

Q34 In figure E and v_{cm} represent the total energy and speed of centre of mass of an object of mass 1 kg in pure rolling. The object is



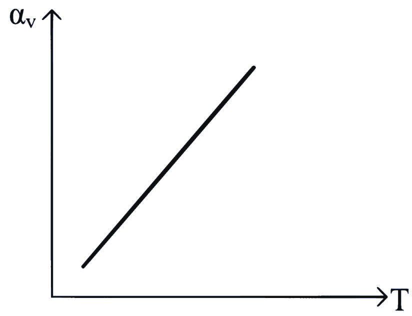
(A) shape
(B) ring
(C) disc
(D) hollow cylinder

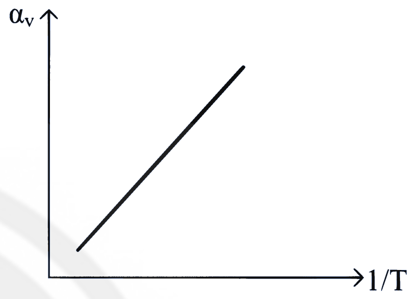
Q35 Two bodies of masses 8 kg are placed at the vertices A and B of an equilateral triangle ABC. A third body of mass 2 kg is placed at the centroid G of the triangle. If $AG = BG = CG = 1m$, where should a fourth body of mass 4 kg be placed, so that the resultant force on the 2 kg body is zero?
(A) At C
(B) At a point P on the line CG such that PG = $\frac{1}{\sqrt{2}}$ m
(C) At a point P on the line CG such that PG = 0.5 m
(D) At a point P on the line CG such that PG = 2 m

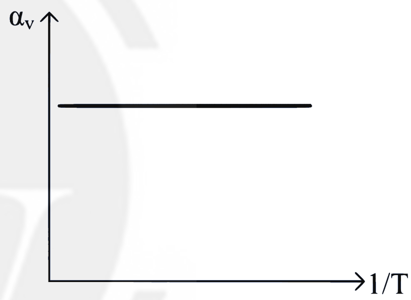
Q36 Two capillary tubes P and Q are dipped vertically in water. The height of water level in capillary tube P is of the height in capillary tube Q. The ratio of their diameter is

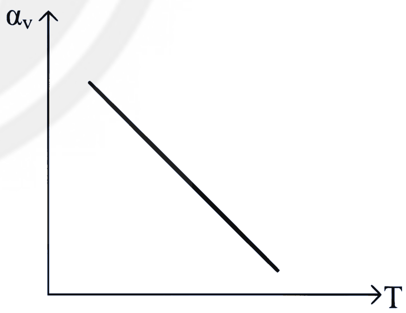
(A) 2 : 3	(B) 3:2
(C) 3 : 4	(D) 4 : 3

Q37 Which of the following curves represent the variation of coefficient of volume expansion of an ideal gas at constant pressure?

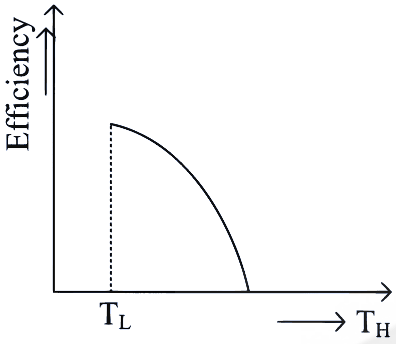
(A)


(B)


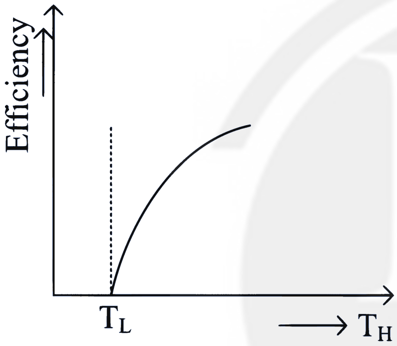
(C)


(D)


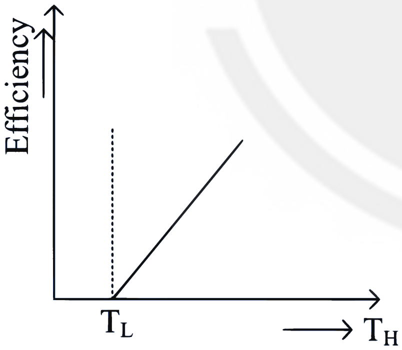
Q38 A number of Carnot engines are operated at identical cold reservoir temperatures (T_L). However, their hot reservoir temperatures are kept different. A graph of the efficiency of the engines versus hot reservoir temperature (T_H) is plotted. The correct graphical representation is



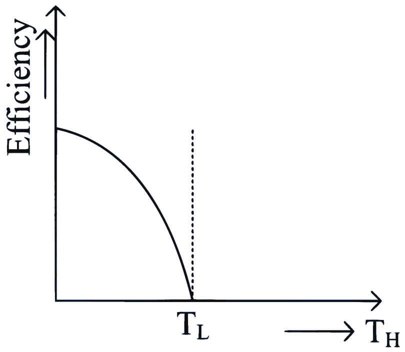
(A)



(B)



(C)



(D)

Q39 A gas mixture contains monoatomic and diatomic molecules of 2 moles each. The mixture has a total internal energy of (symbols have usual meanings)

(A) 3RT (B) 5RT

(C) 8RT (D) 9RT

Q40 A pendulum oscillates simple harmonically and only if

I. the sizer of the bob of pendulum is negligible in comparison with the length of the pendulum.

II. the angular amplitude is less than 10°.

Choose the correct option.

(A) Both I and II (B) Only I

(C) Only II (D) None of these

Q41 To propagate both longitudinal and transverse waves, a material must have

(A) bulk and shear moduli

(B) bulk modulus

(C) shear modulus

(D) Young's and bulk modulus

Q42 A copper rod *AB* of length *l* is rotated about end *A* with a constant angular velocity ω. The electric field at a distance *x* from the axis of rotation is

(A) $\frac{m\omega^2 x}{e}$ (B) $\frac{m\omega x}{e}$

(C) $\frac{mx}{\omega^2 l}$ (D) $\frac{me}{\omega^2 x}$

Q43 Electric field due to infinite, straight uniformly charged wire varies with distance *r* as

(A) r (B) $\frac{1}{r}$

(C) $\frac{1}{r^2}$ (D) r^2

Q44 A 2g object, located in a region of uniform electric field $E = (300\ NC^{-1})\ \hat{i}$ carries a charge *Q*. The object released from rest at x = 0, has a kinetic energy of 0.12J at x = 0.5 m. Then, *Q* is

(A) 400μC

(B) –400μC

(C) 800μC

(D) –800μC

Q45 If a slab of insulating material (conceptual). 4×10^{-3} thick is introduced between the plates of a parallel plate capacitor, the separation between the plates has to be increased by 3.5×10^{-3} to restore the capacity to original value. The dielectric constant of the material will be

(A) 6 (B) 8
(C) 10 (D) 12

Q46 Eight drops of mercury of equal radii combine to form a big drop. The capacitance of a bigger drop as compared to each smaller drop is

(A) 2 times (B) 8 times
(C) 4 times (D) 16 times

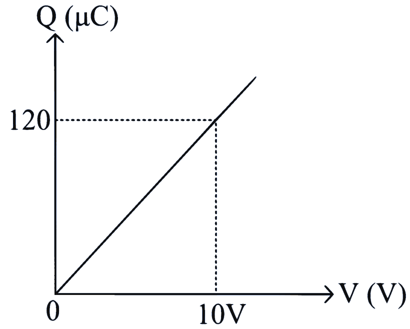
Q47 Which of the following statements is false in the case of polar molecules?

(A) Centres of positive and negative charges are separated in the absence of external electric field.
(B) Centres of positive and negative charges are separated in the presence of external electric field.
(C) Do not possess permanent dipole moments
(D) Ionic molecule HCl is the example of polar molecule.

Q48 An electrician requires a capacitance of 6μF in a circuit across a potential difference of 1.5 kV. A large number of 2μF capacitors which can withstand a potential difference of not more than 500 V are available. The minimum number of capacitors required for the purpose is

(A) 3 (B) 9
(C) 6 (D) 27

Q49 In figure, charge on the capacitor is plotted against potential difference across the capacitor. The capacitance and energy stored in the capacitor are respectively.

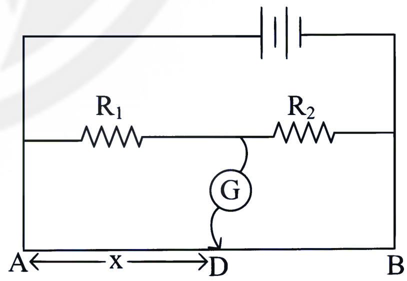


(A) $12\mu F,\ 1200\mu J$
(B) $12\mu F,\ 600\mu J$
(C) $24\mu F, 600\mu J$
(D) $12\mu F,\ 1200\mu J$

Q50 A wire of resistance 3Ω is stretched to twice its original length. The resistance of the new wire will be

(A) 1.5Ω (B) 3Ω
(C) 6Ω (D) 12Ω

Q51 In the given arrangement of experiment on meter bridge, if *AD* corresponding to null deflection of the galvanometer is *X*, what would be its value if the radius of the wire *AB* is doubled?



(A) X (B) $\frac{X}{4}$
(C) 4X (D) 2x

Q52 A copper wire of length 1m and uniform cross-sectional area 5×10^{-7} m^2 carries a current of 1A. Assuming that, there are 8×10^{28} free electrons per m^3 in copper, how long will an electron take to drift from one end of the wire to the other?

(A) 0.8×10^3 s

(B) 1.6×10^3 s

(C) 3.2×10^3 s

(D) 6.4×10^3 s

Q53 Consider an electrical conductor connected across a potential difference V. Let Δq be a small charge moving through it in time Δt. If I is the electric current through it,

I. the kinetic energy of the charge increases by $IV\,\Delta t$

II. the electric potential energy of the charge decreases by $IV\,\Delta t$

III. the thermal energy of the conductor increases by $IV\,\Delta t$

Choose the correct option.

(A) Only I (B) I and II

(C) I and III (D) II and III

Q54 A strong magnetic field is applied on a stationary electron. Then, the electron

(A) moves in the direction of the field

(B) moves in an opposite direction of the field

(C) remains stationary

(D) starts spinning

Q55 Two parallel wires in free space are 10 cm apart and each carries a current of 10 A in the same direction. The force exerted by one wire on the other [per unit length] is

(A) $2\ x\ 10^{-7}\ Nm^{-1}\ (attractive)$

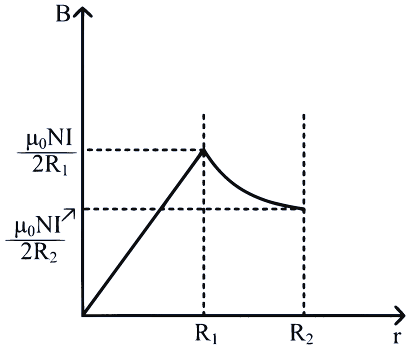
(B) $2 \times 10^{-4} Nm^{-1} [attractive]$

(C) $2 \times 10^{-4} Nm^{-1} [repulsive]$

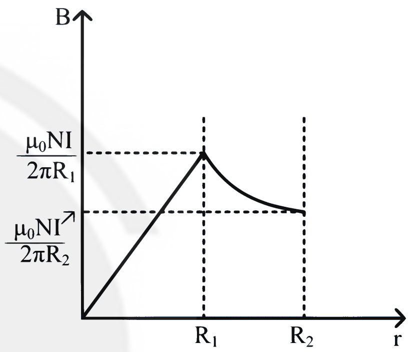
(D) $2 \times 10^{-7} Nm^{-1} [repulsive]$

Q56 A toroid with thick windings of N turns has inner and outer radii R_1 and R_2, respectively. If it carries certain steady current I, the variation of the magnetic field due to the toroid with radial distance is correctly graphed in.

(A)



(B)



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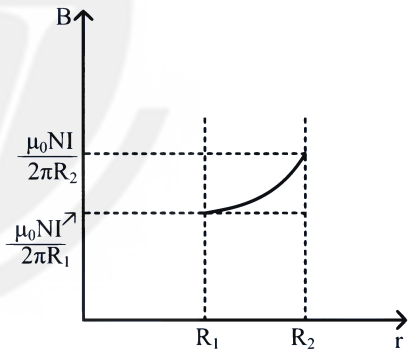

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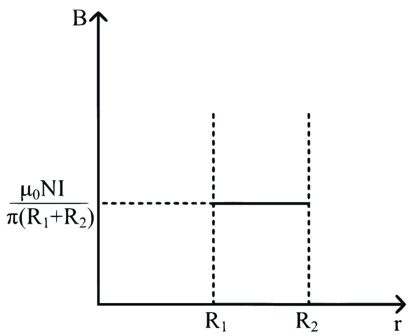


Q57 A tightly wound long solenoid has n turns per unit length, a radius r and carries a current I. A particle having charge q and mass m is projected from a point on the axis in a direction perpendicular to the axis. The maximum speed of the particle for which the particle does not strike the solenoid is

(A) $\frac{\mu_0 n I q r}{m}$ (B) $\frac{\mu_0 n I q r}{2m}$

(C) $\frac{\mu_0 n I q r}{4m}$ (D) $\frac{\mu_0 n I q r}{8m}$

Q58 Earth's magnetic field always has a horizontal component except at

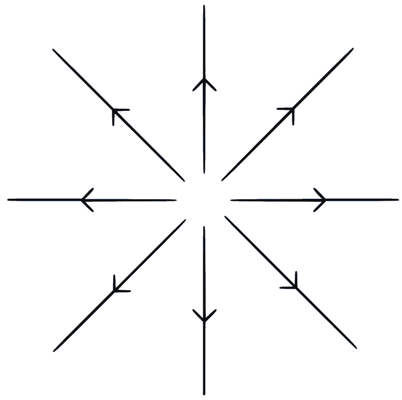
(A) equator

(B) magnetic poles

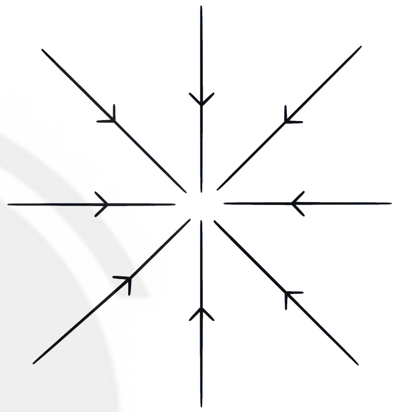
(C) a latitude of 60°

(D) an altitude of 60°

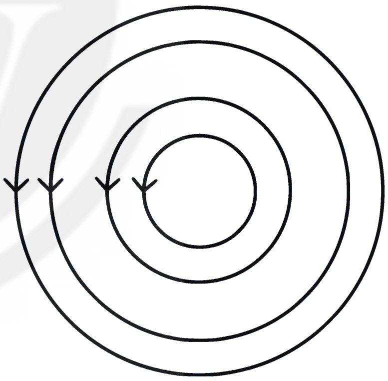
Q59 Which of the field pattern given below is valid for electric field as well as for magnetic field?



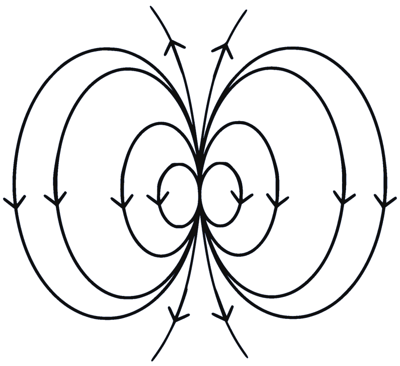
(A)



(B)

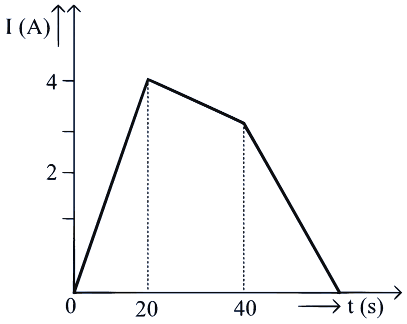


(C)



(D)

Q60 The current following through an inductance coil of self-inductance 6 mH at different time instants is as shown. The emf induced between t = 20 s and t = 40 is nearly



(A) 2×10^{-2} V

(B) 3×10^{-2} V

(C) 4×10^{-2} V

(D) 30×10^{-2} V

Answer Key

Q1	D
Q2	B
Q3	C
Q4	B
Q5	C
Q6	B
Q7	B
Q8	D
Q9	D
Q10	B
Q11	B
Q12	A
Q13	B
Q14	D
Q15	D
Q16	D
Q17	B
Q18	A
Q19	B
Q20	D
Q21	B
Q22	B
Q23	D
Q24	C
Q25	B
Q26	B
Q27	C
Q28	D
Q29	A
Q30	D
Q31	A
Q32	B
Q33	C
Q34	C
Q35	B
Q36	B
Q37	B
Q38	B
Q39	C
Q40	A
Q41	A
Q42	A
Q43	B
Q44	C
Q45	B
Q46	A
Q47	C
Q48	D
Q49	B
Q50	D
Q51	A
Q52	D
Q53	D
Q54	C
Q55	B
Q56	D
Q57	B
Q58	B
Q59	D
Q60	A

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

The self-inductance (L) and mutual inductance (M), both has the same unit as, both are equal to magnetic flux per unit current i.e.

$M = L = \frac{\phi}{I} = \left(in\ wb\ A^{-1}\right)$

Q2 Text Solution:

Given, $X_L = X_C = 4\Omega$

$\therefore$ Voltage accross X_C and X_L is same in magnitude but opposite in direction. So, net voltage is

$V_{net} = V_C - V_L = 0$

Since, the voltmeter is connected accross the series connection of capacitor and inductor. So, the reading of voltmeter is equal to V_{net} i.e., zero. Current in the circuit,

$I = \frac{V}{Z}$

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

$= \frac{90}{\sqrt{(45)^5+(4-4)^2}} = \frac{90}{45} = 2A$

Q3 Text Solution:

For LC-oscillations,

$L\frac{di}{dt} + \frac{q}{C} = 0$

Differentiating further it w.r.t t, we get

$L\frac{d^2i}{dt^2} + \frac{I}{C} = 0 \qquad .....(i)$

Similarly, for spring-block system,

$\frac{d^2x}{dt^2} + kx = 0 \qquad ....(ii)$

Comparing Eqs.(i) and (ii), we get

$m \propto L$ *and* $k \propto \frac{1}{C}$

Q4 Text Solution:

The charge is a function of time (t), is given by

$q = q_0 \sin \omega t \qquad ....(i)$

where, q_0 = maximum charge,

and ω = angular frequency.

Differentiating Eq.(i), we get

$I = \frac{dq}{dt} = \frac{d}{dt}\left(q_0 \ \sin\ \omega t\right) = \omega q_0\ \cos\ \omega t$

$At,\ t = 0,$

$I = \omega q_0\ \cos(0) = \omega q_0$

$\therefore \quad I = \frac{1}{\sqrt{LC}} q_0\ or\ q_0$

$= I\sqrt{LC}\left[\because \omega = \frac{1}{\sqrt{LC}}\right]$

$= 2\sqrt{3 \times 2.7 \times 10^{-6}}$

$= 18 \times 10^{-5} C$

Q5 Text Solution:

Given,

$E_0 = 120\text{NC}^{-1}$

$f = 50\text{MHz} = 50 \times 10^6\ \text{Hz}$

(a) magnetic field amplitude,

$B_0 = \frac{E_0}{c} = \frac{120}{3 \times 10^8} = 40 \times 10^{-8}\ \text{T}$

$= 400\text{nT}$

(b) Angular frequency, $\omega = 2\pi f = 2\pi \times 50 \times 10^6$

$= \pi \times 10^8\ \text{rad/s}$

(c) Propagation constant,

$k = \frac{\omega}{c} = \frac{\pi \times 10^8}{3 \times 10^8} = 1.047\text{rad/m}$

(d) Wavelength, $\lambda = \frac{c}{f} = \frac{3\times10^8}{50\times10^6} = \frac{30}{5} = 6m$

Q6 Text Solution:

Electromagnetic waves are produced by accelerated charges. In given options, only a charge particle moving in a circular orbit is in accelerated motion. So, it produces electromagnetic wave.

Q7 Text Solution:

The bending of light as it passes from one medium to another is due to the refractive index of the second medium relative to the first. The refractive index is determined by the speed of light in the two media and is expressed by the equation:

$_1\mu_2 = \frac{\text{Speed of light in first medium}}{\text{Speed of light in second mediun}}$

Therefore, when light transitions from one medium to another, it is the change in the speed of light that causes its path to bend.

Q8 Text Solution:

Given:

Refractive index from air to glass: ${}_a\mu_g = \frac{3}{2}$

Refractive index from air to water: ${}_a\mu_w = \frac{4}{3}$

Using the Lens Maker's Formula:

$\frac{1}{f} = ({}_1\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

The ratio of the focal lengths of the glass lens in water and in air is given by:

$\frac{f_{\text{water}}}{f_{\text{air}}} = \frac{({}_a\mu_g - 1)}{\left(\frac{a\mu g}{a\mu w} - 1\right)}$

Substituting the provided values:

$\frac{f_{\text{water}}}{f_{\text{air}}} = \frac{(\frac{3}{2} - 1)}{\left(\frac{\frac{3}{2}}{\frac{4}{3}} - 1\right)}$

Simplify:

$= \frac{1/2}{(\frac{3}{2} \times \frac{3}{4} - 1)} = \frac{1/2}{(\frac{9}{8} - 1)}$

This further simplifies to:

$= \frac{1}{2} \times \frac{8}{1} = \frac{4}{1}$

Therefore, the ratio of the focal lengths is 4:1.

Q9 Text Solution:

To understand the powers of the combined lenses, consider the following:

The focal length of the first biconvex lens is f_1.

The focal length of the second biconvex lens is f_2.

The focal length of the third biconcave lens, due to Cartesian sign conventions, is $-f_3$.

Power of Combined Lenses

Combination of the First and Second Biconvex Lenses:

The reciprocal of the combined focal length is given by:

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

Therefore, the power of the combination of the first and second lenses, P_1, is:

$P_1 = \frac{1}{f} = \frac{f_1 + f_2}{f_1 f_2}$

Combination of the First Biconvex and Third Biconcave Lens:

The reciprocal of the combined focal length is:

$\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_3}$

Thus, the power of this combination, P_2, is:

$P_2 = \frac{1}{f} = \frac{f_3 - f_1}{f_1 f_3}$

Combination of the Second Biconvex and Third Biconcave Lens:

The reciprocal of the combined focal length is:

$\frac{1}{f} = \frac{1}{f_2} - \frac{1}{f_3}$

Therefore, the power of the second and third lens combination, P_3, is:

$P_3 = \frac{1}{f} = \frac{f_3 - f_2}{f_2 f_3}$

These calculations show how we derive the combined power of lenses using their individual focal lengths and considering the sign convention for convex and concave lenses.

Q10 Text Solution:

Given:

Focal length of the convex lens, f_1 = 30 cm

Focal length of the concave lens, f_2 = –20 cm

Original image height, h_0 = 2 cm

Distance from the convex lens to the concave lens, u_2 = (30 - 26) = 4 cm

To find the new size of the image:

Use the lens formula for the concave lens:

$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = -\frac{1}{20} + \frac{1}{4} = \frac{4}{20} = \frac{1}{5}$

Solving gives:

v_2 = 5 cm

Calculate the magnification (m) of the concave lens:

$m = \frac{v_2}{u_2} = \frac{4}{5} = 1.25$

Determine the new image height (h_i):

$m = \frac{h_i}{h_0} = 1.25$

Therefore, the new size of the image is:

$h_i = h_0 \times 1.25 = 2 \times 1.25 = 2.5\ cm$

Thus, the new size of the image upon adding the concave lens is 2.5 cm.

Q11 Text Solution:

Given values:

Wavelength, $\lambda = 6500\mathring{A}$ = 6500 × 10^{-10} m

Angle, $\theta = 30°$

In a single-slit diffraction pattern, the position of the first diffraction minimum is determined by the equation:

$a \sin\theta = n\lambda$

where n is the order of the minima. For the first minimum, $n = 1$.

Let's substitute the given values into the equation:

$a \sin 30^\circ = 1 \times 6500 \times 10^{-10}$

Since $\sin 30^\circ = \frac{1}{2}$, *we have* :

$\frac{a}{2} = 6500 \times 10^{-10}$

Solving for a :

$a = 13000 \times 10^{-10}$

Converting the value a into microns, we find :

$a = 1.3 \times 10^{-6} m = 1.3\ micron$

Q12 Text Solution:

In single slit diffraction pattern, the width of central maxima is larger than the width of maxima on either sides and the intensity decreases rapidly on either side, but the light energy remains conserved.

Hence, statements I and II are correct.

Q13 Text Solution:

Path difference, $\Delta x = \frac{xd}{D}$

So, corresponding phase difference,

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

$= \frac{2\pi}{\lambda}\left(\frac{xd}{D}\right)$

The resultant intensity at P is

$I_P = 4I_0\cos^2\left(\frac{\phi}{2}\right)$

$= 4I_0\cos^2\left(\frac{2\pi}{\lambda}\frac{xd}{D} \times \frac{1}{2}\right) = 4I_0\cos^2\left(\frac{\pi dx}{\lambda D}\right)$

Q14 Text Solution:

Given, work − function $\phi_0 = 1\ eV = 1.6 \times 10^{-19} J$

Wavelength, $\lambda = 3000 \mathring{A} = 3000 \times 10^{-10} m$

As, we know that,

$E = h\nu = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{3000\times10^{-10}}$

$= 6.6 \times 10^{-19} J$

Also, $E = \phi_0 + KE$

$\Rightarrow KE = E - \phi_0 \Rightarrow \frac{1}{2}mv^2 = E - \phi_0$

$v^2 = \frac{(6.6\times10^{-19} - 1.6\times10^{-19})\times2}{9.1\times10^{-31}}$

$= \frac{5\times10^{-19}\times2}{9.1\times10^{-31}} = 1.1 \times 10^{12}$

$v = 1.01 \times 10^6$

$\approx 1 \times 10^6 m/s$

Q15 Text Solution:

For proton, $v^2 = \frac{c^2}{4}\left(\because v = \frac{c}{2}\right)$

$p_1 = \sqrt{2mE_k}$

$= \sqrt{2 \times m \times \frac{1}{8}mc^2}\left(\because E_k = \frac{1}{8}mc^2\right)$

$p_1 = \frac{mc}{2}$

For photon,

$E = KE$

$\frac{hc}{\lambda} = \frac{1}{8}mc^2$

$\Rightarrow p_2 = \frac{h}{\lambda} = \frac{mc}{8}$

$\therefore \frac{p_1 - p_2}{p_1} = \frac{\frac{mc}{2} - \frac{mc}{8}}{\frac{mc}{2}} = \frac{4-1}{8} \times 2 = \frac{3}{4}$

Q16 Text Solution:

The maximum kinetic energy of photoelectron ejected is given by

$KE = h\nu - \phi_0 = h\nu = h\nu_0 = h(\nu - \nu_0)$

If the frequency of incident radiation is greater than threshold frequency ν_0, then the ejection of photoelectrons starts. After that as frequency increases, kinetic energy also increases linearly. It is shown in option (d).

Q17 Text Solution:

The energy of the electron in the nth orbit is given by

$$E_n = -13.6\,\text{eV}\frac{Z^2}{n^2}$$

$$E_n \propto \frac{Z^2}{n^2}$$

For hydrogen atom, Z = 1

In second orbit, n = 2

$$E_2 \propto \frac{1}{(2)^2}$$

$$In\ case\ of\ He^+,\ Z = 2\ and\ n = 3$$

$$E_3 \propto \frac{(2)^2}{(3)^2}$$

$$\therefore\ \frac{E_2}{E_3} = \frac{1}{4} \times \frac{9}{4} = \frac{9}{16}$$

$$\Rightarrow E_3 = \frac{16E_2}{9}$$

Q18 Text Solution:

According to de-Broglie, the circumference of a stationary orbit must be an integral number of wavelengths.

$$n\lambda = 2\pi r_n$$

Also, angular momentum, $mv_nr_n = \frac{nh}{2\pi}$

$$\Rightarrow\ m\frac{e^2}{2nh\varepsilon_0}r_n = \frac{nh}{2\pi}\left[\because\ v_n = \frac{e^2}{2nh\varepsilon_0}\right]$$

$$\Rightarrow r_n = \frac{n^2h^2\varepsilon_0}{me^2\pi} = \frac{n^2h^2\varepsilon_0}{\pi me^2}$$

Here, number of standing waves, n = 6

$$\therefore\ r_n = \frac{(6)^2h^2\varepsilon_0}{\pi me^2} = \frac{36h^2\varepsilon_0}{\pi me^2}$$

Q19 Text Solution:

According to de-Broglie hypthesis,

$$\Rightarrow L = \frac{nh}{2\pi} = \frac{3h}{2\pi} = mvr$$

$$n = 3$$

$$As,\ wavelength,\ \lambda = \frac{h}{p} = \frac{h}{mv} = \frac{hr}{mvr}$$

$$= \frac{hr}{\frac{3h}{2\pi}} = \frac{2}{3}\pi r$$

$$For\ Li^{2+}\ atom,\ radius\ of\ orbit,$$

$$r = r_0\frac{n^2}{Z} = a_0\frac{3^2}{3} = 3a_0$$

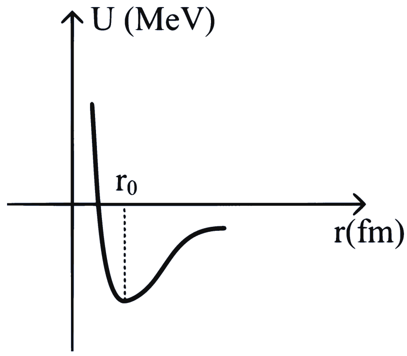
$$\Rightarrow\quad \lambda = \frac{2}{3}\pi \times a_0 \times 3 = 2\pi a_0$$

$$= p\pi a_0(given)$$

$$\therefore\quad p = 2$$

Q20 Text Solution:

The graph between potential energy of a pair of nucleons (in MeV) and their separation is shown below.



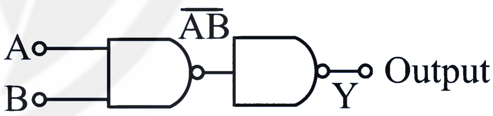
For, r < r_0, force repulsive and force r > r_0, the force is attractive between nucleons.

Q21 Text Solution:

The moderator used in nuclear reactor, have light nuclei (like proton). When protons undergo perfectly elastic collision with the neutrons emitted, their velocities are exchanged i.e. neutrons. Heavy nuclei will not serve the purpose because elastic collision of neutrons with heavy nuclei will not slow them down.

Q22 Text Solution:

This diagram can be shown as



$$Y = \overline{\overline{AB}}$$

$$= AB$$

$$\therefore\ Output\ represents\ logic\ operations\ of\ AND\ gate$$

Q23 Text Solution:

The LED is a heavily doped *p-n* junction with forward biasing. It is a specially designed forward biased *p-n* junction diode that emits light spontaneously when energised.

Q24 Text Solution:

$Given,\ E_1 = 2.5\ eV,\ E_2 = 2\ eV,\ E_3 = 3\ eV\ and\ \lambda = 600nm$

$As\ we\ know,$

$E = \frac{1242}{\lambda} = \frac{1242}{600}$

$= 2.07\ eV$

Since, E_1 and E_3 is greater than E. So, only D_2 will able to detect the given light of wavelength 600 nm.

Q25 Text Solution:

Since, the area under *v*-*t* graph gives the displacement of object.

i.e., *s* = Area of *v*-*t* graph

As area under uniform motion > Area under uniform acceleration

∴ Displacement during uniform acceleration is less than that during uniform motion.

Q26 Text Solution:

As, we know

Area under *a*-*t* graph = *v* - *u*

$\Rightarrow\ \frac{1}{2} \times 8 \times 10 = v\ (\because\ u = 0)$

$\Rightarrow v = 40ms^{-1}$

Q27 Text Solution:

The maximum range R of a projectile on a horizontal plane is given by the formula:

$R = \frac{v^2 \sin\ 2\theta}{g}$

For the maximum range, θ is 45° and sin 2θ = sin 90° = 1. Hence, the formula simplifies to:

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

We can rearrange this equation to solve for the initial muzzle velocity *v*:

$v^2 = R.g$

$v = \sqrt{R.g}$

Given:

R = 16 km = 16000 m

g = 10 m/s^2

Substitute these values into the equation:

$v = \sqrt{16000.10}$

$v = \sqrt{160000}$

$v = 400m/s$

Therefore, the muzzle velocity of a shell is Option C: 400 m/s.

Q28 Text Solution:

The trajectory of a projectile is a parabola in the absence of air resistance. In the presence of air resistance, range and maximum height of projectile, both will decrease, hence path of projectile will not remain parabolic.

Q29 Text Solution:

In projectile motion, centre of acceleration is directed towards the centre of earth and at peak point, the angle between velocity and acceleration is 90°, because at peak point the vertical component of velocity is zero. Thus, it is minimum and acute at only one point (i.e. at highest point)

Q30 Text Solution:

$\mathbf{u} = 10\hat{\mathbf{j}}\ \mathrm{ms}^{-1}, \mathbf{a} = 8\hat{\mathbf{i}} + 2\hat{\mathbf{j}}\ \mathrm{ms}^{-2}$

$\mathrm{x} = 16\mathrm{m}$

Using equation of motion,

$s = ut + \frac{1}{2}at^2$

$x\hat{\mathbf{i}} + y\hat{\mathbf{j}} = 10\hat{\mathbf{j}} \times t + \frac{1}{2}\left(8\hat{\mathbf{i}} + 2\hat{\mathbf{j}}\right)t^2$

$\Rightarrow\ 16\hat{\mathbf{i}} + y\hat{\mathbf{j}} = 10\hat{\mathbf{j}} + 4t^2\hat{\mathbf{i}} + t^2\hat{\mathbf{j}}$

Comparing both sides, we get

$4t^2 = 16$

$\Rightarrow\ t = 2\ \mathrm{s}$

and $y = 10t + t^2$

$= 10 \times 2 + (2)^2$

$= 24m$

Q31 Text Solution:

When a coin is placed on a rotating turntable and is about to slip, the necessary centripetal force for maintaining its rotation is provided by friction. This relationship can be expressed as:

$mr\omega^2 = \mu mg$

where:

m is the mass of the coin,

r is the distance of the coin from the center of the turntable,

ω is the angular velocity of the turntable,

μ is the coefficient of friction, and

g is the acceleration due to gravity.

Since m, μ, and *g* are constant, the equation can be simplified to:

rω^2 = *constant*

From this, it follows that:

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

Thus, the relationship between the initial and the final conditions can be expressed as:

$\frac{r_2}{r_1} = \left(\frac{\omega_1}{\omega_2}\right)^2$

Given that $\omega_2 = 2\omega_1$ and $r_1 = 4$ cm, we compute:

$\frac{r_2}{r_1} = \left(\frac{\omega_1}{2\omega_1}\right)^2$

Therefore,

$r_2 = \frac{r_1}{4} = \frac{4}{4} = 1 \text{ cm}$

Q32 Text Solution:

Given the problem parameters:

Mass of the first ball, m_1 = 1 kg

Initial velocity of the first ball, u_1 = 12m / s

Mass of the second ball, m_2 = 2 kg

Initial velocity of the second ball, u_2 = - 24m / s

(the negative sign indicates movement in the opposite direction)

Coefficient of restitution, $e = \frac{2}{3}$

The coefficient of restitution is defined as:

$e - \frac{v_2 - v_1}{u_1 - u_2}$

Plugging in the values:

Solving the above equation:

$v_2 - v_1 = 24 \quad ......(i)$

Next, we apply the law of conservation of momentum, which states that the initial momentum equals the final momentum:

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

Substitute the known values:

$1 \times 12 + 2 \times (-24) = 1 \times v_1 + 2 \times v_2$

$12 - 48 = v_1 + 2v_2$

$v_1 + 2v_2 = -36$ .....(ii)

Now, solving equations (i) and (ii) together:

From equation (i):

$v_2 - v_1 = 24$

$v_2 = v_1 + 24$

Substitute into equation (ii):

$v_1 + 2(v_1 + 24) = -36$

$v_1 + 2v_1 + 48 = -36$

$3v_1 + 48 = -36$

$3v_1 = -36 - 48$

$3v_1 = -84$

$v_1 = -28 \text{ m/s}$

Using in equation (i):

$v_2 - (-28) = 24$

$v_2 + 28 = 24$

$v_2 = 24 - 28$

$v_2 = -4 \text{ m/s}$

Therefore, the velocities after the collision are:

Velocity of the first ball,

Velocity of the second ball,

Q33 Text Solution:

When the net external force on the system is zero, the total momentum of the system is conserved.

In the given case, when a ball hits the floor and rebounds, no external force is acting on them. Thus, the total momentum of the system is conserved.

However, it is an elastic collision.

So, some energy will be lost in the form of heat, etc.

Hence, the total mechanical energy of the system will not conserved

Q34 Text Solution:

As we know, kinetic energy of an object in pure rolling motion is given as

$E = \frac{1}{2} m v_{\text{cm}}^2 \left(1 + \frac{k^2}{R^2}\right)$

where, k is radius of gyration and m is the mass of the object.

$\Rightarrow \frac{E}{v_{\text{cm}}^2} = \frac{1}{2}\left[1 + \frac{k^2}{R^2}\right]$ (i)

[Given, m = 1 kg]

From the given graph, substituting the value of $\frac{E}{v_{\text{cin}}^2}$ in Eq. (i), we get

$\frac{3}{4} = \frac{1}{2}\left[1 + \frac{k^2}{R^2}\right]$

$\frac{3}{2} - 1 = \frac{k^2}{R^2}$

$\frac{k^2}{R^2} = \frac{1}{2}$

Since, for a

(a) Sphere, $\frac{k^2}{R^2} = \frac{2}{5}$

(b) Ring, $\frac{k^2}{R^2} = 1$

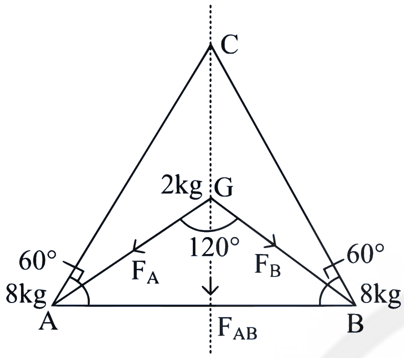
(c) Hollow cylinder, $\frac{k^2}{R^2} = 1$

(d) Disc, $\frac{k^2}{R^2} = \frac{1}{2}$

So, the given object is disc.

Q35 Text Solution:

According to the question, the arrangement of the masses is as shown below,



Gravitational force between two masses is given as

$F = \frac{Gm_1 m_2}{r^2}$

where, G = gravitational constant and r = distance between them. From the given values, we can say that force between masses at A and G.

= Force between masses at B and G.

$\Rightarrow F_A = \frac{Gm_A m_G}{AG^2}$ and $F_B = \frac{Gm_B m_G}{BG^2}$ (i)

or $F_A = F_B = \frac{G\times8\times2}{1^2} = 16G$

[Given, $m_1 = m_A = m_B = 8$ kg, $m_2 = m_G = 2$ kg,]

$AG = BG = r = 1$ m

From the figure, resultant of F_A and F_B is given as

$$F_{AB} = \sqrt{F_A^2 + F_B^2 + 2F_A F_B \cos\theta}$$

$$= \sqrt{2F_A^2 + 2F_A^2 \cos 120^\circ}$$

$$= \sqrt{F_A^2} = \sqrt{(16G)^2} = 16G$$

[from Eq. (i)]

$\Rightarrow F_{AB} = F_A = F_B = 16G$

For resultant force on 2 kg body to be zero, 4 kg body should be placed at a certain distance from G such that

$F_{CG} = -F_{AB}$

$\Rightarrow |F_{CG}| = |F_{AB}|$

or $\frac{G\times m_C m_G}{x^2} = G(16)$

where, x = distance between 4 kg and 2 kg body.

Here, m_C = 4 kg

$\Rightarrow \frac{G\times4\times2}{x^2} = G(16)$

$\Rightarrow x^2 = \frac{1}{2}$

$\Rightarrow x = \frac{1}{\sqrt{2}}$ m

This means, 4 kg body should be placed at point P on line CG such that PG = $\frac{1}{\sqrt{2}}$ m.

Q36 Text Solution:

As we know, height of capillary rise or fall of a liquid in a capillary tube is given as

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

$\Rightarrow h \propto \frac{1}{r}$ (i)

where, r is the radius of the capillary tube. Given, height of water level in capillary tube $P = \frac{2}{3}$ height of water in capillary tube Q.

$\Rightarrow h_P = \frac{2}{3} h_Q$

or $\frac{h_P}{h_Q} = \frac{2}{3}$

From Eq. (i), we can write

$\frac{h_P}{h_Q} = \frac{r_Q}{r_P}$

$\Rightarrow \frac{2}{3} = \frac{r_Q}{r_P}$

$r_P : r_Q = 3 : 2$

As diameter of the tube is equals to twice the radius.

So, $\frac{(\text{diameter})_P}{(\text{diameter})_Q} = \frac{3}{2}$

Q37 Text Solution:

Volume expansion is the expansion of volume of a gas due to increase in its temperature.

Coefficient of volume expansion is given as

$\alpha_V = \frac{\Delta V}{V\times\Delta T}$ (i)

here, V = real volume of gas,

ΔV = . change in volume

and ΔT = change in temperature.

From ideal gas equation,

$pV = nRT$ or $T = \frac{pV}{nR}$ (ii)

For constant pressure,

$p\Delta V = nR\Delta T$

or $\frac{\Delta V}{\Delta T} = \frac{nR}{p}$ (iii)

From Eqs. (i) and (iii), we get

$\alpha_V = \frac{nR}{pV} = \frac{1}{T}$ (ii)

Thus, the variation of α_V with temperature is correctly depicted in option (b).

Q38 Text Solution:

Efficiency of a Carnot's engine is given as

$\eta = 1 - \frac{T_L}{T_H}$

where, T_L = temperature of cold reservoir and T_H = temperature of hot reservoir.

At constant T_L, we can say that, with the increase in the value of T_H, η will also increase.

So, the graph between efficiency and T_H is correctly depicted in option (b).

Q39 Text Solution:

Total internal energy of a gas is given as

$U = \frac{n}{2} f RT$

where, n = number of moles

and f = degree of freedom.

Given, $n_{\text{diatomic}} = n_{\text{monoatomic}} = 2$

As, $f_{\text{monoatomic}} = 3$

$f_{\text{diatomic}} = 5$

$\Rightarrow U_{\text{monoatomic}} = \frac{2}{2} \times 3RT = 3RT$

$U_{\text{diatomic}} = \frac{2}{2} \times 5RT = 5RT$

Total internal energy of the mixture of gases,

$U_{\text{total}} = U_{\text{monoatomic}} + U_{\text{diatomic}}$

$= 3RT + 5RT = 8RT$

Q40 Text Solution:

A simple pendulum in practice, consists of a heavy but small sized metallic bob suspended by a light, inextensible and flexible string.

It will oscillates simple harmonically, only if

(I) the size of the bob is negligible as compare to the length of the string of pendulum.

(II) the angle between the normal drawn at the mean position and string at extreme point or angular amplitude is less than 10°.

Thus, both the statements are correct.

Q41 Text Solution:

In transverse waves, the particle motion is normal to the direction of the wave. Therefore, as the wave propagates each element of the medium undergoes shearing strain. in longitudinal waves, the constituents of the medium oscillate about their mean position along the direction of wave propagation like propagation of sound wave. This involves compressive stress (pressure). Thus, transverse waves be propagated in medium which can sustain shearing stress. Similarly, longitudinal waves can be propagated in medium which can sustain bulk modulus.

Q42 Text Solution:

In circular motion, net force on the particle is given as

$F_c = \frac{mv^2}{r} = m\omega^2 r$

where, ω is angular speed. When the rod rotates, electrons in it also rotates which produce electric field E at a distance x.

So, force on electron,

$F_e = eE$

This force provide the centripetal force,

i.e., $F_e = F_e$

or $eE = m\omega^2 x$

or $E = \frac{m\omega^2 x}{e}$

Q43 Text Solution:

Electric field intensity due to infinity straight uniformly charged wire at some distance r is,

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

where, λ = the surface charge density.

If λ, π and ε_0 are constants, then

$E \propto \frac{1}{r}$

Q44 Text Solution:

Given, m = 2g = 2×10^{-3} kg

E = (300 NC^{-1}) $\hat{i}$

At, x = 0, $(KE)_1$ = 0 and x = 0.5m, $(KE)_2$ = 0.12J

From work-energy theorem,

work done = change in kinetic energy

$\Rightarrow$ Force × displacement = ΔKE

$$QE \times d = KE_2 - KE_1$$

$$\Rightarrow Q \times 300 \times 0.5 = 0.12$$

$$or\ Q = \frac{0.12}{300 \times 0.5} = 800\mu C$$

The charge Q is moving in the direction of electric field. Hence, it is positive.

Q45 Text Solution:

Let t be the thickness of the dielectric slab and K is the dielectric constant.

So, the increase in the distance of separation between the plates due to dielectric is given as

x = t - $\frac{t}{K}$

= t= $t\left(1 - \frac{1}{k}\right)$

given, x = 3.5×10^{-3} m, t = 4×10^{-3} m

Substituting the given values in the above equation, we get

$$1 - \frac{1}{k} = \frac{x}{t} = \frac{3.5 \times 10^{-3}}{4 \times 10^{-3}} = \frac{3.5}{4}$$

$$or\ \frac{1}{k} = 1 - \frac{3.5}{4} = \frac{0.5}{4}$$

$$or\ k = 8$$

Q46 Text Solution:

Let R and r be the radii of bigger and each smaller drop, respectively.

Volume of bigger drop = 8 × volume of smaller drop

$$\Rightarrow\ \frac{3}{4}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$$

$$or\ R = 2r \quad .....(i)$$

As, capacitance of a smaller spherical drop is

C = $4\pi\varepsilon_0 r$

$\Rightarrow C \propto r$

So, $\frac{C_{bigger}}{C_{smaller}} = \frac{r_{bigger}}{r_{smaller}} = \frac{R}{r} = \frac{2r}{r}$

$$= 2\ [\text{using } Eq.\ (i)]$$

So, capacitance of bigger drop is two times as compared to each smaller drop.

Q47 Text Solution:

Polar molecules are the molecules in which the centres of positive and negative charges are separated even there is no external field. Such molecules have a permanent dipole moment. e.g., HCl, H_2O, etc.

Thus, statement given in option (c) is false.

Q48 Text Solution:

Number of capacitors that can be connected in each row,

$$m = \frac{Desired\ voltage}{Voltage\ across\ each\ capacitor}$$

$$= \frac{1.5kV}{500V} = \frac{1500}{500} = 3$$

Effective capacitance when m capacitors are connected in n rows is given as

$$C_{eff} = \frac{nC}{m}$$

$$Here,\ m = 3,\ C = 2\mu F,\ C_{eff} = 6\mu F$$

$$\Rightarrow n \times \frac{2}{3} = 6$$

$$or\ n = \frac{18}{2} = 9$$

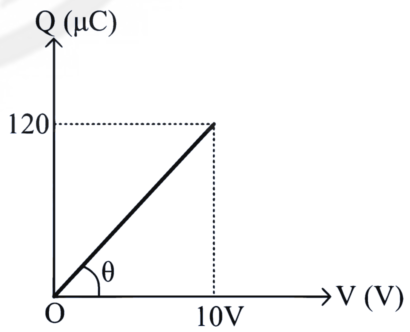
$\therefore$ Total number of capacitors required, $N = mn$ = 3 × 9 = 27

Q49 Text Solution:

Energy stored in a capacitor is given as

$$U = \frac{1}{2}CV^2 \quad .....(i)$$

where, C is the capacitance. From the given graph, we get



Slope = $\tan\theta = \frac{Q}{V} = \frac{120\mu C}{10V} \quad ....(ii)$

As we know, capacitance is given as

C = $\frac{Q}{V}$

Substituting the value of $\frac{Q}{V}$ from Eq.(ii) in the above relation, we get

$$C = \frac{120\mu C}{10V} = \frac{120 \times 10^{-6}}{10} = 12 \times 10^{-6} F$$

$$= 12\mu F$$

Now, substituting the values of C and V in Eq: (i), we get

$$U = \frac{1}{2} \times 12 \times (10)^2$$

$$= 600\mu J$$

Q50 Text Solution:

Given, resistance, $R_1 = 3\Omega$

If *l* is the original length of the wire, then after stretching the length of wire is

$l' = 2l$

where, *p* is the resistivity and *A* is cross-sectional area.

$$R \propto \frac{l}{A}$$

$$\Rightarrow R \propto \frac{l^2}{V}\left[\because A = \frac{Volume}{Length}\right]$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{l_1^2}{V} \times \frac{V}{l_2^2}$$

$$Here,\ l_1 = l,\ l_2 = 2l$$

$$\Rightarrow \frac{3}{R_2} = \frac{l^2}{4l^2}$$

$$or\ R_2 = 3 \times 4 = 12\Omega$$

Q51 Text Solution:

In a meter bridge, balancing length of the wire is independent of the area of cross-section of the wire.

So, if the radius of wire *AB* is doubled, the balancing length will still be *X* only.

Q52 Text Solution:

Given,

$l = 1\text{m}$

$A = 5 \times 10^{-7}\ \text{m}^2$

$I = 1\text{A}$

$n = 8 \times 10^{28}$ electrons / m^3

Time taken by an electron to take the drift from one end to the other is given as

$$T = \frac{1}{v_2} \quad .....(i)$$

$$where,\ v_2\ is\ the\ drift\ velocity$$

As, $v_2 = \frac{I}{n\varepsilon A}$

$$= \frac{1}{8\times10^{2B}\times1.6\times10^{-10}\times5\times10^{-7}} = \frac{1}{6.4\times10^{2}}$$

So, substituting the given values in Eq. (i), we get

$$T = \frac{1}{\frac{1}{6.4\times10^{3}}} = 6.4 \times 10^3\, s$$

Q53 Text Solution:

As the charges flow from higher potential to lower potential.

So, its potential energy decreases by $IV\,\Delta t$ but kinetic energy increase.

This increase in energy is transferred to conductor which increases the thermal energy by $IV\,\Delta t$

So, statements (II) and (III) are correct.

Q54 Text Solution:

When a magnetic field is applied to a charged particle, such as an electron, the force on the particle depends on its velocity relative to the field, and the direction of the force is given by the Lorentz force law. The magnetic component of the Lorentz force is described by the equation:

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

where:

$\vec{F}$ is the force on the particle,

q is the electric charge of the particle,

$\vec{v}$ is the velocity of the particle, and

$\vec{B}$ is the magnetic field.

The symbol x denotes the cross product, which means that the force is always perpendicular to both the velocity of the charged particle and the direction of the magnetic field. In the scenario described where the electron is initially stationary, its velocity is zero. Therefore, applying the equation:

$$\vec{F} = q\vec{v} \times \vec{B} = q.\vec{0} \times \vec{B} = \vec{0}$$

Since both qand $\vec{B}$ are nonzero, but $\vec{v}$ is zero, the cross product yields a zero vector, which means there is no force on the stationary electron due to the magnetic field. Consequently, a stationary electron will not move just because a magnetic field is applied. It will remain stationary until an electric field or some other force acts upon it.

Therefore, the correct answer is:

Option C

remains stationary

Q55 Text Solution:

Given,

r = 10cm = 10 × 10^{-2} m

$I_1 = I_2$ = 10A

Force exerted by one wire on the other per unit length is given as

$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$

Substituting the given values, in the above relation, we get

$\frac{F}{l} = \frac{4\pi\times10^{-7}\times10\times10}{2\pi\times10\times10^{-2}} = 2\times10^{-4}\,Nm^{-1}$

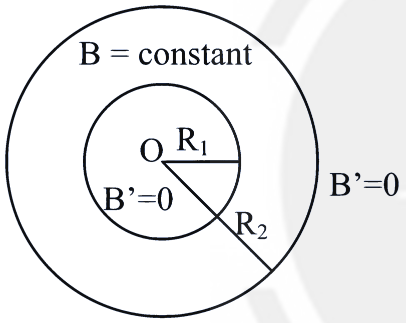
Since, the current is flowing in the same direction, so the force will be attractive in nature.

Q56 Text Solution:

Magnetic field due to toroid can be given as

(i) In the open space, exterior of a toroid,

B = 0



(ii) Inside the toroid,

B = $\frac{\mu_0 NI}{2\pi r}$

Here, r = $\frac{R_1+R_2}{2}$

$\Rightarrow B = \frac{\mu_0 NI}{\pi(R_1+R_2)} = cons\tan$

So, the variations of *B* with *r* is correctly depicted in option (d).

Q57 Text Solution:

Magnetic force on the charged particle is given as

$F_B = q(v \times B) = qvB = sin\theta$

Here, $\theta = 90°$

$F_B = qvB \sin 90° = qvB$

Since, the particle is projected perpendicular to he field, so its trajectory will be circular in nature, where necessary centripetal force = F_B

$\Rightarrow \frac{mv^2}{r'} = qvB$

$\frac{mv^2}{\left(\frac{r}{2}\right)} = qvB\left(\because r' = \frac{r}{2}\right)$

$\Rightarrow v = \frac{qBr}{2m} \quad .....(i)$

Magnetic field inside the solenoid is given as,

$B = \mu_0 nI$

Substituting the value of B in Eq. (i), we get 2m

$v = \frac{\mu_0 nIgr}{2m}$

Q58 Text Solution:

At poles magnetic dip, $\delta = 90°$

As, horizontal component of Earth's magnetic field,

$B_H = B\cos\delta$

where, B is net earth's magnetic field.

$\Rightarrow B_H = B\cos 90° = 0$

So, at poles, the horizontal component of earth's magnetic field is zero.

Q59 Text Solution:

Option (a) and (b) represents electric field lines due to positive and negative charges. However, magnetic monopoles does not exist in nature.

So, option (a) and (b) is not correct for magnetic field lines.

Option (c) represents magnetic field lines for current carrying conductor.

Also, electric field lines cannot form closed loop. So, option (c) is incorrect.

Option (d) is possible for magnetic field lines of solenoid and electric field lines of dipole.

Thus, option (d) is valid for both electric and magnetic field.

Q60 Text Solution:

As we know,

Induced emf, $|e| = L\frac{dI}{dt}$

Here, L = 6 mH = 6 × 10^{-3} H

From the given graph,