Physics

Single correct answer type:

1. A gun fire bullets each of mass 1g with velocity of $10\ ms^{-1}$ by exerting a constant force of 5g weight. Then, the number of bullets fired per second is

(A) 50 (B) 5 (C) 10 (D) 25

Solution: (B)

Mass of Each bullet, $(m) = 1g = 0.001\ kg$.

Velocity of bullet, $(v) = 10\ ms^{-1}$

Applied force, $(F) = 5\ gwt$

$$= \frac{5}{1000} \times 10 = 0.05N.$$

Let n bullets are fired per second, then

Force = rate of change of linear momentum

i.e., $F = n \times mv$

$\therefore$ Number of bullets fired per second,

$$n = \frac{f}{mv} = \frac{0.05}{0.001 \times 10} = 5$$

2. A body of mass m_1 collides elastically with another body of mass m_2 at rest. If the velocity of m_1 after collision becomes $\frac{2}{3}$ times its initial velocity, the ratio of their masses is

(A) $1 : 5$ (B) $5 : 1$ (C) $5 : 2$ (D) $2 : 5$

Solution: (B)

In elastic collision, if u_1 and u_2 are initial velocities and v_1 and v_2 are final velocities of body with masses m_1 and m_2 respectively. Then,

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1 + \left(\frac{2m_2}{m_1 + m_2}\right) u_2.$$

If the second ball is at rest, i.e., $u_2 = 0$, then

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1$$

According to the question,

$\frac{2}{3} u_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1$ $\left\{\because \quad v_1 = \frac{2}{3} u_1\right\}$

$\Rightarrow \quad 2m_1 + 2m_2 = 3m_1 - 3m_2$

$\Rightarrow \quad -m_1 = -5m_2$

$\Rightarrow \frac{m_1}{m_2} = \frac{5}{1}$

3. If a charged spherical conductor of radius 10cm has potential V at a point distant 5cm from its centre, then the potential at a point distant 15cm from the centre will be

(A) $\frac{1}{3} V$ (B) $\frac{2}{3} V$ (C) $\frac{3}{2} V$ (D) $3\ V$

Solution: (B)

For charged spherical conductor, potential inside the sphere is same as that on its surface.

$\therefore$ Potential inside the surface, $V_{in} = V_{\text{surface}}$

$$= \frac{q}{10} \text{stat volt} = V$$

and potential outside the surface, $V_{15} = \frac{q}{15} \text{stat Volt}$.

$\therefore$ The ratio $\frac{V_{15}}{V} = \frac{q}{15} \times \frac{10}{q} = \frac{2}{3}$

$\Rightarrow \quad V_{15} = \frac{2}{3}$

$\Rightarrow \quad V_{out} = \frac{2}{3} V$ $\{\because \quad V_{in} = V\}$

4. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of coil is B. It is then bent into a circular loop of n turns. The magnetic field at the centre of coil will be

(A) nB (B) n^2B (C) $3nB$ (D) n^3B

Solution: (B)

Suppose cength of wire is l.

Then, for circle of n turn.

Magnetic field, $B_n = \frac{\mu_0 \, l_n}{2R}$, where R is the radius of circle

Then $B_s = \frac{\mu_0 \, l}{2R}$ ……(i)

Here, $2\pi R = l$ …….(ii)

Now, if same wire is turned into a coil of n turns of radius a then,

$2\pi a \times n = l$ …….(iii)

Thus, $2\pi R = 2\pi a \times n$

$$\Rightarrow \quad a = \frac{R}{n}$$

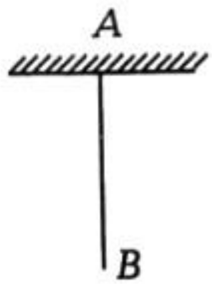
Now, magnetic field for the coil of n turns, is

$$B_n = \frac{\mu_0 l}{2a} \times n$$

$= \frac{\mu_0 l}{2R} \times n^2$ $\left(\because \quad a = \frac{R}{n}\right)$

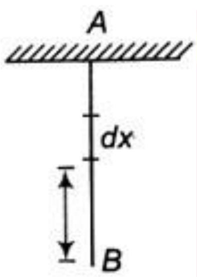
$= n^2 B$

5. A bar of mass m and length l is hanging from point A as shown in the figure. If the Young's modulus of elasticity of the bar is Y and area of cross-section of the wire is A, then the increase in its length due to its own weight will be



(A) $\frac{mgL}{2\ AY}$ (B) $\frac{mgA}{2\ LY}$ (C) $\frac{mg}{2\ LAY}$ (D) $\frac{2\ LY}{mgA}$

Solution: (A)



Consider a small section dx of the bar at a distance x from B. The weight of the bar for a length x is, $W = \left(\frac{mg}{L}\right) x$.

Elongation in x will be

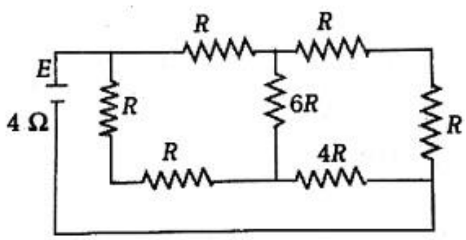
$dL = \left(\frac{W}{AY}\right) dx = \left(\frac{mg}{LAY}\right) dx \cdot x.$

Total elongation of the bar can be obtained by integrating this expression for $x = 0\ to\ x = L$.

$$\therefore \quad \Delta l = \int_{x=0}^{x-L} dL = \left(\frac{mg}{LAY}\right) \int_0^L x \cdot dx$$

$$\Rightarrow \quad \Delta l = \frac{MgL}{2AY}$$

6. A battery of internal resistance $4\ \Omega$ is connected to the network of resistances, as shown in the figure. In order that the maximum power can be delivered to the network, the value of R in Ω should be



(A) $\frac{4}{9}$ (B) 2 (C) $\frac{8}{3}$ (D) 18

Solution: (B)

The given figure is a balanced form of Wheatstone bridge therefore, 6R resistance can be removed.

$$\therefore \quad \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3R} + \frac{1}{6R} = \frac{1}{2R}$$

$\Rightarrow \quad R_P = 2R.$

The power delivered to the network is maximum when internal resistance = External resistance.

$4 = 2R$

$\Rightarrow \quad R = 2\Omega$

7. A hole is made at the bottom of the tank filled with water (density = 1000 kg/m^3). If the total pressure at the bottom of the tank is three atmospheres (1 atmosphere = $10^5\ N/m^2$), then the velocity of efflux is

(A) $\sqrt{400}\ m/s$ (B) $\sqrt{200}\ m/s$ (C) $\sqrt{600}\ m/s$ (D) $\sqrt{500}\ m/s$

Solution: (C)

Pressure at the bottom of the tank, $p = \rho g h = 3$ atm $= 3 \times 10^5\ N/m^2$

So, the height of the liquid in confainer

$$h = \frac{3 \times 10^5}{9 \times 10^3} = \frac{300}{9}$$

Now, velocity of efflux = $\sqrt{2gh} = \sqrt{2 \times 9 \times \frac{30}{9}}$

$= \sqrt{600}\ m/s$

8. Two coils have a mutual inductance $0.005\ H$. The current changes in the first coil according to equation $I = I_0 \sin(\omega t)$, where $I_0 = 10A$ and $\omega = 100\pi\ rad\ s^{-1}$. The maximum value of emf in the second coil is

(A) 2π (B) 5π (C) π (D) 4π

Solution: (B)

emf, induced in second coil $e = M\frac{dI}{dt}$

$\Rightarrow \quad e = M\frac{d}{dt}(I_0 \sin \omega t) = MI_0\omega \cos(\omega t)$

$\Rightarrow \quad e = 0.005 \times 10 \times 100\pi \cos \omega t$

$\Rightarrow \quad e = 5\pi \cos \omega t\,, e_{max} = 5\pi$

(emf is maximum for $\cos \omega t = 1$)

9. A ray of light passing through a prism of refractive index $\sqrt{2}$ undergoes minimum deviation. It is found that the angle of incidence is double the angle of refraction within the prism. The angle of prism is

(A) 60^o (B) 90^o (C) 75^o (D) 30^o

Solution: (B)

According to given problem, $i = 2r = A$

$(\because \quad \text{angle of prism}, A = 2r)$

Since, $\delta_m = 2i - A$

$\Rightarrow \quad \delta_m = 2A - A = A$

We have, $n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} \Rightarrow \sqrt{2} = \frac{\sin A}{\sin\left(\frac{A}{2}\right)}$

$$\Rightarrow \quad \sqrt{2} = \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\Rightarrow \quad \cos\left(\frac{A}{2}\right) = \frac{\sqrt{2}}{2} \Rightarrow \frac{A}{2} = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right)$$

$$\Rightarrow \quad \frac{A}{2} = 45^o \Rightarrow \quad A = 90^o$$

10. In a single slit, Fraunhoffer diffraction experiment, with decrease in the width of the slit, the width of the central maximum

(A) Remains the same

(B) Increase

(C) Decrease

(D) Can be any of these depending on the intensity of the source

Solution: (B)

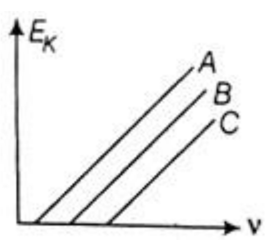
Width of the central maximum is independent of intensity of the source.

Its width is given by $\beta = \frac{2\lambda D}{d}$, where d= width of slit

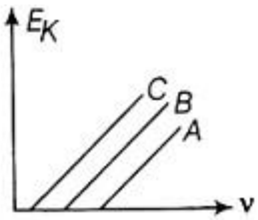
i.e., $\beta \propto \frac{1}{d}$; hence as d decreases, β increases.

11. The work functions of three metals A, B and C are W_A, W_B and W_C respectively. They are in the decreasing order. The correct graph between kinetic energy and frequency v of incident radiation is

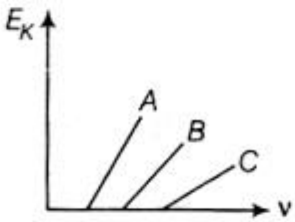
(A)



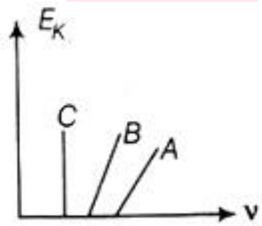
(B)



(C)



(D)



Solution: (B)

Irrespective of the photosensitive material used, the slope of each line should be same, since slope $= \frac{h}{e}$

Since, $W_A > W_B > W_C \; \Rightarrow \; (v_0)_A > (v_0)_B > (v_0)_C$.

Indicates $(v_0)_A < (v_0)_B < (v_0)_C$.

∴ a is not possible.

Options (iii) and (iv) are not possible, since the graphs are not parallel.

12. The energy released during the fission of 1kg of U^{235} is E_1 and that produced during the fusion of 1kg of hydrogen is E_2. If energy released per fission of Uranium -235 is 200 MeV and that per fusion of hydrogen is 24.7 MeV, then the ratio $\frac{E_2}{E_1}$ is

(A) 2 (B) 7 (C) 10 (D) 20

Solution: (B)

Number of fissions that can occur in 1 kg of U^{235} is $n_1 = \frac{N_A}{235\ (kg)}$: N_A is the Avogadro number.

Number of fusions that can occur for 1 kg of hydrogen is $n_2 = \frac{N_A/(1\ kg)}{4}$, because 4 hydrogen nuclei fuse to form one helium nuclei.

$\frac{E_2}{E_1} = \frac{n_2 \times 24.7\ MeV}{n_1 \times 200 MeV} = \frac{235 \times 24.7}{4 \times 200} = 7.25$ (approx)

$= 7$

13. A particle of mass M at rest decays into two particles of masses m_1 and m_2 having non-zero velocities. The ratio of the de-broglie wavelengths of the particles $\frac{\lambda_1}{\lambda_2}$ is

(A) $\frac{m_1}{m_2}$ (B) $\frac{m_2}{m_1}$ (C) 1 (D) $\frac{\sqrt{m_2}}{\sqrt{m_1}}$

Solution: (C)

From the law of conservation of momentum,

$p_1 = p_2$ (in opposite direction)

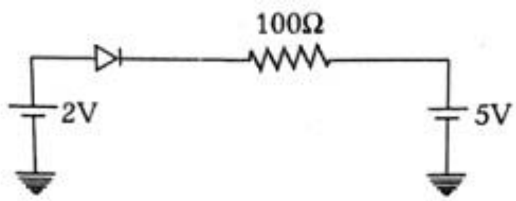
Now, de-broglie wave length is given by $\lambda = \frac{h}{p}$, where h = Plank's constant.

Since, magnitude of momentum (p) of both particles is equal.

Therefore, $\lambda_1 = \lambda_2$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = 1$

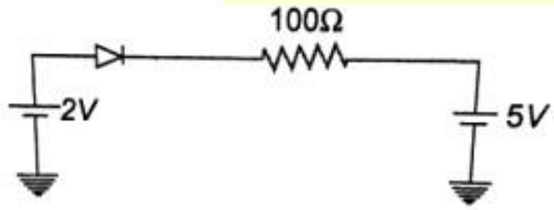
14. Current through the ideal diode as shown in the figure given alongside is



(A) Zero (B) $200A$ (C) $\left(\frac{1}{20}\right)A$ (D) $\left(\frac{1}{50}\right)A$

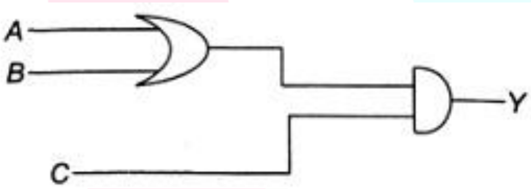
Solution: (A)

Here, p-b junction is reverse biased.



Therefore, the current flowing through P – N junction is zero.

15. To get an output $y = 1$ in the given circuit, which of the following input is correct?



(A)

A	B	C
1	0	0

(B)

A	B	C
1	0	1

(C)

A	B	C
1	1	0

(D)

A	B	C
0	1	0

Solution: (B)

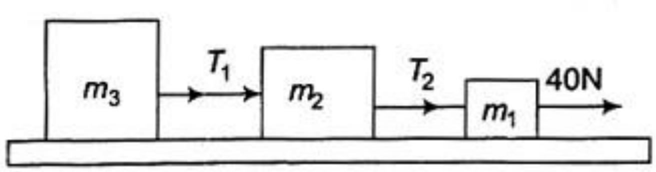
The Boolean expression for output of the given combination is $Y = (A + B) \, . \, C$

The truth table of the combination is

A	B	C	$Y = (A + B) \, . \, C$
0	0	0	0
1	0	0	0
0	1	0	0
0	0	1	0
1	1	0	0
0	1	1	1
1	0	1	1
1	1	1	1

Hence, for output, $Y = 1, A = 1, B = 0$ and $C = 1$.

16. Three blocks of masses m_1, m_2 and m_3 are connected to a massless string on a frictionless table as shown in the figure. They are pulled with a force of 40N. If $m_1 = 10 \; kg, m_2 = 6 \; kg$ and $m_3 = 4 \; kg$, then tension T_2 will be



(A) 10N (B) 20N (C) 32N (D) 40N

Solution: (C)

Since, the table is frictionless, i.e., it is smooth, therefore, force on the block is given by

$F = (m_1 + m_2 + m_3)a$

$$\Rightarrow \quad a = \frac{F}{m_1 + m_2 + m_3}$$

$$\Rightarrow \quad a = \frac{40}{10 + 6 + 4} = \frac{40}{20} = 2\ ms^{-2}$$

Now, the tension between 10 kg and 6 kg masses is given by

$T_2 = (m_1 + m_2)a$

$= (10 + 6)2 = 16 \times 2$

$T_2 = 32\ N$

17. A metallic road of length L and cross-sectional area A is heated through $t^o C$. If Young's modulus of elasticity of the metal is Y, and the coefficient of linear expansion of the metal is α, then the compressional force required to prevent the rod from expanding along its length, is

(A) $YA\alpha t$ (B) $\frac{YA\alpha t}{1-\alpha t}$ (C) $\frac{YA\alpha t}{1+\alpha t}$ (D) $\frac{YA\,(1+\alpha t)}{\alpha t}$

Solution: (A)

For linear expansion of the rod, increase in length,

$\Delta L = \alpha\ Lt$ …..(i)

Now, $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{FL}{A\,\Delta L}$

$$\Rightarrow \quad \Delta L = \frac{FL}{YA}$$

Equating equations (i) and (ii), we get

$$\frac{FL}{YA} = \alpha\ Lt, \quad \Rightarrow \quad F = YA\,\alpha\,t$$

18. Two charged particles of masses m and $2m$ have charges $+2q$ and $+q$ respectively. They are kept in uniform electric field and allowed to move for some time. The ratio of their kinetic energies will be

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

Solution: (A)

Let E be uniform field in which both the charged particles are allowed to move for time t.

Force on I particle = 2qE

Force on II particle = qE

Their accelerations are $a_1 = \frac{2qE}{m}$ and $a_2 = \frac{qE}{2m}$.

Their final velocities after time t.

$v = 0 + at = at$.

$\therefore \quad v_1 = \left(\frac{2q\ E}{m}\right) t$

and $v_2 = \left(\frac{qE}{2m}\right) t$

$$\frac{v_1}{v_2} = \frac{2q\ Et}{m} \times \frac{2m}{qEt} = 2$$

$\Rightarrow \quad v_1 = 2v_2$

Ratio of kinetic energies of two particles,

$$\frac{K_1}{K_2} = \frac{\frac{1}{2} m v_1^2}{\frac{1}{2} 2m v_2^2}$$

$$= \frac{v_1^2}{2v_2^2} = \frac{(2v_2)^2}{2v_2^2}$$

$$= \frac{4v_2^2}{2v_2^2} = 2 : 1$$

19. In a region, electric field varies as $E = 2x^2 - 4$, where x is the distance in metre from origin along x-axis. A positive charge of $1\mu C$ is released with minimum velocity from infinity for crossing the origin, then

(A) The kinetic energy at the origin may be zero

(B) The kinetic energy at the origin must be zero

(C) The kinetic energy at $x = \sqrt{2}m$ must be zero

(D) The kinetic energy at $x = \sqrt{2}m$ may be zero

Solution: (C)

For minimum velocity, the velocity of the point charge will be zero at the point where electric field is zero. Let at point $x = x_0$, the electric field is zero, then

$E = (2x^2 - 4)_{x = x_0} = 0.$

$2x^2 - 4 = 0$

$\Rightarrow \quad 2x_0^2 = 4 \;\Rightarrow\; x_0 = \sqrt{2m}$

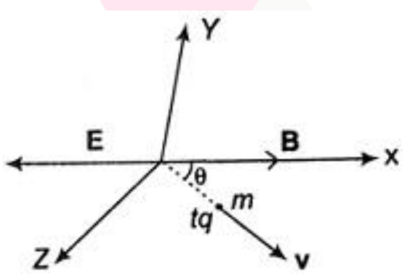
20. In a certain region, uniform electric field E and magnetic field B are present in opposite direction. A particle of mass m and of charge q enters in this region with a velocity v at an angle θ from the magnetic field. The time after which the speed of the particle would be minimum is equal to

(A) $\frac{2\pi m}{Bq}$ (B) $\frac{mv\sin\theta}{qE}$ (C) $\frac{mv\cos\theta}{qE}$ (D) $\frac{mv}{qE}$

Solution: (C)

The charges experiences a retarding force $F = qE$ along x-axis

Retardation $= \frac{qE}{m}$.



It is clear that the speed of the particle will be minimum when its component of velocity is along the direction of electric field.

Then, using the equation of motion,

$v = u + at$

$$\Rightarrow \quad 0 = v\cos\theta - \frac{qE}{m}t$$

$$\Rightarrow \quad t = \frac{mv\cos\theta}{qE}$$

21. A battery of emf 6V and internal resistance 5Ω is joined in parallel with another battery of emf 10V and internal resistance 1Ω and the combination sends a current through an external resistance of 12Ω. The ratio of currents drawn from 6V battery to that of 10V battery is

(A) $\frac{3}{4}$ (B) $\frac{-3}{7}$ (C) $\frac{10}{11}$ (D) $\frac{-10}{11}$

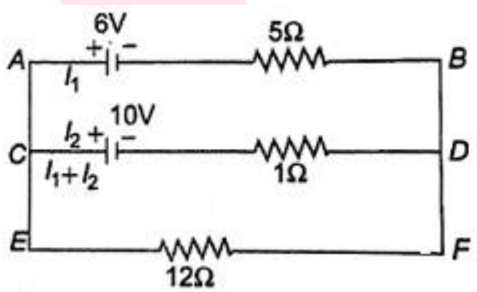
Solution: (B)

Let the currents drawn 6V and 10V batteries be l_1 and l_2 respectively as shown in the figure. Applying Kirchhoff's second law to closed meshes BAEF, BACDE and DCEFD, we get

$5l_1 + 12(l_1 + l_2) = 6$

$\Rightarrow \quad 17l_1 + 12l_2 = 6$

and $\quad l_2 + 12(l_1 + l_2) = 10$



$\Rightarrow \quad 12l_1 + 13l_2 = 10$

Solving Equations (i) and (ii) for l_1 and l_2 we get

$$l_1 = \frac{-6}{11}A, l_2 = \frac{14}{11}A.$$

$$\therefore \quad \frac{l_2}{l_1} = \frac{-6}{14} = \frac{-3}{7}A.$$

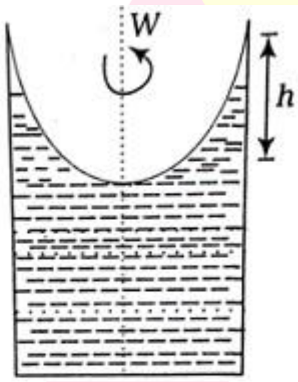
22. A liquid is kept in a cylindrical vessel which is rotated along its axis. The liquid rises at its sides. If the radius of vessel is 0.05m and the speed of rotation is $2\,rev/s$, the difference in the height of liquid at the centre of the vessel and its sides is

(A) 0.001 m (B) 0.002 m (C) 0.01 m (D) 0.02 m

Solution: (D)

$p + \frac{1}{2}pv^2 =$ constant

At the walls of the tube, the velocity is maximum, say $v\,m/s$ so the pressure will be minimum. At the axis of rotation, linear velocity of liquid layer is zero and pressure is maximum say p. Now, pressure at the same horizontal level must be equal. Therefore, the liquid rises at the sides to height h to compensate for this drop in pressure.



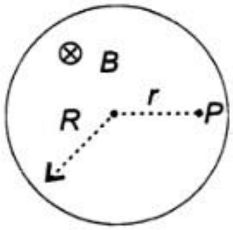
$$p = pgh = \frac{1}{2}pv^2 \;\Rightarrow\; h = \frac{v^2}{2g}$$

Now, $v = \omega r = 2\pi f r = 2 \times 3.14 \times 2 \times 0.05 = 0.628\ m/s$

$$\Rightarrow \quad h = \frac{(0.628)^2}{2 \times 9.8}$$

$$\Rightarrow \quad h = 0.02m$$

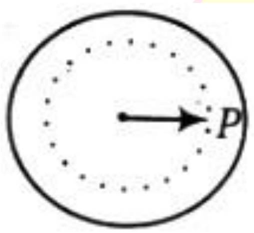
23. A uniform magnetic field of induction B is confined in a cylindrical region of radius R. If the field is increasing at a constant rate of $\frac{dB}{dt} = \frac{\alpha T}{s}$, then the intensity of the electric field induced at point P distant r from the axis as shown in the figure is proportional to



(A) $\frac{1}{8}r$ (B) $\frac{1}{8}r\alpha$ (C) $\frac{1}{2}r\alpha$ (D) r

Solution: (C)

Magnetic flux linked with circular section of radius r of the cylinder , $\phi = (\pi r^2)B$.



Due to this induced emf, an electric field E is established which is equal to potential difference per unit length.

$$E = \frac{e}{2\pi r} = \frac{\pi r^2 \alpha T}{s} \times \frac{1}{2\pi r}$$

$$\Rightarrow \quad E = \frac{1}{2} r . \frac{\alpha T}{s}$$

∴ Electrical field is proportional to $\frac{1}{2}r$

24. The current in LR circuit builds up to $\left(\frac{3}{4}\right)^{th}$ of its maximum value in 4s. The time constant of the circuit is

(A) $0.25s$ (B) $0.30s$ (C) $0.35s$ (D) $0.38s$

Solution: (C)

As it known as that

$$I = I_0\left(1 - e^{1\left(\frac{R}{L}\right)t}\right) = I_0\left(1 - e^{-\frac{t}{t}}\right)$$

$\tau = \frac{L}{R}$

So, $\frac{3}{4}I_0 = I_0\left(1 - e^{-\frac{4}{\tau}}\right)$

$\Rightarrow \quad 1 - e^{-\frac{4}{\tau}} = \frac{3}{4}$

$\Rightarrow \quad e^{-\frac{4}{\tau}} = 1 - \frac{3}{4} = \frac{1}{4}$

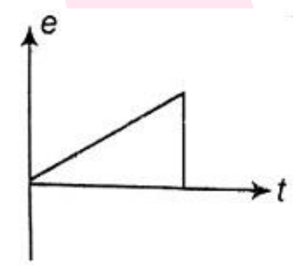
$\Rightarrow \quad \frac{4}{\tau} = \log(4)$

$\Rightarrow \quad \tau = \frac{1}{4}\log_e(4) = \frac{1\log_e(2)}{4} = \frac{\log_e(2)}{2}$

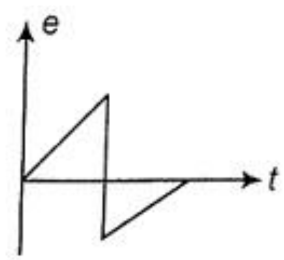
$\tau = \frac{0.693}{2} = 0.355.$

25. An a.c. source of variable angular frequency ω is connected to an L-C-R series circuit. Which one of the following graphs in the figure represents the variation of current I with angular frequency ω?

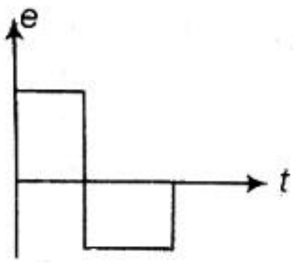
(A)



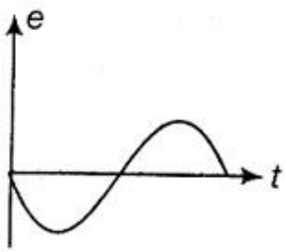
(B)



(C)



(D)



Solution: (B)

Current, $I = \frac{E}{Z} = \frac{E}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$

The impedance first decreases, becomes minimum and then increases. As a result the current at first increases, becomes maximum and then decreases.

26. A concave mirror of focal length f produces an image P times the size of the object. If the image is real, then the distance of the object from the mirror is

(A) $(P-1)f$ (B) $(P+1)f$ (C) $\left(\frac{P-1}{P}\right)f$ (D) $\left(\frac{P+1}{P}\right)f$

Solution: (D)

Given, Magnification, $M = \frac{I}{0} = \frac{v}{u} = P$

Or $v = uP$.

Using mirror's formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Here, the image of the real object is also real, therefore, v.u.f, all are on the negative side.

Hence, $\frac{1}{-uP} + \frac{1}{-u} = \frac{1}{-f}$

$$\Rightarrow \quad \frac{1}{u}\left(\frac{1}{P}+1\right)=\frac{1}{f}$$

$$\Rightarrow \quad u=\left(\frac{P+1}{P}\right)f$$

27. White light is used to illuminate the two slits in Young's double slit experiment. The separation between the slits is d and the distance between the slit and screen is D $(d << D)$. At a point on the screen directly in front of one of the slits, certain wavelengths are missing. The missing wavelengths are

(A) $\lambda=\frac{d^2}{D}(n-1)$ (B) $\lambda=\frac{d^2}{D(2n-1)}$

(C) $\lambda=\frac{d^2}{D}n$ (D) $\lambda=\frac{d^2}{Dn}$

Solution: (B)

The nth order dark fringe is at a distance y_n from the control zero-order bright fringe where

$y_n=\left(n+\frac{1}{2}\right)\frac{\lambda D}{d}$, Here, $n=0,1,2\ldots\ldots$etc.

$y_n=\left(n-\frac{1}{2}\right)\frac{\lambda D}{d}$, Here $n=1,2\ldots\ldots.$etc.

For the point on the screen directly infront of one of the slits, $y_n=\frac{d}{2}$.

So, $\frac{d}{2}=\left(n-\frac{1}{2}\right)\frac{\lambda D}{d} \Rightarrow \lambda=\frac{d^2}{D(2n-1)}$

28. When a electron jumps from a higher energy state to a lower energy state with an energy difference of ΔE electron-volt, then the wavelength of the spectral line emitted is approximately

(A) $\frac{12375}{\Delta E}m$ (B) $\frac{12375}{\Delta E}\ nm$ (C) $\frac{12375}{\Delta E}\ nm$ (D) $\frac{12375\ \text{Å}}{\Delta E}$

Solution: (D)

Energy, $hv=\Delta E$ electron volt.

$\Rightarrow \quad \frac{hc}{\lambda}=\Delta E$ electron volt.

$\Rightarrow \quad \lambda = \dfrac{hc}{\Delta E} = \dfrac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\Delta E}$

But, $\quad 1EV = 16 \times 10^{-19}\,J$

$\therefore \quad \lambda = \dfrac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\Delta E \times 16 \times 10^{-19}}\,m$

$\Rightarrow \quad \lambda = \dfrac{12375 \times 10^{-10}}{\Delta E}\,m$

$\Rightarrow \quad \lambda = \dfrac{12375}{\Delta E}\,\text{Å}$

29. The mass of ${}_{6}^{12}C$ nucleus is 11.99671 amu and the mass of the ${}_{5}^{11}B$ nucleus is 11.00657 amu. The mass of proton is 1.00728 amu. The binding energy of the last proton in ${}_{6}^{12}C$ nucleus is nearly

(A) $0.012\ MeV$ (B) $0.12\ MeV$ (C) $1.6\ MeV$ (D) $16 MeV$

Solution: (D)

The nuclear equation is <math> <mrow> <mtable> <mtr> <mtd> <msubsup> <mspace></mspace> <mn>5</mn> <mrow> <mn>1</mn> <mn>1</mn> </mrow> </msubsup> <mtext>B</mtext> <mo>+</mo> <msubsup> <mspace></mspace> <mn>1</mn> <mn>1</mn> </msubsup> <mtext>H</mtext> </mtd> <mtd> <mo>→</mo> </mtd> <mtd> <msubsup> <mspace></mspace> <mn>6</mn> <mrow> <mn>1</mn> <mn>2</mn> </mrow> </msubsup> <mtext>C</mtext> </mtd> </mtr> <mtr> <mtd> <mfenced close=")" open="(" separators=","> <mrow> <mtext>Proton</mtext> </mrow> </mfenced> </mtd> <mtd> </mtd> <mtd> </mtd> </mtr> </mtable> </mrow> </math>

Mass defect = mass of ${}_{5}^{11}B + mas\ of\ {}_{1}^{1}H - mass\ of\ {}_{6}^{12}C$.

$\Delta m = 11.00657 + 1.00728 - 11.99671$

$\Rightarrow \quad \Delta m = 0.01714\ amu$

Its energy is $\Delta E = 0.01714 \times 931\ MeV$

$\Rightarrow \quad \Delta E = 16\ MeV$

30. Some amount of a radioactive substance (half life = 10 days) is spreaded inside a room and consequently, the level of radiation becomes 50 times the permissible level for normal occupancy of the room. After how many days will the room be safe for occupation?

(A) 20 days (B) 34.8 days (C) 56.4 days (D) 62.9 days

Solution: (C)

Since, the initial activity is 50 times the activity for safe occupancy, therefore, $R_0 = 50R,$ where $R = \lambda N$.

Since, $R \propto N$

$$\Rightarrow \quad \frac{R}{R_0} = \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\Rightarrow \quad \left(\frac{1}{2}\right)^{\frac{t}{10}} = \frac{1}{50}$$

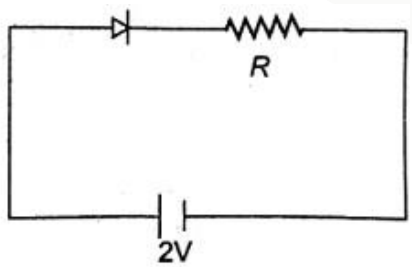
$$\Rightarrow \quad (2)^{\frac{t}{10}} = 50$$

$$\Rightarrow \quad \frac{t}{10}\log_{10}(2) = \log_{10}(50)$$

$$\Rightarrow \quad t = \frac{10\log_{10}50}{\log_{10}2} = \frac{10 \times 1699}{0.301}$$

$= 56.4$ days.

31. In the circuit shown in figure, the minimum current required for the junction diode to be at/above the knee-point is $2.0\ mA$. The knee point of the diode is 1.0 volt. The maximum value of resistance R, so that voltage across the diode above the knee point is



(A) $100\ \Omega$ (B) $200\ \Omega$ (C) $500\ \Omega$ (D) $1\ k\ \Omega$

Solution: (C)

The knee points of the junction diode is given to be 1V. The battery used in the circuit is of 2V. Hence, the voltage drop across the resistance R is $2 - 1 = 1V$

New, since the minimum current required for the diode to be at or above the knee point is $2.0\ mA$. Therefore, the maximum value of R is

$$R_{max} = \frac{1V}{2mA} = \frac{1V}{2 \times 10^{-3}A} = 500\Omega$$

32. A coin is of mass $4.8\ kg$ and radius 1m, is rolling on a horizontal surface without sliding, with an angular velocity of $600\ rad/min$. What is the total kinetic energy of the coin?

(A) $360\ J$ (B) $1440\ \pi^2 J$ (C) $4000\ \pi^2 J$ (D) $600\ \pi^2 J$

Solution: (A)

Angular velocity is given by, $\omega = 600\ rad/min$

$$\omega = 3.18\,\pi\ rad/s$$

$$k = \frac{1}{2}l\omega^2 + \frac{1}{2}mv^2$$

$$= \frac{1}{2} \times \frac{1}{2}mr^2\omega^2 + \frac{1}{2} \times m(\omega r)^2$$

$$= \frac{1}{4} \times m\omega^2 r^2 + \frac{1}{2}m\omega^2 r^2 = \left(\frac{1}{4} + \frac{1}{2}\right)m\omega^2 r^2$$

$$= \frac{3}{4} \times 4.8 \times 1^2 \times (3.18\pi)^2 = 359J = 360J$$

33. A black body of mass $34.38\ g$ and surface area $19.2\ cm^2$ is at an initial temperature of $400K$. It is allowed to cool inside an evacuated enclosure kept at constant temperature of 300 K. The rate of cooling is $0.04^o\ C/s$. The specific heat of body is

(A) $2800\ J/kg - k$ (B) $2100\ J/kg - k$

(C) $1400\ J/kg - k$ (D) $1200\ J/kg - k$

Solution: (C)

From stefan's law,

$$mc\left(\frac{dT}{dt}\right) = \sigma(T^4 - T_0^4)A$$

$$\Rightarrow \quad c = \frac{\sigma(T^4 - T_0^4)\, A}{m\left(\frac{dT}{dt}\right)}$$

$$= \frac{(573 \times 10^{-8})\,[(400)^4 - (300)^4 \times 192 \times 10^{-4}]}{(34.38 \times 10^{-3}) \times (0.004)}$$

$$\Rightarrow \quad c = 1400\, J/kg - K$$

34. A parallel plate capacitor of capacitance 100 pF is to be constructed by using paper sheets of 10 mm thickness as dielectric. If dielectric constant of paper is 4, the number of circular metal foils of diameter 2cm each required for the purpose is

(A) 40 (B) 20 (C) 30 (D) 10

Solution: (D)

The arrangement of n metal plates separated by dielectric acts as a parallel combination of (n -1) capacitors.

Therefore, $C = \frac{(n-1)\, K\varepsilon_0\, A}{d}$

Here, $C = 100\, pF = 100 \times 10^{-12}\, F$

$K = 4, \varepsilon_0 = 8.85 \times 10^{-12}\, C^2N^{-1}m^{-2}$

Area, $A = \pi r^2 = 3.14 \times (1 \times 10^{-2})^2, d = 1mm = 1 \times 10^{-3}\, m$

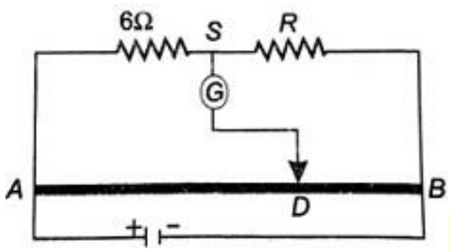
$$\Rightarrow \quad 100 \times 10^{-12}$$

$$= \frac{(n-1)\, 4 \times (8.85 \times 10^{-12}) \times 3.14 \times (1 \times 10^{-2})^2}{1 \times 10^{-3}}$$

$$\Rightarrow \quad n = \frac{1111.156}{111.156} = 9.99 = 10$$

$$\Rightarrow \quad n = 10$$

35. The potentiometer wire AB shown in the adjoining figure is 100 cm long when $AD = 30\ cm$, no deflection occurs in galvanometer. The value of R is



(A) $6\ \Omega$ (B) $9\ \Omega$ (C) $14\ \Omega$ (D) $15\ \Omega$

Solution: (C)

Let ρ be the resistance per unit length of the from the condition of balance of Wheatstone bridge.

$$\frac{P}{Q} = \frac{R}{S}$$

$$\Rightarrow \frac{6}{R} = \frac{30\rho}{(100-30)\rho} = \frac{30}{70} = \frac{3}{7}$$

$$\Rightarrow R = \frac{7 \times 6}{3} = 144\ \Omega$$

$$\Rightarrow R = 14\ \Omega$$

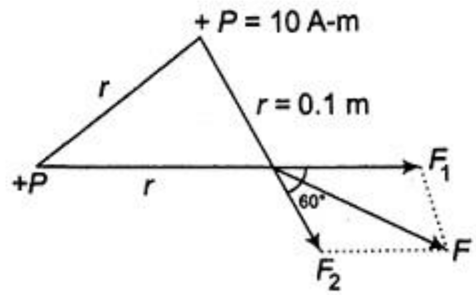
36. Three identical magnetic north poles each of the pole strength 10 A-m are placed at the corners of an equilateral triangle of side 10 cm. The net magnetic force on one of the pole is

(A) $10^{-3}\ N$ (B) $\sqrt{2} \times 10^{-3} N$ (C) $\sqrt{3} \times 10^{-3}\ N$ (D) None of the above

Solution: (C)

From the figure, $|F_1| = |F_2| = \frac{\mu_0\, P^2}{4\pi r^2} = \frac{10^{-7} \times (10)^2}{(0.1)^2}\ N$

$= 10^{-3}\ N$



Resultant force,

$$F = [(10^{-3})^2 + (10^{-3})^2 + 2(10^{-3}) \times (10^{-3}) \cos 60^o]^{\frac{1}{2}}$$

$$\left\{\because \quad (R = P^2 + Q^2 + 2PQ\cos\theta)^{\frac{1}{2}}\right\}$$

$$F = \sqrt{2} \times 10^{-3}\,[1 + \cos 60^o]^{\frac{1}{2}}$$

$$\Rightarrow \quad F = \sqrt{2} \times 10^{-3}\left[1 + \frac{1}{2}\right]^{\frac{1}{2}}$$

$$\Rightarrow \quad F = \sqrt{3} \times 10^{-3}\,N$$

37. The transparent media A and B are separated by a plane boundary. The speed of light in medium A is $2 \times 10^6\ m/s$ and in medium B is $2.5 \times 10^8\, m/s$. The critical angle for which a ray of light going from A to B is totally internally reflected is

(A) $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$ (B) $\sin^{-1}\left(\frac{1}{2}\right)$ (C) $\sin^{-1}\left(\frac{4}{5}\right)$ (D) 90

Solution: (C)

Refractive index of the medium A relative B is given by

$$_{B}\mu^{A} = \frac{\mu_A}{\mu_B} = \frac{V_B}{V_A} = \frac{2.5}{2} = \frac{5}{4}$$

Since, critical angle for the light ray going from medium A to B is given by

$$C = \sin^{-1}\left(\frac{1}{_{B}\mu^{A}}\right) = \sin^{-1}\left(\frac{4}{5}\right)$$

38. Two coherent beams of wavelength $5000\ \text{Å}$ reaching a point would individually produce intensities 1.44 and 4.00 units. If they reach there together, the intensity is 10.24 units. Calculate the lowest phase difference with which the beams reach that point

(A) zero (B) $\frac{\pi}{4}$ (C) $\frac{\pi}{2}$ (D) π

Solution: (A)

Resultant intensity at the point where the two coherent beam reach together is given by

$I = I_1 + I_2 + 2\sqrt{I_1\, I_2}\cos\phi$

$\Rightarrow \quad 10.24 = 1.44 + 4.00 + 2\sqrt{1.44 \times 4.00}\cos\phi$

$\Rightarrow \quad 10.24 = 5.44 + 4.8\cos\phi$

$$\Rightarrow \cos\phi = \frac{10.24 - 5.44}{4.8} = 1$$

$\Rightarrow \quad \phi = 0$

39. An electron accelerated under a potential difference of V volt has a certain wavelength $'\lambda'$ Mass of proton is about 1800 times the mass of electron. If the gas has to have the same wavelength λ, then it will have to be accelerated under the potential difference of

(A) $V\ volt$ (B) $1800\ volt$ (C) $\frac{V}{1800}\ volt$ (D) $\sqrt{1800}\ volt$

Solution: (C)

Wavelength $\lambda = \frac{h}{\sqrt{2mqV}}$

$$\Rightarrow \quad mqV = \frac{h^2}{2\lambda^2}$$

$$\Rightarrow \quad mV = \frac{h^2}{2\lambda^2 q} = \text{Constant}$$

(since, λ and q are same for electron and proton both)

$$\therefore \quad V \propto \frac{1}{m}$$

$$\Rightarrow \quad \frac{V_P}{V_e} = \frac{m_e}{m_P}$$

$$\Rightarrow \quad V_P = \left(\frac{m_e}{m_P}\right) . V_e = \frac{V}{1800} \text{ volt}$$

40. At what speed should the electron revolve around the nucleus of an hydrogen atom in order that it may not be pulled into the nucleus by electrostatic attraction. Take the radius of orbit of electron as 0.5 Å, mass of electron as $9.1 \times 10^{-31} kg$ and charge as $1.6 \times 10^{-119} C$.

(A) $225 \times 10^4 \, m/s$ (B) $225 \times 10^5 \, m/s$

(C) $225 \times 10^6 \, m/s$ (D) $225 \times 10^7 \, m/s$

Solution: (C)

Fro motion of the electron around the nucleus,

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0} . \frac{e . e}{r^2}$$

$$\Rightarrow \quad v^2 = \frac{1}{4\pi\varepsilon_0} . \frac{e^2}{mr}$$

$$\Rightarrow \quad v^2 = \frac{9 \times 10^9 \times (16 \times 10^{-19})^2}{9.1 \times 10^{-31} \times 0.5 \times 10^{-10}} = 5 \times 10^{12}$$

$$\Rightarrow \quad v \approx 2.25 \times 10^6 \; m/s$$