CBSE–AIPMT–2009

General Instructions

1. *There are objective type questions with four options having single correct answer.*
2. *For each incorrect response, one fourth (1/4) of the total marks allotted to the question would be deducted.*
3. *No deduction from the total score will, however, be made if no response is indicated for an item in the answer sheet. The candidates are advised not to attempt such item in the answer sheet if they are not sure of the correct response.*
4. *More than one answer indicated against a question will be deemed as incorrect response and will be negatively marked.*

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1. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be

(a) velocity if $a=1, b=0, c=-1$

(b) acceleration if $a=1, b=1, c=-2$

(c) force if $a=0, b=-1, c=-2$

(d) Pressure if $a=1, b=-1, c=-2$

Solution

(d)

Pressure

$$P=\frac{\text{force}}{\text{area}}=\frac{ma}{l^2}$$

$$[P]=\frac{MLT^{-2}}{L^2}=ML^{-1}T^{-2}$$

Therefore, if $a = -1$, $b = -1$, $c = -2$, the dimension is of pressure.

2. A bus is moving with a speed of 10 m s^{-1} on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what speed should the scooterist chase the bus?

(a) 40 m s^{-1}

(b) 25 m s^{-1}

(c) 10 m s^{-1}

(d) 20 m s^{-1}

Solution

(d) The distance moved by the bus in 100 s

$$s=s_0+ut=1000+10\times100=2000\text{ m.}$$

Therefore, the scooterist must cover at least 2 km in 100 s.

$$vt=2000\text{ m}$$

$$v=\frac{2000}{100}=20\text{ ms}^{-1}.$$

3. A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 seconds is s_1 and that covered in the first 20 seconds is s_2, then

(a) $s_2=3s_1$

(b) $s_2=4s_1$

(c) $s_2=s_1$

(d) $s_2=2s_1$

Solution

(b)

$$s_1=\frac{1}{2}\times a\times10^2$$

$$s_2=\frac{1}{2}\times a\times(20)^2$$

$$\Rightarrow s_2=4s_1$$

4. A body under the action of a force $\vec{F}=6\hat{i}-8\hat{j}+10\hat{k}$, acquires an acceleration of 1m/s^2. The mass of this body must be

(a) 10 kg

(b) 20 kg

(c) $10\sqrt{2}$ kg

(d) $2\sqrt{10}$ kg

Solution

(c) Force acting

$$\vec{F}=6\hat{i}-8\hat{j}+10\hat{k}$$

$$|\vec{F}|=\sqrt{6^2+8^2+10^2}=10\sqrt{2}\text{ kgms}^{-2}$$

$$ma=10\sqrt{2}\text{ kgms}^{-2}$$

But $a=1\text{m/s}^2$.

Therefore,

$$m=10\sqrt{2}\text{ kg}$$

5. The mass of a lift is 2000 kg. when the tension in the supporting cable is 28000 N, then its acceleration is

(a) 4 m s^{-2} upwards

(b) 4 m s^{-2} downwards

(c) 14 m s^{-2} upwards

(d) 30 m s^{-2} downwards

Solution

(a)

Tension on the cable is $T=m(g+a)$

$$28000N = 2000(10 + a)$$

or $$a = 4\ \text{ms}^2 \text{ upwards.}$$

6. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water jet. What is the rate at which kinetic energy is imparted to water?

(a) mv^3 (b) $\frac{1}{2}mv^2$

(c) $\frac{1}{2}m^2v^2$ (d) $\frac{1}{2}mv^3$

Solution

(d) Mass of the water pumped in one second

$$M = mv$$

Therefore, kinetic energy

$$\frac{1}{2}Mv^2 = \frac{1}{2}(mv)v^2 = \frac{1}{2}mv^3$$

7. An explosion blows a rock into three parts. Two parts go off at right angles to each other. These two are, 1 kg first part moving with a velocity of $12\ \text{m s}^{-1}$ and 2 kg second part moving with a velocity $8\ \text{m s}^{-1}$. If the third part flies off with a velocity of $8\ \text{m s}^{-1}$, its mass would be

(a) 7 kg

(b) 17 kg

(c) 3 kg

(d) 2.5 kg.

Solution

(d) Assume the first particle flies in x-axis and second particle along y-axis, then from conservation of momentum

$$8M\cos\theta = 12\ \text{kgms}^{-1}$$

or $$M\cos\theta = \frac{3}{2}\ \text{kg}$$

or $$M^2\cos^2\theta = \frac{9}{4}\ \text{kg}^2 \qquad (1)$$

and $$8M\sin\theta = (2\ \text{kg} \times 8\ \text{ms}^{-1}) = 16\ \text{kgms}^{-1}$$

$$M^2\sin^2\theta = 4\ \text{kg}^2 \qquad (2)$$

(1) + (2)

$$M^2 = \frac{25}{4}\text{kg}^2$$

or

$$M = 2.5\ \text{kg.}$$

8. A body of mass 1 kg is thrown upwards with a velocity 20 m/s. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction? $(g = 10\ \text{m/s}^2)$

(a) 30 J

(b) 40 J

(c) 10 J

(d) 20 J

Solution

(d) Initial energy

$$E_i = \frac{1}{2}mv^2 = 400\ \text{J}$$

Final energy

$$E_f = mgh = 180\ \text{J}$$

Therefore, loss of energy due to air friction

$$E_{\text{lost}} = (400 - 180) = 20\ \text{J.}$$

9. A block of mass M is attached to the lower end of a vertical spring. The spring is hung from a ceiling and has force constant value k. The mass is released from rest with the spring initially unstretched. The maximum extension produced in the length of the spring will be

(a) $2\ Mg/k$

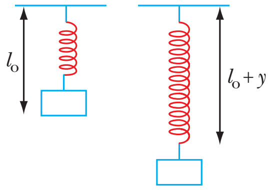
(b) $4\ Mg/k$

(c) $Mg/2k$

(d) Mg/k.

Solution

(a)



$$Mgy = \frac{1}{2}ky^2$$

$$y = \frac{2Mg}{k}.$$

10. A thin circular ring of mass M and radius R is rotating in a horizontal plane about an axis vertical to its plane with a constant angular velocity ω. If objects each of mass m be attached gently to the opposite ends of a diameter of the ring, the ring will then rotate with an angular velocity

(a) $\frac{\omega M}{M + 2m}$ (b) $\frac{\omega(M + 2m)}{M}$

(c) $\frac{\omega M}{M + m}$ (d) $\frac{\omega(M - 2m)}{M + 2m}$.

Solution

(a) The initial angular momentum is

$$L = I\omega = MR^2\omega.$$

After attaching the mass m, the angular momentum is

$$L' = (MR^2 + 2mR^2)\omega'$$

The angular momentum is a conserved quantity,

$$L = L'$$

$$MR^2\omega = (MR^2 + 2mR^2)\omega'$$

or $$\omega' = \frac{MR^2\omega}{(MR^2 + 2mR^2)} = \frac{M}{M + 2m}\omega.$$

11. If $\vec{F}$ is the force acting on a particle having position vector $\vec{r}$ and $\vec{\tau}$ be the torque of this force about the origin, then

(a) $\vec{r}\cdot\vec{\tau}>0$ and $\vec{F}\cdot\vec{\tau}<0$ (b) $\vec{r}\cdot\vec{\tau}=0$ and $\vec{F}\cdot\vec{\tau}=0$

(c) $\vec{r}\cdot\vec{\tau}=0$ and $\vec{F}\cdot\vec{\tau}\neq 0$ (d) $\vec{r}\cdot\vec{\tau}\neq 0$ and $\vec{F}\cdot\vec{\tau}=0$

Solution

(b) Torque is perpendicular to both $\vec{r}$ and $\vec{F}$.
Therefore, both $\vec{r}\cdot\vec{\tau}$ and $\vec{F}\cdot\vec{\tau}$ are zero

12. Four identical thin rods each of mass M and length ℓ, from a square frame. Moment of inertia of this frame about an axis through the centre of the square and perpendicular to its plane.

(a) $\frac{2}{3}M\ell^2$ (b) $\frac{13}{3}M\ell^2$

(c) $\frac{1}{3}M\ell^2$ (d) $\frac{4}{3}M\ell^2$

Solution

(d) Moment of inertia of one rod of mass M and length ℓ about its centre and perpendicular to its length is

$$i=\frac{M\ell^2}{12}$$

Therefore, from parallel axis theorem moment of inertia of the ring about the centre of frame is.

$$I'=i+M\left(\frac{\ell}{2}\right)^2=\frac{4M\ell^2}{12}$$

Therefore, moment of inertia of the total frame

$$I=4I'$$

$$I=\frac{4}{3}M\ell^2.$$

13. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i}+2\hat{j}+\hat{k}$ and $-3\hat{i}-2\hat{j}+\hat{k}$, respectively. The centre of mass of this system has a position vector

(a) $-2\hat{i}-\hat{j}+\hat{k}$

(b) $2\hat{i}-\hat{j}-2\hat{k}$

(c) $-\hat{i}+\hat{j}+\hat{k}$

(d) $-2\hat{i}+2\hat{k}$.

Solution

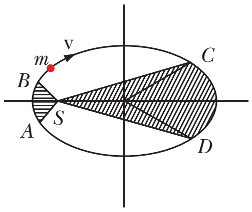
(a) Centre of mass

$$R_{\text{cm}}=\sum M_i r_i/\sum M_i$$

Therefore,

$$R_{\text{cm}}=\frac{\left(\hat{i}+2\hat{j}+\hat{k}\right)+3\left(-3\hat{i}-2\hat{j}+\hat{k}\right)}{3+1}=-2\hat{i}-\hat{j}+\hat{k}.$$

14. The figure shows elliptical orbit of a planet m about the sun S. The shaded area SCD is twice the shaded area SAB. If t_1 is the time for the planet to move from A and B, and t_2 is the time for the planet to move from C to D, then



(a) $t_1=4t_2$ (b) $t_1=2t_2$ (c) $t_1=\frac{t_2}{2}$ (d) $t_1>t_2$.

Solution

(c) From Kepler's second law of planetary motion, area ℓ velocity A is a constant

Therefore, the area swept is

$$SAB=At_1$$

$$SCD=At_2$$

$$t_1=\frac{t_2}{2}.$$

15. In thermodynamic processes which of the following statement is not true?

(a) In an isochoric process pressure remains constant

(b) In an isothermal process the temperature remains constant

(c) In an adiabatic process $PV^\gamma=$ constant

(d) In an adiabatic process the system is insulated from the surroundings.

Solution

(a) A process is called isochoric if the volume remains constant.

16. The two ends of a rod of length L and a uniform cross-sectional area A are kept at two temperatures T_1 and T_2 ($T_1>T_2$). The rate of heat transfer, $\frac{dQ}{dt}$, through the rod in a steady state is given by

(a) $\frac{dQ}{dt}=\frac{k(T_1-T_2)}{LA}$ (b) $\frac{dQ}{dt}=kLA(T_1-T_2)$

(c) $\frac{dQ}{dt}=\frac{kA(T_1-T_2)}{L}$ (d) $\frac{dQ}{dt}=\frac{kL(T_1-T_2)}{A}$.

Solution

(c) The rate of heat conduction

$$\frac{dQ}{dt}=-kA\frac{\Delta T}{\Delta x}$$

where k is the conductivity, A area of cross section, ΔT is the temperature difference and Δx is the separation between the ends.

Therefore,

$$\frac{dQ}{dt}=kA\frac{(T_1-T_2)}{L}.$$

17. A black body at 227°C radiates heat at the rate of 7 cals/cm^{2}s. At a temperature of 727°C, the rate of heat radiated in the same units will be

(a) 50 (b) 112 (c) 80 (d) 60

Solution

(b) From Stefan's law

$$J=\sigma T^4$$

$$7\frac{\text{cals}}{\text{cm}^2}=\sigma(227+273)^4=\sigma(500)^4$$

$$\sigma=\frac{7}{500^4}.$$

Therefore, radiation at 727 °C (1000 K) is

$$J=\frac{7}{(500)^4}(1000)^4\ \text{cal/cm}^2$$

$$J=112\frac{\text{cal}}{\text{cm}^2}.$$

18. The internal energy change in a system that has absorbed 2 kcal of heat and done 500 J of work is

(a) 6400 J (b) 5400 J (c) 7900 J (d) 8900 J

Solution

(c) 1 Cal = 4.2 J

The body absorbs 2 kcal energy and does 500 J work, therefore, from first law of thermodynamics

$$U=Q-W$$

$$U=8400-500$$

$$U=7900\,\text{J}.$$

19. A simple pendulum performs simple harmonic motion about $x = 0$ with an amplitude a and time period T. The speed of the pendulum at $x = a/2$ will be

(a) $\frac{\pi a}{T}$ (b) $\frac{3\pi^2 a}{T}$

(c) $\frac{\pi a\sqrt{3}}{T}$ (d) $\frac{\pi a\sqrt{3}}{2T}$.

Solution

(c) Equation of pendulum is

$$x=a\sin\omega t.$$

At $\quad x=a/2$

$$\frac{a}{2}=a\sin\omega t\Rightarrow\omega t=\frac{\pi}{6}$$

and velocity

$$v=a\omega\cos\omega t$$

Therefore, velocity of pendulum when $x = a/2$ is

$$v=a\left(\frac{2\pi}{T}\right)\cos\left(\frac{\pi}{6}\right)$$

$$=\frac{\pi a\sqrt{3}}{T}$$

or

$$v=\omega\sqrt{A^2-x^2}$$

$$=\frac{2\pi}{T}\sqrt{a^2-\frac{a^2}{4}}$$

$$=\frac{\sqrt{3}a.\pi}{T}.$$

20. Which one of the following equations of motion represents simple harmonic motion?

(a) Acceleration $=-k(x+a)$

(b) Acceleration $=k(x+a)$

(c) Acceleration $=kx$

(d) Acceleration $=-k_0x+k_1x^2$

where k, k_0, k_1, and a are all positive.

Solution

(a) Equation of simple harmonic motion is

$$\frac{d^2x}{dt^2}=-\frac{k}{m}(x+a)$$

Therefore, when mass is unity

$$\text{Acceleration }=-k(x+a).$$

21. Each of the two strings of length 51.6 cm and 49.1 cm are tensioned separately by a 20 N force. Mass per unit length of both the strings is same and equal to 1 g/m. When both the strings vibrate simultaneously the number of beats is

(a) 7 (b) 8 (c) 3 (d) 5

Solution

(a) Frequency of string is

$$f_n=\frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

Therefore,

$$f_1=\frac{1}{2\times 51.6\times 10^{-2}}\sqrt{\frac{20}{1\times 10^{-3}}}=\frac{10^4}{\sqrt{2}}\times\frac{1}{51.6}$$

$$f_2=\frac{1}{2\times 49.1\times 10^{-2}}\sqrt{\frac{20}{1\times 10^{-3}}}=\frac{10^4}{\sqrt{2}}\times\frac{1}{49.1}$$

The beat frequency is

$$F=f_2-f_1=\frac{10^4}{\sqrt{2}}\left(\frac{1}{49.1}-\frac{1}{51.6}\right)=7$$

Therefore, no of beats is 7.

22. The driver of a car travelling with speed 30 m/s towards a hill sounds a horn of frequency 600 Hz. If the velocity of sound in air is 330 m/s, the frequency of reflected sound as heard by driver is

(a) 555.5 Hz (b) 720 Hz (c) 500 Hz (d) 550 Hz.

Solution

(b) The observed frequency due to Doppler shift is given by

$$f=\frac{v+v_r}{v-v_s}f_0$$

Both v_r and v_s are positive if they are moving towards each other.

Therefore, frequency of reflected sound is

$$f'=\frac{330}{330-30}f_0=\frac{330}{300}f_0.$$

Therefore, the frequency observed by the driver

$$f''=\frac{330+30}{330}f'$$

$$= \frac{360}{300} \times 600 \text{ Hz}$$

$$= 720 \text{ Hz.}$$

23. A wave in a string has an amplitude of 2 cm. The wave travels in the +ve direction of x-axis with a speed of 128 m/s and it is noted that 5 complete waves fit in 4 m length of the string. The equation describing the wave is

(a) $y = (0.02)\,\text{m}\sin(15.7\,x - 2010t)$

(b) $y = (0.02)\,\text{m}\sin(15.7\,x + 2010t)$

(c) $y = (0.02)\,\text{m}\sin(7.85\,x - 1005t)$

(d) $y = (0.02)\,\text{m}\sin(7.85\,x + 1005t)$.

Solution

(c) Wavelength is $\lambda = \frac{4}{5} m$

Velocity of wave is

$$v = \nu\lambda$$

$$\nu = \frac{128 \times 5}{4} = 160 \text{ Hz.}$$

Equation of motion is

$$y = a\sin\left(\frac{2\pi}{\lambda}x - 2\pi\nu t\right)$$

$$y = 0.02\sin\left(\frac{2 \times 3.14 \times 5}{4}x - (2 \times 3.14 \times 160\ t)\right)$$

$$y = (0.02)\,\text{m}\sin(7.85\,x - 1005t).$$

24. Three concentric spherical shells have radii a, b and c $(a < b < c)$ and have surface charge densities $\sigma, -\sigma$ and σ respectively. If V_A, V_B and V_C denote the potentials of the three shells, then for $c = a + b$, we have

(a) $V_C = V_B \neq V_A$

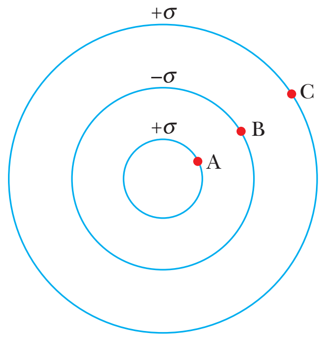
(b) $V_C \neq V_B \neq V_A$

(c) $V_C = V_B = V_A$

(d) $V_C = V_A \neq V_B$.

Solution

(a)



$$V_A = \frac{\sigma a}{\varepsilon_0} + \frac{-\sigma b}{\varepsilon_0} + \frac{\sigma c}{\varepsilon_0}$$

$$V_B = \frac{\sigma b}{\varepsilon_0} + \frac{-\sigma b}{\varepsilon_0} + \frac{\sigma c}{\varepsilon_0}$$

$$V_C = \frac{\sigma c}{\varepsilon_0} + \frac{-\sigma c}{\varepsilon_0} + \frac{\sigma c}{\varepsilon_0}$$

25. Three capacitors each of capacitance C and of breakdown voltage V are joined in series. The capacitance and breakdown voltage of the combination will be

(a) $3C, \frac{V}{3}$ (b) $\frac{C}{3}, 3V$ (c) $3C, 3V$ (d) $\frac{C}{3}, \frac{V}{3}$.

Solution

(b) The effective capacitance is $C/3$.

Since each capacitor breaks down at V volts the new breakdown voltage is 3 V.

26. The electric potential at a point (x, y, z) is given by $V = -x^2y - xz^3 + 4$.

The electric field $\vec{E}$ at that point is

(a) $\vec{E} = \hat{i}\,2xy + \hat{j}(x^2 + y^2) + \hat{k}(3xz - y^2)$

(b) $\vec{E} = \hat{i}z^3 + \hat{j}\,xyz + \hat{k}z^2$

(c) $\vec{E} = \hat{i}(2xy - z^3) + \hat{j}\,xy^2 + \hat{k}\,3z^2x$

(d) $\vec{E} = \hat{i}(2xy + z^3) + \hat{j}\,x^2 + \hat{k}\,3xz^2$.

Solution

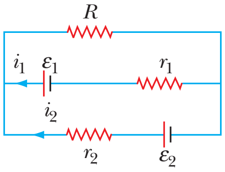
(d) Electric field is

$$\vec{E} = -\nabla V$$

$$= -\frac{\partial(-yx^2 - xz^3 + 4)}{\partial x}\hat{i} - \frac{\partial(-yx^2 - xz^3 + 4)}{\partial x}\hat{j} - \frac{\partial(-x^{2y} - xz^3 + 4)}{\partial x}\hat{k}$$

$$\vec{E} = \left(2xy + z^3\right)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$$

27. See the electrical circuit shown in this figure. Which of the following equations is a correct equation for it?



(a) $\varepsilon_2 - i_2r_2 - \varepsilon_1 - i_1r_1 = 0$

(b) $-\varepsilon_2 - (i_1 + i_2)R + i_2r_2 = 0$

(c) $\varepsilon_1 - (i_1 + i_2)R + i_1r_1 = 0$

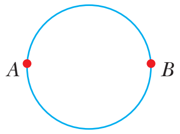
(d) $\varepsilon_1 - (i_1 + i_2)R - i_1r_1 = 0$

Solution

(a) Consider the loop shown in the figure

$$\varepsilon_2 - i_2r_2 - \varepsilon_1 - i_1r_1 = 0.$$

28. A wire of resistance 12 ohms per meter is bent to form a complete circle of radius 10 cm. The resistance between its two diametrically opposite points, A and B as shown in the figure is



(a) 3 Ω (b) 6π Ω (c) 6 Ω (d) 0.6π Ω.

Solution

(a) The bent wire consist of 2 resistors of 6 Ω connected parallel.

Therefore, the net resistance is $R = 6\Omega \| 6\Omega = 3\Omega$.

29. A student measures the terminal potential difference (V) of a cell (of emf ε and internal resistance r) as a function of the current (I) flowing through it. The slope, and intercept, of the graph between V and I, then, respectively, equal

(a) $-r$ and ε (b) r and $-\varepsilon$

(c) $-\varepsilon$ and r (d) ε and $-r$.

Solution

(d) Terminal potential is

$$V = \varepsilon - Ir.$$

Therefore, intercept and slope of the curve gives ε and $-r$ respectively.

30. The mean free path of electrons in a metal is 4×10^{-8} m. The electric field which can give on an average 2 eV energy to an electron in the metal will be, in units of V/m

(a) 5×10^{-11} (b) 8×10^{-11} (c) 5×10^{7} (d) 8×10^{7}

Solution

(c) The kinetic energy given by the electric field is

$$eV = 2\,\text{eV}$$

or $$V = 2\,\text{volts}$$

Therefore, electric field

$$E = \frac{V}{\text{mean free path}} = \frac{2}{4\times10^{-8}} = 5\times10^{7}\,\text{V/m}.$$

31. A galvanometer having a coil resistance of 60 Ω shows full scale deflection when a current of 1.0 A passes through it. It can be converted into an ammeter to read currents upto 5.0 A by

(a) putting in series a resistance of 15 Ω

(b) putting in series a resistance of 240 Ω

(c) putting in parallel a resistance of 15 Ω

(d) putting in parallel a resistance of 240 Ω

Solution

(c) The current required for a full scale deflection $i = 1.0$ A. If a resistor r is connected parallel to it then current passing through the circuit is

$$iR = IR$$

$$I = 4\,\text{A}$$

$$R = \frac{60}{4}\,\Omega$$

$$R = 15\,\Omega$$

Therefore, the galvanometer can be converted to an ammeter to read current up to 5.0 A by connecting a parallel resistor of 15 Ω.

32. The magnetic force acting on a charged particle of charge $-2\,\mu$C in a magnetic field of 2 T acting in y-direction, when the particle velocity is $(2\hat{i}+2\hat{j})\times10^{6}\,\text{m s}^{-1}$, is

(a) 4 N in z-direction (b) 8 N in y-direction

(c) 8 N in z-direction (d) 8 N in $-z$-direction.

Solution

(d) The force acting on the particle is

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

$$= -2\left(\left(2\hat{i}+2\hat{j}\right)\times2\hat{j}\right) = -8\hat{k}.$$

The force is 8 N in $-z$-direction.

33. Under the influence of a uniform magnetic field, a charged particle moves with constant speed v in a circle of radius R. The time period of rotation of the particle

(a) depends on R and not on v

(b) is independent of both v and R

(c) depends on both v and R

(d) depends on v and not on R.

Solution

(b) The time period is

$$T = \frac{2\pi m}{eB}$$

where m is the mass of the electron and e is charge.

Therefore, the time period of rotation of the particle is independent of both v and R.

34. A bar magnet having a magnetic moment of 2×10^{4} JT^{-1} is free to rotate in a horizontal plane. A horizontal magnetic field $B = 6\times10^{-4}$ T exists in the space. The work done in talking the magnet slowly from a direction parallel to the field to a direction 60° from the field is

(a) 12 J (b) 6 J (c) 2 J (d) 0.6 J

Solution

(b) Work done is

$$U = \mu\cdot B$$

where μ is magnetic moment

$$U = 2\times10^{4}\times6\times10^{-4}\cos60^{\circ}$$
$$U = 6\,\text{J}.$$

35. If a diamagnetic substance is brought near the north or the south pole of a bar magnet, it is

(a) repelled by the north pole and attracted by the south pole

(b) attracted by the north pole and repelled by the south pole

(c) attracted by both the poles

(d) repelled by both the poles.

Solution

(d) The diamagnetic materials create a magnetic field which opposes the external magnetic field irrespective of nature of external magnetic pole.

Therefore, it is repelled in both cases.

36. A rectangular, a square, a circular and an elliptical loop, all in the (x-y) plane, are moving out of a uniform magnetic field with a constant velocity, $\vec{V} = v\hat{i}$. The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for

(a) the circular and the elliptical loops
(b) only the elliptical loop
(c) any of the four loops
(d) the rectangular, circular and elliptical loops.

Solution

(a) Since the rate of change of flux varies in circular and elliptical loop, the induced emf does not remain the same in them.

37. Power dissipated in an *LCR* series circuit connected to an A.C. source of emf ε is

(a) $\dfrac{\varepsilon^2\sqrt{R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2}}{R}$ (b) $\dfrac{\varepsilon^2\left[R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2\right]}{R}$

(c) $\left[\dfrac{\varepsilon^2 R}{R^2+\left(l\omega-\dfrac{1}{C\omega}\right)^2}\right]^{1/2}$ (d) $\dfrac{\varepsilon^2 R}{\sqrt{\left[R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2\right]}}$.

Solution

(c) The current in the circuit is

$$i=\frac{\varepsilon}{\left[R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2\right]^{\frac{1}{2}}}$$

$$\text{Power } P=\varepsilon i\cos\phi$$

$$=\frac{\varepsilon^2 R}{\left[R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2\right]}$$

$$\text{where}\cos\phi=\frac{R}{Z}=\frac{R}{\left[R^2+\left(L\omega-\dfrac{1}{C\omega}\right)^2\right]^{\frac{1}{2}}}$$

38. A conducting circular loop is placed in a uniform magnetic field 0.04 T with its plane perpendicular to the magnetic field. The radius of the loop starts shrinking at 2 mm/s. The induced emf in the loop when the radius is 2 cm is

(a) $4.8\,\pi\mu$ V (b) $0.8\,\pi\mu$ V (c) $1.6\,\pi\mu$ V (d) $3.2\,\pi\mu$ V

Solution

(d) Area of the circle is given by

$$a=\pi r^2$$

The rate of change of area is

$$\frac{da}{at}=2\pi r\cdot\frac{dr}{dt}$$

The emf induced is

$$\text{emf}=\frac{d\phi}{dt}=B\cdot\frac{da}{dt}$$

$$=0.04\times2\pi\times2\times10^{-2}\times2\times10^{-3}$$

$$\text{emf}=3.2\pi\mu\,\text{V}$$

39. The electric field part of an electromagnetic wave in a medium is represented by $E_x=0$; $E_y=2.5\dfrac{N}{C}\cos\left[\left(2\pi\times10^6\dfrac{\text{rad}}{\text{m}}\right)t-\left(2\pi\times10^{-2}\dfrac{\text{rad}}{\text{s}}\right)x\right]$; $E_z=0$.
The wave is

(a) Moving along *x*-direction with frequency 10^6 Hz and wavelength 100 m
(b) Moving along *x*-direction with frequency 10^6 Hz and wavelength 200 m
(c) Moving along –*x*-direction with frequency 10^6 Hz and wavelength 200 m
(d) Moving along *y*-direction with frequency $2\pi\times10^6$Hz and wavelength 200 m.

Solution

(a) The equation of electromagnetic wave moving in +ve *x* direction is

$$E_y=A\cos\left(\frac{2\pi}{\lambda}x-\omega t\right).$$

40. In the nuclear decay given below:
${}^{A}_{z}X\to{}^{A}_{z+1}Y\to{}^{A-4}_{z-1}B^*\to{}^{A-4}_{z-1}B$, the particles emitted in the sequence are

(a) γ,β,α (b) β,γ,α (c) α,β,γ (d) β,α,γ

Solution

(d) Since the first reaction increases the atomic no., it is *a* beta emission

$${}^{A}_{z}X\to{}^{A}_{z+1}X+\beta$$

Next reaction reduces the mass no. by 4 and atomic no. by 2 therefore, it is an alpha emission.

$${}^{A}_{z+1}X\to{}^{A-4}_{z-1}X+\alpha$$

Third reaction excites the nucleus,

$${}^{A-4}_{z-1}X^*\to{}^{A-4}_{z-1}X+\gamma$$

41. The number of photoelectrons emitted for light of a frequency ν (higher than the threshold frequency ν_0) is proportional to

(a) Threshold frequency (ν_0) (b) Intensity of light
(c) Frequency of light (ν) (d) $\nu-\nu_0$

Solution

(b) Intensity of light.

42. The number of beta particles emitted by a radioactive substance is twice the number of alpha particles emitted by it. The resulting daughter is an

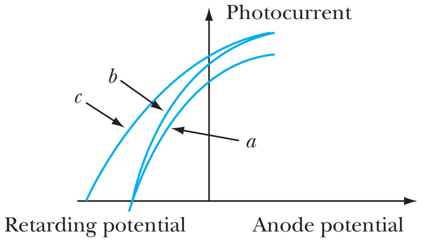
(a) isomer of parent
(b) isotone of parent
(c) isotope of parent
(d) isobar of parent.

Solution

(c) An alpha particle reduce the atomic no. by 2, and a beta particle increase the mass no. by 1. Therefore

An alpha particle emission and two beta particle emission results in same atomic no but different mass number, That is it is an isotope of parent.

43. The figure shows a plot of photo current versus anode potential for a photo-sensitive surface for three different radiations. Which one of the following is a correct statement?



(a) Curves (*a*) and (*b*) represent incident radiations of same frequency but of different intensities

(b) Curves (*b*) and (*c*) represent incident radiations of different frequencies and different intensities

(c) Curves (*b*) and (*c*) represent incident radiations of same frequency having same intensity

(d) Curves (*a*) and (*b*) represent incident radiations of different frequencies and different intensities.

Solution

(a) Since the stopping potential of both curves *a* and *b* are the same, they represents incident radiation of same frequency but different intensities.

44. In a Rutherford scattering experiment, when a projectile of charge z_1 and mass M_1 approaches a target nucleus of charge z_2 and mass M_2, the distance of closest approach is r_0. The energy of the projectile is

(a) Directly proportional to $z_1 z_2$

(b) Inversely proportional to z_1

(c) Directly proportional to mass M_1

(d) Directly proportional to $M_1 \times M_2$.

Solution

(a) The kinetic energy

$$\frac{1}{2}M_1 v^2 = \frac{1}{4\pi\varepsilon_0} \bullet \frac{z_1 z_2}{r_0}$$

Therefore,energy of projectile is directly proportional to $z_1 z_2$.

45. Monochromatic light of wavelength 667 nm is produced by a helium neon laser. The power emitted is 9 mW. The number of photons arriving per sec. on the average at a target irradiated by this beam is

(a) 3×10^{16} (b) 9×10^{15} (c) 3×10^{19} (d) 9×10^{17} .

Solution

(a) Energy of single photon

$$E = \frac{hc}{\lambda} = \frac{6.626068\times10^{-34}\times3\times10^{8}}{667\times10^{-9}} J$$

$$= 2.977\times10^{-19}\,\text{J}$$

The power

$$P = nE$$

Where *n* is the no of photons

$$9\times10^{-3} W = n\times2.977\times10^{-19}$$

or

$$n = 3.023\times10^{16}$$

46. The ionization energy of the electron in the hydrogen atom in its ground state is 13.6 eV. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

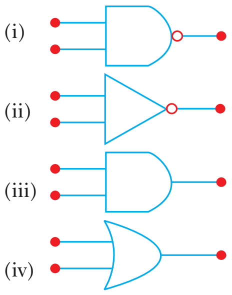
(a) $n=3$ to $n=1$ states (b) $n=2$ to $n=1$ states

(c) $n=4$ to $n=3$ states (d) $n=3$ to $n=2$ states .

Solution

(d) The atom can emit a maximum of 6 wavelengths if the principal quantum number is 3. The maximum wavelength is given by the less energetic transition i.e. $n=3$ to $n=2$ states

47. The symbolic representation of four logic gates are given below;



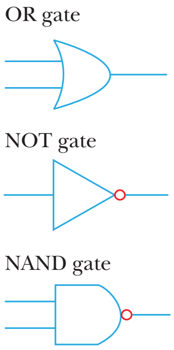
The logic symbols for OR, NOT and NAND gates are respectively

(a) (*iv*), (*i*), (*iii*) (b) (*iv*), (*ii*), (*i*)

(c) (*i*), (*iii*), (*iv*) (d) (*iii*), (*iv*), (*ii*) .

Solution

(b)



48. A *p-n* photodiode is fabricated from a semiconductor with a band gap of 2.5 eV. It can detect a signal of wavelength

(a) 4000 nm (b) 6000 nm

(c) 4000 Å (d) 6000 Å.

Solution

(c) The detection occurs only when the energy of incident photon is greater than or equal to the energy band gap.

$$\frac{hc}{\lambda} = 2.5\text{ eV}$$

Therefore,

$$\lambda = \frac{hc}{2.5\text{ eV}} = \frac{1240\text{ eV-nm}}{2.5\text{ eV}} = 496\text{ nm}$$

Therefore, the detector can detect 4000 Å.

49. A transistor is operated in common-emitter configuration at $V_C = 2\text{ V}$ such that a change in the base current from $100\ \mu\text{A}$ to $200\ \mu\text{A}$ produces a change in the collector current from 5 mA to 10 mA. The current gain is

(a) 100
(b) 150
(c) 50
(d) 75.

Solution

(c) Current gain

$$\beta = \frac{\Delta I_c}{\Delta I_B}$$

$$= \frac{(10-5)\times 10^{-3}\text{ A}}{(200-100)\times 10^{-6}\text{ A}} = 50.$$

50. Sodium has body centered packing. Distance between two nearest atoms is 3.7 Å. The lattice parameter is

(a) 4.3 Å
(b) 3.0 Å
(c) 8.6 Å
(d) 6.8 Å.

Solution

(c) The lattice parameter and radius of atom is related by

$$4r = \sqrt{3}\,a$$

where a is the lattice parameter and r the radius of atom.

$$a = \frac{4}{\sqrt{3}}r = 8.6\text{ Å}$$