Reliable INSTITUTE
Unleashing Potential

JEE(Advanced) 2022
Memory Based Paper

PAPER-1 & 2

Questions & Solutions

Date : 28 August, 2022

SUBJECT : PHYSICS

SECTION-I

1. In a particular system a of units, a physical quantity can be expressed in terms of the electric charge e, electron mass m_e, Planck's constant h, and coulombs constant $K = \frac{1}{4\pi\varepsilon_0}$, where ε_0 is permittivity of vacuum, In terms of these physical constants, the dimension of the magnetic field is $[B] \propto [e]^{\alpha} [m_e]^{\beta} [h]^{\gamma}[k]^{\delta}$. the value of $\alpha + \beta + \gamma + \delta$ is

Ans. **4**

Sol. $[B] = [e]^{\alpha} [M_e]^{\beta} [h]^{\gamma} [k]^{\delta}$

Dimension formula for magnetic field.

F = qvB

$$\frac{[MLT^{-2}]}{[C][LT^{-1}]} = B = [MT^{-1}C^{-1}]$$

Dimension of electron charge $[e]^{\alpha} = [c]^{\alpha}$

Dimension of mass of electron $[m_e] = [M]^{\beta}$

Dimension of Planck's constant h [unit is Js]

$[h] = [ML^2T^{-2}][T] = [ML^2T^{-1}]^r$

Dimension K' coulombs constant

$F = \frac{kQ^2}{r^2}$ $\quad\quad$ $K = \frac{[MLT^{-2}][L^2]}{[C]^2}$

$K = [ML^3T^{-2}C^{-2}]^{\delta}$

For dimensional constancy.

$[MT^{-2}C^{-1}] = [C]^{\alpha}[M]^{\beta}\ ML^2T^{-1}]^{r}\ [ML^3T^{-2}C^{-2}]^{\delta}$

$[M]^1[L]^0[T]^{-1}\ [C]^{-1} = [C]^{\alpha-2\delta}\ [M]^{\beta+\gamma+\delta}\ [L]^{2r+3\delta}[T]^{-r-2\delta}$

$2\gamma + 3\delta = 0$ ….(1)

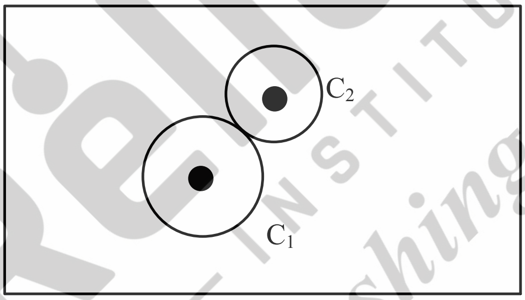
$-\gamma - 2\delta = -1$ ….(2)

$\beta + \gamma + \delta = 0$ ….(3)

$\alpha - 2\delta = -1$ ….(4)

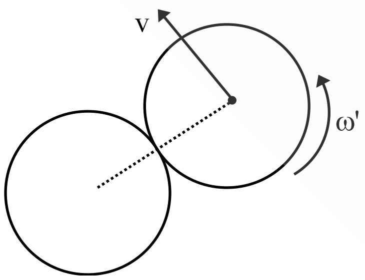
$\alpha + \beta + \gamma + \delta = 4$

2. Disc C_1 of radius R is fixed on horizontal table by its flat surface and another disc C_2 of radius R does pure rolling on C_1. Angular momentum of C_2 wrt to centre of C_1 is $nm\omega^2R$. Find n = ?



Ans. 5

Sol. Assuming angular velocity about centre as ω'



$\frac{v}{2R} = \omega$

and $\omega' = v/R$

so $\omega' = 2\omega$

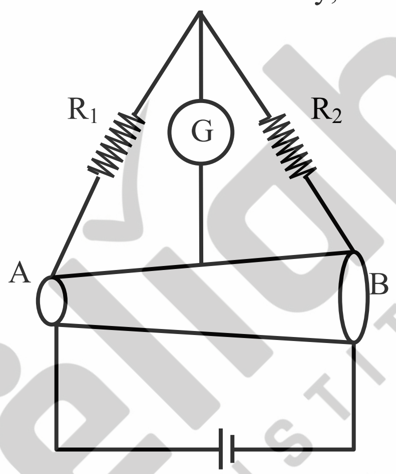
hence, $\vec{L} = \vec{L}_{CM} + m(\vec{r} \times \vec{v})$

$|L| = \frac{mR^2}{2}\omega' + mR(\omega' R)$

$= \frac{mR^2}{2} \times 2\omega + M \times 2R(2\omega)R = 5\ MR^2\omega$

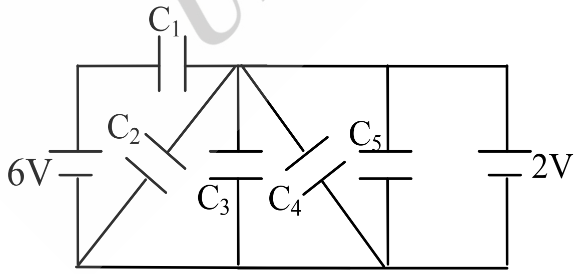
n = 5

3. Two resistances $R_1 = x\Omega$ and $R_2 = 1\Omega$ are connected to a wire AB of uniform resistivity as shown in the figure. The radius of the wire varies linearly along its axis from 0.2 mm at A to 1 mm at B. A galvanometer (G) connected to the center of the wire, 50 cm from each end along its axis shows zero deflection when A and B are connected to a battery, the value of X is _______

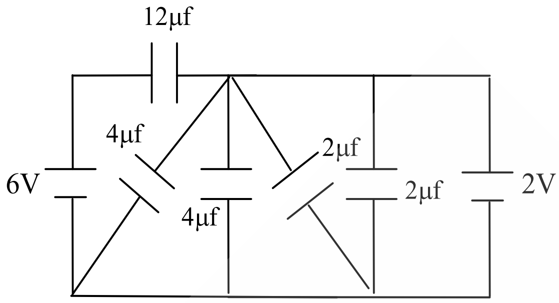


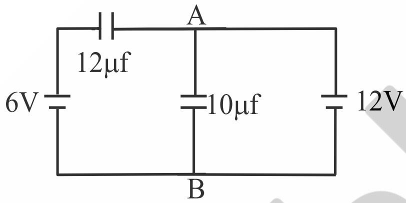
Ans. 5

4. In the following circuit $C_1 = 12\mu f$, $C_2 = C_3 = 4\mu f$ and $C_4 = C_5 = 2\mu f$ the charge scored in C_3 is _______μC.



Sol.





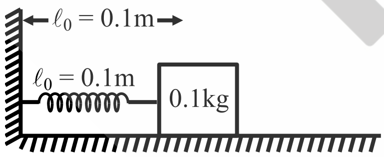
$V_A - V_B = 2V$

Charge on $C_3 = 2 \times 4 = 8\mu C$

5. On a frictionless horizontal plane, a bob of mass m = 0.1 kg is attached to a spring with natural length $\ell_0 = 0.1$ m. The spring constant is $k_1 = 0.009\ Nm^{-1}$ when the length of the spring $\ell > \ell_0$ and is $k_2 = 0.016\ Nm^{-1}$ when $\ell < \ell_0$. Initially the bob is released from $\ell = 0.15$ m. Assume that Hooke's law remain valid throughout the motion. If the time period of the full oscillation is $T = (n\pi)$s, then the integer closest to n is …….

Ans. 6

Sol.



if $\ell > \ell_0$

$K_1 = 0.009$ N/m

$$T_1 = \pi\sqrt{\frac{m}{K_1}}$$

if $\ell < \ell_0$

$k_2 = 0.016$ N/m

$$T_2 = \pi\sqrt{\frac{m}{K_2}}$$

Total time period $T = T_1 + T_2$

$$T = \pi\sqrt{m}\left[\frac{1}{\sqrt{0.009}}+\frac{1}{\sqrt{0.16}}\right]$$

$$T = \frac{35\pi}{6}\sec = n\pi\sec$$

$$n = \frac{35}{6} \approx 6$$

6. A particle of mass 1 kg is subjected to a force which depends on the position as $\vec{F} = -k(x\hat{i}+y\hat{j})$ kg ms^{-2} with $k = 1\text{kgs}^{-2}$. At time t = 0, the particle position $\vec{r} = \left(\frac{1}{\sqrt{2}}\hat{i}+\sqrt{2}\hat{j}\right)$ m and its velocity $\vec{v} = \left(-\sqrt{2}\hat{i}+\sqrt{2}\hat{j}+\frac{2}{\pi}\hat{k}\right)$ ms^{-1}. Let v_x and v_y denote the x and the y components of the particles velocity respectively. Ignore gravity. When z = 0.5 m, the value of $(xv_y - yv_x)$ is ….. m^{2}s^{-1}.

Ans. 3

Sol. in $A_2 = 0 \quad V_2 = \frac{2}{\pi} = \text{const}^n$

$S_2 = V_2 t$

$0.5 = \frac{2}{\pi}t \Rightarrow \boxed{t = \frac{\pi}{4}\sec}$

Now $\vec{F} = -x\hat{i} - y\hat{j} = m(a_x\hat{i} + a_y\hat{j})$

In x-dir^n

$a_x = -x$ [Motion is SHM]

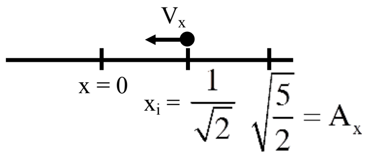
$$V\times\frac{dV_x}{dx} = -x \quad \int_{-\sqrt{2}}^{V_x} V_x dV_x = -\int_{1/\sqrt{2}}^{x} x\,dx$$

$$V_x^2 - 2 = -x^2 + \frac{1}{2}$$

$$V_x = \sqrt{\frac{5}{2} - x^2}$$

$\omega = 1$ and $A_x = \sqrt{\frac{5}{2}}$

at t = 0



eq^n of SHM

$$x = \sqrt{\frac{5}{2}}\sin(t+\phi)$$

at t = 0 $\quad x = \frac{1}{\sqrt{2}}$ then $\sin\phi = \frac{1}{\sqrt{5}}$

$\cos\phi = -\frac{2}{\sqrt{5}}$

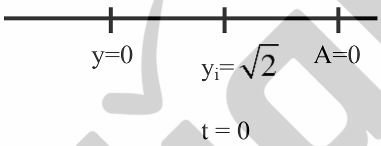
at $t = \frac{\pi}{4} \quad x = \sqrt{\frac{5}{2}}\sin\left[\frac{\pi}{4}+\phi\right]$

$x = -\frac{1}{2}$ and $V_x = -\frac{3}{2}\text{m/s}$

In y–dir^n $\quad -y = V_y\frac{dV_y}{dy}$

$$\int_{\sqrt{2}}^{V_y} V_y dV_y = -\int_{\sqrt{2}}^{y} g\,d_y$$

$V_y = \sqrt{4-y^2}$



$A_y = 2$ & $\omega = 1$

$y = 2\sin\omega = 1$

at t = 0 $\quad y = \sqrt{2} \quad \phi = \frac{\pi}{4}$

$y = 2\sin\left(t+\frac{\pi}{4}\right)$

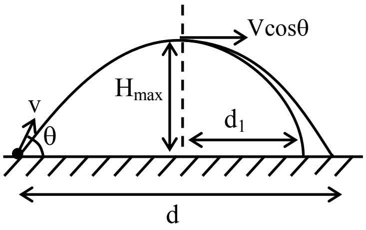
at $t = \frac{\pi}{4} \quad y = 2 \quad V_y = \sqrt{y^2 - y^2} = 0$

$[xV_y - y\,V_x] = 3$ Ans.

7. A projectile is thrown with velocity V at inclination of θ from horizontal and its range is d in presence of gravity g. Same projectile is now thrown at same angle θ and same velocity V but after covering half of the range (d/2), g' is acting. And now the total range of particle becomes d'. If g' = $\frac{g}{(0.81)}$ then d' = nd, find n?

Ans. 0.95

Sol. $d = \frac{2v_x v_y}{g}$



$H_{max} = \frac{v_y^2}{2g}, d_1 = v_x\sqrt{\frac{2H_{max}}{g'}}$

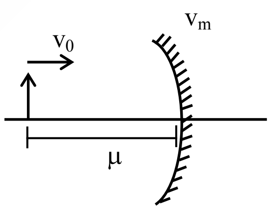
$d_1 = v_x\sqrt{\frac{2v_y^2 \times 0.81}{2g.g}}$

$d_1 = \frac{v_y.v_x}{g} \times 0.9 = \frac{0.9d}{2}$

$d_{Total} = \frac{d}{2} + \frac{9d}{20} = \frac{19d}{20}$

$n = \frac{19}{20} = \boxed{0.95}$

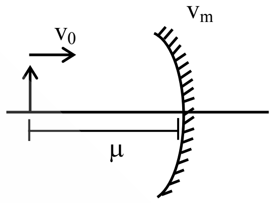
8. An object and a concave mirror of focal length f = 10 cm both move along the principal axis of the mirror with constant speed. The object move with speed $v_o = 15$ cm s^{-1} towards the mirror with respect to a laboratory frame. The distance between the object and the mirror at a given moment is denoted by μ when μ = 30 cm the speed of the mirror v_m is such that the image is instantaneously at rest with respect to the laboratory frame and the object forms a real image. The magnitude of v_m is_______cm s^{-1}



Ans. 3

Sol. u = –30 cm f = –10cm

$$m = \frac{f}{f-4}$$



$$m = \frac{-10}{-10-(-30)} = \frac{-10}{30-10}$$

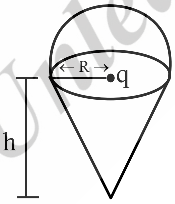
$$m = -\frac{1}{2}$$

$$\vec{V}_I = -m^2\vec{V}_0 + (m^2+1)\vec{V}_m$$

$$0 = \left(-\frac{1}{2}\right)^2 \times 15 + \left(\left(-\frac{1}{2}\right)^2 + 1\right) \times V_m$$

$$\frac{5}{4}V_m = \frac{15}{4} \quad \Rightarrow \quad V_m = 3 \text{ cm/s}$$

9. A charge q is surrounded by a closed surface consisting of an inverted cone of height h and base radius R and a hemisphere of radius R as shown in the figure the electric flux through the conical surface is $\frac{nq}{6\varepsilon_0}$ (in SI units) the value of n is __________



Ans. 3

Sol. $\frac{q}{2\varepsilon_0} = \frac{nq}{6\varepsilon_0}$

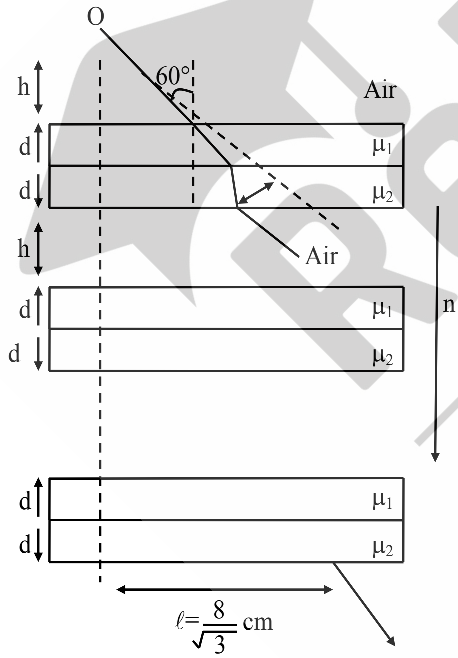
n = 3

10. Consider a configuration of n identical units, each consisting of three layers. The first layer is a column of air of height $h = \frac{1}{3}$cm and the second & third layers are of equal thickness $d = \frac{\sqrt{3}-1}{2}$cm, and refractive indices $\mu = \sqrt{\frac{3}{2}}$and $\mu_2 = \sqrt{3}$ respectively. A light source O is placed on the top of the first unit, as shown in the figure. A ray of light from O is incident on the second layer of the first unit at an angle of Q = 60º to the normal, for a specific value of n, the ray of light emerges from the bottom of the configuration at a stance $\ell = \frac{8}{\sqrt{3}}$cm as shown in the figure, the value of n is

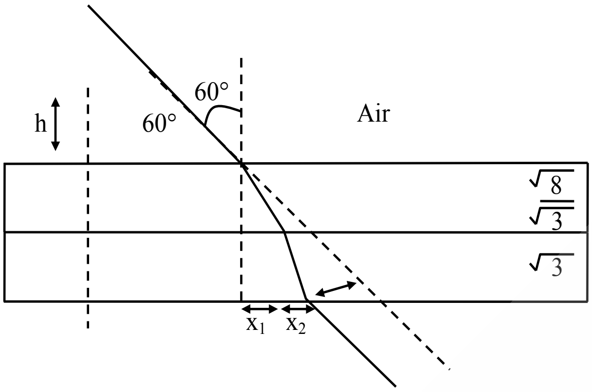
____

Ans. 4

Sol.



$$\Delta = d\frac{\sin(i-r_1)}{\cos r_1} + d\frac{\sin(i-r_2)}{\cos r_2}$$



$\sin 60 = \frac{\sqrt{3}}{\sqrt{2}} \sin r_1$

$r_1 = 45°$

& $\sin 60 = \sqrt{3} \sin r_2$

$\frac{\sqrt{3}}{2} = \sqrt{3} \sin r_2$

$r_2 = 30°$

Now,

Due to 1^{st} slab (arrangement)

Δ : h tan60° + d tan45° + d tan 30°

$= \frac{1}{3} \times \sqrt{3} + \left(\frac{\sqrt{3}-1}{2}\right)\left(1+\frac{1}{\sqrt{3}}\right)$

$= \frac{1}{\sqrt{3}} + \left(\frac{(\sqrt{3}-1)(\sqrt{3}+1)}{2\sqrt{3}}\right)$

$= \sqrt{\frac{1}{3}} + \frac{2}{2\sqrt{3}} = \frac{2}{\sqrt{3}}$

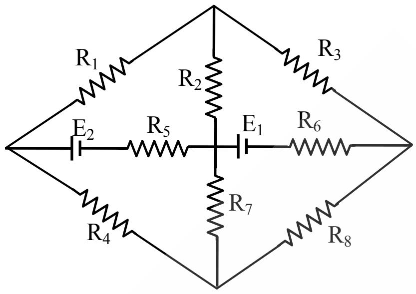
So,

$\ell = n\Delta$

So, $= \sqrt{\frac{8}{3}} = n\left(\frac{2}{\sqrt{3}}\right)$

$\therefore n = 4$

11. All resistance are 1Ω. Find current in each resistance :-



Ans.

12. Lc circuit with L = 0.1 H and C = 10^{-3}F, Area of the circuit = $1m^2$

magnetic field is charging as $B = B_0 + Bt$

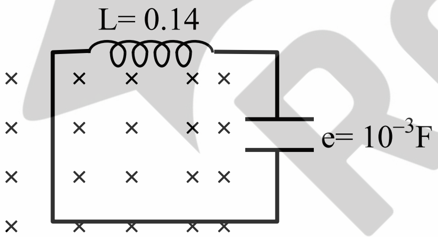
where B = 0.4 T/sec

Find max current through circuit

At t = 0, I = 0

Ans. 0.04

Sol.



$\phi = BA = (B_0 + Bt)$ (1)

$t = \dfrac{dB}{dt} = 0.4$

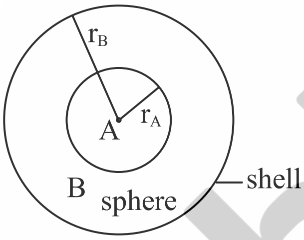
For $I = I_{max} \Rightarrow \dfrac{dI}{dt} = 0, \dfrac{Ldi}{dt} = 0$

$w_b = BV_C + BV_L$

(C) $E = \dfrac{1}{2}Li^2 + \dfrac{1}{2}CE^2 \Rightarrow I = \sqrt{\dfrac{C}{L}}(E) = 0.04A$

Reliable INSTITUTE Unleashing Potential

13. In the figure, the inner (shaded) region A represents a sphere of radius $r_A = 1$, within which the electrostatics charge density varies with radial distance r from the centre as $\rho_A = kr$. Where k is positive. In the spherical shell B of outer radius rB. The electrostatics charge density varies as $\rho_B = \frac{2k}{r}$



(A) $r_B = \frac{3}{2}$, V just outside B is $\frac{k}{\varepsilon_0}$

(B) If $r_B = \sqrt{3/2}$ then Electric field is zero every where outside B

(C) If $r_B = 2$, then total charge of configuration if 15 πk

(D) If $r_B = \frac{5}{2}$ then the magnitude of electric field just outside B is $\frac{13\pi k}{\varepsilon_0}$

Sol. $Q = \int_0^1 kx4\pi x^2 dx + Q = \int_0^{r_B} \frac{2k}{x} 4\pi x^2 dx$

$4\pi k\left[\frac{1}{4}\right] + \frac{8\pi k}{2}\left[r_B^2 - 1\right]$

$Q = 4\pi k\left[\frac{1}{4} + r_B^2 - 4\right]$

(A) $r_B = \frac{3}{2}, Q = 4\pi k\left[\frac{1}{4} + \frac{9}{4} - 1\right] = 4\pi k\left[\frac{6}{4}\right] = 6\pi k \quad V = \frac{k}{3/2}(6\pi k) = \frac{k}{3}\left(6\pi \cdot \frac{1}{4}\right) = \frac{k}{60}$

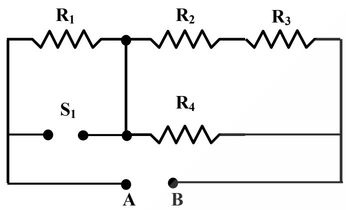
(B) $r_B = \sqrt{\frac{3}{2}}, Q = 4\pi k\left[\frac{1}{4} + \frac{3}{2} - 1\right] = 4\pi k\left[\frac{1+6-4}{4}\right] = 3\pi k \;\; E \neq 0$

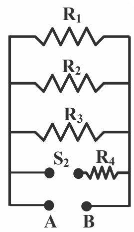
(C) $Q = 4\pi k\left[\frac{1}{4} + 4 - 1\right] = 4\pi k\left[\frac{1+12}{4}\right] = 13\pi k$

(D) $Q = 4\pi k\left[\frac{1}{4} + \frac{25}{4} - 1\right] = 4\pi k\left[\frac{26-4}{4}\right] = 22\pi k \qquad E = \frac{KQ}{r_B^2} = \frac{KQ}{25/4} = \frac{1}{4/100} \times 4 = \frac{22K}{2500}$

14. $R_1 = 1\,\Omega$, $R_2 = 2\,\Omega$, $R_3 = 3\,\Omega$, $R_4 = \frac{1}{2}\,\Omega$

Circuit–1 **Circuit–2**





Let P & Q be the power dissipated when (s_1, s_2) open & (s_1, s_2) close respectively.

(A) If $V_{AB} = 6$ Volt then $P_1 < P_2$

(B) If I = 2 Ampere then $Q_2 > Q_1$

(C) If I = 2 Ampere then $Q_1 > Q_2$

(D) If $V_{AB} = 6$ Volt then $P_1 < Q_1$

15. In a radioactive decay chain reaction ${}^{230}_{90}\text{Th}$ nucleus decay into ${}^{214}_{84}\text{P}_0$ nucleus. The ratio of number of α to no. of β^- particles emitted in this process is?

Ans. 2

Sol. ${}^{230}_{90}\text{Th} \rightarrow {}^{214}_{84}\text{P}_0 + x.\ {}_{-}e^0 + y.\ {}^{4}_{2}\text{He}$

$90 = 84 - x + 2y$ ......(i)

$230 = 214 + xy$ .....(ii)

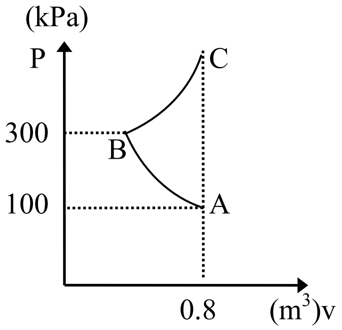
$xy = 16$, $\boxed{y = 4}$

$\boxed{x = 2}$

$\frac{y}{x} = 2$

Reliable INSTITUTE Unleashing Potential

16.



AB → adiabatic

BC → isothermal

$r = \frac{5}{3}$

options

$W_{AB} = ?$

$W_{CA} = ?$

$W_{ABC} = ?$

Sol. (i) $W_{AB} = \frac{P_iV_i - P_tV_t}{r-1} = \frac{100\times0.8\times10^3 - 300\times0.4\times10^3}{\frac{2}{3}} = \frac{10^5(0.4)\times3}{2} = 6\times10^4$

$\Rightarrow W_{AB} = -60$ kJ

$100(0.8)^{5/3} = 300\ V^{5/3}$

$\left(\frac{1}{3}\right)^{3/5}(0.8) = V$

$V = 0.4$

$W_{CA} = 0$

(iii) $w = nRT\ell n\frac{0.8}{0.4}$

$nRT\ell n2$

$= 300\times10^3\times0.4\ \ell n2$

$= 120\ell n2$

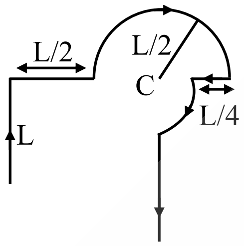
W_{ABC}

$= 120\ell n2 - 60$

$= 120\times0.693 - 60$

$= 23.16$ kJ

17. Find magnetic field at center 'C'.



(A) $\frac{\mu_0 I}{4}\left[\frac{1}{4\sqrt{2}\pi}+1\right]$ (B) $\frac{\mu_0 I}{4}\left[\frac{1}{4\sqrt{2}\pi}+\frac{3}{2}\right]$ (C) $\frac{\mu_0 I}{4}\left[\frac{1}{4\sqrt{2}\pi}+2\right]$ (D) $\frac{\mu_0 I}{4}\left[\frac{1}{4\sqrt{2}\pi}+\frac{1}{2}\right]$

Ans. (A)

Sol. $\vec{B}=\frac{\mu_0 I}{4\pi L}\left(\frac{1}{\sqrt{2}}\right)+\frac{\mu_0 I}{4\times L/2}+\frac{\mu_0 I}{8\times L/4}$

$\vec{B}=\frac{\mu_0 I}{L}\left(\frac{1}{4\pi\sqrt{2}}+1\right)$

18. α-particle bombards N at rest and following reaction occurs.

${}_7N^{16} + {}_2\alpha^4 \rightarrow {}_8O^{19} + {}_0n^1$

Find minimum kinetic energy of α-particle of reaction to occur.

M_N = 16.006 amu, M_α = 4.003 amu, M_O = 19.003 amu

M_n = 1.008 amu and 1 amu = 930 Mev/c^2

Ans. 2.35

Sol. Q value = $[M_O + M_n - (M_N + M_\alpha)] \times 930$ Mev

= [(19.003 + 1.008) – (16.006 + 4.003)] × 930 Mev

= 1.86 Mev

By momentum and energy conservation

Minimum KE of α = $\left[1+\frac{m}{M}\right]Q$

$KE_{min} = \left[1+\frac{4}{16}\right]\times 1.86$

= 2.35 Mev