

JEE Main 2021 September 1 Shift 2 Physics

1. Temperature of three moles of monoatomic gas is increased by 400 K under isobaric condition. If the ratio of work done by gas and increase in internal energy is given as $\frac{10}{x}$. Find x .

- (A) 25
- (B) 5
- (C) 15
- (D) 30

Correct option: (C)

$$\text{Solution: } \frac{W}{\Delta U} = \frac{nR\Delta T}{\frac{3}{2}nR\Delta T} = \frac{2}{3} = \frac{10}{15}$$

So $x = 15$

2. The speed of the ball after being released from height 'h' is $0.8\sqrt{gh}$. Calculate the work done by the resistance of air. Use $g = 10 \text{ m/s}^2$. Assume mass of the ball be m .

- (A) $-6.8 mh$
- (B) $8.6 mh$
- (C) $-8.6 mh$
- (D) $6.8 mh$

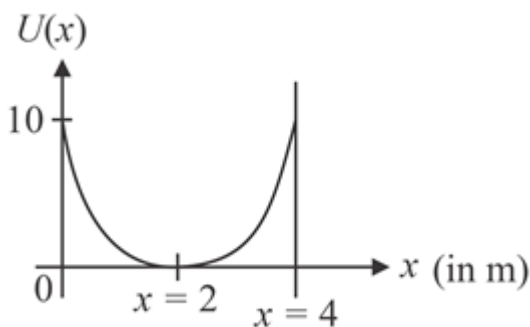
Correct option: (A)

Solution: Using Work energy theorem:

$$W_f + W_g = \frac{1}{2}m^2 - 0$$

$$W_f = -mgh + \frac{1}{2}m(0.8)^2 gh = -mgh + 0.32 mgh = -mgh(0.68) = -6.8 mh$$

3. Potential energy versus displacement graph of a block of mass 5 kg oscillating on a planet is as shown below. The time period of oscillation of given block is same as time period of simple pendulum of length 4 m on this planet. Calculate the value of gravitational field at the surface of planet.



- (A) 4
- (B) 6
- (C) 8
- (D) 10

Correct option: (A)

Solution:

From the figure, amplitude of oscillation of block is $A = 2 \text{ m}$

Potential energy of the block is $\frac{1}{2}m\omega^2 A^2 = 10$

$$\frac{1}{2}m\omega^2(2)^2 = 10$$

$$m\omega^2 = 5$$

$$5(\omega^2) = 5$$

$$\omega^2 = 1$$

$$\omega = 1$$

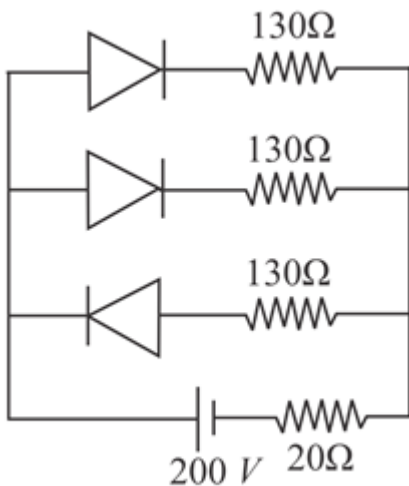
Time period of oscillation of block, $T = \frac{2\pi}{\omega} = 2\pi$

Time period of simple pendulum, $2\pi \sqrt{\frac{l}{g_p}} = 2\pi$

$$2\pi \sqrt{\frac{4}{g_p}} = 2\pi$$

$$g_p = 4 \text{ m/s}^2$$

4. In the circuit given below, find the current through cell, when the diodes offer forward bias resistance of 30Ω and reverse bias resistance of infinite.



(A) 1A

(B) 5A

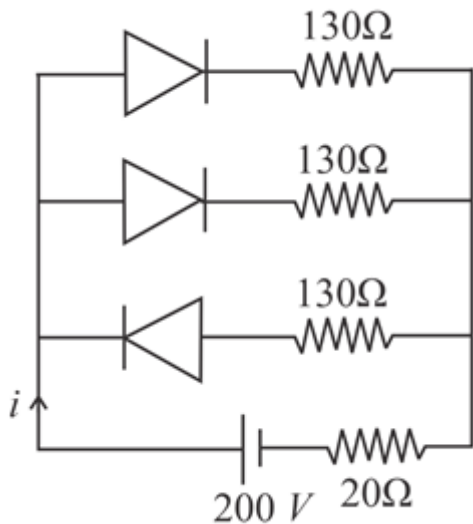
(C) 3A

(D) 2A

Correct option: (D)

Solution:

Third diode from the top is in reverse bias and other two are in forward bias. As the resistance offered by diode in reverse bias is infinite, current through lower branch will be zero. Hence, we have two parallel branches of effective resistance 160Ω and together they are in series with 20Ω and cell.



Effective resistance is given as $R_{eq} = \frac{160}{2} + 20$

$$R_{eq} = 80 + 20 \Rightarrow R_{eq} = 100 \Rightarrow i = \frac{200}{100} = 2A$$

5. Determine the correct relation between the range of projectile R_1, R_2 and maximum height of projectile H_1 and H_2 . Angle of projection of first and second projectile is 42° and 48° respectively. Assume the speed of projection is same for both projectiles.

- (A) $R_1 = R_2, H_1 < H_2$
- (B) $R_1 = R_2, H_1 = H_2$
- (C) $R_1 > R_2, H_1 = H_2$
- (D) $R_1 < R_2, H_1 < H_2$

Correct option: (A)

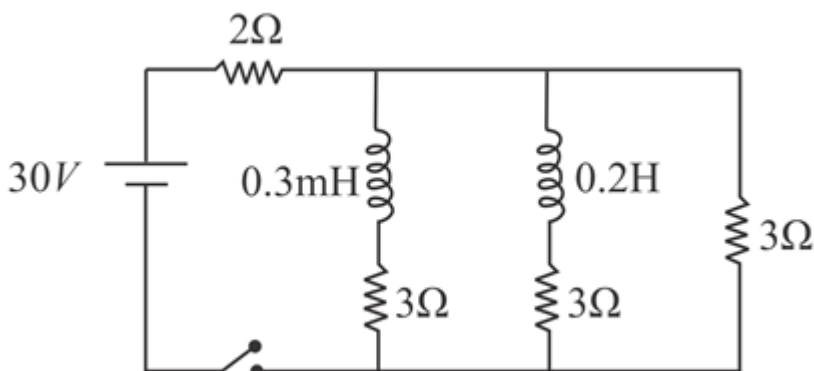
Solution: $42^\circ + 48^\circ = 90^\circ$

As the sum of angle of projection of both projectile is 90° , range of projectiles will be same. $R_1 = R_2$

$$\theta_1 < \theta_2$$

So $H_1 > H_2$

6. Calculate the steady state current through the cell in the circuit given below.



- (A) 8A
- (B) 20A
- (C) 15A
- (D) 10A

Correct option: (D)

Solution: At steady state, current in the circuit becomes constant. As current is not changing, induced emf in the inductors will be zero. Hence, they will behave as short circuit.

We will have three parallel branches of $3\ \Omega$ whose equivalent is $1\ \Omega$. Now this is in series with $2\ \Omega$.

Hence, current through cell is given as $I = \frac{30}{3} = 10\ A$

7. In a radioactive process, two types of nuclei are produced, A and B. The mean life of B is equal to the half-life of A. Then which of the following option is correct?

- (A) Both will decay with same rate
- (B) B will decay faster than A
- (C) A will decay faster than B
- (D) Initial decay rate is same then both will decay with different rate

Correct option: (B)

$$\text{Ans. } \frac{0.693}{\lambda_A} = \frac{1}{\lambda_B}$$

$$\lambda_A = .693\lambda_B$$

$$\lambda_A < \lambda_B$$

Rate of decay is directly proportional to decay constant.

8. A capacitor is connected to a $20\ V$ battery and $10\ \Omega$ resistance. The potential difference across the capacitor rises from $0\ V$ to $2\ V$ in $10\ \mu s$. Find capacitance of capacitor (given $\ln\left(\frac{10}{9}\right) = 0.105$):

- (A) $9.5\ \mu F$
- (B) $12\ \mu F$
- (C) $14.5\ \mu F$
- (D) $15\ \mu F$

$$\text{Ans. } V = V(1 - e^{-t/RC})$$

$$2 = 20 \left(1 - e^{-\frac{10\ \mu s}{10C}}\right)$$

$$\frac{1}{10} = \left(1 - e^{-\frac{10 \times 10^{-6}}{10C}}\right)$$

$$e^{-\frac{10 \times 10^{-6}}{10C}} = \frac{9}{10}$$

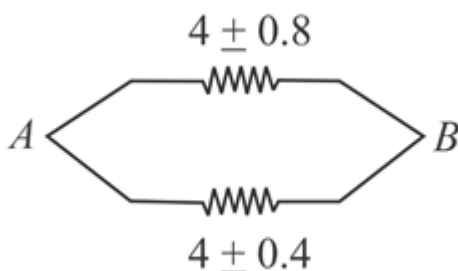
$$\frac{10 \times 10^{-6}}{10C} = \ln \frac{9}{10}$$

$$C = \frac{10 \times 10^{-6}}{10 \times \ln \frac{9}{10}} = \frac{10^{-6}}{1.05} = \frac{10}{1.05} \mu F = \frac{1000}{105} \mu F = 9.5 \mu F$$

9. Two resistances $R_1 = (4 \pm 0.8)\ \Omega$ and $R_2 = (4 \pm 0.4)\ \Omega$ are connected in parallel combination. Find equivalent resistance of circuit:

- (A) (4 ± 0.4)
- (B) (4 ± 0.3)
- (C) (2 ± 0.4)
- (D) (2 ± 0.3)

Ans. (D)



$$\frac{\Delta R}{R^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$$

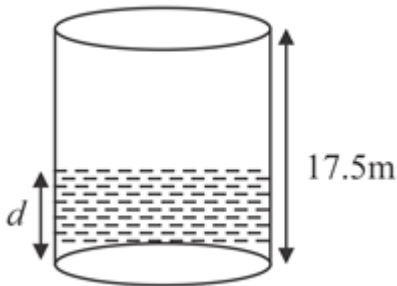
$$\Delta R = (R)^2 \left[\frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2} \right]$$

$$= (2)^2 \left[\frac{0.8}{4^2} + \frac{0.4}{4^2} \right]$$

$$= [0.2 + 0.1] = 0.3$$

$$R_{net} = R + \Delta R = 2 \pm 0.3$$

10. Find height of liquid in container when observer in air observes that height of liquid is half of actual height of cylinder.



- (A) 12 cm
- (B) 11.7 cm
- (C) 22.8 cm
- (D) None

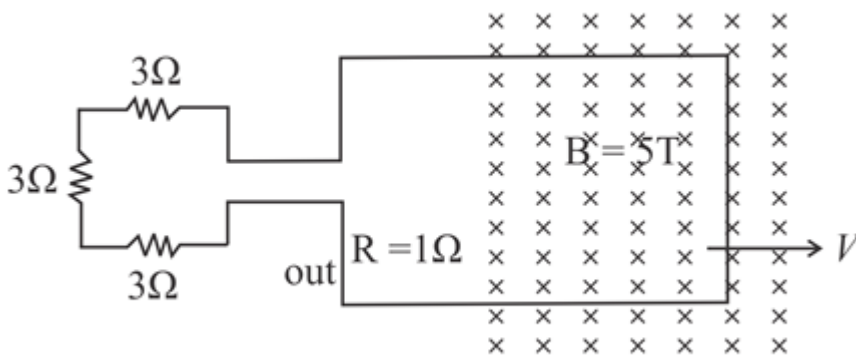
Ans. (B)

$$\frac{d}{\left(\frac{\mu}{i}\right)} = \frac{17.5}{2}$$

$$d = \frac{17.5}{2} \times \frac{4}{3} = 5.83 \times 2 = 11.7 \text{ cm}$$

EMBIBE

11. A square loop enters in uniform magnetic field $B = 5 \text{ T}$ as shown in figure, whose one side is out of magnetic field. Current flow in loop just after entering in magnetic field is 200 mA . Then find the velocity of loop at the time of entering in magnetic field (length of side of loop 20 cm and Resistance of square loop 1Ω)



- (A) 2 ms^{-1}
- (B) 4 ms^{-1}
- (C) 6 ms^{-1}
- (D) 7 ms^{-1}

Ans. (A)

$$\frac{BlV}{Req} = 200mA$$

$$V = \frac{200 mA \times Req}{Bl}$$

$$= \frac{200 \times 10^{-3} \times 10}{5 \times (2)} = 2 \text{ ms}^{-1}$$

12. An electron accelerated through a potential difference of 0.1 V from rest attains a kinetic energy (K.E.)e also there is a molecule of nitrogen gas having temperature 300 K and kinetic energy $(KE)_{N_2}$. Find $\frac{(KE)_e}{(KE)_{N_2}}$

- (A) 1.50
 (B) 2
 (C) 2.5
 (D) 1

Ans. $KE_{N_2} = \frac{f}{2}KT$

$$= \frac{5}{2}KT = \frac{5}{2} \times 1.38 \times 10^{-23} \times 300 = 1.035 \times 10^{-20} \text{ J}$$

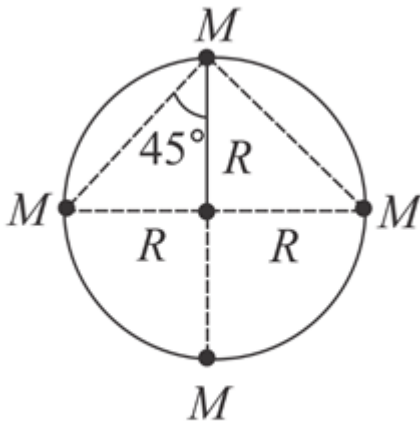
$$K.E_e = 1.6 \times 10^{-19} \times 0.1 \text{ J} = 1.6 \times 10^{-20}$$

$$\frac{KE_e}{KE_{N_2}} = \frac{1.6 \times 10^{-20}}{1.035 \times 10^{-20}} = 1.54$$

13. Four identical planets each of mass M are revolving in a circle of radius R due to mutual gravitational interaction. The speed of each planet will be?

- (A) $\sqrt{\frac{(4+\sqrt{2}) GM}{4\sqrt{2} R}}$
 (B) $\sqrt{\frac{(4-\sqrt{2}) GM}{4\sqrt{2} R}}$
 (C) $\sqrt{\frac{(4+\sqrt{2}) GM}{4 R}}$
 (D) $\sqrt{\frac{(1+\sqrt{2}) GM}{4\sqrt{2} R}}$

Ans.



$$F_{net} = F_1 + 2F_2 \cos 45^\circ$$

$$= \frac{GM^2}{(2R)^2} + 2 \times \frac{GM^2}{(\sqrt{2}R)^2} \times \frac{1}{\sqrt{2}} = \frac{GM^2}{4R^2} + \frac{GM^2}{\sqrt{2}R^2} = \frac{14+\sqrt{2}GM^2}{4\sqrt{2}R^2}$$

Now $F_C = F_{net}$

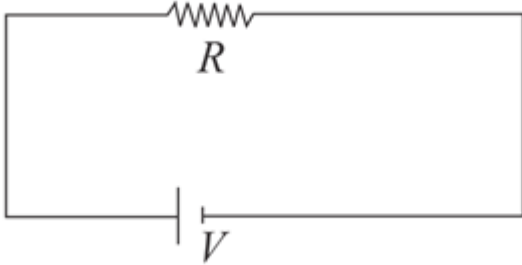
$$\frac{MV^2}{R} = \frac{14+\sqrt{2}GM^2}{4\sqrt{2}R^2}$$

$$V = \sqrt{\frac{(4+\sqrt{2}) GM}{4\sqrt{2} R}}$$

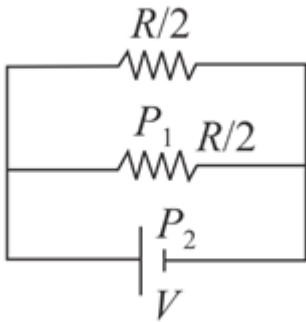
14. A wire of resistance 36Ω is connected across $220 V$ supply. It is divided into two pieces of equal resistance connected in parallel combination across same source. Ratio of final power output to initial power output is:

- (A) 8
- (B) 4
- (C) $1/4$
- (D) 2

Ans. (B)



$$P = V^2/R$$



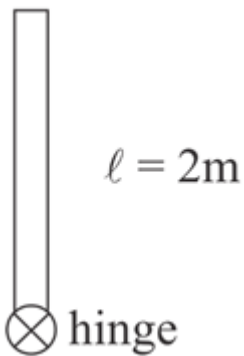
$$P_1 = \frac{V^2}{\frac{R}{2}}$$

$$P_2 = \frac{V^2}{\frac{R}{2}} \Rightarrow P_1 + P_2 = \frac{4V^2}{R}$$

$$\text{Now } \frac{P_1 + P_2}{P} = \frac{\frac{4V^2}{R}}{\frac{V^2}{R}} = 4$$

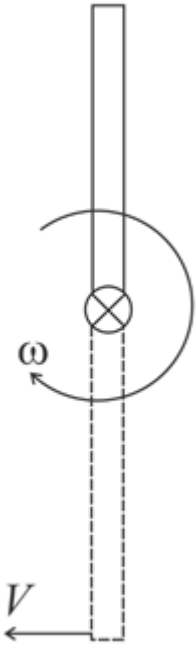
EMBIBE

15. A rod hinge from lower end and free to rotate in vertical plane about horizontal axis. It is released from rest from this position. Find Speed of free end when rod again become vertical:



- (A) $\sqrt{9g}$
- (B) $\sqrt{12g}$
- (C) $\sqrt{4g}$
- (D) $\sqrt{5g}$

Ans. (B)



$$mgl = \frac{1}{2} \frac{ml^2}{3} \omega^2$$

$$\omega = \sqrt{\frac{6g}{l}} = \sqrt{\frac{6g}{2}} = \sqrt{3g}$$

$$v = l\omega = \sqrt{12g}$$

16. In a YDSE, ratio of slit width is 1 : 9. If $\frac{I_{max}}{I_{min}} = \frac{x}{4}$ then find x ? (I is intensity)

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$$

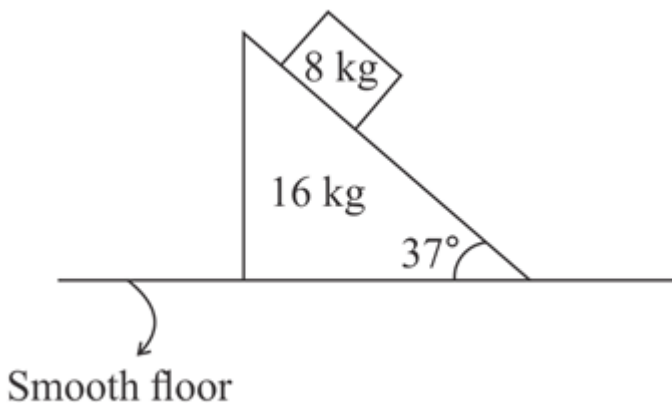
$$= \left[\frac{\sqrt{9I} + \sqrt{I}}{\sqrt{9I} - \sqrt{I}} \right]^2$$

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

$$= 4 = \frac{x}{4}$$

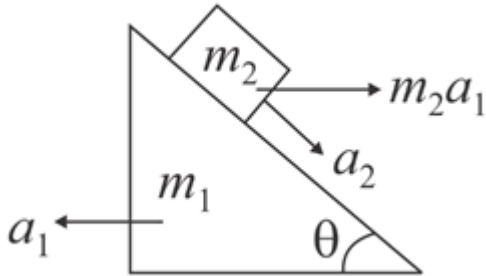
$$x = 16$$

17. A block of mass 8 kg is placed on an inclined wedge of mass 16 kg. The wedge is placed on smooth plane. What will be the acceleration of block w.r.t. wedge?



- (A) $\frac{450}{59} m/s^2$
- (B) $\frac{400}{49} m/s^2$
- (C) $\frac{120}{25} m/s^2$
- (D) $\frac{60}{25} m/s^2$

Ans. (A)



$$m_2 a_1 \cos \theta + m_2 g \sin \theta = m_2 a_2$$

$$8 a_1 \cos 37^\circ + 8 g \sin 37^\circ = 8 a_2$$

$$\frac{4}{5} a_1 + 10 \times \frac{3}{5} = a_2 \dots (i)$$

$$m_2 (a_2 \cos \theta - a_1) = m_1 a_1$$

$$8 (a_2 \cos 37^\circ - a_1) = 16 a_1$$

$$a_2 \times \frac{4}{5} = 3 a_1 \dots (ii)$$

From equation (i)

$$\frac{4}{5} a_1 + \frac{10 \times 3}{5} = \frac{15}{4} a_1$$

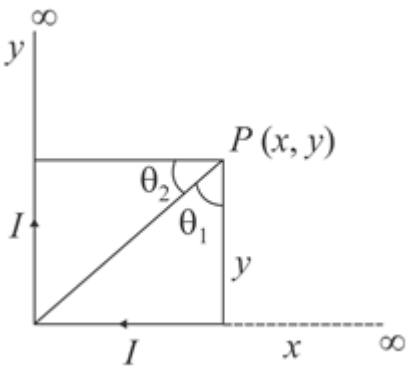
$$\left(\frac{15}{4} - \frac{4}{5} \right) a_1 = \frac{10 \times 3}{5}$$

$$\frac{75 - 16}{20} a_1 = \frac{10 \times 3}{5}$$

$$a_1 = \frac{10 \times 3 \times 4}{59} = \frac{120}{59} m/s^2$$

$$a_2 = \frac{15}{4} a_1 = \frac{450}{59} m/s^2$$

18. Find magnetic induction at P due to wire:



(A) $\frac{\mu_0 I}{4\pi} \left[\frac{x+y+\sqrt{x^2+y^2}}{xy} \right]$

(B) $\frac{\mu_0 I}{4\pi} \left[\frac{x-y-\sqrt{x^2+y^2}}{xy} \right]$

$$(C) \frac{\mu_0}{4\pi} \left[\frac{x-y-\sqrt{x^2+y^2}}{xy} \right]$$

$$(D) \frac{\mu_0}{2\pi} \left[\frac{x-y+\sqrt{x^2+y^2}}{xy} \right]$$

Ans. (A)

$$B = \frac{\mu_0 l}{4\pi y} (1 + \sin\theta_1) + \frac{\mu_0 l}{4\pi x} (1 + \sin\theta_2)$$

$$B = \frac{\mu_0 l}{4\pi y} \left(1 + \frac{x}{\sqrt{x^2+y^2}} \right) + \frac{\mu_0 l}{4\pi x} \left(1 + \frac{y}{\sqrt{x^2+y^2}} \right)$$

$$B = \frac{\mu_0 l}{4\pi x} + \frac{\mu_0 l}{4\pi y} + \frac{\mu_0}{4\pi} \left[\frac{x}{y\sqrt{x^2+y^2}} + \frac{y}{x\sqrt{x^2+y^2}} \right] = \frac{\mu_0 l}{4\pi} \left[\frac{1}{x} + \frac{1}{y} \right] + \frac{\mu_0}{4\pi} \frac{\sqrt{x^2+y^2}}{xy} = \frac{\mu_0 l}{4\pi} \left[\frac{x+y+\sqrt{x^2+y^2}}{xy} \right]$$

19. In an amplitude modulation, amplitude of carrier wave is 250 mV and amplitude of message signal is 150 mV. If

$$\frac{A_{max}}{A_{min}} = \frac{x}{50} \text{ then find } x:$$

Ans. 200

$$\frac{A_{max}}{A_{min}} = \frac{250+150}{250-150} = \frac{400}{100} = 4$$

$$\frac{x}{50} = 4$$

$$x = 200$$

20. Find percentage error of $y = \frac{g\alpha^3}{ad^3b}$ if the error in measurement of $g, \alpha, a, d,$ and b are 0.2, 0.03, 0.01, 0.04 and 0.25 respectively:

(A) 0.67%

(B) 1.72%

(C) 0.267

(D) 0.037%

Ans. (A)

$$y = \frac{g\alpha^3}{ad^3b}$$

$$\frac{dy}{y} = \frac{dg}{g} + 3 \frac{d\alpha}{\alpha} + \frac{da}{a} + 3 \frac{dd}{d} + \frac{db}{b}$$

$$= 0.2 + 3 \times 0.03 + 0.01 + 3 \times 0.04 + 0.25$$

$$= 0.2 + 0.09 + 0.01 + 0.12 + 0.25 = 0.67\%$$

21. Electromagnetic wave in a medium of $\mu_r = 1$ is given as $E = 20\sin(20 \times 10^{10} - 20 \times 10^2 x)$. Dielectric constant of medium is $1/x$, then find x :

Ans. 9

$$v = \frac{\omega}{x} = \frac{20 \times 10^{10}}{20 \times 10^2} = 10^8 \text{ ms}^{-1}$$

$$n = \frac{c}{v} = \frac{3 \times 10^8}{10^8} = 3 = \frac{1}{\sqrt{\mu_r \epsilon_r}} \text{ } (\mu_r = 1 \text{ given})$$

$$3 = \frac{1}{\sqrt{\epsilon_r}}$$

$$\epsilon_r = \frac{1}{9}$$

22. De-Broglie's wave length of an electron gas at 300 K is $x\text{\AA}$, then x is:

Ans. 62

$$k = 1.38 \times 10^{-23} \text{ J/K}$$

$$\text{Mass of electron} = 9 \times 10^{-31} \text{ kg}$$

$$\lambda_D = \frac{h}{\sqrt{2m_e^3 kT}}$$

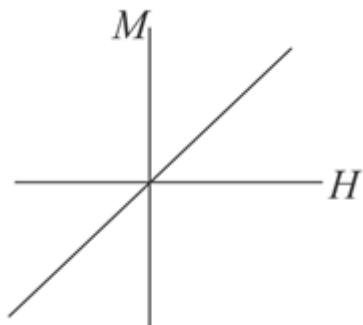
$$= \frac{h}{\sqrt{3mkT}}$$

$$= \frac{6.6 \times 10^{-34}}{\sqrt{3 \times 9 \times 10^{-31} \times 1.38 \times 10^{-23} \times 300}}$$

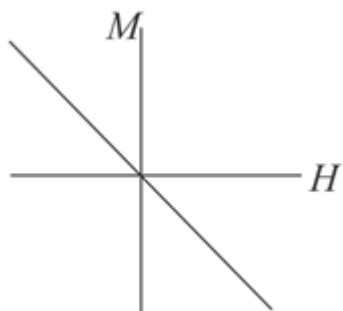
$$= \frac{6.6 \times 10^{-34}}{105.72 \times 10^{-27}} = 62 \text{ \AA}$$

Thus $x = 62$

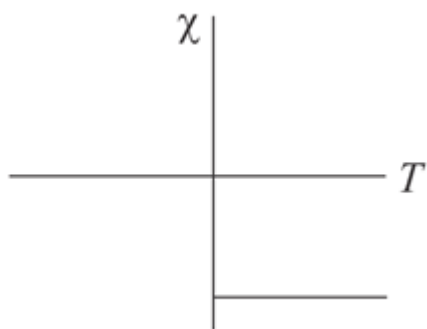
23. Which one is correct for diamagnetic material ? (Symbols have their usual meaning)



(A)



(B)



(C)



(D)

- (A) A and C
- (B) B and D
- (C) A and D
- (D) B and C

EMBIBE

Ans. (D)

24. An ice slab of cross-sectional area 1 cm^2 and length 1 m is being heated by a heater with resistance $R = 1 \text{ k}\Omega$ and current through it is 1 A . Find time in which ice slab melts down.

Given: $S_{ice} = 2400 \text{ J/KgK}$

Density of ice = 10^3 kg/m^3

Temperature of ice slab = -10°C

Latent heat of ice = $330 \times 10^3 \text{ J/kg}^{-1}$

(A) 30.4 sec

(B) 51.4 sec

(C) 35.4 sec

(D) 22.4 sec

Ans. (C)

$$i^2 R t = m S \Delta T + m L$$

$$\Rightarrow (1)^2 \times 10^3 \times t = (10^3 \times 1 \times 10^{-4}) \times 2400 \times 10 + (10^3 \times 1 \times 10^{-4}) \times 330 \times 10^3$$

$$\Rightarrow t = 24 \times 10^3 \times 10^{-4} + 33 \times 10^4 \times 10^{-4}$$

$$T = 2.4 + 33$$

$$T = 35.4 \text{ sec}$$

25. In space electric field is given by $\vec{E} = 150y^2 \hat{j} \text{ N/C}$. a cube of side 0.5 m is placed with one corner at origin along positive y -axis. Find charge enclosed inside cube:

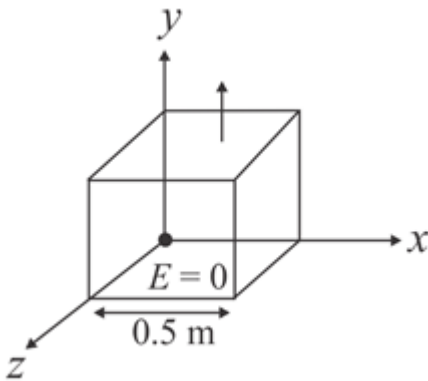
(A) $3.8 \times 10^{-11} \text{ C}$

(B) $16.6 \times 10^{-11} \text{ C}$

(C) $8.3 \times 10^{-10} \text{ C}$

(D) $8.3 \times 10^{-11} \text{ C}$

Ans. (D)



By gauss law $\oint \vec{E} \cdot d\vec{s} = \frac{q_{in}}{\epsilon_0}$

$$\epsilon_0 (150)(0.5)^2 \times (0.5)^2 = q_{in}; q_{in} = \frac{8.85 \times 10^{-12} \times 150}{16} = 8.3 \times 10^{-11} \text{ C}$$