Moving Charges and Magnetism JEE Main PYQ - 3

Total Time: 50 Minute **Total Marks:** 80

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Moving Charges and Magnetism

1. Two long straight wires P and Q carrying equal current $10\,A$ each were kept parallel to each other at $5\,cm$ distance Magnitude of magnetic force experienced by $10\,cm$ length of wire P is F_1 If distance between wires is halved and currents on them are doubled, force F_2 on $10\,cm$ length of wire P will be: **(+4, -1)**

   a. $10F_1$

   b. $8F_1$

   c. $\frac{F_1}{8}$

   d. $\frac{F_1}{10}$

---

2. The magnetic moments associated with two closely wound circular coils A and B of radius $r_A = 10\ cm$ and $r_B = 20cm$ respectively are equal if : (Where N_A, I_A and N_B, I_B are number of turn and current of A and B respectively) **(+4, -1)**

   a. $2N_AI_A = N_BI_B$

   b. $N_A = 2N_B$

   c. $N_AI_A = 4N_BI_B$

   d. $4N_AI_A = N_BI_B$

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3. A current i is flowing through the loop. The direction of the current and the shape of the loop are as shown in the figure.The magnetic field at the centre of the loop is, $\frac{0}{}$ times **(+4, -1)**

   [MA = R , MB = 2R, DMA = 90°]

   a. $\frac{5}{16}$, but out of the plane of the paper

   b. $\frac{5}{16}$, but into the plane of the paper

   c. $\frac{7}{16}$, but out of the plane of the paper

d. $\frac{7}{16}$, but into the plane of the paper

---

4. Two coaxial solenoids of different radii carry current I in the same direction. Let $\vec{F}_1$ be the magnetic force on the inner solenoid due to the outer one and $\vec{F}_2$ be the magnetic force on the outer solenoid due to the inner one. Then, (+4, -1)

a. $\vec{F}_1$ is radially outwards and $\vec{F}_2$ = 0

b. $\vec{F}_1$ is radially inwards and $\vec{F}_2$ is radially outwards

c. $\vec{F}_1$ is radially inwards and $\vec{F}_2$ = 0

d. $\vec{F}_1 = \vec{F}_2 = 0$

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5. To know the resistance G of a galvanometer by half deflection method, a battery of emf V_E and resistance R is used to deflect the galvanometer by angle θ. If a shunt of resistance S is needed to get half deflection then G, R and S are related by the equation : (+4, -1)

a. $2S(R+G) = RG$

b. $S(R+G) = RG$

c. $2S = G$

d. $2G = S$

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6. This question has Statement I and Statement II. Of the four choices given after the Statements, choose the one that best describes the two Statements. Higher the range, greater is the resistance of ammeter. To increase the range of ammeter, additional shunt needs to be used across it. (+4, -1)

a. Statement - I is true, Statement - II is true, Statement - II is the correct explanation of Statement-I

b. Statement - I is true, Statement - II is true, Statement - II is not the correct explanation of Statement-I

c. Statement - I is true, Statement - II is false

d. Statement - I is false, Statement - II is true

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7. The magnetic moment of an octahedral homoleptic Mn(II) complex is $5.9\,BM$. The suitable ligand for this complex is : **(+4, -1)**

a. CN^-

b. NCS^-

c. CO

d. ethylenediamine

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8. When a current of $5\,mA$ is passed through a galvanometer having a coil of resistance $15\,\Omega$, it shows full scale deflection. The value of the resistance to be put in series with the galvanometer to convert it into a voltmeter of range $0-10\,V$ is : **(+4, -1)**

a. $1.985\times10^3\,\Omega$

b. $2.045\times10^3\,\Omega$

c. $2.535\times10^3\,\Omega$

d. $4.005\times10^3\,\Omega$

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9. Two wires A & B are carrying currents I_1 & I_2 as shown in the figure. The separation between them is d. A third wire C carrying a current I is to be kept parallel to them at a distance x from A such that the net force acting on it is zero. The possible values of x are : **(+4, -1)**

a. $x=\left(\frac{I_1}{I_1-I_2}\right)d$ and $x=\frac{I_2}{(I_1+I_2)}d$

b. $x=\pm\frac{I_1 d}{(I_1+I_2)}$

c. $x=\left(\frac{I_1}{I_1+I_2}\right)d$ and $x=\frac{I_2}{(I_1-I_2)}d$

d. $x=\left(\frac{I_1}{I_1+I_2}\right)d$ and $x=(\frac{I_2}{I_1+I_2})d$

10. In a circuit for finding the resistance of a galvanometer by half deflection method, a $6\,V$ battery and a high resistance of $11\,k\,\Omega$ are used. The figure of merit of the galvanometer is $60\,muA$ division. In the absence of shunt resistance, the galvanometer produces a deflection of $\theta = 9$ divisions when current flows in the circuit. The value of the shunt resistance that can cause the deflection of $\theta/2$, is closest to : **(+4, -1)**

a. $550\,\Omega$

b. $220\,\Omega$

c. $55\,\Omega$

d. $110\,\Omega$

11. Find the magnetic field at point P due to a straight line segment AB of length $6\,cm$ carrying a current of $5\,A$. (See figure) $(\mu_0 = 4\pi \times 10^{-7}\,N - A^{-2})$ **(+4, -1)**

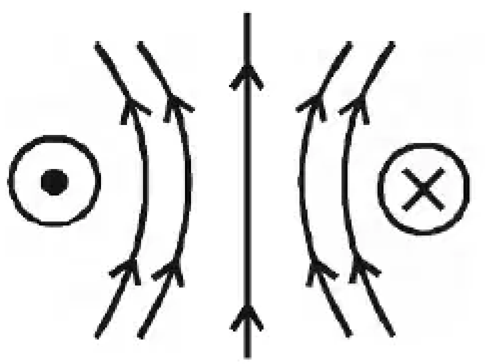
a. $3.0 \times 10^{-5}T$

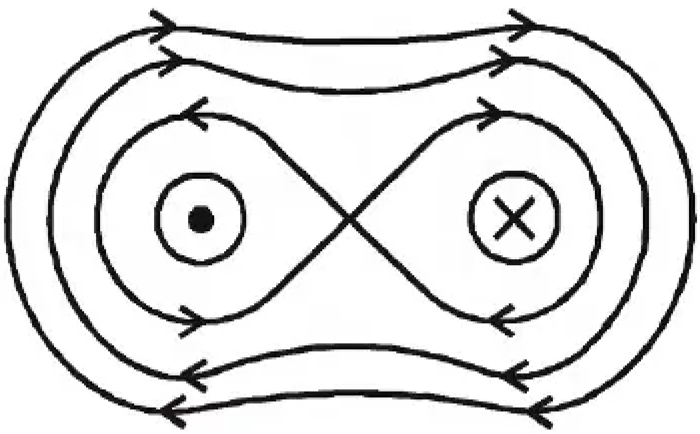
b. $2.5 \times 10^{-5}T$

c. $2.0 \times 10^{-5}T$

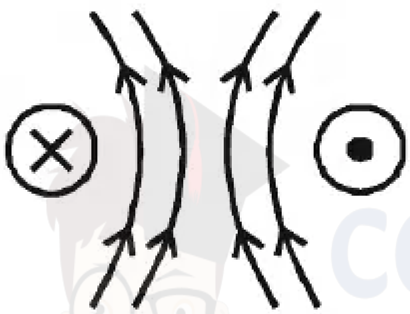
d. $1.5 \times 10^{-5}T$

12. Choose the correct sketch of the magnetic field lines of a circular current loop shown by the dot ? and the cross ?. **(+4, -1)**

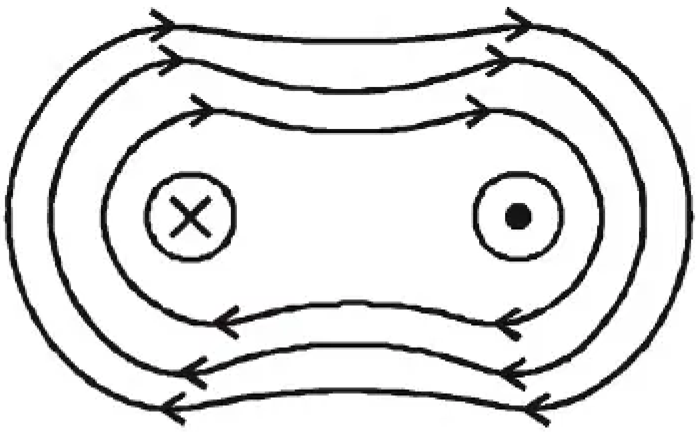
a. 



b.



c.



d.

13. An electron, moving along the x-axis with an initial energy of $100\,eV$, enters a region of magnetic field $\vec{B} = (1.5 \times 10^{-3} T)\hat{k}$ at S (See figure). The field extends between $x = 0$ and $x = 2\,cm$. The electron is detected at the point Q on a screen placed $8\,cm$ away from the point S. The distance d between P **(+4, -1)**

and Q (on the screen) is : (electron's charge = $1.6 \times 10^{-19} C$. mass of electron = $9.1 \times 10^{-31} kg)$

a. 12.87 cm

b. 1.22 cm

c. 11.65 cm

d. 2.25 cm

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14. An electron , a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is : **(+4, -1)**

a. $r_e > r_p = r_\alpha$

b. $r_e < r_p = r_\alpha$

c. $r_e < r_p < r_\alpha$

d. $r_e < r_\alpha < r_p$

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15. A proton (mass m) accelerated by a potential difference V flies through a uniform transverse magnetic field B. The field occupies a region of space by width d. If α be the angle of deviation of proton from initial direction of motion (see figure), the value of $\sin \alpha$ will be : **(+4, -1)**

a. $\frac{B}{2}\sqrt{\frac{qd}{mV}}$

b. $\frac{B}{d}\sqrt{\frac{q}{2mV}}$

c. $Bd\sqrt{\frac{q}{2mV}}$

d. $qV\sqrt{\frac{Bd}{2m}}$

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16. A proton and an α-particle (with their masses in the ratio of $1:4$ and charges in the ratio of $1:2$) are accelerated from rest through a potential difference V. If a uniform magnetic field (B) is set up perpendicular to their **(+4, -1)**

velocities, the ratio of the radii $r_p : r_\alpha$ of the circular paths described by them will be :

a. $1 : \sqrt{2}$

b. $1 : 2$

c. $1 : 3$

d. $1 : \sqrt{3}$

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17. A particle having the same charge as of electron moves in a circular path of radius $0.5\,cm$ under the influence of a magnetic field of $0.5\,T$. If an electric field of $100\,V/m$ makes it to move in a straight path, then the mass of the particle is (Given charge of electron = $1.6 \times 10^{-19} C$) **(+4, -1)**

a. $2.0 \times 10^{-24}\ kg$

b. $1.6 \times 10^{-19}\ kg$

c. $1.6 \times 10^{-27}\ kg$

d. $9.1 \times 10^{-31}\ kg$

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18. A parallel plate capacitor of area $60\,cm^2$ and separation $3\,mm$ is charged initially to $90\,\mu C$. If the medium between the plate gets slightly conducting and the plate loses the charge initially at the rate of $2.5 \times 10^{-8}\,C/s$, then what is the magnetic field between the plates ? **(+4, -1)**

a. $2.5 \times 10^{-8}\,T$

b. $2.0 \times 10^{-7}\,T$

c. $1.63 \times 10^{-11}\,T$

d. zero

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19. A galvanometer, whose resistance is $50\,ohm$, has 25 divisions in it. When a current of 4×10^{-4} A passes through it, its needle (pointer) deflects by one **(+4, -1)**

division. To use this galvanometer as a voltmeter of range $2.5\,V$, it should be connected to a resistance of:

a. 6250 ohm

b. 250 ohm

c. 200 ohm

d. 6200 ohm

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20. A galvanometer of resistance G is converted into a voltmeter of range $0-1V$ by connecting a resistance R_1 in series with it. The additional resistance that should be connected in series with R_1 to increase the range of the voltmeter to $-2V$ will be : **(+4, -1)**

a. R_1

b. R_1+G

c. R_1-G

d. G

Answers

1. **Answer: b**

Explanation:

Force per unit length between two parallel straight wires:

The force per unit length between two parallel wires carrying currents i_1 and i_2 is given by the formula:

$$F = \frac{\mu_0 i_1 i_2}{2\pi d}$$

Given that the currents in two cases are $i_1 = 10$ A and $i_2 = 20$ A, and the separation distance is $d = 5$ cm in the first case and $d = \frac{5}{2}$ cm in the second case, the force ratio can be calculated as:

$$\frac{F_1}{F_2} = \frac{\frac{\mu_0 (10)^2}{2\pi (5cm)}}{\frac{\mu_0 (20)^2}{2\pi \left(\frac{5cm}{2}\right)}}$$

Simplifying the expression:

$$\frac{F_1}{F_2} = \frac{100}{5} \times \frac{1}{\left(\frac{400}{\frac{5}{2}}\right)}$$

$$= \frac{100}{5} \times \frac{2}{400}$$

$$= \frac{100 \times 2}{5 \times 400}$$

$$= \frac{200}{2000} = \frac{1}{8}$$

Therefore, we get:

$$F_2 = 8F_1$$

Concepts:

1. **Moving Charges and Magnetism:**

Moving charges generate an electric field and the rate of flow of charge is known as c urrent. This is the basic concept in Electrostatics. Another important concept related to moving electric charges is the magnetic effect of current. Magnetism is caused by the current.

Magnetism:

- The relationship between a Moving Charge and Magnetism is that Magnetism is produced by the movement of charges.
- And Magnetism is a property that is displayed by Magnets and produced by moving charges, which results in objects being attracted or pushed away.

Magnetic Field:

Region in space around a magnet where the Magnet has its Magnetic effect is called the Magnetic field of the Magnet. Let us suppose that there is a point charge q (moving with a velocity v and, located at r at a given time t) in presence of both the electric field E (r) and the magnetic field B (r). The force on an electric charge q due to both of them can be written as,

$$F = q [E (r) + v \times B (r)] \equiv E_{Electric} + F_{magnetic}$$

This force was based on the extensive experiments of Ampere and others. It is called the Lorentz force.

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2. **Answer: c**

Explanation:

Given:

$$M = N_A I_A A_A$$

Since $M_A = M_B$, we have:

$$N_A I_A A_A = N_B I_B A_B$$

Substitute the values:

$$N_A I_A \pi (0.1)^2 = N_B I_B \pi (0.2)^2$$

Simplifying the equation:

$$N_A I_A = 4 N_B I_B$$

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3. **Answer: d**

Explanation:

Explanation:
Given:
MA = R, MB = 2R, DMA = 90°We have to find the magnetic field at the center of the loop.The magnitude of magnetic field due to an arc of radius R and angle θ, carrying current at the center of the loop is$B = \pi\frac{0}{4\pi R}$ where, θ is the angle subtended by the arc.Given figure is redrawn below:

The magnetic field due to curve DA isBDA=πR(3π2)
Similarly, magnetic field due to the arc BC isBBC=π2R(π2)[given MB=2R]
Also, the magnetic field due to the curve DC and AB isBDC=BAB=[since the angle between the current element and the position vector is zero, i.e. × =0
Now, the resultant magnetic field at the centre M isBnet =BDA+BAb+BBC+BCD
⇒Bnet=πR(3π2)++8πR(π2)+
⇒Bnet=R[32+1]⇒Bnet=R×[6+1]⇒Bnet=716R
Using the right-hand thumb rule for the magnetic field, the direction of the magnetic field is into the plane of the paper, as the direction of the current is clockwise.
Hence, the correct option is (D).

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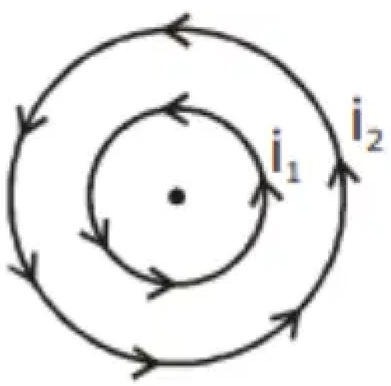
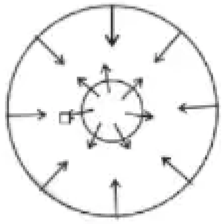
4. **Answer: d**

Explanation:

Cross-sectional view



(Both solenoids are taken to be ideal in nature.) Both wires will attract each other, but net force on each wire will be zero. Concept: Two current carrying elements attract each other if direction of current is same. $F.B.D$



$\vec{F}_1 = 0$ $\vec{F}_2 = 0$

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5. **Answer: b**

Explanation:

$$I_g = \frac{V}{R+G}\ R_c = R + \frac{GS}{G+s}\ I = \frac{V}{R+\frac{GS}{G+S}}\ I_g'G = \left(I - I_g'\right) S\ I_g' \left(G+S\right) = IS\ \frac{I_g}{2} = \frac{IS}{G+S}\ \frac{V}{2(R+G)} = \frac{V}{R+\frac{GS}{G+S}} \times \frac{S}{G+S}\ \frac{1}{2(R+G)} = \frac{S}{R(G+S)+GS}\ R\left(G+S\right) + GS = 2S\left(R+G\right)\ RG + RS + GS = 2S\left(R+G\right)\ RG = 2S\left(R+G\right) - S\left(R+G\right)\ RG = S\left(R+G\right)$$

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6. **Answer: d**

Explanation:

Answer (d) Statement - I is false, Statement - II is true

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7. **Answer: b**

Explanation:

$\mu = 5.9 BM \therefore n$ (no of unpaired.e-) = 5 Cation $Mn^{II} - 3d^5$ confn only possible for relatively weak ligand. $\therefore NCS^-$

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8. Answer: a

Explanation:

$i_g = 5 \times 10^{-3} A$
$G = 15\,\Omega$
Let series resistance be R.
$V = i_g(R + G)$
$10 = 5 \times 10^{-3}(R + 15)$
$R = 2000 - 15 = 1985 = 1.985 \times 10^3\,\Omega$

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9. **Answer: b**

Explanation:

Net force on wire carrying current I per unit length is

$$\frac{\mu_0 I_1 I}{2\pi x} + \frac{\mu_0 I_2 I}{2x(d-x)} = 0$$

$$\frac{I_1}{x} = \frac{I_2}{x-d}$$

$$\Rightarrow x = \frac{I_1 d}{I_1 - I_2}$$

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10. Answer: d

Explanation:

Current required by unit deflection is $60\,\mu A$
For, $\theta = 9$ current is $I = 9 \times 60\,\mu A$
$\Rightarrow I = 540\,\mu A = 540 \times 10^{-6} A$
Let G is resistance of galvanometer. Then,
$540 \times 10^{-6} = \frac{6}{(11000+G)}$
$[11000 + G]90 \times 10^{-6} = 1$
$99000 + 9G = 10^5$
$9G = 100000 - 99000$
$9G = 1000$
$G = \frac{1000}{9}\Omega$
Also in half deflection method,
$G = \frac{RS}{R-S}$
$\Rightarrow \frac{1000}{9} = \frac{11000S}{11000-S}$
$\frac{1}{9} = \frac{11S}{11000-S}$
$\Rightarrow 11000 - S = 99\,S$
$100\,S = 11000 \Rightarrow S = 110\,\Omega$

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---

11. **Answer: d**

Explanation:

$b = \frac{\mu_0 I}{4\pi d} 2sin\theta$
d = 4 cm
$sin\theta = \frac{3}{5}$

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$$F = q [E (r) + v \times B (r)] \equiv E_{Electric} + F_{magnetic}$$

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12. **Answer: a**

Explanation:

If magnetic field is perpendicular and into the plane of the paper, it is represented by cross ⊗ and if the direction of the magnetic field is perpendicular out of the plane of the paper it is represented by dot ?.

Concepts:

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13. Answer: a

Explanation:

$R = \frac{mv}{qB}$

$= \frac{\sqrt{2m(K.E.)}}{qB}$

$R = \frac{\sqrt{2 \times 9.1 \times 10^{-31} \times (100 \times 1.6 \times 10^{-19}}}{1.6 \times 10^{-19} \times 1.5 \times 10^{-3}}$

$R = 2.248$ cm

$sin\theta = \frac{2}{2.248}$

$tan\theta = \frac{QU}{TU}$

$\frac{2}{1.026} = \frac{QU}{6}$

$QU = 11.69$

$PU = R(1 - cos\theta)$

$= 1.22$

$d = QU + PU$

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14. **Answer: b**

Explanation:

$$r = \frac{\sqrt{2mk}}{qB}$$
$$\frac{r_\alpha}{r_p} = \frac{\sqrt{2m_\alpha}}{q_\alpha} \times \frac{q_p}{\sqrt{2m_p}}$$
$$\begin{bmatrix} m_\alpha = 4m_p \\ q_\alpha = 2q_p \end{bmatrix}$$
$$= 1$$

Mass of electron is least and charge $q_e = e$

So, $r_e < r_p = r_\alpha$

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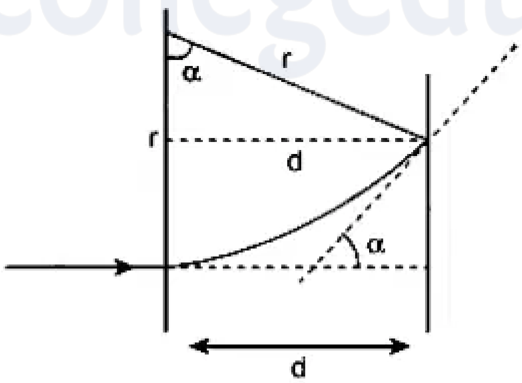
15. **Answer: c**

Explanation:



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16. **Answer: a**

Explanation:

The correct option is(A): $1 : \sqrt{2}$

$KE = q\Delta V$
$r = \frac{\sqrt{2mq\Delta V}}{qB}$
$r \propto \sqrt{\frac{m}{q}}$
$\frac{r_p}{r_\infty}\sqrt{\frac{1}{4} \times \frac{2}{1}} = \frac{1}{\sqrt{2}}$

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17. **Answer: a**

Explanation:

$\frac{mv^2}{R} = qvB$
$mv = qBR$ ....(i)
Path is straight line
it $qE = qvB$
$E = vB$ ....(ii)
From equation (i) & (ii)
$m = \frac{qB^2R}{E}$
$m = 2.0 \times 10^{-24} kg$

Concepts:

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18. **Answer: d**

Explanation:

Magnetic field between the plates in this case is zero.

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---

19. **Answer: c**

Explanation:

$I_g = 4 \times 10^{-4} \times 25 = 10^{-2} A$
$2.5 = (50 + R)10^{-2} \ \therefore \ R = 200\Omega$

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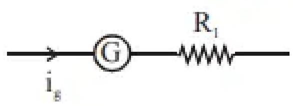
20. **Answer: b**

Explanation:



$\Rightarrow 1 = i_g(G + R_1) \quad \dots (1)$

$\Rightarrow 2 = i_g\,(R_1 + R_2 + G)\dots(2)$

(1) $\%(2)$

$\Rightarrow \frac{1}{2} = \frac{G+R_1}{G+R_1+R_2}$

$G + R_1 + R_2 = 2G + 2h_1$

$(R_2 = G + R_1)$

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