BK BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS
SENIOR SECONDARY | CO-ED DAY CUM BOYS' RESIDENTIAL SCHOOL

MID-TERM EXAMINATION 2023-24

PHYSICS (042)

Class : XII
Date : 14/09/2024

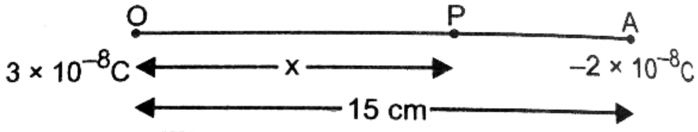
MARKING SCHEME

Duration: **3 Hrs**
Max. Marks: **70**

1. (c) 6.25 X 10^{18} 1
2. (a) Zero 1
3. (b) Parallel currents attract and anti-parallel currents repel. 1
4. (d) The electron will continue to move with uniform velocity along the axis of the solenoid. 1
5. (c) Energy is constant but momentum changes. 1
6. (b) Weber 1
7. (c) the resistivity of the wire of the coil 1
8. (d) (a) and (c) both 1
9. (b) increase 1
10. (a) perpendicular to E and B and out of the plane of the paper 1
11. (b) Light travels from denser to rarer medium. 1
12. (c) 40 cm 1
13. (a) 1
14. (c) 1
15. (c) 1
16. (b) 1
17. According to **Coulomb's law**, the force of attraction or repulsion between two charged bodies is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. It acts along the line joining the two charges considered to be point charges. 1

    $\vec{F}_{12} = k\frac{q_1 q_2}{r^2} \cdot \hat{r}_{12}$ 1

18. Let the location of positive charge be taken as the origin O, Fig and line P be required point, where potential is zero.



2

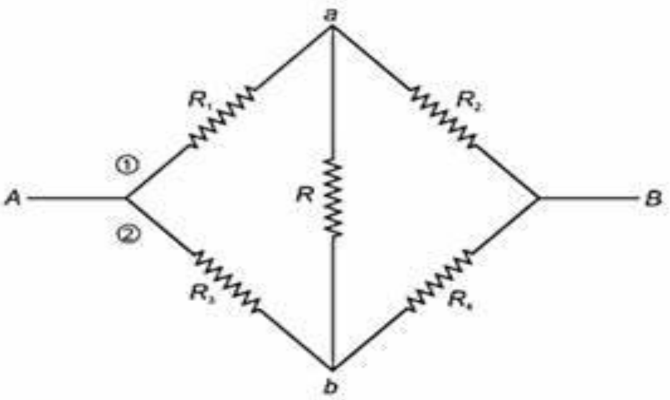
Let OP = x cm

Potential at P is V = $3 \times 10^{-8} / 4\pi\epsilon_0 (x \times 10^{-2}) + (-2 \times 10^{-8}) / 4\pi\epsilon_0 (15 - x) \times 10^{-2} = 0$

$\therefore 3/x - 2/(15 - x) = 0$, which gives x = 9 c m. If P lies on extended line OA, the condition for zero electric potential would be $3/x - 2/(x - 15) = 0$, which gives x = 45 cm.

19. 2

A



Condition for a balanced Wheatstone bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

If we go from *A* to *B* from branch (1) and branch (2) the potential difference is the same (Parallel Resistances).

If potential drop is in R_1 and R_2 is in the ratio of resistances (in series connection for explanation study basics) or R_1: R_2

Similarly potential drop in resistances of branch (2) is R_3: R_4

If $\frac{R_3}{R_4} = \frac{R_1}{R_2}$ then a and b are in same potential and no current is through *R*.

Equipotential points are an important concept when dealing with symmetrical resistors.

20. (a) Infrared ½
(b) Ultraviolet ½
(a) Infrared: By Nernst Lamp ½
(b) Ultraviolet: By arc of Mercury ½

21. **First law:** The first law of refraction states that the incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane. 1

Second law: According to Snell's law, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This constant is the refractive index.

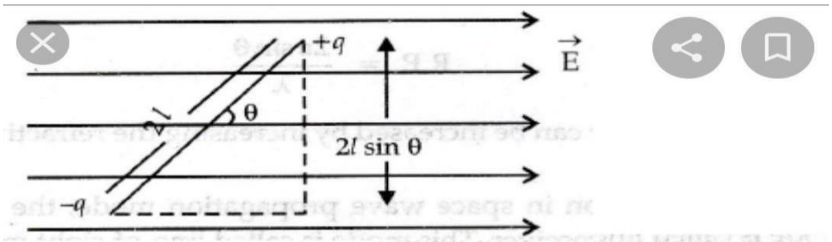
Sin i/sin r = constant

This constant or refractive index is denoted by 'n'. 1

Or

The ratio between the speed of light in medium to speed in a vacuum is the refractive index. When light travels in a medium other than the vacuum, the atoms of that medium continually absorb and re-emit the particles of light, slowing down the speed light. 2

22.



Force on each charge $= q\vec{E}$

Perpendicular distance between two forces $= 2\vec{l}\sin\theta$

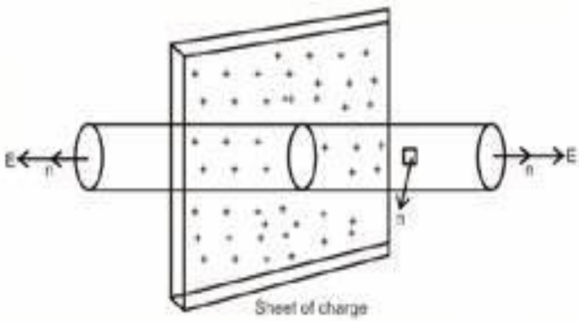
$$\therefore \quad \text{Torque} = q\vec{E}\times 2\vec{l}\sin\theta$$
$$= \left(q\times 2\vec{l}\right)\vec{E}\sin\theta$$
$$= pE\sin\theta$$
$$= \vec{P}\times\vec{E}$$ 3

Or 3

Gauss's Law: It relates the total flux of an electric field through a closed surface to the net charge enclosed by that surface and according to it, the total flux linked with a closed surface is $\left(\frac{1}{\epsilon_0}\right)$ times the charge enclosed by the closed surface i.e.

$$\oint_S \vec{E}.\vec{ds} = \frac{q}{\epsilon_0}$$

Gauss' law is a power tool for calculating electric intensity in case of symmetrical charge distribution by choosing a Gaussian surface in such a way that $\vec{E}$ is either parallel or perpendicular to its various faces.



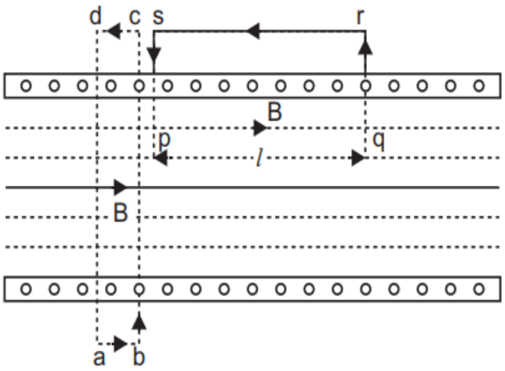
Let surface charge density of sheet is σ. To calculate E at a point P close to it consider a Gaussian–surface in the form of 'Pill box' of cross section S as shown in figure.

The charge enclosed by the Gaussian surface $= \sigma S$ and flux links with the pill box $\phi = ES + 0 + ES = 2ES$ as E is parallel to curve surface and perpendicular to plane surface

$$\Rightarrow \phi_1 = \frac{q}{\varepsilon_0}$$

$$\Rightarrow 2ES = \frac{\sigma S}{\epsilon_0} \Rightarrow E = \frac{\sigma}{2\epsilon_0}$$

23.



Field outside the solenoid: Consider a closed path abcd. Applying Ampere's law to this path (since net current enclosed by path is zero) As dl ≠ 0 ∴ B = 0 This means that the magnetic field outside the solenoid is zero. Field Inside the solenoid: Consider a closed path pqrs. The line integral of magnetic field vector B along path pqrs is

$$\oint_{pqrs} \vec{B}\bullet\vec{dl} = \int_{pq} \vec{B}\bullet\vec{dl} + \int_{qr} \vec{B}\bullet\vec{dl} + \int_{rs} \vec{B}\bullet\vec{dl} + \int_{sp} \vec{B}\bullet\vec{dl} \quad ...(i)$$

For path pq, $\vec{B}$ and $\vec{dl}$ are along the same direction,

$$\therefore \qquad \int_{pq} \vec{B}\bullet\vec{dl} = \int B\,dl = Bl \qquad (pq = l \text{ say})$$

For paths qr and sp, $\vec{B}$ and $d\vec{l}$ are mutually perpendicular.

$$\therefore \qquad \int_{qr} \vec{B}\bullet\vec{dl} = \int_{sp} \vec{B}\bullet d\vec{l} = \int B\,dl\cos 90^\circ = 0$$

For path rs, $B = 0$ (since field is zero outside a solenoid)

$$\therefore \qquad \int_{rs} \vec{B}\bullet\vec{dl} = 0$$

In view of these, equation (i) gives

$$\oint_{pqrs} \vec{B}\bullet\vec{dl} = \int_{pq} \vec{B}\bullet\vec{dl} = Bl \qquad ...(ii)$$

By Ampere's law $\oint \vec{B}\bullet\vec{dl} = \mu_0 \times$ net current enclosed by path

$$\therefore \qquad Bl = \mu_0\,(nl\,I) \qquad \therefore \quad B = \mu_0\,nI$$ 3

24. Diamagnetic Materials: 1

They are barely magnetized when they are placed in the presence of a magnetic field. Magnetic dipoles here tend to align in opposition to the applied field. As a result, an internal magnetic field is produced by them that opposes the applied field and the substances tend to repel the external force around them. Some examples of diamagnetic materials are silver, mercury, lead, carbon (graphite and diamond), and copper.

Paramagnetic Materials: 1

Paramagnetic substances are attracted by a magnet if it applies a considerable amount of strong field. It is to be kept in mind that such materials are still feebly magnetized and the magnetization will disappear right when the external field is removed. A few examples of paramagnetic materials are as follows: Tungsten, Caesium, Aluminium, Lithium, Magnesium, and Sodium.

Ferromagnetic Materials: 1

These materials produce a very strong magnetism in the direction of the magnetic field when a magnetic field is applied to it. Some examples of ferromagnetic materials are cobalt, iron, nickel, gadolinium, and terbium.

25. Area of the circular loop = πr^2

$$= 3.14 \times (0.12)^2 \text{ m}^2 = 4.5 \times 10^{-2} \text{ m}^2$$

$$E = -\frac{d\varphi}{dt} = -\frac{d}{dt}(\text{BA}) = -\text{A}\frac{dB}{dt} = -\text{A} \cdot \frac{B_2 - B_1}{t_2 - t_1}$$

For $0 < t < 2$s

$$E_1 = -4.5 \times 10^{-2} \times \left\{\frac{1-0}{2-0}\right\} = -2.25 \times 10^{-2} \text{ V}$$

$$\therefore I_1 = \frac{E_1}{R} = \frac{-2.25 \times 10^{-2}}{8.5} \text{ A} = -2.6 \times 10^{-3} \text{ A} = -2.6 \text{ mA}$$

For $2\text{s} < t < 4\text{s}$,

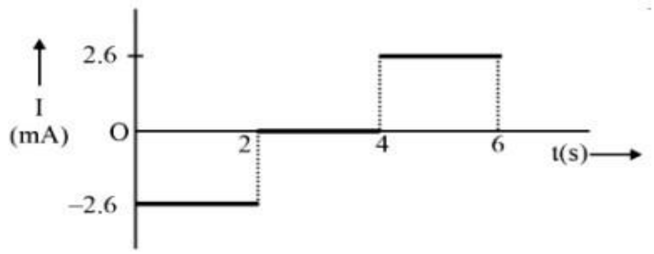
$$E_2 = -4.5 \times 10^{-2} \times \left\{\frac{1-1}{4-2}\right\} = 0$$

$$\therefore I_2 = \frac{E_2}{R} = 0$$

For $4\text{s} < t < 6\text{s}$,

$$I_3 = -\frac{4.5 \times 10^{-2}}{8.5} \times \left\{\frac{0-1}{6-4}\right\}\text{A} = 2.6 \text{ mA}$$

	0<t<2s	2<t<4s	4<t<6s
E(V)	-0.023	0	+0.023
I(mA)	-2.6	0	+2.6



3

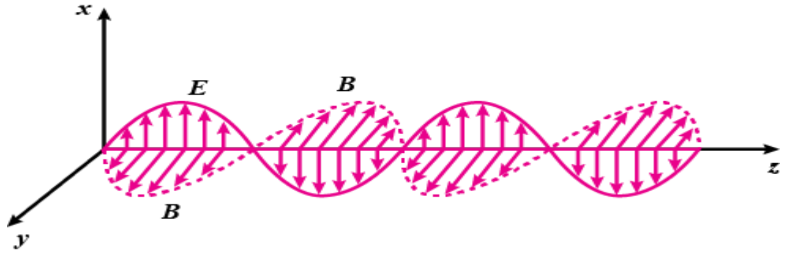
26. (a) $X_L = \omega L$

$L = X_L/\omega = 10/314 = 0.0318$ H 1

(b) Zero. For battery, $\omega = 0$ 1

(c) Zero. For an inductive circuit power dissipation is zero for full cycle. 1

27. (i) An oscillating charge produces an oscillating electric field in space, which produces an oscillating magnetic field. The oscillating electric and magnetic fields regenerate each other, and this results in the production of em waves in space. 1
(ii) Electric field is along x−axis and magnetic field is along y−axis.



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28.

LENS MAKER'S FORMULA

Lens Maker's formula gives the focal length of a lens in terms of the nature of the surfaces by which the lens is bounded and the nature of material (refractive index) of the lens.

Let us consider the situation shown in figure. C_1 and C_2 are the centers of curvature of two spherical surfaces of the thin lens. O is the object and O_1 is the image due to first refraction. Let radii of curvature be R_1 and R_2.

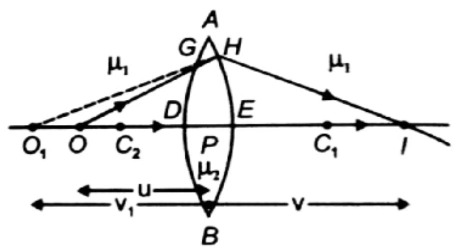
For the first refraction at ADB, image distance (PO_1) is v_1. From the formula for refraction at a curved surface, we get

$$\frac{\mu_2}{v_1} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R_1} \qquad \text{...(i)}$$

Final image position is I, which is also the image due to second refraction. Let this image distance be v. For the second refraction, v_1 becomes the object distance.

Hence we get,

$$\frac{\mu_1}{v} - \frac{\mu_2}{v_1} = \frac{\mu_1 - \mu_2}{R_2} \qquad \text{...(ii)}$$



Adding (i) and (ii), we get

$$\mu_1\left(\frac{1}{v} - \frac{1}{u}\right) = (\mu_2 - \mu_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

or, $$\frac{1}{v} - \frac{1}{u} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right), \text{ where } \mu = \frac{\mu_2}{\mu_1} \qquad \text{...(iii)}$$

According to the definition of the focal length f,

when $u = \infty$, $v = f$

$\therefore$ From equation (iii), $\boxed{\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$ ...(iv)

This is called the "Lens Maker's formula".

2

Comparing (iii) and (iv) 1/f=1/v-1/u-----------Lens Formula. 1

29. (i) b (ii) d (iii) b (iv) a Or (iv) d (1+1+1+1)

30. (i) a (ii) b (iii) c (iv) a Or (iv) b (1+1+1+1)

31. (a) Relation between Electric Field and Electric Potential Derivation:
Consider the two equipotential surfaces divided by a distance dx, with V representing the

potential on surface 1 and V−dV representing the potential on surface 2. Let 'E' be the electric field, and let its direction be perpendicular to the equipotential surfaces.
Consider a unit positive charge +1C close to point B; the force felt by unit positive charge is given by:
F= qE……(1)
We assume that q= +1C, equation (1) becomes F= E………..(2) 1
If we keep moving the charge from point B to point A, the work done through moving the charge is given by the equations below
W_{BA}= F·dx

W_{BA}= FdxCosθ…… (3)

We get W_{BA}= EdxCosθ……. (4)

By substituting the value of F in equation (3) for equation (2).

Because the force experienced is acting upward, but the displacement is acting downward, the angle between force and displacement is 180°.

As a result, the work done in moving the point charge from point B to point A is given by: W_{BA} =−E dx……. (5) 1

$V_A−V_B= W_{BA}$

W_{BA}=V− (V−dV) = dV…….. (6)
By substituting the corresponding potential values at points A and B.

Combining equations (5) and (6):

dV=−E dx

E =−dV/dx…….. (7) 1

(b) Here, dipole moment of each molecule = 10^{-29} Cm.
As one mole of substance contains 6 × 10^{23} molecules, therefore, total dipole moment of all the molecules, p = 10^{-29}× 6 × 10^{23} Cm = 6× 10^{-6} C.
As polarisation is 100 % therefore initial potential energy U_1 =− p E cos 0◦ = −6× 10^{-6} × 10^6 = − 6 J when θ = 60◦, final potential energy U_2 =± p E cos 60◦ =−6× 10^{-6} × 10^6 × 1/2 =− 3 J
Change in P.E. = $U_2 − U_1$ = −3− (−6) = 3J. This loss in P.E. is the energy released is the form of heat in aligning the dipoles. 2

Or

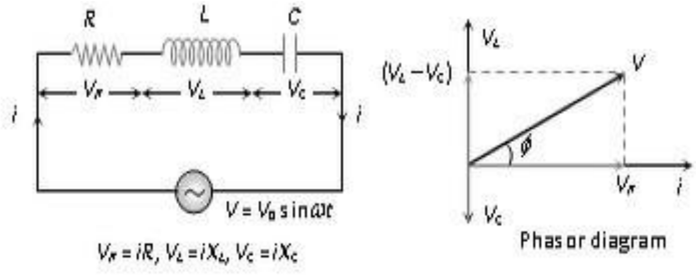
(a)

Area of each plate $A=6\times10^{-3}m^2$
Distance between the plates d=3mm=0.003m
Capacitance of capacitor $C=A\epsilon_o/d$ 1
∴ $C=6\times10^{-3}\times8.85\times10^{-12}/0.003=17.7pF$ 1
Voltage across the capacitor V=100 volts
Thus charge on each plate Q=CV
∴ $Q=17.7\times10^{-12}\times100$
⟹ $Q=1.77\times10^{-9}$ C 1

(b) C= KC_0= 40 X 17.7pF= 608pF. 1

Q= remains same= 1.77×10^{-9} C 1

32. (a)



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(a) X is a resistor and y is a capacitor. 1

(b) The resistance of X and the reactance of Y are

$$R = \frac{V_{rms}}{I_{rms}} = \frac{220}{0.5} = 440\Omega$$

$$R = X_C = 440\Omega$$

When R and C are in series, then

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{\sqrt{R^2 + (X_C)^2}}$$

$$= \frac{220\text{ V}}{\sqrt{(440\ \Omega)^2 + (440\ \Omega)^2}}$$

$$= \frac{220\text{ V}}{440\sqrt{2}\ \Omega} = 0.3536\text{ A}.$$

2

Or

(a)

Phasor Diagram for a series LCR circuit is shown in the attached figure.

From definition of impedance,

For inductor, $V_L=IX_L=I\ \omega\ L$

For capacitance, $V_C=IX_C=I\ \omega\ C$

For resistance, $V_R=IR$

From the phasor diagram,

$V_s^2=V_R^2+(V_L-V_C)^2$

$Z=\sqrt{(R^2+(\omega L-1/\omega\ C)^2)}$ 1

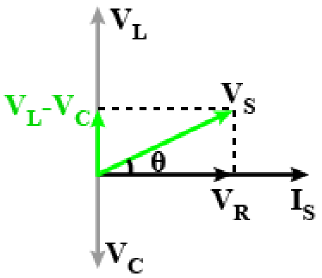
Variation of current in the circuit on the variation of applied frequency is shown in the attached figure.

Current is given as: $I=V_s\ Z$

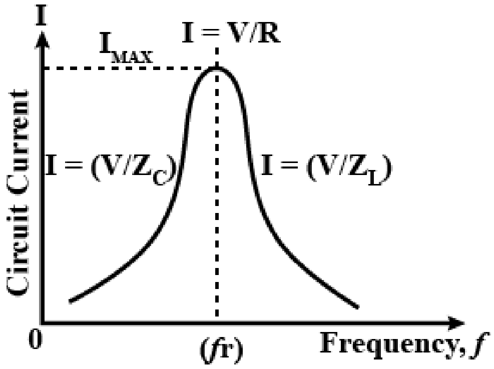
At resonance, impedance is minimum and hence, current is maximum as shown in the plot.

For frequencies smaller than the resonant frequencies, $V_C > V_L$ and hence circuit is capacitive.

For frequencies greater than the resonant frequencies, $V_L > V_C$ and hence circuit is inductive.



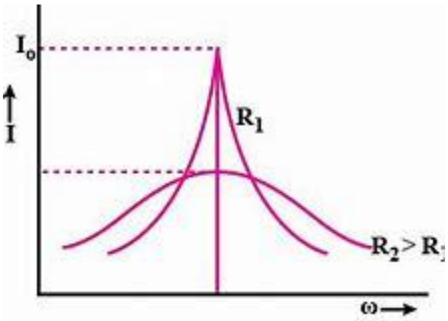
Phasor Diagram



Series Resonance

2

(b)



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33 (a) Sensitivity of a galvanometer: A galvanometer is said to be sensitive, if it gives a large deflection, even when a small current passes through it. (1+1)

(i) Current sensitivity, $\frac{\phi}{I} = \frac{nAB}{k}$ ...(μA^{-1})

(ii) Voltage sensitivity, $\frac{\phi}{V} = \frac{nAB}{kR}$ ...(μV^{-1})

(b) $A = 16 \times 10^{-4}\ m^2$, $N = 200$ turns, $B = 0.2$ T,

$k = 10^{-6}$ Nm per degree

$$\theta = 30° = \frac{30 \times \pi}{180} = \frac{\pi}{6} \text{ Rad}$$

As $NABI = k\theta$

$$\therefore\ 200 \times (16 \times 10^{-4}) \times (0.2) \times I = 10^{-6} \times \frac{\pi}{6}$$

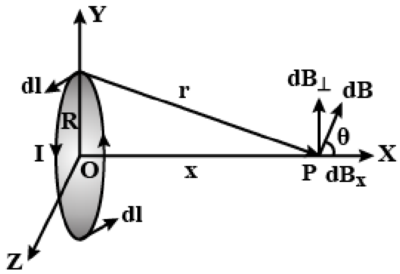
$$\therefore\ I = \frac{\pi \times 10^{-6}}{6 \times 200(16 \times 10^{-4}) \times (0.2)}$$

$$= 8.17 \times 10^{-6} \text{ A} = \mathbf{8.17\ \mu A}$$

3

Or

(a)



Let dB be the magnetic field due to a small length dl of the ring,
As per biot-savert rule,
$dB = \mu_o Idl/4\pi r^2$ 1
We know that $r=\sqrt{(x^2+R^2)}$
So $dB = \mu_o Idl/4\pi\sqrt{(x^2+R^2)}$
This field have vertical dBy= dB sinθ and horizontal component dBx= dB cosθ, Vertical component will cancel out each other, only horizontal components are responsible,
So, $B= dB_1+ dB2+.....$
$dB = \mu o Ix^2/4\pi(R^2+x^2)^{3/2}$ 1
The magnetic field due to the circular current loop of radius a at a point which is a distance R away, and is on its axis,
So $B=\mu o Ix^2/2(R^2+x^2)^{3/2}$
At the center of the circle, R=0
$B= \mu o I/2x$ ½

(b) we find $r = m\, v / (qB) = 9 \times 10^{-31}$ kg $\times 3 \times 10^7$ m s^{-1} / (1.6×10^{-19} C $\times 6 \times 10^{-4}$ T)
$= 28 \times 10^{-2}$ m = 28 cm 1
n = v / (2 pr) = 17×10^6 Hz =17 MHz. ½
E = (½) mv^2 = (½) 9×10^{-31} kg $\times 9\times10^{14}$ $m^2 /s^2 = 40.5\times10^{-17}$ J ≈ 4×10^{-16} J = 2.5 keV. 1

-------------------------END OF MS--------------------------