SECTION - B

QUESTION - 2

Attempt any 10 parts - - - .

Part - 1

Find electric field at a - - - ?

Given:

Distance = r = 30 cm
= 30×10^{-2} m.

Charge = q = 3 μC
= 3×10^{-6} C.

Required:

E = ?

Solution:,

We know that,

$$E = \frac{kq}{r^2}$$

Putting values,

$$E = \frac{9\times10^9 \times 3\times10^{-6}}{(30\times10^{-2})^2} \text{ N/C}$$

$$= \frac{9\times10^9 \times 3\times10^{-6}}{30\times10^{-2}\times30\times10^{-2}} \text{ N/C}$$

4

$$E = 300000 \text{ N/C}$$

$$\boxed{E = 3\times10^5 \text{ N/C.}}$$

Part-2

Show that $E = -\frac{\Delta V}{\Delta r}$

Consider a test charge that is being moved from a point of high potential to a point of low potential in an electric field of a positive charge. Work **is done on the test charge** by the positive charge. The work done is given by

$$\Delta W = -F \cdot \Delta r \quad \text{— (1)}$$

Δr is the distance through which the test charge moves.

We know that,

$$F = qE \quad \text{— (2)}$$

Putting eq. (2) in (1),

$$\Delta W = -qE\Delta r \quad \text{--- (3)}$$

We know that,

$$\frac{\Delta W}{q} = \Delta V$$

$$\Delta W = \Delta V q \quad \text{--- (4)}$$

Putting eq. (4) in eq. (3).

$$\Delta V q = -qE\Delta r$$

$$\Delta V = -E\Delta r$$

$$\frac{\Delta V}{\Delta r} = -E$$

$$E = -\frac{\Delta V}{\Delta r}$$

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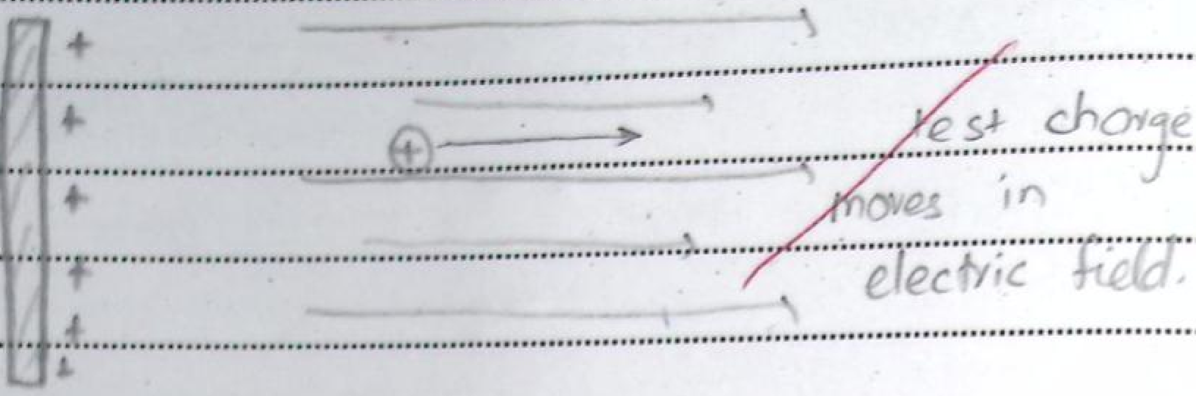


Part - 3

Discuss Various factors . . . ?

FACTORS AFFECTING INDUCTANCE:-

There are various factors which affect the inductance of a coil. They are discussed below.

1) Material of Core:-

The material of core used in the coil

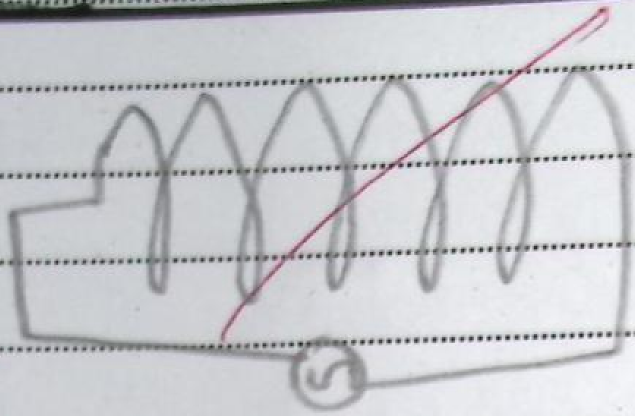
affects the inductance (L) of the coil. The greater the magnetic permeability of the coil, the greater will be the inductance of the coil.

2) Length and Number of Turns of Coil:

The no. of turns of coil is another factor affecting inductance. Greater the no. of turns of coil, greater will be the inductance.

3) Shape and Area:

Shape and area of coil also affect the inductance of coil. It is one of the main factors affecting inductance.



Part - 4

How does doubling the - - - - ?

1) Effect on Inductor:

By doubling the frequency, the reactance of inductor will also double. The reactance of inductor is given by,

$$X_L = \omega L$$
$$X_L = 2\pi f L$$

Now if we double the frequency such that $f' = 2f$, then,

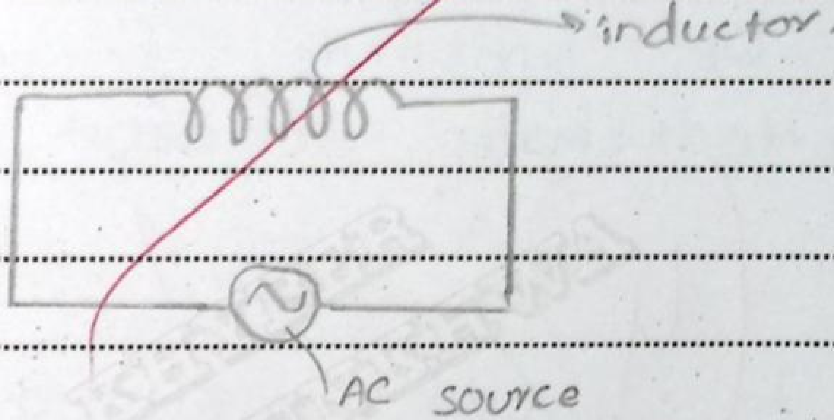
$$X_L' = 2\pi f' L$$

$$X_L' = 2\pi (2f) L$$

$$X_L' = (2\pi f L) 2$$

$$X_L' = 2 X_L$$

Thus by doubling frequency, inductive reactance also doubles.



2) Effect on Capacitor:

By doubling the frequency, the capacitive reactance will become half of the original.

The Capacitive reactance is given by,

$$X_c = \frac{1}{\omega C}$$

$$X_c = \frac{1}{2\pi f C}$$

If we substitute 'f' with 'f′' such that $f' = 2f$, then,

4

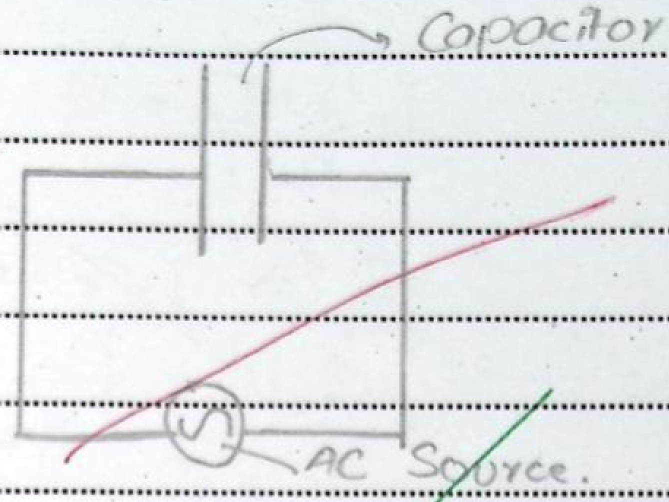
$$X_c' = \frac{1}{2\pi f' C}$$

$$X_c' = \frac{1}{2\pi (2f) C}$$

$$X_c' = \left(\frac{1}{2\pi f C}\right) \frac{1}{2}$$

$$X_c' = \frac{1}{2} (X_c)$$

Thus the capacitive reactance becomes half.



Part-5

For a transistor, show that ---?

In a transistor, the ratio of collector current to base current is known as beta factor (β)

$$\beta = \frac{I_C}{I_B} \longrightarrow (1)$$

We know that, the emitter current is sum of base current and collector current.

$$I_E = I_B + I_C$$

OR,

$$I_B = I_E - I_C \quad \text{—— (2)}$$

Putting eq. (2) in (1),

$$\beta = \frac{I_C}{I_E - I_C}$$

Dividing nominator and denominator by I_E.

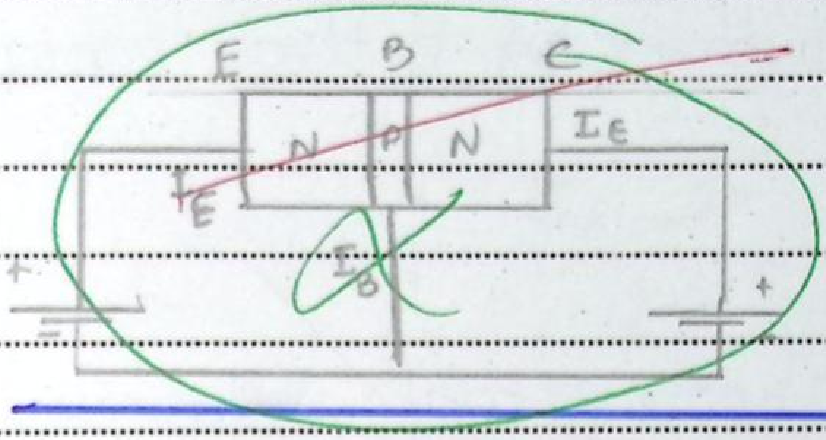
$$\beta = \frac{I_C / I_E}{(I_E - I_C)/I_E}$$

$$\beta = \frac{I_C/I_E}{1 - I_C/I_E}$$

We know that,

$$\frac{I_C}{I_E} = \alpha$$

$$\beta = \frac{\alpha}{1-\alpha}$$



Part -6

If an electron and a proton - - -
- - - - ?

ANSWER:

If an electron and a proton have the same de-Broglie wavelengths, then electron will have greater speed.

EXPLANATION:

According to de-Broglie, the wavelength of a particle is given by the equation.

$$\lambda = \frac{h}{p}$$

We know that $P = mv$.

$$\lambda = \frac{h}{mv}$$

Rearranging,

$$v = \frac{h}{m\lambda}$$

Since Planck's constant, mass of particle and the wavelength are constants, therefore,

$$v \propto \frac{1}{m}$$

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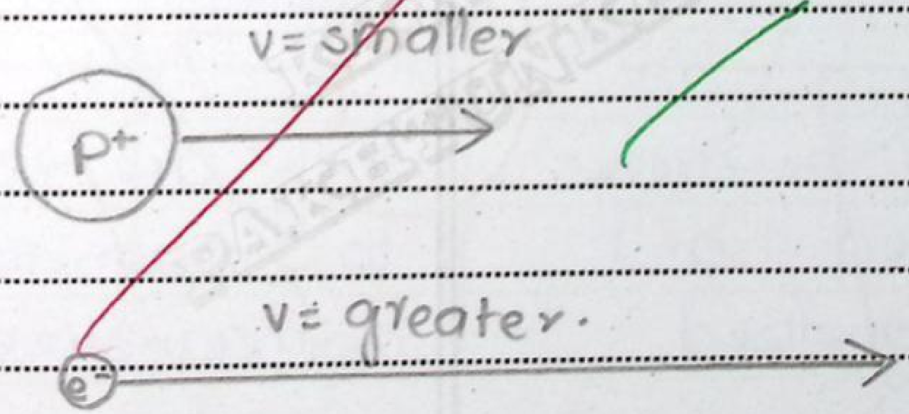
From above relation, it is clear that the velocity will be greater for a particle having less mass than for a particle having greater mass.

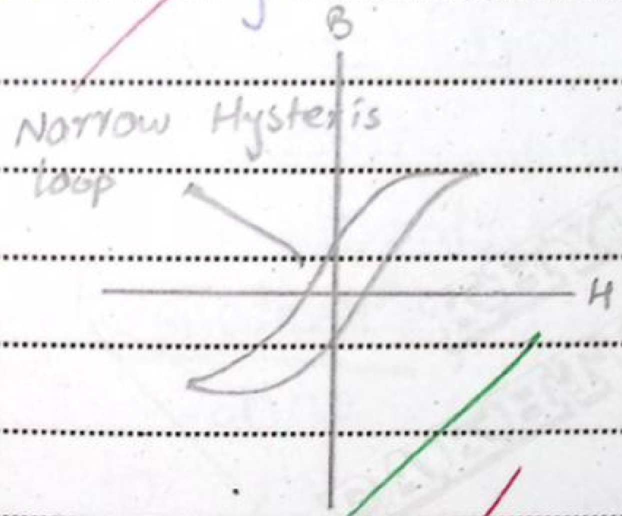
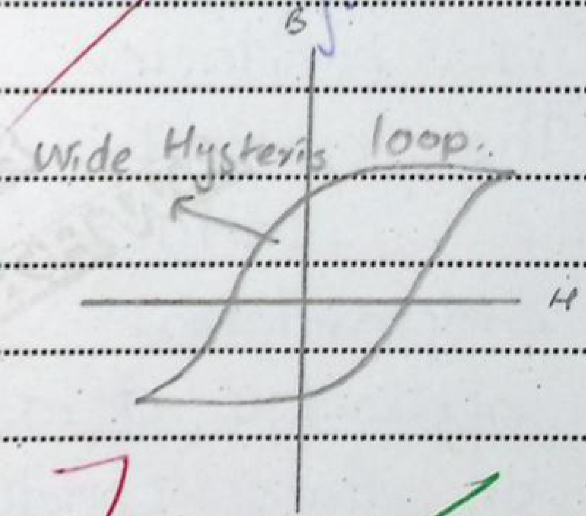
Since mass of proton is much higher than that of electron (About 1836 times), therefore the velocity of proton will be less than that of electron.



Part - 7

Differentiate b/w soft & hard - - - ?

SOFT MAGNETIC MATERIALS	HARD MAGNETIC MATERIALS
Those substances having a narrow loop of hysterisis are known as soft magnetic materials.	Those substances having a wide loop of hysterisis are known as hard magnetic materials.
They can be easily magnetized and de-magnetized.	They are harder to magnetize and de-magnetize.
They have relatively low hysterisis loss.	They have relatively higher hysterisis loss.

They are used in transformers.	They are used to make permanent magnets.
They have low coercivity.	They have high coercivity.
They have low retentivity.	They have high retentivity.
	
Soft steel is an example	Iron is an example.

Part - 8

State Ohm's law . . . ?

Ohm's Law:

Statement:

Ohm's law states that as long as temperature of a conductor is kept constant, the current flowing through the conductor is directly proportional to the voltage applied across the ends of the conductor.

Mathematically:

According to Ohm's law,

$$I \propto V$$

$$I = \frac{V}{R}$$

Or,

$$V = IR$$

Here, 'R' is the resistance of the conductance. It is the opposition to the flow of electrons provided by the conductor.

$$R = \frac{V}{I}$$

Resistance:- It is the opposition to the flow of electrons.

Unit:- Its SI unit is ohm (Ω).

$$1\,\Omega = \frac{1\,V}{1\,A}$$

Resistance is said to be 1 ohm

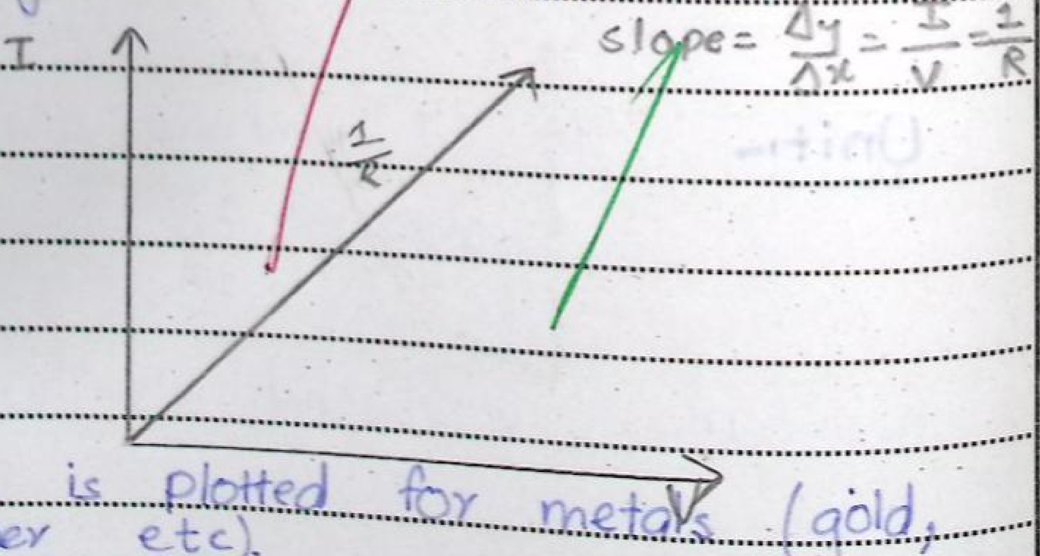
if 1A of current passes through a conductor with a potential difference of 1V.

Ohmic Substance:

Those materials that follow Ohm's law are called Ohmic substances.

Graph:

The graph of I versus V for these materials is a straight line. Its slope gives us 1/R. Slope remains constant if voltage is increased.



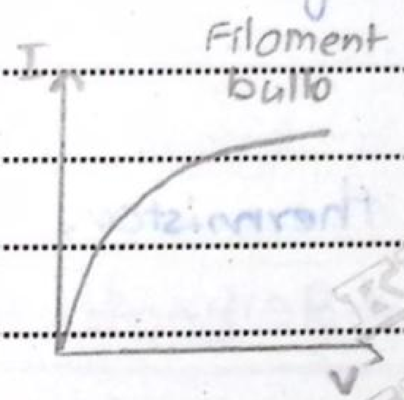
This graph is plotted for metals (gold, copper etc).

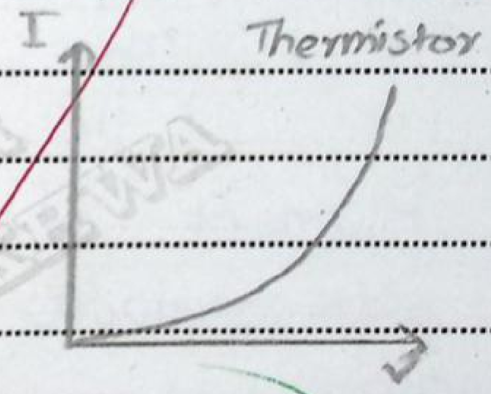
Non-Ohmic Materials:

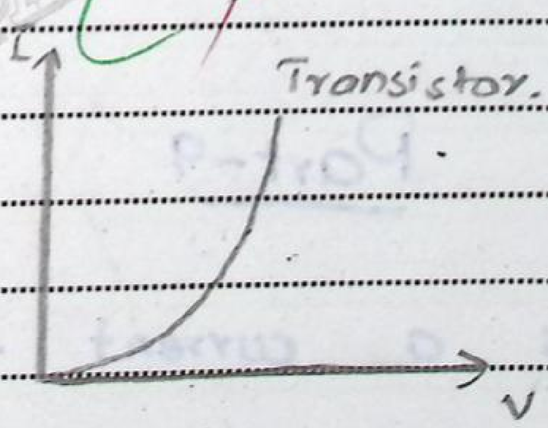
These substances do not follow Ohm's law.

Graph:

The graph of I versus V is a curved line. Its slope gives 1/R which varies non-linearly with voltage.







Difference:-
For Ohmic materials, the slope of graph remains constant while it varies non-linearly for non-Ohmic materials.

EXAMPLES:-
Metals (gold, copper etc) are ohmic materials.

Filament of bulb, thermistor, semiconductor are non-ohmic materials.

Part-9

How does a current ....?

Answer:-

When current flows through a coil, it will establish a magnetic field.

Magnetic Field of Coil:-

The magnetic field of coil will have a north-pole and south-pole. Its orientation will be given by Right Hand Rule III.

Right Hand Rule III:-

It states that curl the fingers of right hand along the direction of current, the thumb will give the direction of N-pole.

Rough Work

$F = BIL$

$B = \frac{F}{IL} = \frac{N}{Am}$

$1 meV = 10^6 \times 1.6 \times 10^{-19}$

$E = \frac{F}{q} = \frac{N}{C}$

$\frac{\Delta L}{L} = \frac{V}{L} = 1$

$I = 20$
$V = 220$
$f = 50$
$L = ?$

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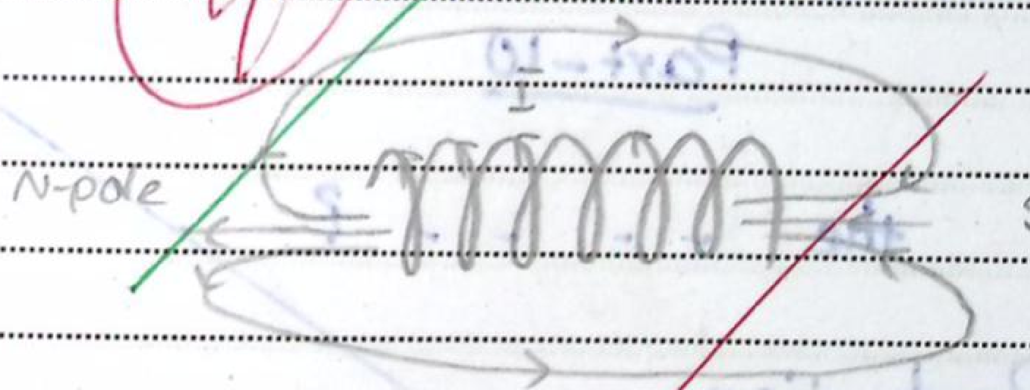
①

Orientation of Field:

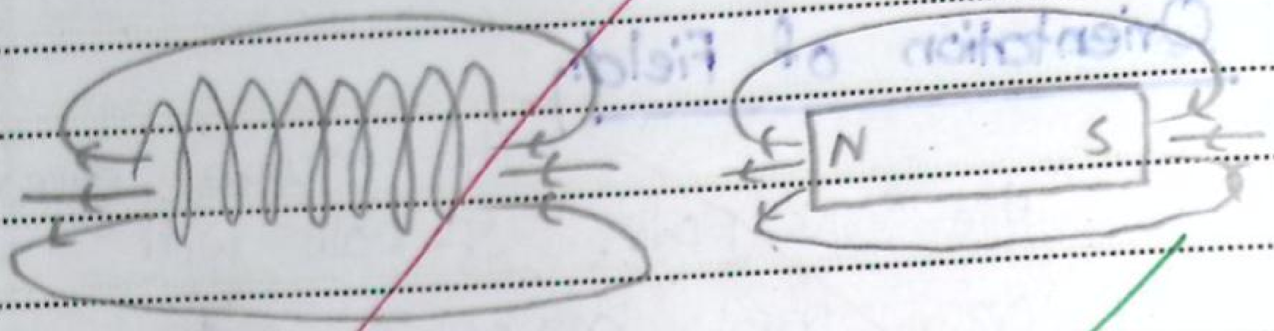
The thumb gives us the N-pole. S-pole will be on the opposite sides. Magnetic field lines will flow from N-pole to South-pole.



Similarity to Bar Magnet:

By comparing the field of coil with that of bar magnet, we see that they have the same orientation of magnetic field. Both have similar N-pole and S-pole.

therefore a current carrying coil acts like a bar magnet.



Part-10

Explain the - - - - ?

Pair Production:-

Introduction:- The phenomenon in which 2 photons interact and p

How are units of - - - ?

Electron Volt:

It is the energy gained or lost by an electron as it moves through a potential difference of 1V.

$$\Delta(K.E) = eV$$

Volt:

It is the difference in potential between 2 points A and B.

$$V = \frac{\Delta W}{q}$$

RELATION:

Electron volt is related to volt in such a way that it is the energy gained or lost by an electron as it moves through a potential difference of 1 volt.

Mathematically,

$$\Delta(K.E) = eV$$

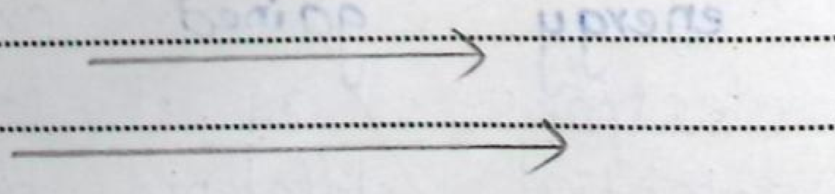
$$1eV = 1 \times 1.6 \times 10^{-19} \times VC$$

$$= 1.6 \times 10^{-19} J$$

1 electron-Volt = Charge on electron × potential difference.

Difference:

The electron volt is a unit of energy while volt is a unit of potential difference. They are different physical quantities.



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SECTION-C

Q.3

Part (a)

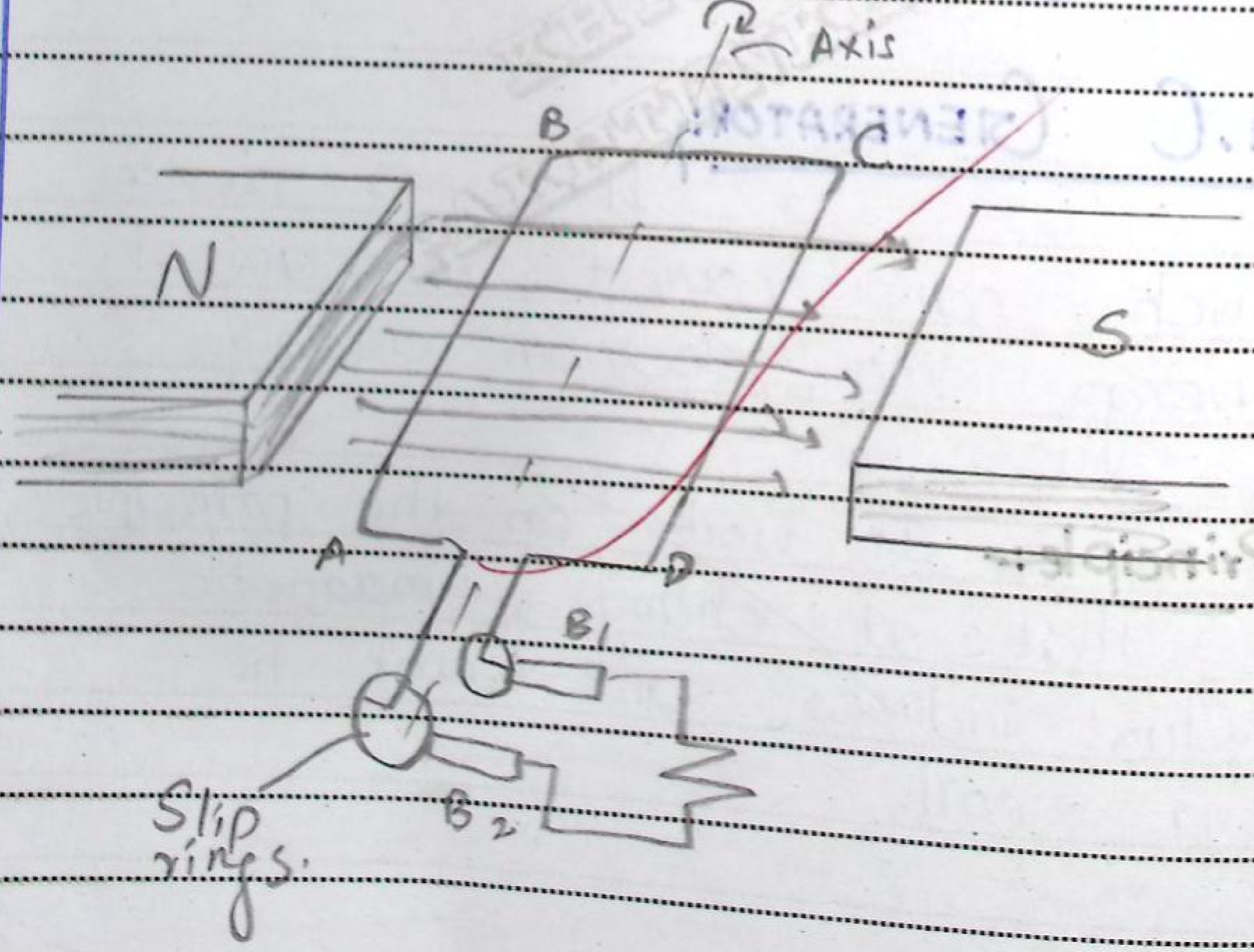
What is A.C Generator . . . . ?

A.C GENERATOR:- It is a device which can convert mechanical energy into electrical energy.

Principle:- It works on the principle that a changing magnetic flux induces an emf in a coil.

CONSTRUCTION:

It consists of 2 poles of magnet with uniform magnetic field. A coil of rectangular shape is placed b/w the 2 poles of magnet. The ends of the coil are connected to slip rings for AC generation. 2 Brushes are connected with the slip rings which provide AC to resistor.



Working:
The coil is rotated such that side AB moves upward and CD downward. The coil will experience a change in magnetic flux which will induce an emf in the coil. The direction of current, given by Flemming's right hand rule is from A to B and from C to D. After half rotation, CD will occupy the position of AB and AB will replace CD. The rotation is continued. The direction of current is now reversed i.e. from D to C and from B to A. Hence the polarity of emf is changing with each turn. Therefore, an AC is generated!

Formula Derivation:

Let the coil rotate with angular velocity ω, the flux is given by,

$$\phi = BAN \cos \theta$$

$$\phi = BAN \cos \omega t.$$

Induced emf is given by Faraday's law,

$$\varepsilon = -\frac{\Delta \phi}{\Delta t}$$

$$= -\frac{\Delta (BAN \cos \omega t)}{\Delta t}$$

B, A and N are constants, therefore.

$$= -BAN \left(\frac{\Delta \cos \omega t}{\Delta t}\right)$$

$$= -BAN \lim_{\Delta t \to 0} \left(\frac{\Delta \cos \omega t}{\Delta t}\right)$$

We know that,

$$\lim_{\Delta t \to 0} \frac{\Delta \cos \omega t}{\Delta t} = -\omega \sin \omega t$$

(3)

$$\varepsilon = -BAN(-\omega \sin\omega t)$$

$$\varepsilon = NAB\omega \sin\omega t$$

For ε_{max}, $\sin \omega t = 1$.

$$\varepsilon_{max} = NAB\omega$$

Current is given by,

$$I = \frac{\varepsilon}{R}$$

$$I = \frac{NAB\omega \sin\omega t}{R}$$

Part-b

Given:

$\Delta I = 5 A$

$\Delta t = 0.1 s$

$V/\varepsilon = 200V$

Required:

$L = ?$

Solution:

We know that,

$$\varepsilon = L \frac{\Delta I}{\Delta t}$$

$$L = \frac{\varepsilon \Delta t}{\Delta I}$$

$$L = \frac{200 \times 0.1}{5} H$$

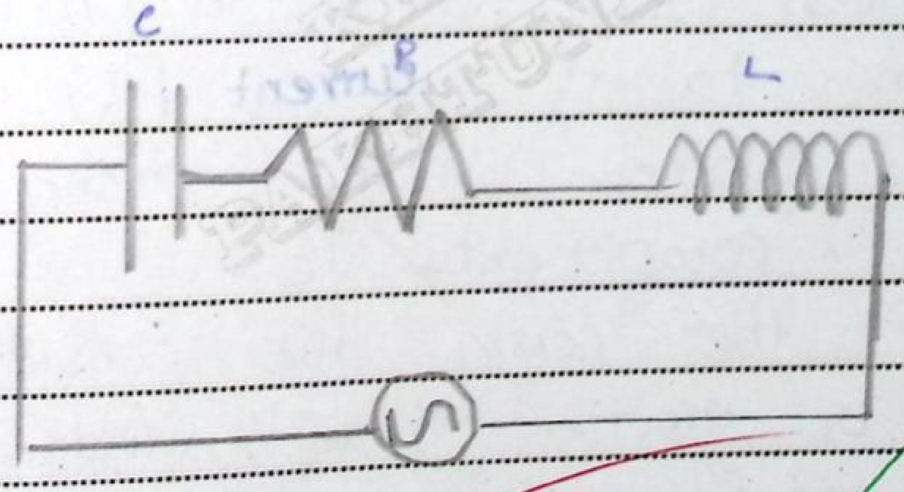
$$\boxed{L = 4 H}$$

Q. 5

Part-a

Describe RLC . . . . ?

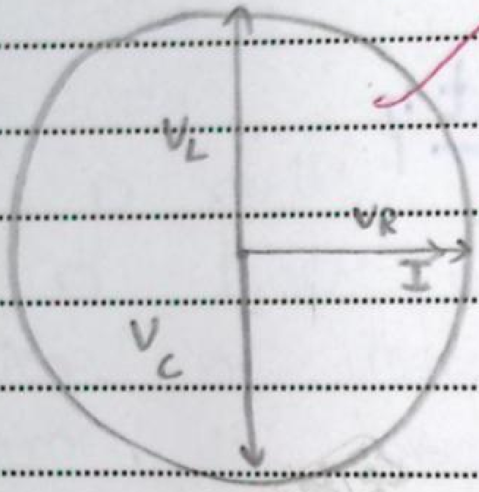
RLC Circuit: When a resistor, an inductor and a capacitor are connected in series with an AC source, it forms RLC series AC circuit.



In this circuit, the energy oscillates b/w capacitor and inductor, generating magnetic and electric fields.

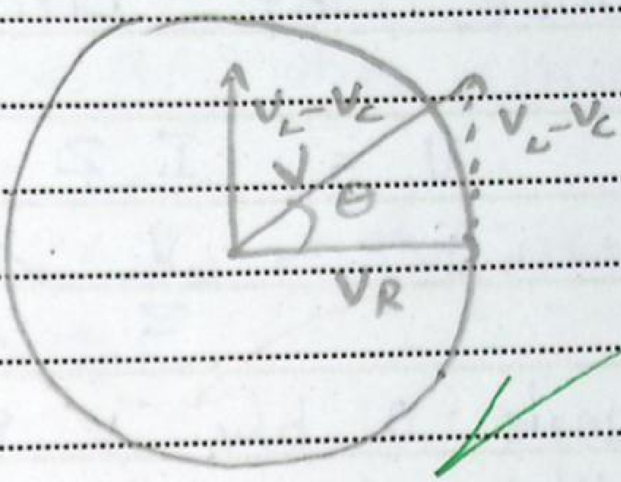
Phasor Diagram:

The phasor diagram for RLC circuit is given below,



It is clear that V_L is in phase opposition to V_C. current (I) is the common factor among the 3 components. To simplify the case, we consider V_L to be greater than V_C, under such conditions, the circuit is inductive. We take the different of V_L & V_C to obtain V, and impedance triangle.

(4)



From impedence triangle, it is clear that Voltage (V) is phasor sum of $V_L - V_C$ & V_R.

$$\sqrt{V^2} = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{(IR)^2 + \{(IX_L) - (IX_C)\}^2}$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

The term, $\sqrt{R^2 + (X_L - X_C)^2}$ is the impedence 'Z' of the circuit. It is the total resistance of circuit.

$$V = I Z$$

$$I = \frac{V}{Z}$$

The angle θ b/w V & V_R can be calculated as,

$$\tan\theta = \frac{V_L - V_C}{V_R}$$

$$= \frac{IX_L - IX_C}{IR}$$

$$\tan\theta = \frac{X_L - X_C}{R}$$

The power factor, cos θ, is calculated as,

$$\cos\theta = \frac{V_R}{V} = \frac{IR}{IZ}$$

$$\cos\theta = \frac{R}{Z}$$

Cases:-

1) When $X_L > X_C$, the circuit is inductive.
2) When $X_L < X_C$, the circuit is capacitive.
3) When $X_L = X_C$, the circuit is resistive.

Power loss:-

In an RLC circuit, the power loss is due to resistor in the circuit.

$$P = VI \cos\theta$$

5

Part-b

Given:

$1\,U = 1.66 \times 10^{-27}\,kg$

$1\,U = 931.5\,MeV$

Required:

Proof for above equations.

Solution:

We know that,

6.023×10^{23} atoms of C-12 = 12g

1 atom of C-12 $= \frac{12g}{6.023 \times 10^{23}}$

1 atom of C-12 $= \frac{12g}{6.023 \times 10^{23}} \times \frac{1kg}{1000g}$

12 u of C-12 $= \frac{12}{6.023 \times 10^{23} \times 1000}\,kg$

1 u of C-12 $= \frac{12}{12 \times 6.023 \times 10^{23} \times 1000}\,kg$

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$1\ u$ of $C-12 = 1.66 \times 10^{-27}$ kg

$1\ u = 1.66 \times 10^{-27}$ kg

Conversion to MeV;

$(\Delta m_o)c^2 = 1.66 \times 10^{-27} kg \times (3 \times 10^8)^2 m^2 s^{-2}$

$= 1.49 \times 10^{-10}$ J

Dividing by charge of electron,

$1u = \frac{1.49 \times 10^{-10}}{1.6 \times 10^{-19}}$ eV

$= 931250000$ eV

$= 931.25 \times 10^6$ eV

$= 931.25$ MeV

Q-6

Part-a

Derive an expression....

Derivation:-

We know that,

$$E = -\frac{\Delta V}{\Delta r}$$

$$= -\frac{(V_2 - V_1)}{d} \quad \text{let } \Delta r = d$$

$$= \frac{V_1 - V_2}{d}$$

$$E = \frac{V}{d}$$

Consider a capacitor connected to a DC circuit, electric field at a point is given by,

$$E = \frac{\sigma}{A\varepsilon_0} = \frac{Q}{A\varepsilon_0}$$

Equating,

$$\frac{Q}{A\varepsilon_0} = \frac{V}{d}$$

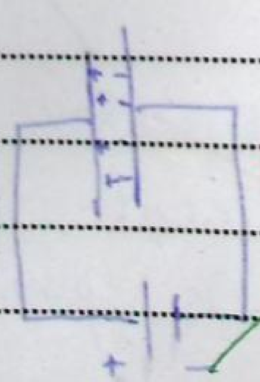
$$Q = \frac{VA\varepsilon_0}{d}$$

$$\frac{Q}{V} = \frac{A\varepsilon_0}{d}$$

$$C = \frac{A\varepsilon_0}{d}$$

For a capacitor in which a material is present b/w the plates, Capacitance is given by.

$$C_{med} = \frac{A\varepsilon_0\varepsilon_r}{d}$$



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Part-b

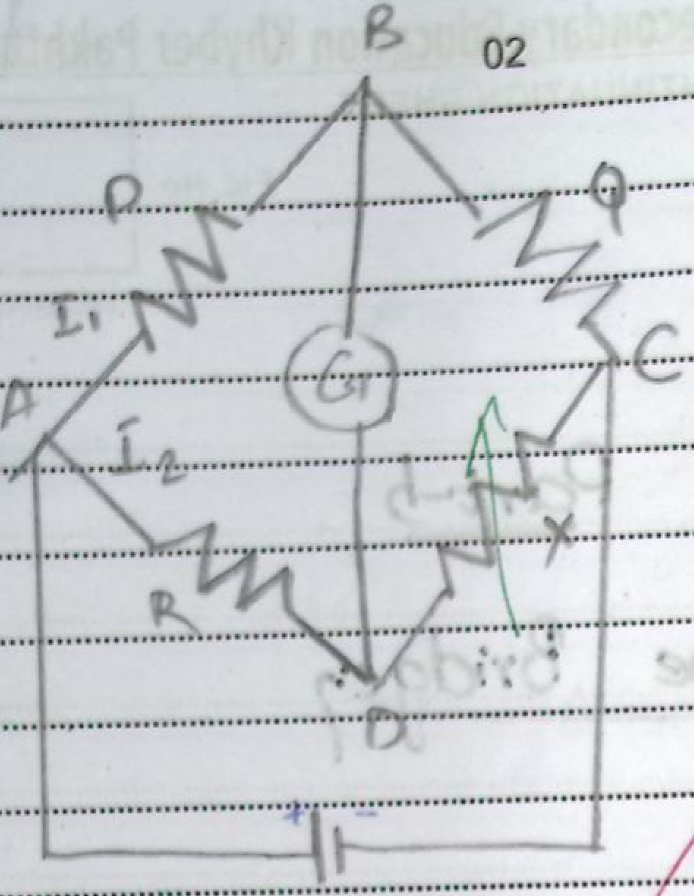
Wheatstone Bridge:-

Introduction:-

It is an apparatus used to find the unknown resistance in circuit.

Construction:-

In this circuit, 4 resistors are used (P, Q, R, X). P & Q are known, R is variable, X is unknown & to be found. The connection is shown in the diagram.



Across A & C, voltage source is connected. Across B & D, Galvanometer is connected. When circuit is closed, current I divides b/w the 2 paths, We vary resistance 'R' till the galvanometer shows zero deflection. This point is called null point and the bridge is said to be balanced. At balanced state, potential drop across AB is equal to PD across AD

I_1 & I_2 flows in P & R respectively,

$$I_1 P = I_2 R \quad \text{— (1)}$$

The potential drop across BC is equal to p.drop across DC. Because the galvanometer shows zero deflection, thus point B and D are at same potential.

$$I_1 Q = I_2 X \quad \text{— (2)}$$

Taking the ratios of eq. (1) and eq. (2),

$$\frac{\cancel{I_1} P}{\cancel{I_1} Q} = \frac{\cancel{I_2} R}{\cancel{I_2} X}$$

$$\frac{P}{Q} = \frac{R}{X}$$

$$X = \frac{QR}{P}$$

Thus the unknown potential can be calcuted using wheatstone bridge.