Section - B

Short Questions

Question : No : viii

Answer:

Affect of dubling Frequency :-

By doubling frequency, the inductive reactance (X_L) of an inductor will increase two times i.e, it will also become double

(a) As an inductor

⇒ **Explanation:**

As inductive reactance X_L is given by the following equation

$$X_L = 2\pi f L \rightarrow (1)$$

By doubling the frequency, the new reaactance is:

$$X'_L = 2\pi f' L$$

As $f' = 2f$ putting in above equation $X'_L = 2\pi(2f)L$

$$\Rightarrow X'_L = 2(2\pi f L)$$

As $2\pi f L = X_L$, putting in above eq.

$$X_L = 2X_L$$

Thus by doubling frequency f, inductive reactance X_L will also become double.

(b) **By doubling frequency :-**

By doubling frequency, the capacitive reactance (X_c) of a capacitor will decrease two times i.e it will become half.

Explanation:

Capacitive reactance X_c is given by the equation:

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

By doubling the frequency f, the new reactance is:

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

As $f' = 2f$, Putting in above eq.

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

$$\Rightarrow X'C = \frac{1}{2(2\pi fC)}$$

$$\Rightarrow X'C = \frac{1}{2}\frac{1}{(2\pi fC)}$$

$$\Rightarrow X'C = \frac{1}{2} X_C$$

So, by doubling the frequency, capacitive reactance X_C will become half.

Question: No: iv

Answer:-

Volt:- Volt is the unit

of electric potential, potential difference or electromotive force (e.m.f) defined as the difference of potential between two points on aconductor carrying a constant current of one ampere when the power dissipiated between the points in one watt. It is named after Alessandro Volta to honour him.

Electron Volt:

eV is the unit of energy. One eV is equal to the amount of energy that an electron acquiers by accelerating (from rest) through a potential difference of one volt. It is usually used as a measure of particle energies although it is not an SI unit. The S.I unit of energy is joule.

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

It may help to relize that the electric potential is a properly associated with the field in the space, while the energy is associated with the particle you place into that field and it depends on the particle.

Difference :

Volt and electron - volt are two different physical quantities. Electric potential is a property associated with the field, while the energy is associated with the particle you place into that field and it depends on the particle.

Question : NO: ix

Answer:

Soft Magnetic Materials:

Materials with narrow magnetic hysterisis loop are easily magnetized and demagnetized and are called soft magnetic materials.

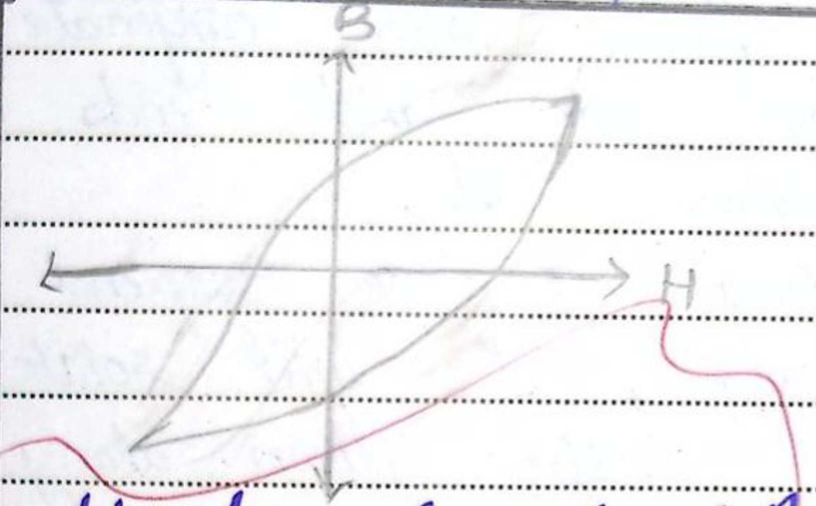
Explanation: Soft materials have narrow hysterisis loop; thus they possess small amount of residual magnetism and to overcome less coercive force is required. Work must be done in closing hysterisis loop and it is dissipiated in the form of heat. Thus due to small area less energy is dissipiated in the form of heat.

Soft Magnetic Material

Hard Magnetic Materials :-

Materials with broad magnetic hysterisis loop are difficult to magnetize and demagnetize ande are called hard magnetic materials.

Explanation: Hard materials have fat hysterisis loop, thus they possess large amount of residual magnetism and to overcome large coercieve force is required. Thus once magnetized they stay magnetized as substantial magnetic flux density remains.



Hard Magnetic Material

Question NO : Vii

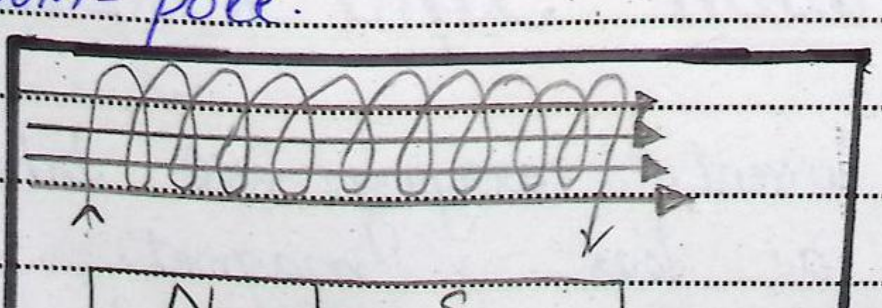
Answer:

Reason And Explanation:

A current carrying coil behaves like a bar magnet.
Considere a coil as shown in

the figure. When current passess through the coil, a uniform magnetic field is produced inside the turns of the coil. The magnetic field lines originate from one side and ends at the other side.

Now if we suspend the coil freely, it will rotate and will settle down along North-South direction. As the earth's magnetic field exisist along north-South direction. As the earth's. So the current carrying coil behaves like a bar magnet. Its one end behaves like a North-pole and the other end behaves like a South-pole.



Question No: 1

Answer:

Given Data:

Charge $= q = 3\,\mu C = 3 \times 10^{-6} C$

distance $= 30\,cm = \frac{30}{100} m = 30 \times 10^{-2} m$

Required:

Electric field $E = ?$

Solution:

We know that.

Formula: $E = \frac{kq}{r^2}$, where $k = 9 \times 10^9$

$$E = \frac{(9 \times 10^9)(3 \times 10^{-6} c)}{(30 \times 10^{-2})^2}$$

$$E = \frac{27 \times 10^3}{900 \times 10^{-4}}$$

$$E = 0.03 \times 10^3 \times 10^4$$

$$E = 3 \times 10^5 \ N/C$$

Question no: iii

Answer:

Dielectric: An insulating material that becomes polarized in an electric field.

Dipole: A pair of equal and opposite charges separated by a small distance.

Dipole Moment: A vector quantity defined as $\vec{p} = q \cdot \vec{d}$, where q is charge and $\vec{d}$ is the separation.

Polarization: The alignment of electric dipoles within a dielectric when placed in an electric field.

Question NO: xi

Answer:

β-Factor in Terms of α-Factor:-

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

Here $I_B = I_E - I_C$, so eq (1)

$$\Rightarrow \beta = \frac{I_C}{(I_E - I_C)} \longrightarrow (2)$$

$$\Rightarrow \beta = \frac{I_C}{I_E\left(1 - \frac{I_C}{I_E}\right)} \longrightarrow (3)$$

$\Rightarrow \frac{I_C}{I_E}$ = alpha factor = α, so eq (3)

$$\Rightarrow \boxed{\beta = \frac{\alpha}{(1-\alpha)}}$$

Question NO: XII

Answer:-

For same De-Broglie wavelength the speed of electron will be greater than the speed of proton.

Reason And Explanation

We know that the De-Broglie wavelength is given by;

$$\Rightarrow \lambda = \frac{h}{mV} \quad \text{——— eq. 1}$$

For electron, eq (1) can be written as,

$$\Rightarrow \lambda = \frac{h}{m_e V_e} \quad \text{——— eq 2}$$

For proton eq (1) can be written as.

$$\Rightarrow \lambda_p = \frac{h}{m_p V_p} \quad \text{—— eq 3}$$

For same De-Broglie wavelength, we have

$$\Rightarrow \lambda_e = \lambda_p$$

$$\Rightarrow \frac{h}{m_e V_e} = \frac{h}{m_p V_p}$$

$$\Rightarrow m_e V_e = m_p V_p$$

$$\Rightarrow V_e = \left(\frac{m_p}{m_e}\right) V_p \quad \text{——} \quad (4)$$

As mass of proton is greater than mass of electron.

$$m_p > m_e$$

$$\frac{m_p}{m_e} > 1$$

so eq (4) becomes

$$\Rightarrow \boxed{V_e > V_p}$$

Thus for same De-Broglie wavelength the speed of electron will be greater than the speed of electron.

Question : No: II

Answer:

Relation between electric field and Potential Gradient :-

Let us consider a uniform field, for which the lines of force are parallel and equidistance from each other. Let A and B be two-points which are very close to each other so that the electric field intensity is almost constant as shown

The work done in moving the charge from plate A to B against the electric field is given by;

$$Work = W_{AB} = \vec{F} \cdot \vec{\Delta r} = F \Delta r \cos\theta \rightarrow (1)$$

As the electric force acting on the charge is $Eq_{\circ}$, so in order to move the charge against electric field uniformly, a force equal in magnitude but opposite in direction must applied on the charge i.e $F = -Eq_{\circ}$

Putting values in Eq (1), we get

$$W_{AB} = -Eq_{\circ} \Delta r \cos 0^{\circ} \quad \because \cos 0^{\circ} = 1$$

$$W_{AB} = -Eq_{\circ} \Delta r$$

$$\frac{W_{AB}}{q_{\circ}} = -E\Delta r$$

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

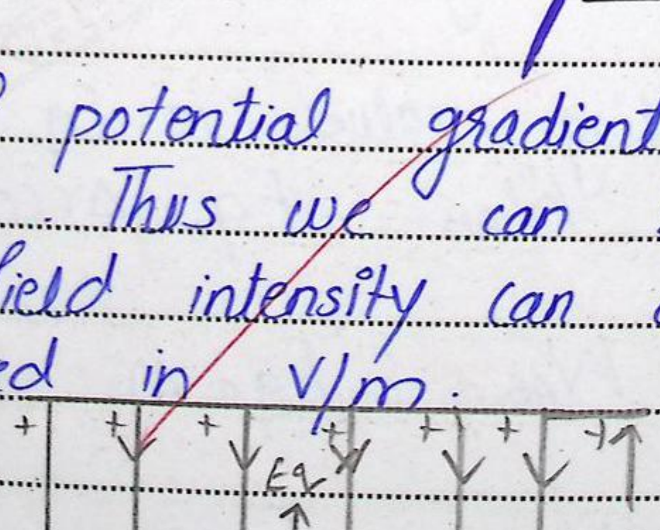
$$\frac{\Delta V}{\Delta r} = -E$$

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

The negitive sign shows that the change in potential decreases in the direction of electric field. Thus the electric field intensity is equal to the negitive of potential gradient.

Unit of Potential Gradient

The unit of potential gradient is volt/meter. Thus we can say that electric field intensity can also be measured in V/m.



Question : No: V

Answer:

Ohm's Law:

Statement: This law states "the magnitude of the current in metals is proportional to the applied voltage if the physical state of the conductor remains unchanged."

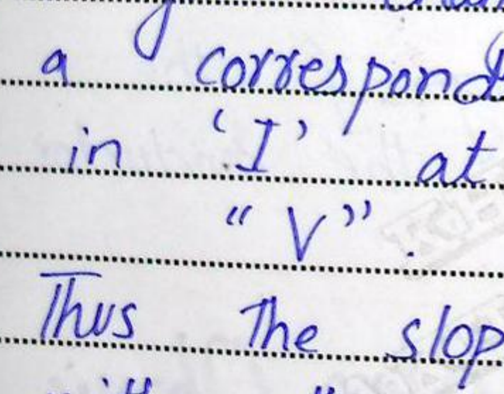
Ohmic And Non-Ohmic Conductor:

The ohm's law is not valid for all conducting materials. Those materials for which the slope of "I" verses "V" graph is not constant are called non-ohmic material.

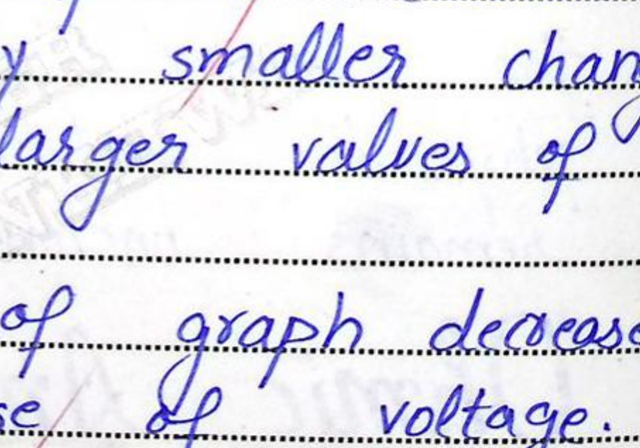
For Example:

The filament of an electric bulb behaves like non-ohmin conductor. The I-V graph for a filament bulb shows that the graph bends over as 'V' and 'I' increases. It shows that a given change of 'V' causes a correspondingly smaller change in 'I' at larger values of "V".

Thus the slope of graph decreases with the increase of voltage.



Filament Bulb



SECTION - C

LONG QUESTIONS

Question No: 6

Answer:

Part (a)

(a) Considere a parallel plate capacitor as shown in the figure. Let the medium between the plates is air and "d" be the distance between the plates. Now we know that,

$$Q = CV$$

$$C = \frac{Q}{V} \quad \text{--- eq (1)}$$

We also know that,

$$V = Ed \quad \text{--- eq (2)}$$

Putting eq (2) in eq (1), we get,

$$C = \frac{Q}{Ed} \longrightarrow \text{eq (3)}$$

For two oppositely charged parallel plates; we have,

$$E = \frac{\sigma}{\varepsilon_0} \longrightarrow (4)$$

Putting eq (4) in eq (3)

$$C = \frac{Q\varepsilon_0}{\sigma d} \quad \text{--- (5)}$$

Here 'σ' represents the charge per unit area, so we have,

$$\sigma = \frac{Q}{A} \Rightarrow Q = \sigma A \quad \text{--- (6)}$$

Putting eq (6) in eq (5), we get

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

$$\Rightarrow \boxed{C = \frac{A \varepsilon_0}{d}} \longrightarrow 7$$

Equation (7) represents the capacitance of a parallel plates capacitor having air as medium between its plates.

(b) When medium is Dielectric

In case of dielectric medium, we replace "ε_0" by "ε", so eq (7) becomes,

$$\Rightarrow C = \frac{A\varepsilon}{d} \quad \text{---} (8)$$

Eq (8) represents the capacitance of a parallel plate capacitor having dielectric medium between their plates.

Comparison of "C" and "C'":

In order to compare "C" and "C'" we introduce relative permitivity "ε_r", which is given by,

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \Rightarrow \varepsilon = \varepsilon_r \varepsilon_0 \longrightarrow (9)$$

Putting eq (9) in eq (8), we get.

$$C' = \frac{A\,\varepsilon_r \varepsilon_0}{d}$$

$$C' = \varepsilon_r \left[\frac{A\varepsilon_0}{d} \right] \longrightarrow (10)$$

Putting eq (7) in eq (10), we get

$$\boxed{C' = \varepsilon_r C}$$

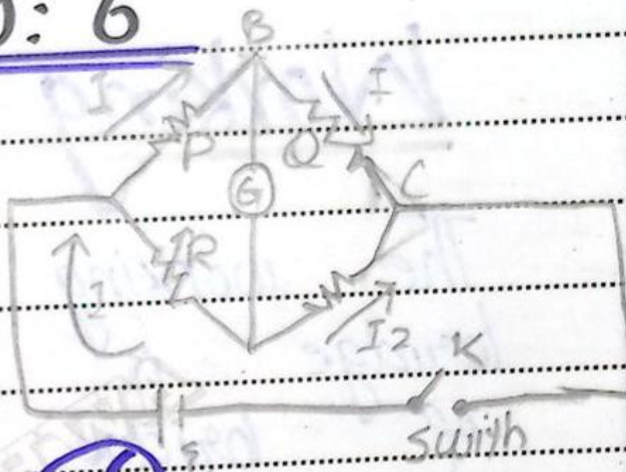
As for dielectric medium, we have $\varepsilon_r > 1$ eq (11) can be also written as,

$$\boxed{C' > C}$$

Question : No: 6

Answer:

Part (b)



Wheatstone Bridge:

Definition: A simple circuit which is used to measure an unknown resistance precisely and accurately is called as Wheatstone bridge.

Construction: The bridge was designed by a Professor Charles Wheatstone (1802-1875)

The circuit diagram of Wheatstone bridge is shown in figure. Four resistance P, Q, R and X are arranged in such a way that they from a closed loop.

Working Principle:

The working of Wheatstone bridge is based on the balancing of bridge The resistance are arranged in such away that there is no current present b/w B and D.

$$I_1 P = I_2 R \longrightarrow (1)$$

Similarly potential drop across BC is equal to potential.

$$I_1 Q = I_2 X$$

Dividing eq 2 by eq 1

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

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

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

Thus by knowing the values of resistance P, Q and R the value of unknown resistance X can be determined.

Question : No: 3

Answer: Part (a)

Alternating Current Generator:

Definition: The device which converts mechanical energy into electrical energy of the form in which the flow of electric charges periodically reverses direction.

Working Principle:

The working of an electric generator is based on Faraday's law of electromagntic induction. The emf generated is dynamically induced emf.

Construction:

It consists of coil CDEF, two slip rings and two carbon brushes. When the coil CDEF rotates between the poles of a magnet, an electromotive force is induced. The current flows through the external circuit.

Current direction is reversed i.e it is form F to E and D to C. The current now enters the circuit at B and leaves B.

Part (b)

Given Data:

Initial current $= I_i = 5A$

Final current $= I_f = 0A$

Change in time $= \Delta t = 0.1s$

Change in current $= \Delta I = (I_f - I_i)$

$= (0-5) = -5A$

Self inductance emf $= \mathcal{E} = 200$ Volts.

Required: Self inductance = ?

Calculation: We know that.

$$\Rightarrow \mathcal{E} = -L\frac{\Delta I}{\Delta t}$$

$$\Rightarrow L = \frac{-\mathcal{E}\Delta t}{\Delta I}$$

$$\Rightarrow L = \frac{-(200) \times (0.1)}{-5}$$

$$\Rightarrow L = \frac{-20}{-5}$$

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

Fic. No. 55

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Question : No: 5

Answer: Part (a)

* Many circuits used in pracical electronics involve resistors, inductors & capacitiors. We would like to find the impedance of the circuit as a whole, the current that flows & the phase differenece b/w sources voltage & current.

→ The V_R across R is in phase which I. The voltage V_L across L leads on I by 90° where as V_C lags behind I by 90°. V_L & V_C are there fore 180°

out of Phase. If V_2 is greater than V_c.

$$V = V_R + (V_1 - V_c)^2$$

But

$V_2 = I R$, $V_2 = X_2$ & $V_c = I X_c$ Hence

$$V_2 = I R + (X_1 - X_2)$$

$$\therefore V = I \sqrt{R^2 + (X_1 - X_1)^2}$$

* The impendance of the RCL Series Combination is given below:

$$Z = \frac{V}{I} = \sqrt{R^2 + (X_2 - X_c)^2}$$

* The Phase angle by which I legs behinds V is given by:

$$\tan \phi = \frac{V_1 - V_c}{V^2} \times \frac{X_1 - X_c}{R}$$

Also

$$\cos \phi = \frac{V_2}{V} = \frac{IR}{IZ} = \frac{R}{Z}$$

→ Because the resestance x_L & x_C depend on the frequency $\omega = 2\pi f$, of the source the impedance Z of the circuit of LCR circuit will depend on the frequency f of the source. The current will become miximum at a paricular frequency f_0 when the term $(x_L - x_C)$ in the denominator of eq. becomes true when.

$$\Rightarrow X_L = X_C \Rightarrow 2\pi FL = \frac{1}{2\pi fc}$$

$$\Rightarrow 4\pi^2 f^2 LC = 1$$

$$\Rightarrow f^2 = \frac{1}{4\pi^2 LC} \qquad \Rightarrow f_0 = \frac{1}{2\pi\sqrt{LC}}$$

→ This frequency is called Resonance frequency.

Q No: 5(b):

Ans:- Mass of 6.02×10^{26} atom of ${}_6C^{12}$ = 12 kg.

$\Rightarrow$ Mass of 1 atom of C_6^{12} = $\frac{12}{6.02\times10^{26}}$ kg.

$\Rightarrow$ Mass of $\frac{1}{12}$th atom of ${}_6C^{12}$ = $\frac{1}{12}\times\frac{12}{6.02\times10^{26}}$ kg.

$\Rightarrow$ $1U = 1\,a.m.u = 1.66\times10^{-27}$ kg.

* Unit of energy in terms of amu:

* In atomic & nuclear physics, the mass is often expressed

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CONTINUATION SHEET

Fic. No. 55

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Q No 8 (b)

in the energy. So by Einstein's energy mass equivalance equation $E = mc^2$.

$E = (1.66\times10^{-27} kg)(3\times10^{8} m/s)$

$= 1.49\times10^{-10} J.$

Since

$\Rightarrow 1 eV = 1.60\times10^{-19} J$

$\Rightarrow 1 J = \frac{1}{1.60\times10^{-19}} eV$

So

$E = 1.49\times10^{-10} \times \frac{1}{1.60\times10^{-19}} eV$

$= 931 MeV.$

→ This is evivalant to
1 amu or 1u.
So
1 amu or 1U = 931 Mev