# SECTION - B

## Part (i) :-

Given :-

$r = 30\,cm = 0.3\,m$

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

$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ Nm^2$

Find :-

$E = ?$

**Solution :-**

As we know,

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

$E = \frac{(9 \times 10^9)(3 \times 10^{-6})}{(0.3)^2}$

$E = 3 \times 10^5\ NC^{-1}$

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## Part (ii) :-

# POTENTIAL GRADIENT :-

When a charge is placed in an electric field it moves from low potential to high potential thus work done is,

$W = -F \cdot \Delta r$ ∴ (- sign indicates that work is done against the field.

As $F = qE$

$W = -q_o E \Delta r$

Also, $E = -\frac{W}{q_o \Delta r}$ ∴ $V = \frac{W}{q}$

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

This is called potential gradient.

"The rate of change of potential different with respect to distance"



## Part (iv)

## Volt and electron volt :-

Volt is the unit of potential difference which is given as,

$V = \frac{W}{q} = JC^{-1}$ or volts.

Whereas the electron volt is the unit of energy.

$$E = (1e)(1V)$$

$$E = (1.607 \times 10^{-19})(1V)$$

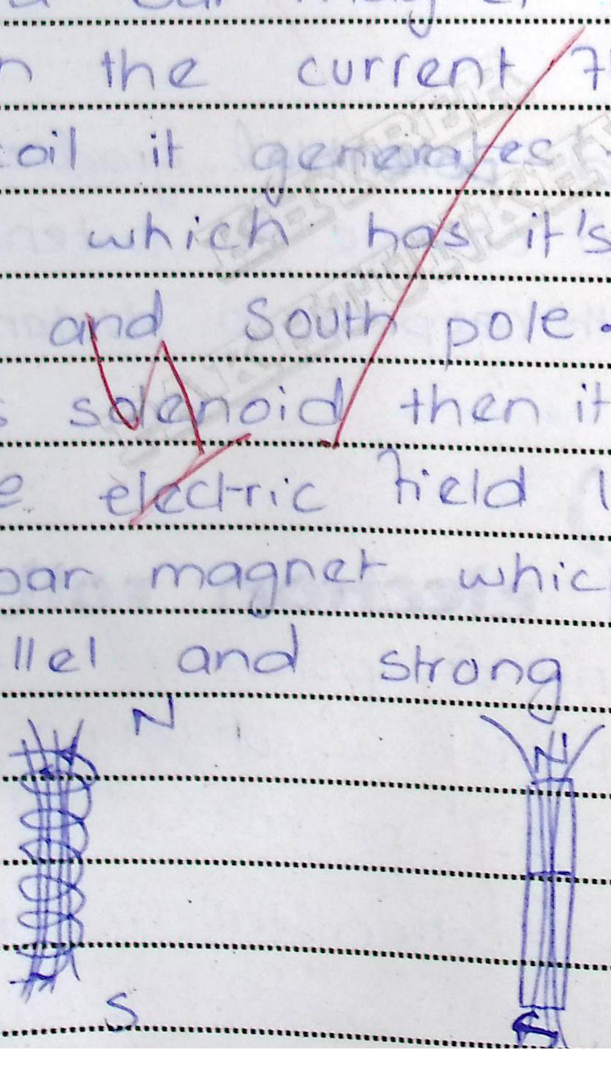
$$1eV = 1.607 \times 10^{-19} J$$

These both are related as eV is equal to Volt times the charge.

## Part (vii) :-

### Current carrying coil :-

The current carrying coil behaves like a bar magnet because when the current flows into the coil it generates magnetic field which has it's own North and South pole. If the coil is solenoid then it has the same electric field lines like a bar magnet which are parallel and strong inside.



Thus the current carrying coil is capable of attracting and repulsing the opposite or same poles respectively.

## Part (viii)

## Reactance of Inductor:

The opposition to the flow of current by an inductor is called inductance or reactance of inductor, which is given as,

$$X_L = \omega L$$

or $X_L = 2\pi f L$ ∴ $(\omega = 2\pi f)$

Doubling frequency.

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

$$X_L = 4\pi f L$$

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

$$X_L = 2X_L$$

Thus, the inductance is doubled.

## Reactance of Capacitor:

The opposition offered to the current while flowing through a capacitor is called reactance of capacitor "$X_C$".

This is given as,

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

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

Doubling 'f'

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

$$X_C = \frac{1}{4\pi f C} \quad \text{or} \quad X_C = \frac{1}{2(2\pi f C)}$$

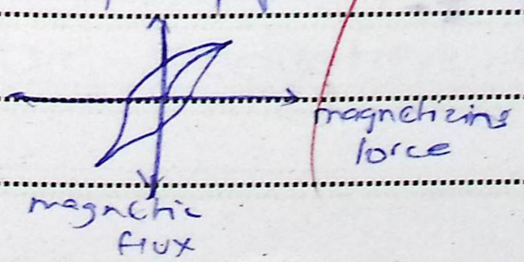
$$X_C = \frac{1}{2} X_C$$

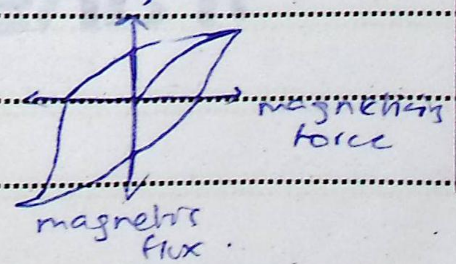
Thus doubling frequency reduces the reactance to half.

**Part (ix)**

**Difference :-**

| Soft Magnetic material | Hard magnetic material |
|---|---|
| Soft magnetic materials have thin hytersis loop | Hard magnetic materials have thick / fat hytersis loop. |
| Easily magnetized and demagnetized | Difficult to magnetize and demagnitize. |
| It requires less coercive force | It requires more coercive force. |
| It is used as temporory magnet | It is used as permanent magnet. |
| For example, zinc, copper | For example, steel, iron. |



## Part (x) :-
### Coercive force of steel and Iron :-

Coercive force of steel is greater than iron which means that large coercive force is required to demagnitize steel whereas iron requires less coercive force this is because of the larger retentivity of steel than Iron as, when we reduce magnetizing force to zero it has greater number of atoms aligned than Iron. In order to demagnitize or random it's atom, steel requires a large coercive force.

## Part (xi)
### Transistor :-

For a transistor we know that

$$I_E = I_B + I_C$$

As $I_E$ is divided into $I_B$ and $I_C$. Also

$$\alpha = \frac{I_C}{I_E} \quad \text{— (i)} \quad \text{and} \quad \beta = \frac{I_C}{I_B} \quad \text{— (ii)}$$

From (ii)

$$\beta = \frac{I_C}{I_B} \quad \text{or} \quad \beta = \frac{I_C}{I_E - I_C} \quad \because \left[\begin{array}{l} I_E = I_B + I_C \\ I_B = I_E - I_C \end{array}\right]$$

Dividing each term by $I_E$

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

$$\beta = \frac{\alpha}{1-\alpha} \quad \because \frac{I_C}{I_E} = \alpha$$

4

The above equation shows the relation between $\alpha$ and $\beta$.

## Part (xiii):-

## Pair Production :-

Pair Production is defined as :-

" The production of particle and anti-particle, usually when photon passes by nucleus it gives of electron and positron, is known as pair production".

$$\gamma \rightarrow e^- + e^+$$

when $\gamma$ passes by nucleus it produces $e^-$ and $e^+$. single electron can't be produced because this will violate the law of conservation energy. large nucleus is required to conserve the momentum. energy of $\gamma$ and $e^+, e^-$ is given as.

$$\because [E = m_o c^2]$$

$$hf = 2m_o c^2$$

By putting values,

$$hf = 2(9.1\times10^{-31})(3\times10^8)^2$$

$$E = 1.02 \text{ MeV}$$

Thus energy of 1.02 MeV of photon is required to produce.

$e^+$ and $e^-$.

**Part (xii):-**

Electron will have greater speed although the wavelength of electron and proton are same. According to de-Broglie.

$$\lambda = \frac{h}{p} \quad \text{or} \quad \lambda = \frac{h}{mv}$$

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

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

As $m_e << m_p$, so. electron will move at greater speed with same wavelength as proton.

# SECTION - C

## Question No 3 :- 9

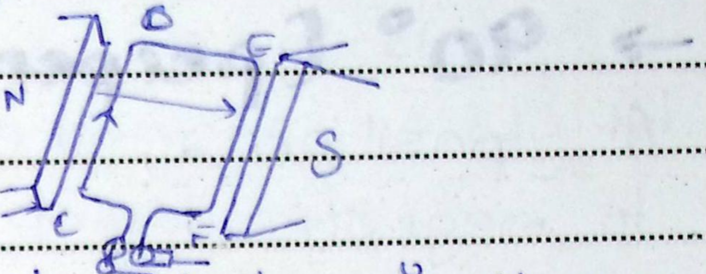
### A·C generator :-

Generator is a device which converts mechanical energy into electrical energy.

A·C Generator works on the principal of motionally induced emf. It produces alternating current when a coil rotates in uniform magnetic field.

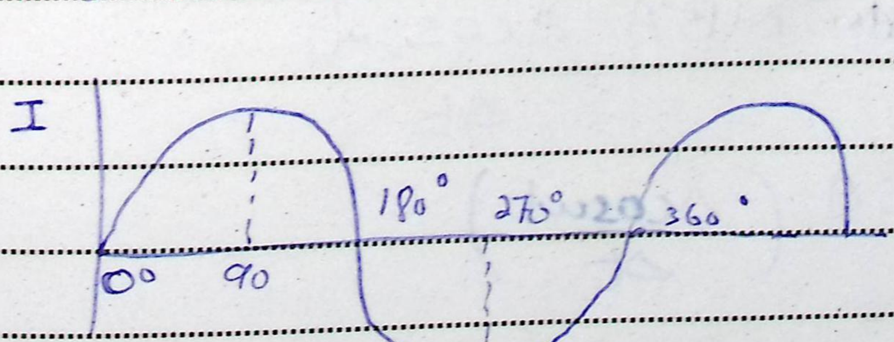
### Construction :-

In A·C generator a coil CDEF is placed between a uniform magnetic field of magnetic. At the ends there as split rings with carbon-brushes which help to collect the alternating current in the coil.




**Working:-**

when the coil rotates in the uniform magnetic field the flux linking to it changes which induces emf in the coil. Thus when the coil completes it's one rotation the direction of current is changed thus alternating current is produced. It's direction can be determined by using flemmings left hand rule. thus it's sinusodial graph is given as,



to magnetic field
∥ $0°$

→ **0° [parallel]**

At position 1 the coil is parallel thus current induced is zero

→ **90° [perpendicular]**

At position 2 the coil is perpendicular to magnetic field 90° thus current is maximum

Thus a wave is created with varying magnitude.

**Mathematically :-**

$\phi = BA\cos\theta$

For N turns:

$\phi = NBA\cos\theta$

For induced emf.

$\mathcal{E} = -\frac{\Delta\phi}{\Delta t} = -\frac{\Delta NBA\cos\theta}{\Delta t}$ ∵ -ive sign due to lenz law

As $\theta = \omega t$

$\mathcal{E} = -\frac{NBA\,\Delta\cos\omega t}{\Delta t}$

$\mathcal{E} = -NBA\left(\frac{\Delta\cos\omega t}{\Delta t}\right)$

$\mathcal{E} = -NBA(-\omega \sin\omega t)$

$\mathcal{E} = NBA\omega \sin\omega t$.

Thus Induced emf generated by A.C generator can be calculated by using above equation.

**Part (b):-**

Given:-

$\Delta I = 0A - 5A = -5A$

$\mathcal{E} = 200V$ , $t = 0.1s$

$L = ?$

**Solution:-**

As we know,

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

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

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

$L = -4\ H$

# QUESTION NO 4 :-

## Part (a) :-

## Bohr's Postulates :-

The following are the postulate of Bohr atomic model,

i) Electrons revolve around a nucleus in circular orbil. The required centripetal force is provide by colowbs force:

$$\frac{mv^2}{r} = k\frac{e^2}{r^2}$$

ii) The electrons orbit only on those orbits whose angular momentum is integral multiple of $\frac{h}{2\pi}$.

$$L = n\frac{h}{2\pi} \Rightarrow mvr = \frac{nh}{2\pi}$$

iii) Electron while revolving around the neucleus do not radiate energy but they emit or absorb energy when they jump from higher to lower orbit or lower to higher orbit. The radiated energy is equal to hf.

$$hf = E_n - E_1$$

## Derivation of radii :-

According to Bohr's,

$$\frac{mv^2}{r} = k\frac{e^2}{r^2}$$

$$mv^2 = \frac{ke^2}{r} \quad \text{— (i)}$$

Also from second postulate:

$$mvr = \frac{nh}{2\pi}$$

$$v = \frac{nh}{2\pi mr}$$

Putting in (i)

$$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{ke^2}{r}$$

$$m\left(\frac{n^2h^2}{4\pi^2m^2r^2}\right) = \frac{ke^2}{r}$$

$$\frac{n^2h^2}{4\pi^2 mr} = ke^2$$

$$\frac{n^2h^2}{4\pi^2 mke^2} = r$$

$$r = n^2\left(\frac{h^2}{4\pi^2 mke^2}\right)$$

$$r = n^2\left(\frac{6.026\times10^{-34}}{4(3.14)^2(9.11\times10^{-31})(9\times10^{9})(1.67\times10^{-19})}\right)$$

$$r = n^2\left(0.53\times10^{-10}\right)$$

5+1

**Part (b) :-**

$n = 4$

$$\frac{1}{\lambda}a = R_H\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

$$\frac{1}{\lambda} = 1.096\times10^{7}\left(\frac{1}{(3)^2} - \frac{1}{(4)^2}\right)$$

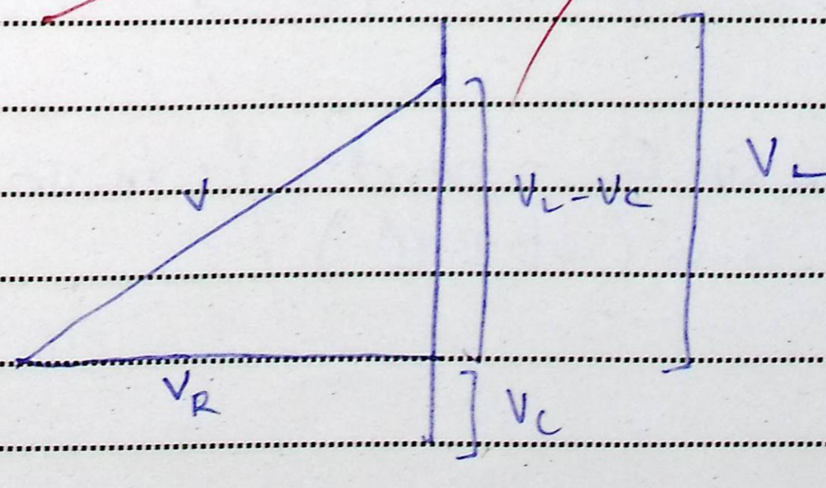
$$\frac{1}{\lambda} = ~~1.?46\times10^{07}~~$$

$$\lambda = 18.86\times10^{-7}$$

# Question No 5:- (8)

## Part (a):

In RLC seriec AC circuit. Resistor with resistance (IR) which is in phase, Inductance ($IX_L$) in which voltage leads by 90° by current and capacitance ($IX_C$) in which current leads voltage by 90° are attached in a circuit thus $V_L$ and $V_C$ are 180° out of phase. The phasor diagram is given as,



By Pythagoras theorem:

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

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

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

$$V = I\sqrt{R^2 + X^2} \quad \because X_L - X_C = X$$

∴ $\sqrt{R^2 + X^2}$ is the impedence offered against th curreznt

$$V = IZ$$

If the $X_L >> X_C$ then the circuit is inductor and when $X_C >> X_L$ the circuit is capacitaive and if $X_L = X_C$ the circuit is purely resistive and it's power factor is 1.

$V = V_m \sin\theta$ and $V = V_m \sin\omega t$.

$$I = I_m \sin(\omega t \pm \phi)$$

## Power dissipation :-

$P = \langle V \rangle \langle I \rangle \cos\theta$

thus power dissipation is given by

$P = VI \cos\phi$

## Part (b) :-

## Unified atomic mass in kg.

a) $1U = 1.66 \times 10^{-27}$ Kg

As

$6.023 \times 10^{+23}$ Na of C = 12 Kg

3+1

$1 \text{ atom} = \frac{12}{6.023 \times 10^{+23} N_A}$

$\frac{1}{12} \text{ atom of C} = \frac{12}{6.023 \times 10^{+23} N_A} \times \frac{1}{12}$

$1U = 1.66 \times 10^{+27}$ Kg

b) **Unified atomic mass in eV**

$$1U = \frac{1.49 \times 10^{-13}\ J}{1.66 \times 10^{-19}}$$

$$1U = 931.5\ MeV$$

$V_m \sin \omega t$

$\omega t = 300t$

$2\pi f = 300$

$f = \frac{300}{2\pi}$

$\frac{\Delta L}{L}$

$I_E - I_C$

$I_E = I_B + I_C$

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

$\frac{I_C}{I_E}$

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

$\frac{I_C}{I_B}$

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

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

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

$\frac{\lambda m}{h} = 1$