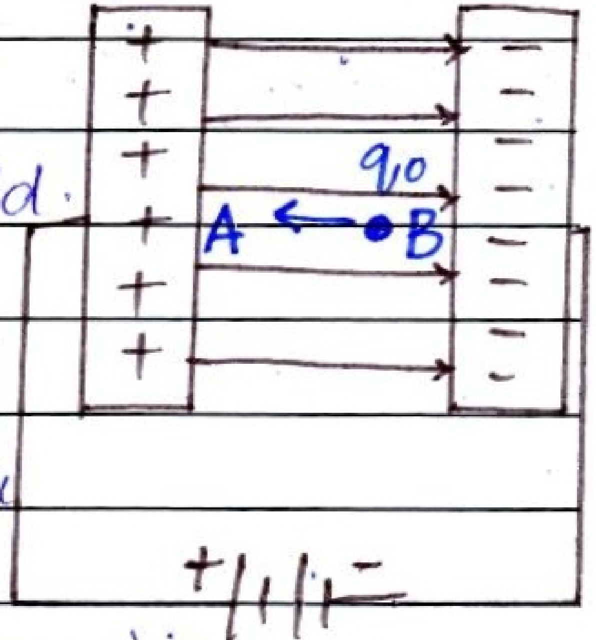
Q. No. 2 Part (i) **Energy decipated per second:-**

The energy decipated per second by a substance exposed to magnetization is called Hysterisis loss. Hysteresis loss depends on the width of the loop. The greater the area/width of the loop the greater is the energy decipated per second (1) **Iron:-** Iron has a narrow hysterisis loop, leading to a decreased area of the loop, which means that the energy lost per second for Iron is less.

(2) **Steel:-** Steel is a hard material, having a fat loop which means that the loop has more surface area, which leads to a greater loss of energy per second in steel as compared to iron.

Q. No. 2 Part (ii) **Condition**:- Suppose a unit positive test charge is moved against the direction of electric field. Work would be needed to bring the charge from point B to A.



Derivation:- Work = Force × distance

$\Delta W = -F\Delta r = -Eq_0\Delta r$ — (i) $\because F = Eq$.

Moreover; $\Delta V = \frac{\Delta W}{q} \Rightarrow \Delta W = \Delta V q$ — (ii)

Comparing equation (i) & (ii);

$$-Eq_0\Delta r = \Delta V q_0$$

$$E = -\frac{\Delta V}{\Delta r}$$ — (iii) Hence proved!

Change in potential per displacement is called potential gradient.

Q. No. 2 Part (iii) The base region of a transistor is the most thin region of the order of 10^{-6} m. It is very lightly doped. It is due to the following reasons:-

Reasons:-

(1) lighly doping the base is helpful so that lesser amount of charges emitted by the base are recombined with the base.

(2) It is made thin to expidite the movement of charges towards the collector thereby increasing the operation of a transistor.

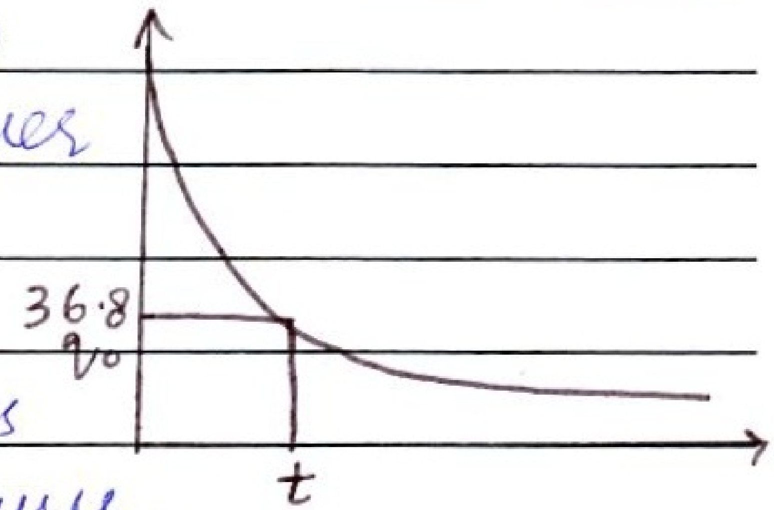
(3) As a result only little base current is produced and maximum collector current is achieved to produce amplified output voltage.

....

Q. No. 2 Part (iv)

N-Type semiconductor:-	P-Type semiconductor:-
> Extrinsic semiconductor formed after doping with pentavalent atoms.	> Extrinsic semi-conductor formed after doping with trivalent atoms.
> Impurity atom is called a donor atom.	> Impurity atom is called acceptor atom.
> Electrons are the majority charge carriers.	> Holes are the majority charge carriers
> Holes are minority charge carriers	> Electrons are minority charge carriers.
Eg:- Intrinsic semiconductor doped with phosphorus or arsenic.	Eg:- Intrinsic semiconductor doped with boron or aluminium.

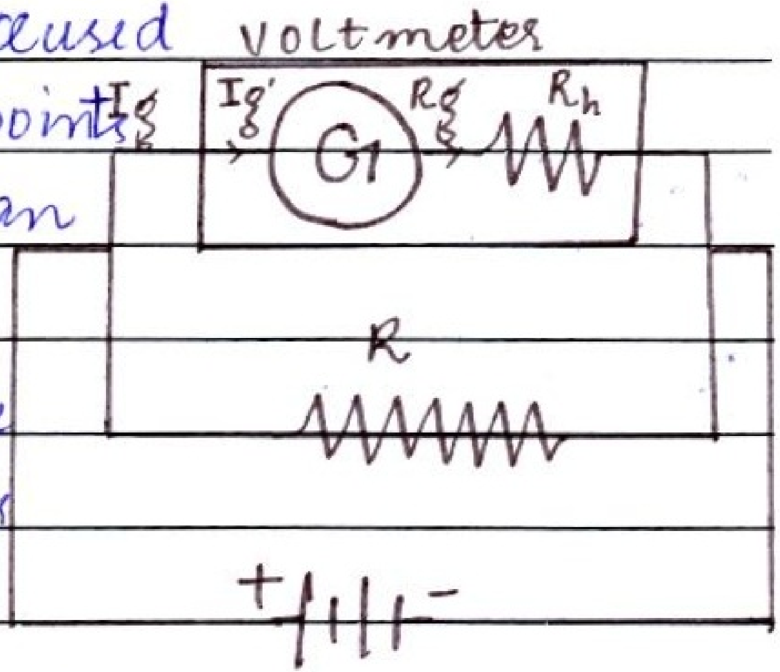
Q. No. 2 Part (v) **Capacitor discharge ignition system:**- A capacitor discharge ignition system works on the principle of charging & discharging of a capacitor, which takes place according to time constant phenomenon. During discharging a charge on a capacitor would decrease to 38.6% quickly when the time constant is small.



function:- It functions to increase the quality of power and increase the spark.

Use:- They are used as electromotive ignition sources in lawn mowers, chain saws, automobiles, etc.

Q. No. 2 Part (vi) **Voltmeter**:- A device used to measure potential between two points



Conversion:- A galvanometer can be converted to a voltmeter by attaching a very high resistance in series with the galvanometer

Derivation:- $V = V_g + V_s$.

$V_g = I_g R_g$, $V_s = I_s R_s$

$\therefore I_s = I_g$ so, $V_s = I_g R_s$.

Putting values:- $V = I_g R_g + I_g R_s$.

$I_g R_s = V - I_g R_g$.

$$R_s = \frac{V - I_g R_g}{I_g}.$$

$$R_s = \frac{V}{I_g} - R_g \quad \text{—(i)}$$

In a circuit:-

In a circuit, a voltmeter is attached in parallel to attain ~~an~~ maximum potential

Q. No. 2 Part (vii) **Eddy Currents:-** "Circular electrical currents produced in a conductor exposed to changing magnetic field or in a conductor moving in a static magnetic field."

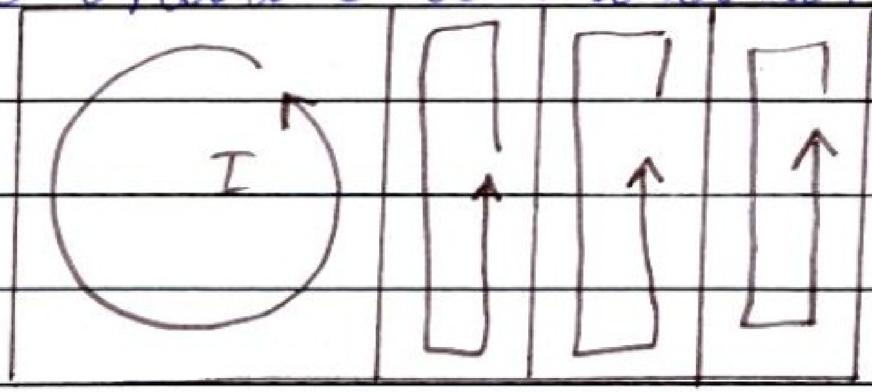
Production:- Eddy currents are usually produced as a result of induced emf. Since the magnetic field is changing, so; the changing magnetic flux leads to an induced emf in the conductor which creates a circular current. Increasing "B" induces counterclockwise whereas decreasing "B" induces clockwise currents.

Heating effect:- Since induced emf reacts against its source, so the eddy currents formed by emf would create a magnetic field which is opposite to source "B" and so a resistive force results in release of heat.

Q. No. 2 Part (viii) In a transformer, a laminated core is used instead of a solid one.

Laminated iron core:- Many thin sheets of iron separated by thin insulating sheets.

Reason:- Eddy currents cause a huge power loss in transformers. So, to reduce this loss, a laminated iron core is used instead of a solid one. This limits the eddy currents to only the thickness of one lamina instead of the entire core. Moreover, a laminated iron core directs the total flux towards the coils.



Q. No. 2 Part (ix) **Peak value**:: Maximum value attained by an ac waveform is called peak value.

Effective value:- That value of steady current which produces the same amount of heat when passing through a resistor as produced by an alternating current after passing through the same resistor in the same time:".

Relation:- ∴ $V = V_m \sin\omega t$ & $I = I_m \sin\omega t$

where V & I are instantaneous values, so

$P_{instantaneous} = V_m I_m (\sin^2\omega t) = \frac{1}{2} V_m I_m = \frac{1}{2} I_m^2 R$ -(i)

$P_{effective} = I_{rms}^2 R$ -(ii) Comparing eq; $\frac{1}{2} I_m^2 R = I_{rms}^2 R$

Taking square root; $I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707(I_m)$ —(*)

Also for, V; $V_{rms} = V_m(0.707)$ (*)

Q. No. 2 Part (x)

Metastable state:- "The excited state in an atom in which it stays for longer duration of time (10^{-3} s) is called metastable state." Usually all the other excited states quickly decompose in very less time (10^{-8} s) to ground state. but in metastable state the electrons remain for long.

Population Inversion:- "The state in which the number of excited atoms are greater than the number of ground state atom is called population Inversion." It is called an inversion because under normal circumstances, the greater number of atoms would be in their ground state not the excited state.

Q. No. 2 Part (xi) **Given:-** $K \cdot E = 1200 \times 10^3\ eV$

$K \cdot E = 1200 \times 1.602 \times 10^{-19} \times 10^3$

$K \cdot E = 1.92264 \times 10^{-13} J$

To find:- $\lambda = ?$

Solution:-

$K \cdot E = \frac{1}{2} m v^2$

$v = \sqrt{\frac{2K \cdot E}{m}}$

$v = \sqrt{\frac{2(1.92264 \times 10^{-13})}{(9.1095 \times 10^{-31})}}$

$v = 6.497 \times 10^8\ ms^{-1}$

$\therefore \lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{m(6.49 \times 10^8)}$

$\lambda = \frac{6.626 \times 10^{-34}}{(9.1 \times 10^{-31})(6.49 \times 10^8)}$

$= 1.11 \times 10^{-12} m$

Q. No. 2 Part (xii) **Alpha factor:-** "The ratio of collector current to emitter current is called alpha factor." $\alpha = \frac{I_C}{I_E}$

Beta factor:- The ratio of collector current to base current is called Beta factor.

$$\beta = \frac{I_C}{I_B}$$

Relation:- $\beta = \frac{I_C}{I_B}$ $\quad \therefore I_E = I_C + I_B$

$I_B = I_E - I_C$.

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

$$\beta = \frac{\alpha I_E}{I_E - \alpha I_E} = \frac{\cancel{I_E}(\alpha)}{\cancel{I_E}(1-\alpha)}$$

$$\beta = \frac{\alpha}{1-\alpha} \quad \text{—(i)}$$

Q. No. 2 Part (xiii)

~~metal detector~~ **Electron volt:- Definition:-**

The energy dessipated or absorbed by the electron while moving from one point to another having a potential difference of 1V.

Equivalence to Joules:- 1eV, where $e = 1.602 \times 10^{-19}$, $V = 1V$,

So, $1eV = (1.6022 \times 10^{-19})(1V)$

$1eV = 1.6022 \times 10^{-19} J$

Other multiples:-

$MeV = 10^{6} eV$

$KeV = 10^{3} eV$

Q. No. 2 Part (xiv) **Maximum power output:-**

"Maximum power will be transfered from the source to the load if the load resistance is equal to source resistance."

Explaination-Derivation:- If the source/load resistances do not match then power would be minimum. Condsides, a resistor connected to a source of voltage V. current I flows through the resistor. Power is given by.

$$P = I^2 R \qquad \therefore I = \frac{\varepsilon}{R+r}$$

$$P = \frac{\varepsilon^2 R}{(R+r)^2}$$

$$P = \frac{\varepsilon^2 R}{(R-r)^2 + 4Rr}$$

When, $R = r$

$$P = \frac{\varepsilon^2 R}{(R-R)^2 + 4R^2}$$

$$P = \frac{\varepsilon^2}{4R} \text{ or } \frac{\varepsilon^2}{4r}$$

Since $\varepsilon^2 > 4r$

so power is max.

Bohr's Atomic model:-

Bohr suggested his atomic model in 1913. He, on Rutherford's observational basis, stated that an atom has a planetary model. Moreover, the classical physics suggested that electron must continuously radiate energy which would eventually fall into the nucleus, thus collapsing the atomic structure.

To this bohr suggested that their are certain states of motion called stationary states in which an atom doesn't radiate any energy.

Postulate #1:- Electrons revolve around the nucleus in circular orbits. The centripetal force required is given off by coloumbs force of attraction between the election and nucleus.

$$F_c = F_{coloumb}.$$

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

Postulate #2:- Electrons do not revolve in any orbits rather, only in those orbits for which the angular momentum of an election is an integral multiple of

 $\frac{h}{2\pi}$ i.e

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

$$mvr = \frac{nh}{2\pi} \quad , n = 1, 2, 3, \cdots$$

Postulate #3:- The electrons while revolving in one stationary state would not emitt radiations. It can only emitt or radiate radiations when it changes its state of motion. Moreover, the photon or energy emitted is equal to the energy difference between the energy levels;

$$\Delta E = E_p - E_n .$$

Quantization of energy

Since, the orbits are quantized, so the energy possessed in each orbit by the electron is also quantized. This is because an electron would have energy (specific) at only specific distances from the nucleus.

Consider, an electron moving in orbit of radius "r".

Total energy = K.E + P.E

$$\therefore K.E = \frac{1}{2}\frac{Ke^2}{r} \quad , P.E = \frac{-Ke^2}{r}$$

$$E = \frac{1}{2}\frac{Ke^2}{r} - \frac{Ke^2}{r}$$

$$E = -\frac{1}{2}\frac{Ke^2}{r}$$

Q. No. 3 (Page 3) $\therefore r = \frac{n^2h^2}{4\pi^2 Ke^2 m}$

So;
$$E = -\frac{1}{2} Ke^2 \left(\frac{4\pi^2 Ke^2 m}{n^2h^2}\right)$$

$$E = -\frac{1}{2} \frac{K^2e^4 4\pi^2 m}{n^2h^2}$$

$$E = \frac{K^2e^4 m\, 2\pi^2}{n^2h^2}$$

$$E = \frac{1}{n^2}\left(-\frac{2\pi^2 K^2 e^4 m}{h^2}\right) \quad \text{(i)}$$

$$\therefore E_0 = \frac{2\pi^2 K^2 e^4 m}{h^2} \quad \text{(ii)}$$

Putting values in (ii);

$$E_0 = \frac{-2(3.142)^2(9\times10^9)^2(1.602\times10^{-19})^4(9.1095\times10^{-31})}{(6.626\times10^{-34})^2}$$

$$E_0 = -2.17\times10^{-18}\,J = 13.6\,eV$$

So;

$$E = \frac{1}{n^2}(-E_0)$$

$$E = \frac{-2.17\times10^{-18}\,J}{n^2} \text{ or } \frac{-13.6}{n^2}\,eV$$

Thus; $E_1 = \frac{-2.17\times10^{-18}}{(1)^2} = -2.17\times10^{-18}\,J \equiv 13.6\,eV$

$$E_2 = \frac{-2.17\times10^{-18}}{(2)^2} = -5.425\times10^{-19}\,J = -3.38\,eV$$

⋮ ⋮

Thus each orbit has a specific energy. Moreover, the negative sign indicates that the electron is bound to the nucleus.

PHOTOELECTRIC EFFECT

Definition:- "When light falls on a metal, it emitts electrons this phenomenon is called photoelectric effect. The electrons released are called photoelectrons."

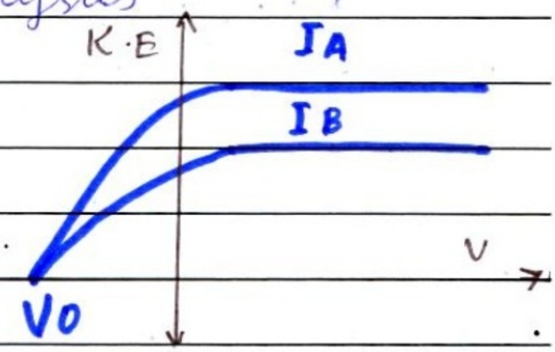
Construction of Assembly:- The emitter and collector are attached with a power source of 30 – 150KeV. A light of certain frequency falls on the emitter to eject electrons. These electrons and accelerated towards the collector. Thus, they constitute current, which is detected through a sensitive galvanometer.

first experiment:- In the first experiment the voltage across emitter and collector were applied such that the collector became negative, thus slowing the speed of electron. at a perticular voltage called the **stopping potential**. At this even the most energetic electrons are stopped and the galvanometer doesn't show any current deflection.

Thus; $K.E_{max} = Vq_{,0}$ —(i).

Here, it was also seen, that even with the increase in the frequency, the kinetic energy measured to be the same i.e, by increasing the intensity the photoelectrons increase & current increases but the stopping potential remains the same.

1 Classical physics:- Classical physics suggests that light, being a wave, if its amplitude is increased by increasing intensity, it must provide excess kinetic energy to the electrons, thereby increasing their V_0, but this doesn't happen.



Second Experiment:- In the second of experiment, the frequency was observed, It was seen that light under a certain frequency (threshold frequency) failed to produce photoelectric effect. Thus, a specific frequency radiations must be used.

(2) Classical Physics:- Here classical physics suggests that light being electromagnetic, no matter what the frequency, if it has a certain energy, it must be capable to remove electrons from the metal.

(3) Classical Physics:- Classical physics suggests that there must be some time delay, but current is produced as soon as the light hits the emitter.

Q. No. 4 (Page 3) **Einstein's explanation:-**

Einstein suggested, that on the basis of photon theory (1. The energy of a photon is localazied. And as soon as a photon of light hits the electron, it transmitts all its energy to the electron. As a result electrons are emitted. The K.E of electrons is given by: $K.E = hf - \phi$, Where ϕ is work function i.e the amount of energy needed to simply remove an electron from the metal. This explains, the independence of the kinetic energy of the electron of the intensity of light. Moreover, if a photon of light has energy/frequency equal to the threshold frequency (f_0), then, the electron would not acquire any K.E as the energy of the photon is just enought to remove it from the metal.

$$K.E = 0 \quad , \quad hf_0 = E_P$$

$$0 = hf_0 - \phi$$

$$hf_0 = \phi \qquad \therefore f = \frac{c}{\lambda}$$

$$\frac{hc}{\lambda} = \phi$$

$$\lambda = \frac{hc}{\phi} \quad \text{—— (i)}$$

Velocity "c" in terms of f_0 & cutoff wavelength λ_0

$$c = (f_0)(\lambda_0)$$

This is the wavelength of the photon. Thus, this proved that intensity increases the photoelectrons but doesn't increase their K.E. and that the specific frequency is required by photons to emit electrons.

Self- Inductance:-

Definition:-

"The emf induced in a coil due to a change in its own electric flux is called self inductance."

Explanation:-

Consider a coil of resistan R, it is attached in a circuit to a swith, a battery of V volts and a Rheostate. When the switch is turned on, the current starts to flow in the circuit. However, when we change the circuit resistance through the rheostat, then the current through the coil also changes, as a result the flux of the coil, linking itself also changes. This change in flux leads to the induction of emf in the coil. This is called self inductance.

Derivation:-

The emf directly depends on the rate of change of current.

So,

$$\mathcal{E} \propto \frac{\Delta I}{\Delta t}$$

$$\mathcal{E} = L \frac{\Delta I}{\Delta t} \quad \text{(i)}$$

 Here "L" is the inductance of a coil.

$$\therefore \mathcal{E} = \frac{\Delta\phi}{\Delta t} N \quad \text{—(ii)}$$

So;

$$\frac{N\Delta\phi}{\Delta t} = \frac{L\Delta I}{\Delta t}$$

$$N\Delta\phi = L\Delta I$$

$$L = \frac{N\Delta\phi}{\Delta I} \quad \text{—(iii)}$$

Self-Inductance:-

The self inductance "L" is measured in Henery.(H).

"The inductance of a coil is said to be one henery when the ~~l~~ current changes in 1 A/s in a potential of 1V".

Moreover:

$$1H = \frac{Vs}{A}$$

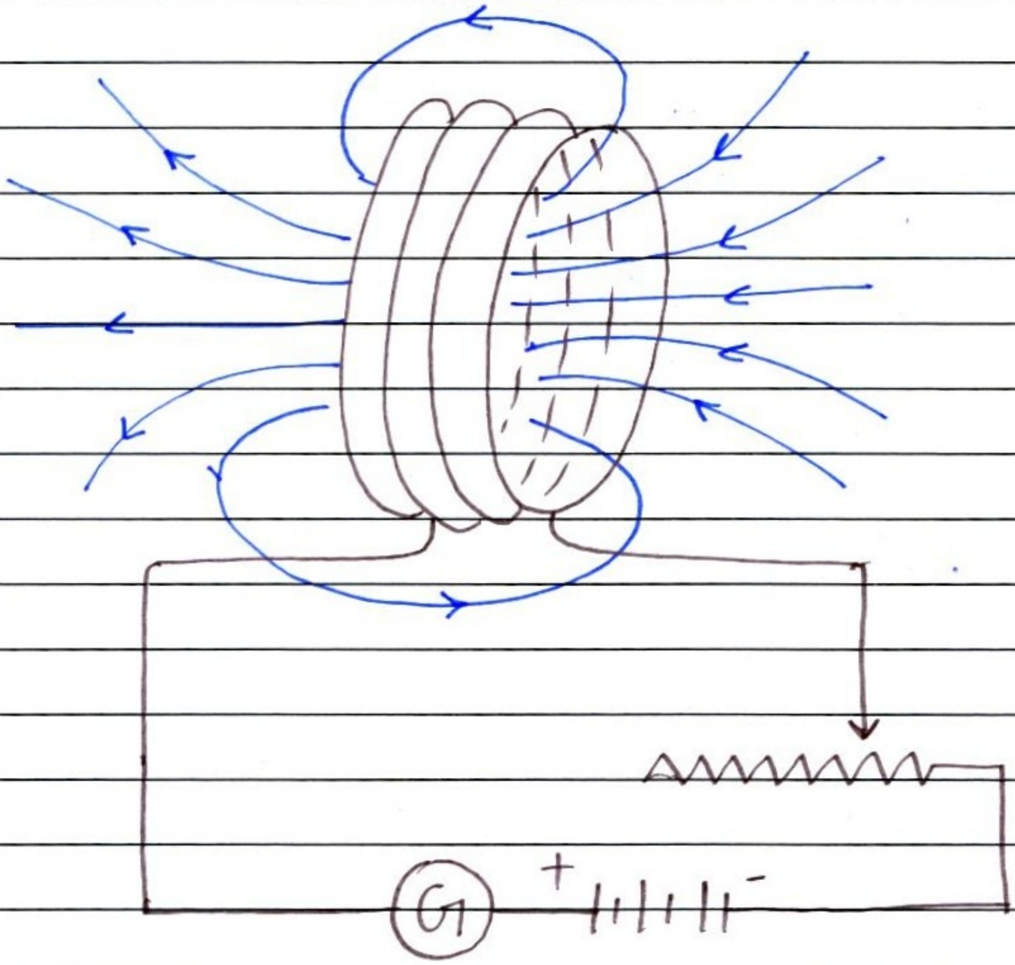
Dependent Factors:-

It depends on three factors,

(1) Shape & size of the coil
(2) Area and length of the coil
(3) Material of the core.

If the core material is such that it has a higher magnetic permeability, then it would greatly increase the inductance.

Q. No. 5 (Page 3)

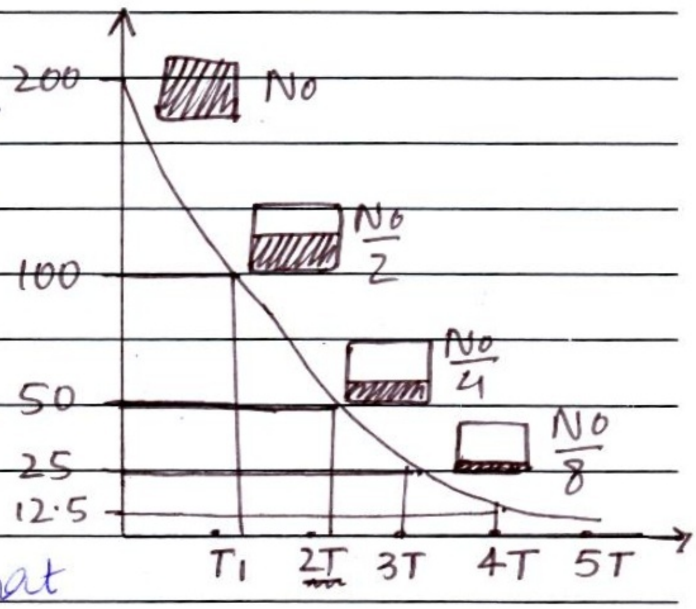


Half-life

Definition:- "The time during which the sample of radioactive nuclei reduces to half is called half-life."

Explaination:- Suppose there is a sample having No numbers of original nuclei in the sample. After one half life has gone past by, the numbers in the nuclei would reduce to half i.e $N = \frac{No}{2}$. This would continue and after each half life, the remaining sample would be reduced to half.
C^{14} has a half life of 5730 years. After 5730 years, the $N = No/2$. After another 5730 years, the $No/4 = N$. And so on uptill infinity years.

Derivation:-



$\Delta N \propto -N$

$\Delta N \propto \Delta t$

$\Delta N \propto -N \Delta t$

$\Delta N = -\lambda N \Delta t$

Here λ is decay constant, ΔN is the numbers of nuclei that have disintegrated. Δt is the time taken. Negative sign is the increase in time but decrease in No.

Q. No. 6 (Page 2) $\frac{\Delta N}{\Delta t} = -\lambda N$ —(i)

$$\frac{dN}{dt} = -\lambda N$$

$$\frac{dN}{N} = -\lambda dt$$

Taking integration;

$$\int_{No}^{N} \frac{dN}{N} = -\lambda \int_{to}^{t} dt$$

$$[\ln N]_{No}^{N} = -\lambda [t]_{to}^{t}$$

$$(\ln N - \ln No) = -\lambda (t - to)$$

$$\ln\left(\frac{N}{No}\right) = -\lambda t$$

Taking antilog; on both sides;

$$\frac{N}{No} = e^{-\lambda t}$$

$$N = Noe^{-\lambda t} \text{ —— (ii)}$$

Now to calculate half-life. Consider that one half life has passed,

$$t = T_{1/2} \quad , \quad \frac{NO}{2} = N$$

$$\frac{\cancel{N}o}{2} = \cancel{N}oe^{-\lambda T_{1/2}}.$$

$$\frac{1}{2} = Ne^{-\lambda T_{1/2}}.$$

Taking inverse

$$2 = e^{\lambda T_{1/2}}.$$

Taking log on both sides;

$\ln 2 = \lambda T_{1/2} (\ln e)$

$\ln 2 = \lambda T_{1/2} (1)$ $\because \ln e = 1.$

$0.693 = \lambda T_{1/2}.$

$T_{1/2} = \frac{0.693}{\lambda}$ —(iii)

equation (iii) is the relation between decay constant λ & half-life.

Moreover; $\lambda = \frac{0.693}{T_{1/2}}$ —(iv).

Activity:- "Number of disintegrations per second is called the activity of a radio-active material."

$$\text{Activity} = \frac{\Delta N}{\Delta t} = -\lambda N \quad \text{—(v)}$$

Units:- Activity is either measured in "Curie" or "Becquarrel"

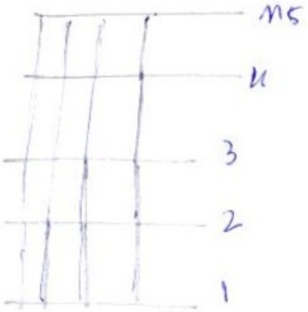
Such that;

1 Cu = 3.70×10^{10} Becquarrel

$\because$ 1 Bq = 1 Decay / second.

So;

1 Cu = 3.70×10^{10} decay / second.



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

$V = Er$

$\Delta V \; \Delta r$

$N =$

$\mathcal{E} = NU$

$\mathcal{E} \propto u$

$C_{eq} = 1 \times 10^{-6}$

$\Delta = 2L_0$

$= L$

$I = \frac{C\varphi}{NAB}$

$\frac{U_0}{U_0}$

$\frac{C}{NAB}\varphi = I$

$\frac{NAB}{C}$

$\varphi = \frac{NAB}{C} (1)$

$\uparrow D > N$

$\frac{\Delta L}{L_0}$

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

$\Delta V = E\Delta r$

$\Delta V \propto \Delta r$

$\uparrow \varphi = \frac{NAB}{C} (1)$

$\frac{\varphi C \downarrow}{\uparrow NAB} = I$

$L = 2L_0$

$\Delta L = L - L_0$

$\Delta L = 2L_0 - L_0$

$\Delta L = L_0$

$\frac{C}{NAB} \downarrow$

$\frac{60 \times 50}{100} =$

30×1

$= 30$

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

$\lambda = \frac{1}{v}$

$\lambda = \frac{h}{m(2v)}$

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

$E = hf$

$f = \frac{c}{\lambda}$

$E = \frac{hc}{\lambda}$