Q. No. 2 Part (i) **Magnetic Flux:**

Magnetic flux is defined as:

"Number of magnetic field lines passing through unit area is called magnetic flux."

Mathematically:

$$\phi_B = \vec{B}\cdot\vec{A} = BA\cos\theta$$

Unit: Its unit is Tm^2, Wb, NmA^{-1}.

Magnetic flux density:

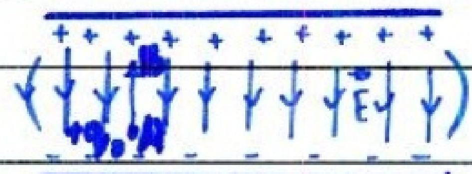
Magnetic flux density is

"Magnetic flux per unit area is magnetic flux density."

Mathematically: $\frac{\vec{B}\cdot\vec{A}}{\vec{A}} = \vec{B}$

Unit: Its unit is T, $Wb\,m^{-2}$, $Nm^{-1}A^{-1}$.

Q. No. 2 Part (ii) **Prove** $E = -\dfrac{\Delta V}{\Delta r}$



$+q_o$ placed in $\vec{E}$.

The work done in moving charge from A to B

$W = \vec{F} \cdot \vec{d}$

$W = Fd\cos\theta$

$\theta = 180^\circ$

$W = -Fd \quad — ①$

As we know:

$F = q_o E$

$W = q_o \Delta V$

Placing in ①

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

$\cancel{q_o} \Delta V = - \cancel{q_o} E \Delta r$

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

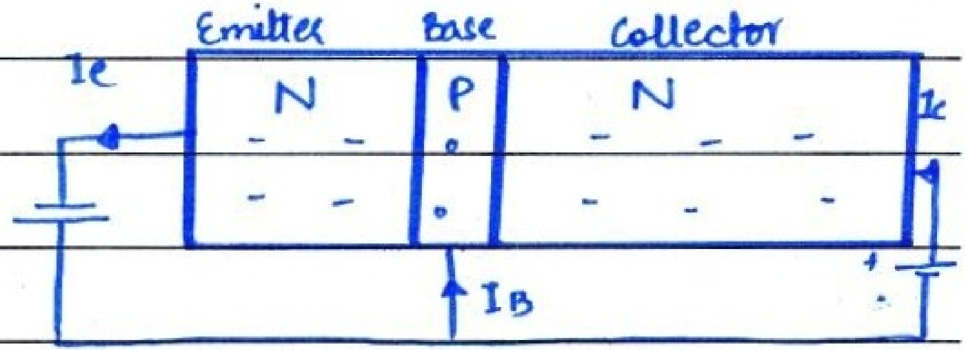
-ve sign shows that **electric field increases in direction of decreasing potential.**

Q. No. 2 Part (iii) **Transistor:**

Transistor is a device which consists of three extrinsic semi conductors.

It consists of three regions:

1. Emitter 2. Base 3. Collector.



Base region:

1. **Thin:** The base region is made thin to **decrease** I_B so that maximum current enters collector. Moreover, to reduce heating effect, base is thin.

2. **Lightly doped.** To **decrease** I_B, base is lightly doped. We want current to enter collector. Hence light doping means less hole in P region hence less e^- enter base.

Q. No. 2 Part (iv) **Longest wavelength of Lyman series:**

- In Lyman series e^- falls in K-shell (n=1).
- For longest wavelength, electron falls from (n=2) to (n=1)
- Since **least energy** is released hence **maximum wavelength** is obtained.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$R = 1.0967 \times 10^7 \, m^{-1}$

Where R is **Rydberg's constant**.

$n_1 = 1 \quad n_2 = 2$

$$\frac{1}{\lambda} = (1.0967 \times 10^7 \, m^{-1})\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$\frac{1}{\lambda} = 8225850 \, m^{-1}$$

$$\lambda = 1.21 \times 10^{-7} \, m$$

$$\lambda_{max} = 121 \, nm$$

Q. No. 2 Part (v)

Difference:

Properties	Curie Temperature	Critical temperature
Definition.	The temperature at which ferromagnetic material becomes paramagnetic is called curie temperature.	The temperature below which the resistivity of conductor is zero is called critical temprature.
Concept	It is related to **magnetism**	It is related to **conductivity**
Below Temperature	Above curie temperature, the material is **paramagnetic material**.	Below critical temperature, the material is **super-conductor**.
Change in nature.	The material's **magnetism decreases**.	The materials **resistivity decreases**.
Material	Co is ferromagnetic which becomes paramagnetic.	ceramic (Th, oxygen, Ca, Cu, Ba) at 125K

Q. No. 2 Part (vi) **Resistivity :**

It is defined as:

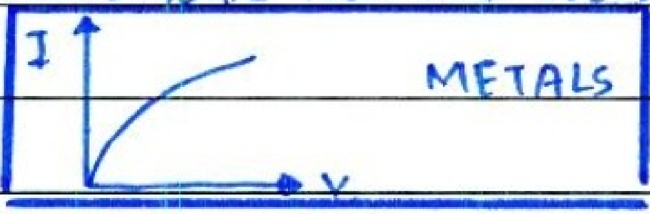
"The opposition offered by any material to the flow of current through it."

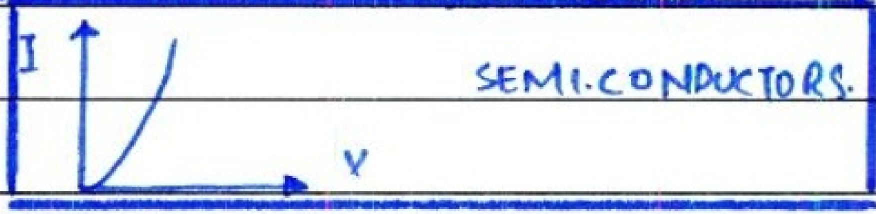
Mathematically:

$$\rho = \frac{RA}{L}$$ and its unit is Ωm.

Effect of temperature :

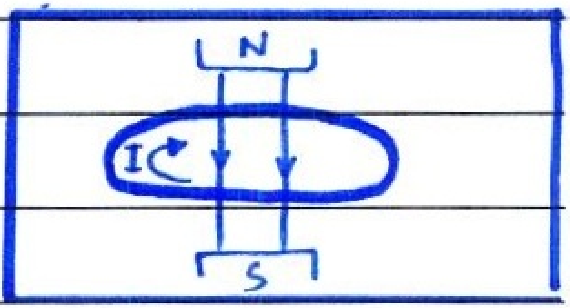
1. **Metals:** With increase in temperature, the collisions increase hence restivity increases. $\rho \propto T$
2. **Semi-conductors:** With increase in temperature, more bonds are cleared hence current increases and ρ decreases. $\rho \propto \frac{1}{T}$





Q. No. 2 Part (vii) **Eddy Currents:**

"Eddy currents are induced when metal is exposed to **changing magnetic field.**"



Due the large amounts of eddy current, heating effect is greatly observed. As

$$H = I^2Rt$$

Where H is heat generated and I is current.

$$H \propto I^2$$

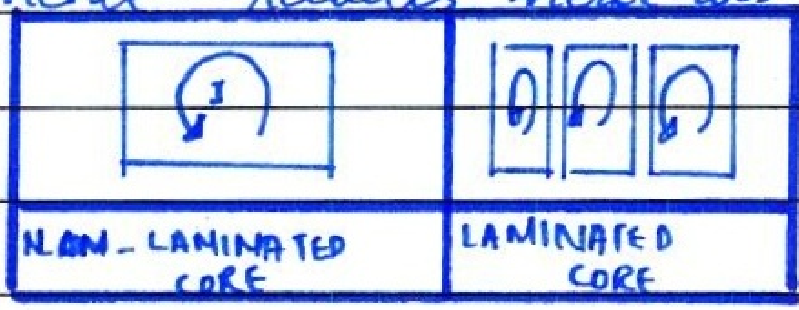
Hence this heating effect has its own applications.

i. **Cooking tops:** The heat generated is used in stoves for food.

ii. **Braking:** Due to magnetic field of eddy current, it can be used in braking systems.

Q. No. 2 Part (viii) **Use of laminated core:**

- In transformer, we use laminated soft iron core to **reduce eddy current** hence to **reduce heat loss**.
- Eddy currents are produced due to changing magnetic field.
- By using laminated core, the iron is **sliced and separated by sheet of insulator**.
- Hence we **reduce loop of current** which helps in reduction of eddy current hence reduces heat loss.



- Heat loss is $H = I^2 R t$

  $H \propto I^2$

By reducing I, H is reduced. Hence by lamination, loop of eddy current is reduced.

Q. No. 2 Part (ix) Difference

Properties	Paramagnetic Materials	Diamagnetic materials
Definition	The materials which are attracted by magnetic field are paramagnetic.	The materials which are repelled slighty by magnetic field are diamagnetic.
Orbital and spin motion	The orbital and spin motion support eachother.	The orbital and spin motion oppose eachother.
Allignment of dipoles	Magnetic dipoles allign in direction of magnetic field.	Magnetic dipoles allign against magnetic field.
Examples.	Alluminium, antimony	~~Iron~~ Bismuth, copper, zinc.

Q. No. 2 Part (x) **Metastable state:**

For production of LASER, the electrons are required to be in exited state but they are very short lived $10^{-8}s$.

Metastable states are defined as:

"The excited state of electron in which it **stays for longer interval** ($10^{-3}s$) is called metastable state."

Population inversion:

It is defined as

"The state in which **no. of electrons in excited state are greater than that in ground state**."

It is called so because it is opposite to that of original state/natural conditions.

Q. No. 2 Part (xi) **De-Broglie Wavelength:**

Data:

$\lambda = ?$

$m = 9.1095 \times 10^{-31}$ kg

$KE = 1200 \times 10^{3}$ eV

$KE = 1200 \times 10^{3} \times 1.6 \times 10^{-19}$ J

$KE = 1.9 \times 10^{-13}$ J

$h = 6.626 \times 10^{-34}$ Js.

Solution:

$$\lambda = \frac{h}{\sqrt{2mE}}$$

$$\lambda = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.10095 \times 10^{-31} \times 1.9 \times 10^{-13}}}$$

$\lambda = 1.1203 \times 10^{-12}$ m

$\lambda = 1.1203$ pm

$\lambda = 1120.3$ nm.

Derivation of formula:

$$KE = qV = \frac{1}{2} mv^2$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$\lambda = \frac{h}{m \times v} = \frac{h}{m \times \sqrt{\frac{2E}{m}}} = \frac{h}{\sqrt{2mE}}$$

Q. No. 2 Part (xii) **Alpha Factor :**

Alpha factor is current gain.

$\alpha_{static} = \frac{I_c}{I_e}$ $\alpha_{dynamic} = \frac{\Delta I_c}{\Delta I_e}$

Where I_c is collector current, I_e is emitter current and I_B is base current.

Beta factor :

$\beta = \frac{I_c}{I_B}$.

$I_e = I_c + I_B$

$I_B = I_e - I_c$

$B = \frac{I_c}{I_e - I_c}$

Multiplying and Dividing by I_e

$B = \frac{I_c / I_e}{(I_e - I_c)/I_e}$

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

Value of B is much greater than that of α.

Q. No. 2 Part (xiii) **Electron Volt:**

Electron volt is defined as:

"The amount of **energy** gained / lost by electron when moving between two points whose potential difference is one volt."

Mathematical relationship:

As we know ; $V = \frac{W}{q}$

$W = qV$

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

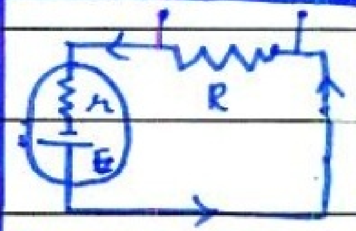
$E = 1eV$ $\qquad e = 1.6 \times 10^{-19} C$

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

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

Q. No. 2 Part (xiv) **Maximum Power Output:**

A battery or cell gives maximum power output when **load resistance is equal to source resistance.**



CIRCUIT DIAGRAM

Mathematically

$$P = IV = I^2R$$

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

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

$$P = \frac{\varepsilon^2 R}{R^2 + r^2 + 2rR + 2rR - 4rR}$$

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

$$\varepsilon = V_t + Ir$$

$$\varepsilon = IR + Ir$$

$$I = \frac{\varepsilon}{(R+r)}$$

$$R = r$$

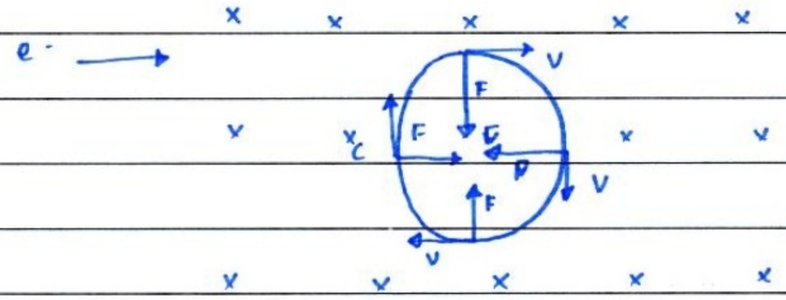
$$P = \frac{\varepsilon^2 R}{(R-R)^2 + 4R^2}$$

$$P_{max} = \frac{\varepsilon^2}{4R}$$

Determination of charge to mass ratio of e^-:

Consider a _ _ charge moving with velocity 'v' in a circle of radius 'r' having mass of m. It is placed in uniform magnetic field $\vec{B}$.

Diagram:



$\vec{B}$ is directed into the page.

The centripetal force required to keep electron moving in circle is provided by magnetic force.

$$F_C = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$\frac{q}{m} = \frac{v}{Br} \quad \text{— (1)}$$

Now, $KE = \frac{1}{2}mv^2$

$$qV = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$v^2 = \frac{2qV}{m}$$

① ⇒ $$\frac{q}{m} = \frac{v}{Br}$$

Squaring BHS

$$\frac{q^2}{m^2} = \frac{v^2}{B^2r^2}$$

$$\frac{q^2}{m^2} = \left(\frac{2qV}{m}\right) \times \frac{1}{B^2r^2}$$

$$\frac{q}{m} = \frac{2V}{B^2r^2}$$

Hence the charge to mass ratio of electron / any chrged particle can be determined if potential, magnetic field and radius is ~~de~~ known.

Charge to mass ratio of e^-:

$\frac{q}{m}$ of e = ?

q of e = 1.6×10^{-19} C.

m = 9.1095×10^{-31} kg

$$\frac{q}{m} = \frac{1.6 \times 10^{-19} C}{9.1095 \times 10^{-31} Kg}$$

Q. No. 3 (Page 3)

$\frac{q}{m} = 1.7588 \times 10^{11}$ C/kg.

Explanation:

It means that 1 kg of electrons posess the charge of 1.7588×10^{11} C.

Q. No. 4 (Page 1)

Potentiometer:

Definition:

"Potentiometer is a null type resistance device used to measure voltage without drawing current through it."

Potentiometer features:

It is a device which is gives measurement with great **precision and accuracy**. Voltmeter can not provide accurate value while CRO is quite expensive.

Principle:

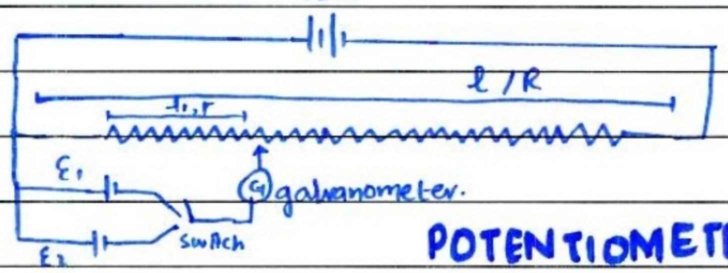
It is based on **null deflection method**.

Construction:

It consists of

1. Rheostat of length approximately 4m.
2. Two cells of emf E_1 and E_2.
3. Battery
4. Galvanometer.
5. Switch

Diagram:



POTENTIOMETER

Q. No. 4 (Page 2)

Working:

① First of all, the cell with emf ε_1 is connected in the potentiometer and the length l_1 is measured. It is the length where the **galvanometer gives no deflection** hence potential is equal.

② Then the cell of emf ε_2 is connected through the switch and measured length l_2 is noted. This is the length where no deflection is given by galvanometer. Hence potential difference is zero.

③ By comparing the lengths of the two cells, the emf can be calculated.

Mathematical Relation.

$$V = I R$$

$$\varepsilon = I r$$

$$\varepsilon' = \frac{r}{R} \varepsilon_0$$

ε_0 is emf of cell.
r is resistance of smaller length.
ε' is emf of cell to be measured.

$$\varepsilon' = \frac{\frac{\rho l}{A}}{R} \varepsilon_0$$

$$\varepsilon' = \frac{\frac{\rho l}{A}}{\frac{\rho L}{A}} \varepsilon_0$$

$$\varepsilon' = \frac{l}{L} \varepsilon_0$$

Q. No. 4 (Page 3)

In terms of two cells.

$$\varepsilon_1 = \frac{l_1}{L} \times \varepsilon \quad -(1)$$

$$\varepsilon_2 = \frac{l_2}{L} \times \varepsilon \quad -(2)$$

Dividing (1) and (2)

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{\frac{l_1}{L} \times \varepsilon}{\frac{l_2}{L} \times \varepsilon}$$

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

For measurement of emf.

$$\varepsilon_1 = \frac{l_1}{l_2} \times \varepsilon_2 \qquad \varepsilon_2 = \frac{l_2}{l_1} \times \varepsilon_1$$

Uses of potentiometer:

Potentiometer is used for.

1. Comparison of two cells.
2. Measurement of voltage
3. Determination of unknown emf.
4. Calibration of Voltmeter and Ammeter.

Q. No. 5 (Page 1) **Gauss's Law:**

Gauss's Law is defined as:

"The electric ~~flux intensity~~ of a closed surface is $1/\varepsilon_0$ times the total charge enclosed by it."

Condition: closed surface is required.

Mathematically:

$$\phi = \frac{Q}{\varepsilon_0}$$

Where ϕ is electric ~~flux intensity~~, Q is the total charge enclosed and ε_0 is ~~absoluted~~ permitivity.

Consider a closed sphere divided in 'n' small patches.

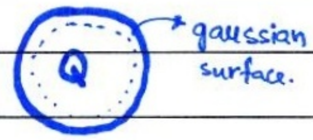
$$\phi = \vec{E_1}.\vec{A_1} + \vec{E_2}.\Delta\vec{A_2} + \vec{E_3}.\Delta\vec{A_3} + \dots + \vec{E_n}.\Delta\vec{A_n}$$

$$\phi = E\Delta A_1 \cos\theta_1 + E_2 \Delta A_2 \cos\theta_2 + \dots E_n \Delta A_n \cos\theta_n.$$

$$\theta = 0° \qquad \cos\theta = 1 \qquad E_1 = E_2 = E_3 = E_n$$

$$\phi = E\ (\Delta A_1 + \Delta A_2 + \Delta A_3 + \dots \Delta A_n)$$

$$\phi = \frac{F}{q}\ (\text{Area of sphere})$$



$$\phi = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2} \times \frac{1}{q} \times 4\pi r^2$$

$$\phi = \frac{Q}{\varepsilon_0}$$

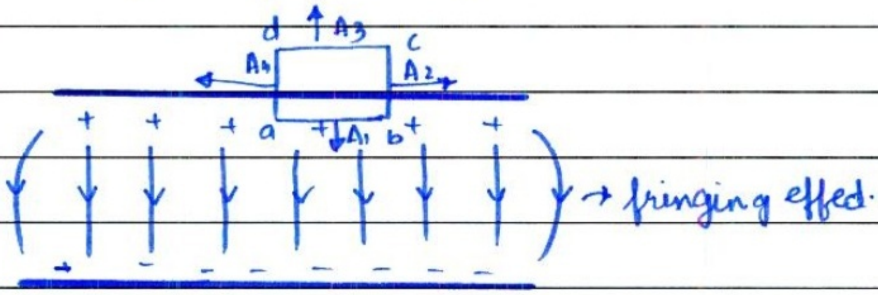
This is mathematical form of gauss's law.

Here, charge Q was enclosed in sphere and gaussian surface was introduced.

Dependence:

- ϕ depends on charge enclosed and ε nature of material.
- ϕ is independent of geometry.

Q. No. 5 (Page 2) **Electric Field intensity between two oppositely charged parallel plates**



Construction:

Consider two infinitely large parallel plates separated by a constant distance. They are considered to be of **infinite length to prevent bulging effect.**

To find $\vec{E}$:

1- Gaussian Surface:

First we introduce gaussian surface in form of cube. The cube abcd.

2. Φ Calculation:

$\Phi = \vec{E_1}.\vec{A_1} + \vec{E_2}.\vec{A_2} + \vec{E_3}.\vec{A_3} + \vec{E_4}.\vec{A_4}$

$\Phi = E_1 A_1 \cos\theta_1 + E_2 A_2 \cos\theta_2 + E_3 A_3 \cos\theta_3 + E_4 A_4 \cos\theta_4$

$\theta_2 = \theta_4 = 90°$ $(\cos 90 = 0)$

$E_3 = 0$ (outside $\vec{E}$)

$\Phi = E_1 A_1 \cos(0) + 0 + 0 + 0$

$\Phi = EA.$

3. Evaluate $\vec{E}$:

$\Phi = EA$ $\qquad\qquad$ $\Phi = \frac{Q}{\varepsilon_0}$

Q. No. 5 (Page 3)

comparing the equations:

$$EA = \frac{Q}{\varepsilon_0} \qquad \sigma = \frac{Q}{A} \text{ (charge density)}$$

$$EA = \frac{\sigma A}{\varepsilon_0} \qquad Q = \sigma A$$

$$E = \frac{\sigma}{\varepsilon_0} \quad \text{— (1)}$$

Hence E between two infinitely charged parallel plate is given by equation. (1)

Vector form:

$$\vec{E} = \frac{\sigma}{\varepsilon_0} \hat{r}$$

Where $\hat{r}$ is position vector.

Radioactive element:

"The element which emits radiation to gain stability is called radivoactive element."

The process /phenomenon is called radioactivity.

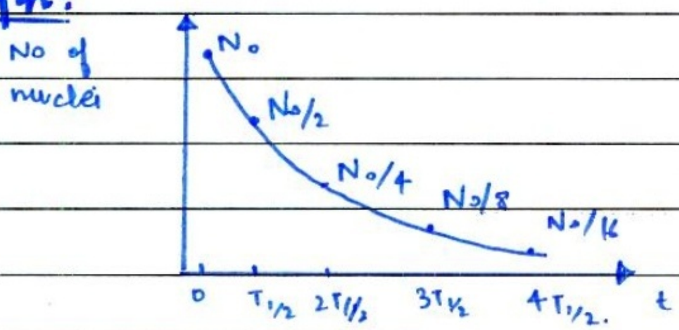
Half life:

"The time taken by radioactive element to **decay half of nuclei** is called half life."

Example:

Half life of carbon is 5730 years. After once half life, $N_o/2$ nuclei are left, after second half life, $N_o/4$ nuclei and upto so on.

Graph:



Mathematically:

ΔN is the number of nuclei decay. Δt is Time.
N is the number of nuclei present..

$\Delta N \propto -N$

$\Delta N \propto \Delta t$

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

Q. No. 6 (Page 2)

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

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

Now,

$$\frac{\Delta N}{N} = -\lambda \Delta t$$

Integrating both sides.

$$\int \frac{\Delta N}{N} = \int -\lambda \Delta t$$

$$\ln N = -\lambda t + \ln C$$

$$\ln N = -\lambda t \ln e + \ln c$$

$$\ln N = \ln e^{-\lambda t} + \ln c$$

$$\ln N = \ln c e^{-\lambda t}$$

$$N = ce^{-\lambda t} \quad — (1)$$

If $t = 0$ $\quad N = N_0$

$$N_0 = c e^0$$

$$c = N_0$$

So eq (1) becomes

$$N = N_0 e^{-\lambda t}$$

For further calculation;

If $t = T_{1/2}$ $\quad N = \frac{N_0}{2}$

$$\frac{N_0}{2} = N_0 e^{-\lambda t}$$

$$\frac{1}{2} = \frac{1}{e^{\lambda t}}$$

$$e^{\lambda t} = 2$$

Q. No. 6 (Page 3)

Taking log on BHS

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

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

$\lambda T_{1/2} = \ln 2$

$T_{1/2} = \frac{\ln 2}{\lambda}$

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

Where λ is decay constant which is specific for every radioactive element.

Activity :

Activity is defined as number of disintegrations per second.

$$A = \frac{\Delta N}{\Delta t}$$

$$A = -\lambda N$$

Its unit is Curie.

1 Curie = 3.70×10^{10} Becqleral.

Becqlaral is the SI unit.

1 Bq = 1 disintegration per second.