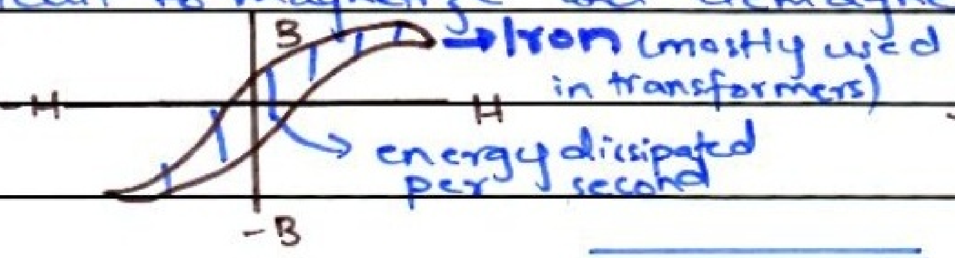
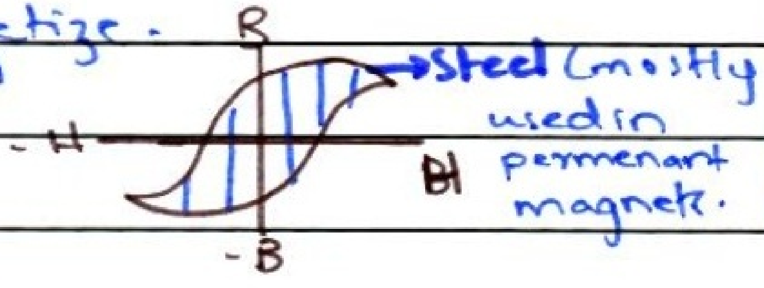
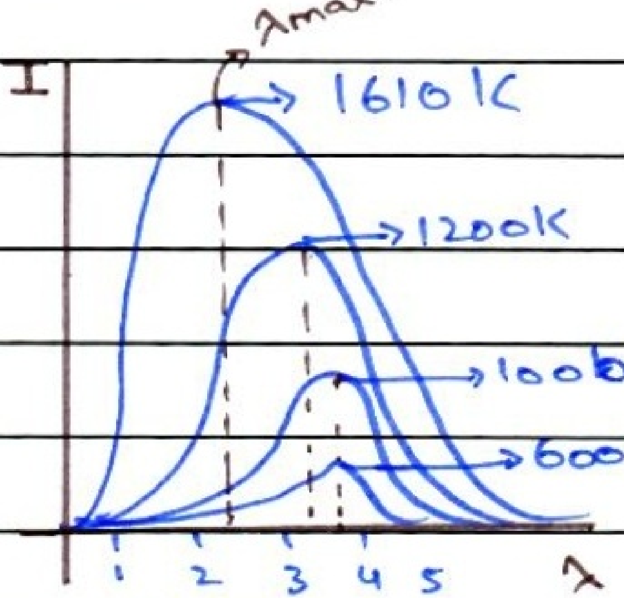
Q. No. 2 Part (i) We know about **hysterisis loss** as energy dissipated when a magnetized substance is subjected to demagnatization. We know almost all substances that when they are magnetized by applying a magnetizing force it retains some of the magnetic flux. External energy needed to demagnatize it appears as hysterisis loop. In steel and iron we see iron is a soft magnetic material which is easy to magnetize and then magnetize with less energy. while steel is hard magnetic material with a fat hysteris loop. Difficult to magnetize and demagnetize.





Q. No. 2 Part (ii) Wein presented this law to measure wavelength of radiations of black body spectrum at different temperature. It states "with the increase in ~~(tempeature)~~ temperature the peak of distribution shifts towards shorter wavelength."



This shift is found to obey wein's displacement law. If λ_{max} is the ~~temperature~~ wavelength at which distribution peaks and T is absolute temperature then

$$\lambda_{max} \propto \frac{1}{T} \qquad \lambda = \frac{k}{T}$$

$$\lambda T = k$$

where $k = 0.2898 \times 10^{-2}$ mk wein's constant.

Q. No. 2 Part (iii) Normally in transistors the emitter base region in forward biased while base is lightly doped and emitter collector region is reverse biased. The emitter and collector zones ~~are~~ or regions are highly doped while base is lightly doped.

This done to transfer maximum of the electrons to the collector. As base is lightly doped it has less chances of recombination of charges and less transit time as well. further more it is thin due to which it cannot accomodate large number of charge carriers This done to take a large current gain from the transistor minimizing base current.

Q. No. 2 Part (iv) LYMAN SERIES

we know that in lyman series the electrons fall from any high orbit to $n=1$.
For hydrogen spectrum we know the empirical formula

$$\frac{1}{\lambda} = 1.0974\times10^{7}\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

for longest wavelength ~~(smallest)~~ we know $n_2 = 2$ so putting

$$\frac{1}{\lambda} = 1.0974\times10^{7}\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = 8230500$$

No taking reciprocal we have $\lambda_{max} = 1.214\times10^{-7}\,m$

Result

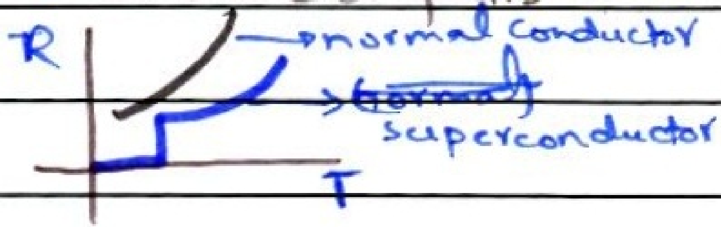
so longest wavelength $1.214\times10^{-7}\,m$ or $121.4\,nm$

Q. No. 2 Part (v)

CURIE TEMPERATURE: "The temperature at which a ferromagnetic material is converted into paramagnetic material is called curie temperature."

It is done by providing a ferromagnetic material heat so that its magnetized domains are dis oriented changing it into a paramagnetic material.

Critical Temperature; "The temperature at or below which the resistance of a super conductor falls to zero."



→ Curie Temperature is usually a high temperature while critical temperature is low.

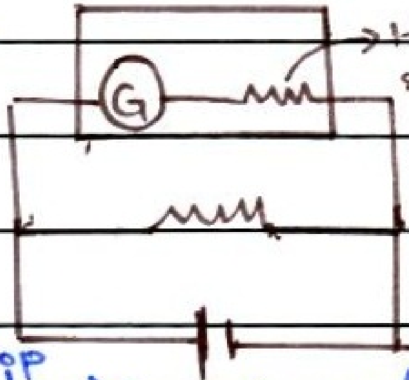
→ Curie Temperature increases the disorder of atoms in material while critical temperature makes the disorder less.

Q. No. 2 Part (vi)

VOLTMETER

A galvanometer can be converted into a voltmeter by ~~connected~~ connecting it with a high resistence in Series. This voltmeter measures the voltage across circuit.

As we know it is series so voltage drop across galvanometer and high resistence will be divided across them. If I is the current across galvanometer Rg is the ~~potential drop~~ potential drop in internal resistance. If I is current across ~~galva~~ high resistance and resistance is Rh



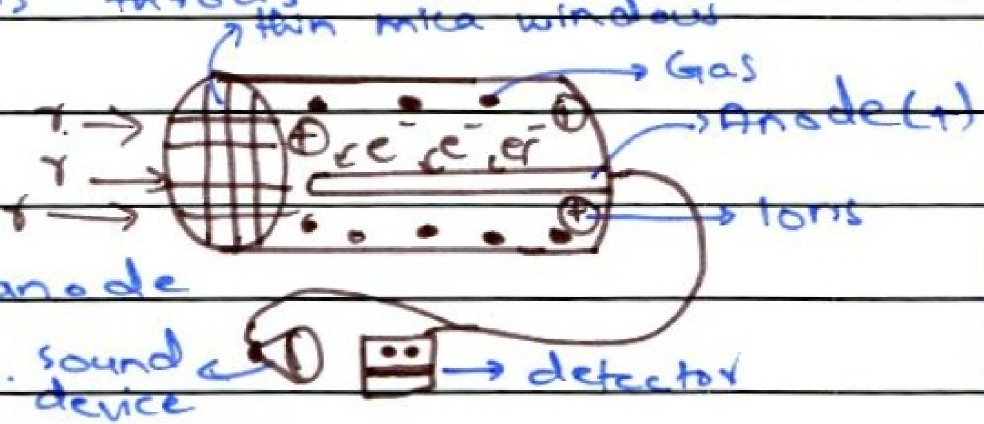
$V = IR_g + IR_h$ $\qquad$ $R_h = \frac{V}{I} - \frac{\cancel{I}R_g}{\cancel{I}}$

current same because Series.

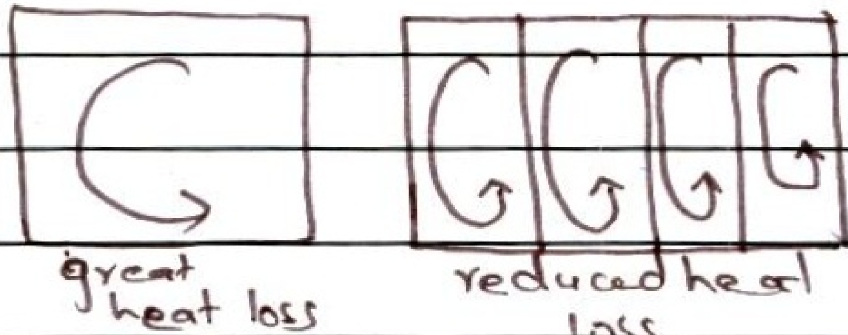
$IR_h = V - IR_g$ $\qquad$ $R_h = \frac{V}{I} - R_g$ → **Formula for Rh**

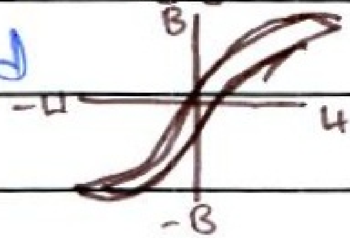
Ideally voltmeter has infinite resistance and connected in parallel in circuit.

Q. No. 2 Part (vii) Geiger- Muller Counter: It uses the effect produced by interaction of electromagnetic radiations with matter. It consists metallic cylinderical tube that is filled with a gas at low pressure. A long metal wire attatched to positive terminal is also suspended along the axis of the counter. This metal wire is attatched to a pulse detection system. which detects radiations and produce sound. WORKING → when an electromagnetic radiation enters through the thin mica window it ionizes the gas to produce electrons and positive ions. These electrons moved towards anode and are detected by counter as pulses.



Q. No. 2 Part (viii) In transformer laminated iron core with thin separations of insulation is used to reduce the heat losses caused due to eddy currents in the iron core which will effect the efficiency of the transformer. By doing so the width of the eddy currents circulating will be reduced to a single lamina instead of whole core. Furthermore the material of iron is used because of its low hysterisis loss i.e. energy that is lost in demagnitization. It can be magnetized and demagnitized easily with a flat hysterisis curve.

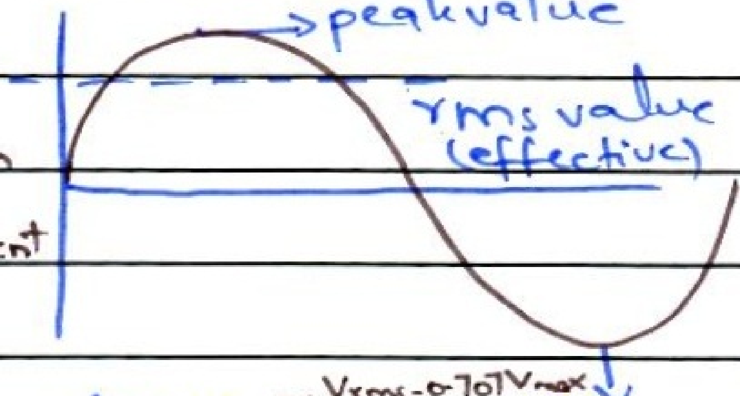




Q. No. 2 Part (ix) **Peak value:** The maximum value that is attained by an alternating quantity is called peak value.

Effective value: "It is the value of that steady current (D.C) that when moving through a resistor ~~(produced)~~ produces the same amount of heat as producted by an alternating current when passing through the same resistence for same time.

It is most important of all ~~(eq)~~ quantities. The relation between peak value and rms value for current and voltage is given as



$$V_{rms} = \frac{V_{max}}{\sqrt{2}} \quad \text{or} \quad I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

or $V_{rms} = 0.707 V_{max}$
$I_{rms} = 0.707 I_{max}$

Q. No. 2 Part (x) **Metastable state:** The state in which an electron remains excited for longer period of time before progressively falling into ground state. The electron's in normal excited state remains for only 10^{-8} s but for meta stable state it remains for 10^{-3} s which provides greater time for photons to carry out stimulated emission of photons. Otherwise in normal excitation the time of contact for photons with atoms is very less.

•) Population inversion: The scenario when the concentration of atoms in excited state is greater than that of ground state. It is called inversion because under normal conditions the population of ground state is greater than excited state. It is achieved through laser pumping and is done to emit more coherent photons.

Q. No. 2 Part (xi) **Data**

K.E of electron $= 1200$ keV $= 1200 \times 10^3$ eV $= 1.9226 \times 10^{-13}$ J

Required Debroglie's wavelength $= ?$

Solution

We know $\lambda = \frac{h}{mv}$ where 'h' = Plancks constant $= 6.63 \times 10^{-34}$ Js

Now we know $K.E = \frac{1}{2} mv^2$

To determine velocity

$$V = \sqrt{\frac{2K.E}{m}}$$ where m = mass of electron $= 9.1 \times 10^{-31}$ kg

$$= \sqrt{\frac{2(1.9226 \times 10^{-13})}{9.1 \times 10^{-31}}} = 6.5 \times 10^8 \, ms^{-1}$$

Now $\lambda = \frac{h}{mv}$ substituting values we have

$$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 6.5 \times 10^8} = 1.119 \times 10^{-12} \, m$$

Result

So Debroglie's wavelength is 1.119×10^{-12} m or 0.00119 nm

Q. No. 2 Part (xii)

Data

mass of U-235 = 0.5 kg = 500 grams

atomic mass = $A = U_{235} = 235\ g/mol$

energy per event = 208 MeV

Required energy released per fission event = ?

Solution

No. of moles of U-235 used

= Given mass / molar mass

$= \frac{500}{235} = 2.12$ moles

No. of molecules of U-235 = 2.12 × NA

$= 2.12 \times 6.02 \times 10^{23}$

$= 1.28 \times 10^{24}$

So energy released per fission = 208 MeV × no. of molecules

$= 208 \times 1.28 \times 10^{24}$

$= 2.665 \times 10^{26}$ MeV

Result

So energy released per fission event is 2.665×10^{26} MeV.

Q. No. 2 Part (xiii) **Electron volt:** It is a unit of energy.

"The amount of energy acquired or lost by an electron when it is displaced across two points between which the potential difference is 1 volt."

so if an e^- with charge e is moved across a point with $\Delta V = 1$ so

Energy = eV

eV converted into SI we have

$1eV = 1.602 \times 10^{-19} VC$ as $V = 1$ and q one $= 1.602 \times 10^{-19} C$

we know VC = Joule

so $1eV = 1.602 \times 10^{-19} J$ → **required relation**

Bigger units are mega electron volt and Giga electron volt.

Q. No. 2 Part (xiv) Many electrical circuit depends on maximum transfer of power from source with internal resistance r and across load R. For that r needs to be matched properly with R. We know maximum power is transferred from ~~(load)~~ source to load when internal resistance of source r is equal to the resistance of load R.

We know power dissipated in load $= I^2 R$

and $I = \frac{\varepsilon}{r+R}$ → emf of batter

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

we know at max power transfer $r = R$ putting $r = R$

so $I = \frac{\varepsilon^2 R}{\cancel{(R-R)^2} + 4RR}$

$$I = \frac{\varepsilon^2 \cancel{R}}{4R^{\cancel{2}}}$$

$$I = \frac{\varepsilon^2}{4R}$$ → required equation

If $r > R$ or $r < R$ maximum power is not transferred.

CHARGE TO MASS RATIO OF ELECTRONS

We ~~need~~ know that when moving charged particles are passed through uniform magnetic field they are subjected to a magnetic force given by

$$F = qvB \sin\theta$$

So the charge to mass ratio of an electron can be determined by ~~a~~ subjecting an electron beam in a perpendicular arranged uniform magnetic field.

Experimental setup

The magnetic field is kept perpendicular the motion of electrons so as to exert maximum magnetic force on them which at every instant is perpendicular to the motion of electrons and moves the electrons in a circular path with a centripetal acceleration The necessary centripetal force required to keep the electrons moving in a circle is provided by the magnetic force at each instant.

We know that magnitude of

Q. No. 3 (Page 2) centripetal force is given by $\frac{mv^2}{r}$ and magnetic force is $qvB \sin\theta$ (in this case $\theta = 90°$), so

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

$$\frac{mv}{r} = qB \rightarrow \text{eq. 1}$$

In the above Equation the value of B (magnetic induction) can be easily determined from ringed coils called **Helmbold's coils** and radius can be determined by making election beam visible through excitation. For velocity we have to apply an electric potential of know value qV which is responsible for kinetic energy of electrons as:-

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

calculating 'v'

$$v^2 = \frac{2qV}{m} \quad \because \quad v = \sqrt{\frac{2qV}{m}} \rightarrow \text{eq. 2}$$

Putting value of eq. 2 in eq. 1 we have

$$\frac{m\sqrt{\frac{2qV}{m}}}{r} = qB$$

Taking square on both sides

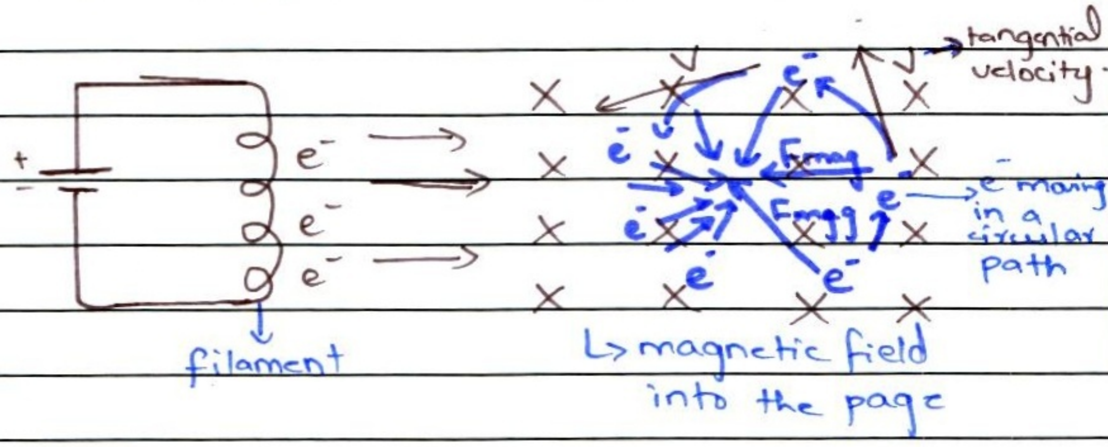
$$\frac{\cancel{m^2} \cdot 2qV}{r^2 \cancel{m}} = q^{\cancel{2}} B^2$$

$$\frac{2Vm}{r^2} = qB^2$$

Now to determine charge to mass ratio

$$\frac{q}{m} = \frac{2V}{r^2B^2} \Rightarrow \text{which is required equation}$$

so knowing values of V, r and B charge to mass ratio of electrons can be determined which comes out to be $1.7588 \times 10^{11}\ Ckg^{-1}$ meaning 1 kg of electrons have a charge of (1 ~~ℓ~~ ω) 1.7588×10^{11} C.



POTENTIOMETER

Definition:

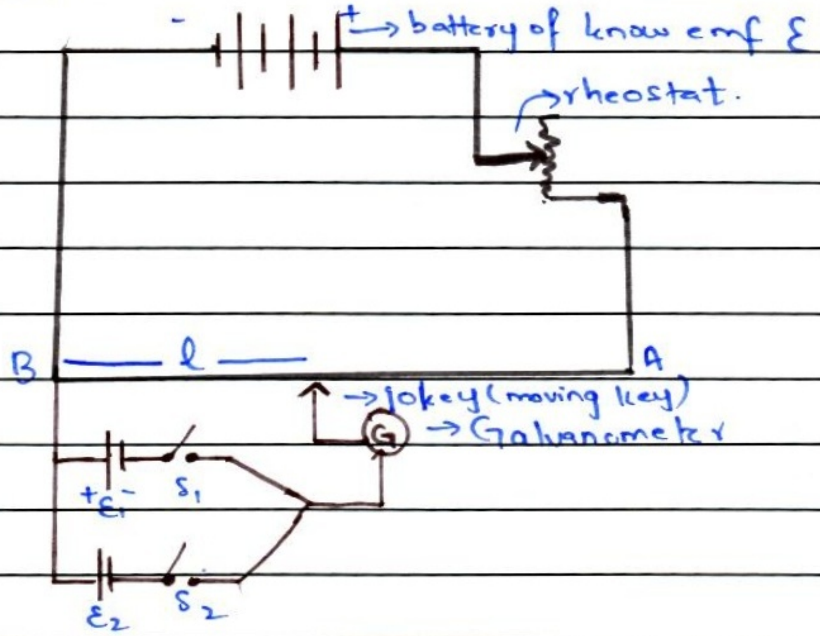
> "A potentiometer is a null type resistance network device used for measuring potential difference"

For accurate measurements of potential differences, currents and resistances potentiometer is used.

Principle:

It works on the principle that a battery of unknown voltage/emf (~~resistance~~) is balanced wholly or partly by a battery of known potential difference.

Construction



→ A typical potentiometer consists of a long wire that is attatched across the terminals of a battery of known emf. The battery through the rheostat (variable) resistor supplies emf from A to B and across secondary circuits. At point B the wire is connected to a battery of unknown emf ε_1 whose emf is to determined. Further along another a battery of unknown emf ε_2 is also connected. The two batteries are further connected through two ~~two~~ way switches S_1 and S_2 to a galvanometer which is further connected to a sliding key K.

WORKING:

To determine Emf ε_1 firstly the S_1 is closed while S_2 is kept open. The sliding key is gently pressed and moved along AB till the galvanometer shows zero reading. The length l_1 on AB corresponds to voltage drop across ε_1

→ voltage drop across length 'l' V

→ voltage drop across length '1' $\frac{V}{l}$

→ voltage drop across length 'l_1' $\frac{V}{l} \times l_1$

$$\text{So} \quad \varepsilon_1 = \frac{V}{l} \times l_1$$

similarly length of ε_2 is also determined by same process and ε_2 is determined as

$$\varepsilon_2 = \frac{V}{l} \times l_2$$

Q. No. 4 (Page 3) Now comparing the emfs of both unknown batteries we have

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{\cancel{\frac{V}{l}} \times l_1}{\cancel{\frac{V}{l}} \times l_2}$$

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{l_1}{l_2}$$

This formula can be used to compare emf of two cells.

APPLICATIONS:

A potentiometer is used to

→ measure small emfs upto 2V and large emfs upto 500V

→ calibration of ammeter and voltmeter

→ Measurement of current, voltage and resistance

→ Comparision of emf of two cells.

Q. No. 5 (Page 1)

GAUSS'S LAW

The electric field intensity for a given charge distribution can be determined by using ~~(gauss's law)~~ coulomb's law. But ~~(something)~~ sometimes the calculations may become quite complicated. An alternative theorem to measure the electric field intensity of a given charge distribution is given by gauss's law. Gauss's law relations the net electrical flux through closed surface with the charge enclosed by that surface.

Statement

"The net electrical flux through a closed surface is equal to total charge enclosed by that closed surface divided by permitivity of free space."

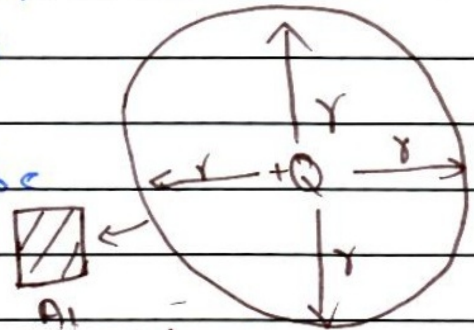
$$\Phi = \frac{Q}{\varepsilon_0}$$

Derivation

Consider a charge of magnitude Q placed in the centre of conducting sphere of radius r. As the charge is placed at centre so distance from all the points on surface from centre will be equal. We also divide the total are into a number small patches A_1, A_2 and A_3 so that electric field along each

Q. No. 5 (Page 2) patch is uniform.

So likely we can see that electric flux through patch A will be



A_1

small patch of surface

$$\phi_A = \Delta E A_1 \cos\theta$$
$$= E\Delta A_1$$

in all cases $\theta = 0^\circ$ as surface is perpendicular to the charge so its vector area will be parallel to electric ~~(magnetic)~~ field lines.

Similarly

$$\phi_B = E\Delta A_2$$
$$\phi_C = E\Delta A_3$$

so total flux

$$\phi_T = \phi_A + \phi_B + \phi_C + \phi_D + \text{-----}$$
$$= E\Delta A_1 + E\Delta A_2 + E\Delta A_3 + E\Delta A_4 + \text{----}$$
$$= \underbrace{E}_{\text{as this is uniform}} (\Delta A_1 + \Delta A_2 + \Delta A_3 + \text{---})$$

$$= E \sum_{i=1}^{i=\infty} A$$

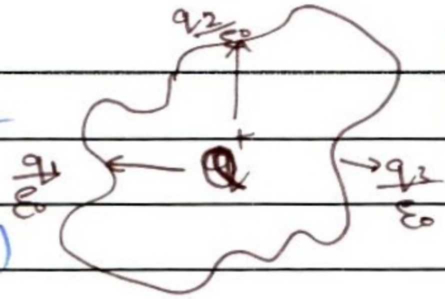
we know $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r^2}$ and S.A of sphere $= 4\pi r^2$

so

$$= \frac{Q}{\cancel{4\pi}\varepsilon_0 \cancel{r^2}} \times \cancel{4\pi r^2}$$

$$= \frac{Q}{\varepsilon_0}$$ → which is required expression to be proved.

Now in case of any irregularly shaped body we can divide its area into different groups and measure the charge distribution.



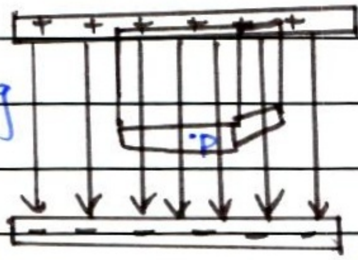
$$\text{So } \Phi_T = \frac{q_1}{\varepsilon_0} + \frac{q_2}{\varepsilon_0} + \frac{q_3}{\varepsilon_0} + \cdots$$

$$= \frac{1}{\varepsilon_0}(q_1 + q_2 + q_3 + \cdots)$$

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

The total flux through a body ~~(charge enclosed by)~~ is $\frac{1}{\varepsilon_0}$ total charge enclosed by it.

OPPOSITELY CHARGED PLATES



Consider two oppositely charged infinite plates (to avoid fringing field at end) having charge densities of $+\sigma$ and $-\sigma$. We need to determine electric field intensity between these plates at point P. A cube is placed between these plates as a gaussian surface with its upper face within the positively charged plate. The electric ~~(magnetic)~~ flux through sides is zero because they are parallel to electric ~~(magnetic)~~ field lines. It is also zero in the upper face because it lies within the plate and charge within conductor is zero. But the electric ~~(magnetic)~~ flux through lower surface is maximum as it is perpendicular to lines and $\Phi = EA$

we know by gauss law

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

and $\sigma = \frac{Q}{A}$, so $Q = A\sigma$

$$\Phi_T = \frac{\sigma A}{\varepsilon_0}$$

Also $\Phi_T = EA + 0 + 0 + 0$

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

$$E = \frac{\sigma}{\varepsilon_0}$$ ⇒ required equation.

So electric between two parallel plates is perpendicular uniform and is independent of the distance of the plates.

HALF LIFE

Definition

"The time during which half of the radioactive nuclei in a sample decays is called as half line."

The process of radioactive decay is random but probability of distintegration for nuclei in a given sample can be predicted.

Example:

All radio active decays as time passes by. For example the half life of Carbon-14 is 5730 years. So if we No C-14 at Time=t=0 then after 5730 years No will be reduced to $\frac{No}{2}$ and after another 5730 years it will reduce to $\frac{No}{4}$ and so on.

ACTIVITY :

" The activity or rate of radioactive decay is the no. of disintegrations that take place in unit time."

Derivation

For example if we have N amount of sample then we know radioactive decay ΔN will be

$$\Delta N \propto -N$$

the negative sign indicates the concentration of

Q. No. 6 (Page 2) N decreases with time

$\Delta N \propto \Delta t$

combining both we have

$\left(\frac{\Delta N}{\Delta t}\right)$

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

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

where λ is decay constant placed as constant of proportionality. so

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

where $\frac{-\Delta N}{\Delta t} = A$ (Activity of sample

so $A = \lambda N$

By simple calculus we can prove that

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

we know that

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

$$\frac{1}{N} \Delta N = -\lambda \Delta t$$

Taking integral on both sides

$$\int \frac{1}{N} \Delta N = -\lambda \int \Delta t$$

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

we know at $t = 0$ $N = N_0$ putting in equation

$$\ln N_0 = -\lambda(0) + C$$
$$\ln N_0 = C$$

replacing in original equation

$$\ln N = -\lambda t + \ln N_0$$
$$\ln N - \ln N_0 = -\lambda t$$
$$\ln \frac{N}{N_0} = -\lambda t$$

Taking power of e at both sides

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

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

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

$\frac{N}{N_0} = e^{-\lambda t}$ Taking ln on both sides

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

$$\ln \frac{N}{N_0} = \cancel{\ln} \cancel{\lambda t} - \lambda t$$ we know that at $T_{1/2}$ $N = \frac{N_0}{2}$

$$\ln \frac{\frac{N_0}{2}}{N_0} = \cancel{(1)} - \lambda t$$

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

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

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

$\hookrightarrow$ required equation

Above equation relates decay constant and half life. Half life is specific for each element and rate of radioactive decay is directly proportional to stability. Units are Curie and Becqueral and

1 Curies = 3.7×10^{10} Becqueral and 1 Becqueral = 1 Decay per sec.

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

$\lambda = \frac{h}{m2v}$

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

$Q = CV$

$2F$

$=$

$\frac{2\ell - \ell}{\ell}$

$1eV = 1.$

$= \frac{\ell}{\ell} = 1$

60watt

power = 50

$\uparrow Q$!

$CQ = NIAB$

$\boxed{\frac{CQ}{NAB} = 1}$

$\mathcal{E} = VBL$

$1 = \frac{1CQ}{NAB}$

$\mathcal{E} = VBL$