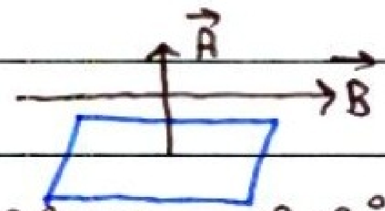
Q. No. 2 Part (i)

MAGNETIC FLUX: The number of magnetic field lines passing through a unit area is called magnetic flux. It is the scalar product between the magnetic field strength and area vector.

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

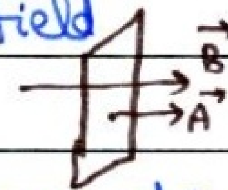


Unit: Its SI unit is Waber $1\,Wb = 1\,Tm^2$.

Minium Flux: If plane of area and $\vec{B}$ are parallel $\phi = BA\cos 90^\circ = 0$. $\theta = 90^\circ$

Maximum Flux: If plane of area and $\vec{B}$ are perpendicular. $\phi = BA\cos 0^\circ = BA$

Waber: The amount of magnetic flux is 1 Wb if 1 T magnetic field passes through unit area of $1\,m^2$.



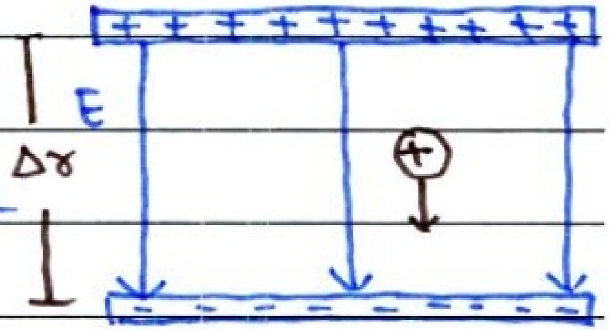
Magnetic Flux Density (B): The magnetic flux density or magnetic field strength is the amount of magnetization produced or the intensity of magnetic field. $B = \mu_0 H$ $B = \mu_0 n I$

Unit: Its SI unit is Tesla $1\,T = 1\,Wbm^{-2}$

Q. No. 2 Part (ii)

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

Potential gradient is the difference in potential with respect to distance.



Consider, a charged particle placed in an electric field. The work done on the charged particle is calculated by:

$$\Delta V = \frac{W}{Q}$$

$$W = \Delta V Q \quad — (1)$$

If the charge is moved in direction opposite to magnetic field then work done can be calculated as.

$$W = F d \cos\theta \qquad \theta = 180^\circ$$

$$= -F \Delta r \qquad \text{As } F = qE$$

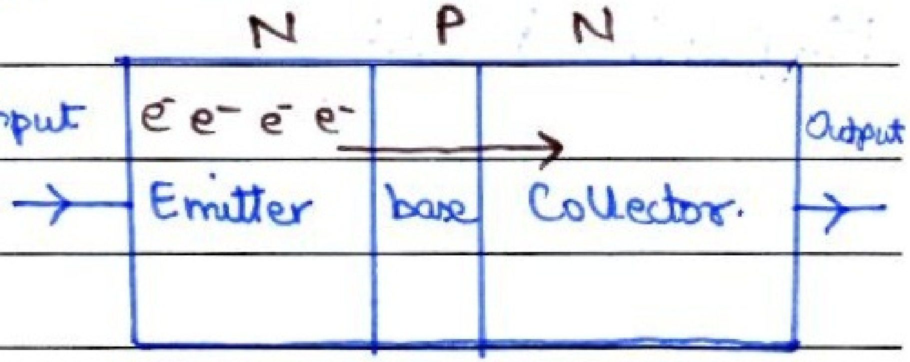
$$= -qE\Delta r \quad — (2)$$

By combining (1) and (2).

$$-Eq\Delta r = \Delta V q$$

$$E = -\frac{\Delta V}{\Delta r} \Rightarrow \text{Proved.}$$

Q. No. 2 Part (iii) **BASE REGION.**



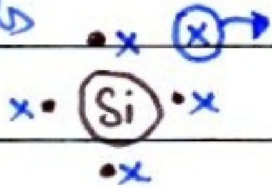
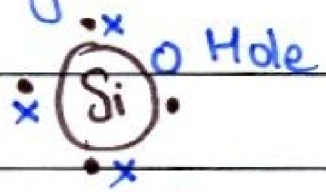
In a transistor, the base region is made thin and lightly doped. This is because the emitter is the input terminal and provides Current and the Collector is the output terminal that is used to collect the majority charges (electrons in NPN and holes in PNP). The base region is made thin so that it does not load and distort the circuit. The base is thin and lightly doped so maximum emitter current can be calculated in collector. and base takes minimum current:

$I_E = I_C + I_B$ if I_B is low

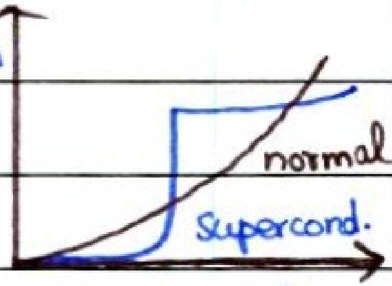
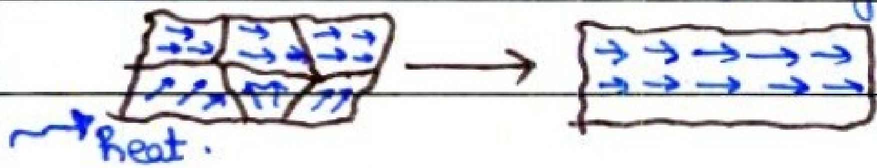
$I_E \approx I_C$. i.e. the output will be maximum.

Size: C > E > Base   Doping: Emitter > Collector > Base.

Q. No. 2 Part (iv)

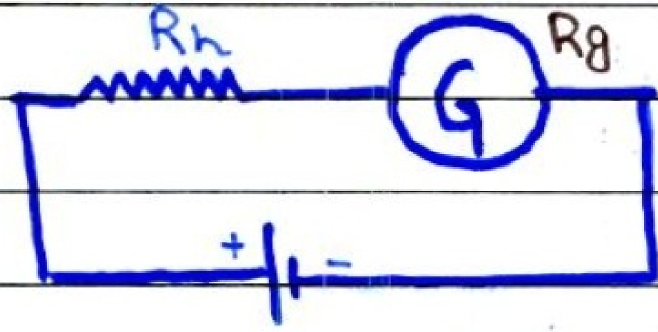
N-Type	P-type
N-type conductor is made when pentavalent atoms of Group-V are added to Si or Ge.	P-type conductor is made when trivalent atoms of Group-III are added to Si or Ge.
Diagram.	
Group V i.e. Phosphorous has 5ē when added to Si or Ge gives an extra electron that travels as majority charge 	Group 3 i.e. Boron has 3ē when added to Si or Ge, makes its e⁻ deficient giving rise to a hole. 
N>P	**Charges** N<P
In N-type, electrons are majority charges and holes minority charge.	In P-types, holes are majority charges and ēs minority.

Q. No. 2 Part (v)

CRITICAL TEMP.	CURIE TEMP.
The low temperature at which a material is converted into superconductor is called Critical temperature.	The high temperature at which a ferromagnetic material becomes paramagnetic is called Curie Temperature.
Resistance: At certain low temperature, the resistance of a superconductor becomes zero and current is maximum. R=0 I=max B=max  Certain materials becomes superconductor at even 125 K.	**Effect of heat:** A ferromagnetic material has domains in it. When certain high heat is provided, the domains break and the material is converted into paramagnetic. 
Application: MRI, Maglev trains.	**Magnetization:** The magnetization is reduced.

Q. No. 2 Part (vi) **VOLTMETER**

A galvanometer can be converted into a voltmeter by connecting a high resistance in series with it.



In this way, the total voltage of circuit is divided,

$$V = V_h + V_g.$$

$$V = I_g R_h + I_g R_g$$

In series I = same.

$$V = V_g (R_h + R_g)$$

$$\frac{V}{V_g} - R_g = R_h.$$

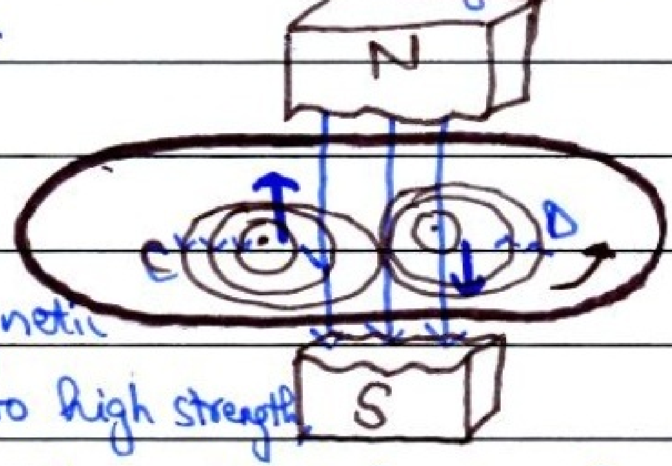
The high resistance takes maximum voltage and increases the range of galvanometer. Range increases with increase in R_h.

Ideal voltometer: Ideal voltometer has infinite resistance so it does not load the circuit.

In circuit: A voltmeter is connected in parallel in a circuit.

Q. No. 2 Part (vii) EDDY'S CURRENT.

Eddy's current are the current produced when a magnetic field passes through a metal (conductor).



BRAKING SYSTEM AND PRODUCTION:

Eddy's current are produced in direction perpendicular to the magnetic field. When a magnetic field passes through a metal, at point C due to high strength, a counterclockwise current is generated and at point D due to low strength, a clockwise current is generated. According to Lenz's law, this eddy's current opposes the cause that produces it and rotates in direction. This is used in braking system.

Heating effects: Eddy's current produce a large amount of heat. This is used in cooking tops. Metal is connected to alternating Current which produces eddy's current and the heat produced is used for cooking food.

Q. No. 2 Part (viii) NUMERICAL.

$R = 10\,\Omega$

$L = 32 \times 10^{-3}\,H$

$V = 220\,V$

$f = 50\,Hz$

Solution: As, $X_L = 2\pi f L$

$= 2 \times \pi \times 50 \times 32 \times 10^{-3}$.

$= 10.05\,\Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{10^2 + 10.05^2}$

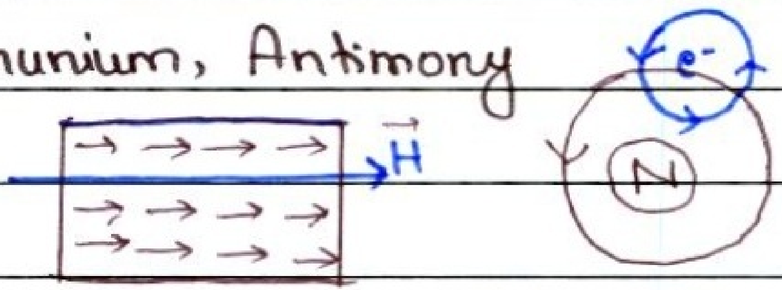
$= 14.177\,\Omega$

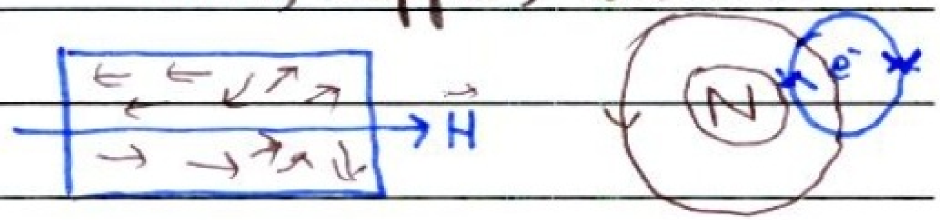
As, $I = \frac{V}{Z} = \frac{220}{14.177}$

$\boxed{I = 15.518\,A}$

Q. No. 2 Part (ix)

PARAMAGNETIC	DIAMAGNETIC.
The material having same spin and orbital motion are paramagnetic as their effect of magnetic field is added and behaves as small magnets.	The material having different spin and orbital motion are diamagnetic as their magnetic fields are cancelled.
Magnet	
They are weakly attracted by magnets. In presence of external field, their magnetic aling themselves with field.	They are weakly repelled by magnets.
Example.	
Almunium, Antimony	Zinc, Copper, Bismuth.



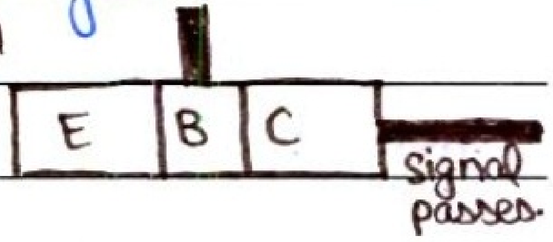


Q. No. 2 Part (x)

TRANSISTOR AS SWITCH.

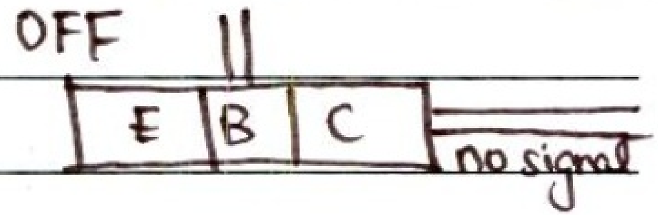
The Transistor can be used in circuit as a switch if it is used in its cut-off and saturation region.

ON State: The transistor is in ON state when both EB Junction and CB Junction are forward biased i.e. saturation.



The base current flows and current is received at collector. The value of $V_{CE} \approx 0$. All the signals are passed in ON state.

OFF State: The transistor is in OFF state when both EB Junction and CB Junction are reverse biased i.e cut off. The base current doesn't flow so no collector current. The value of $V_{CE} \approx +V$. No signal is passed.



Q. No. 2 Part (xi)

LEPTONS	HADRONS.
Leptons are present in weak nuclear forces. In some cases if mass is present then gravitational forces and charge is present so EM forces.	Hadrons have strong nuclear forces in addition of weak nuclear force, gravitational force and EM forces.
Elementary particles.	
Leptons are elementary particles as they are not made of any particles.	Hadrons are further made of particles called Quarks.
Names	
There are 6 leptons i.e. electron, antielectron muons, antimuons Tau Antitau.	Hadrons are divided into: • **Mesons**: Made of 2 Quarks π^+ meson, π^- meson. • **Baryons**: Made of 3 Quarks. proton, neutron.

Q. No. 2 Part (xii) **ALPHA FACTOR.**

Alpha factor is the ratio of Collector current to emitter current or amplification factor of Common Base Transistor.

$$\alpha = \frac{I_C}{I_E} \qquad \alpha = \frac{\text{Output Current}}{\text{Input Current}}$$

$\alpha < 1$

BETA FACTOR:

Beta factor or amplification factor is the current gain in common Emitter transistor.

$$\beta = \frac{\text{Output Current}}{\text{Input Current}} \qquad \beta = \frac{I_C}{I_B} \qquad \beta > 1$$

RELATION:

$$\beta = \frac{I_C}{I_B} \qquad I_E = I_C + I_B.$$

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

Dividing all by I_E.

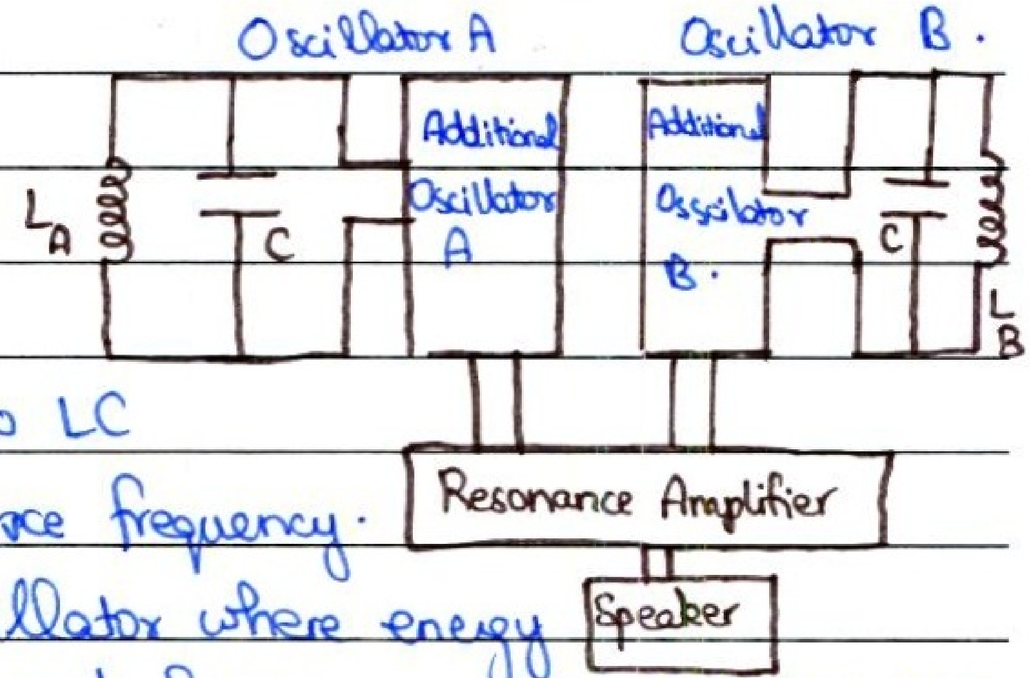
$$\beta = \frac{I_C/I_E}{I_E/I_E - I_C/I_E} = \frac{\alpha}{1-\alpha} \qquad \text{As, } \frac{I_C}{I_E} = \alpha$$

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

Q. No. 2 Part (xiii)

METAL DETECTOR.

PRINCIPLE: A metal detector is a device used to detect a metal object. It works on the principle of beats.

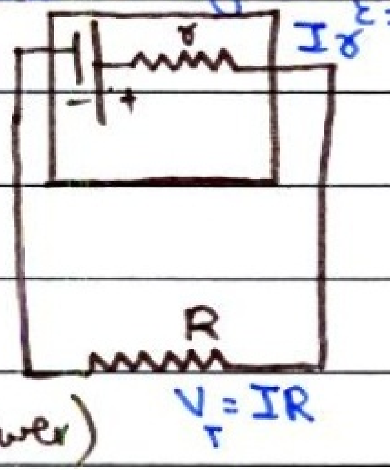


Explanation: It consists of two LC circuits which have same resonance frequency. It is like a mass-spring oscillator where energy is oscillated. The inductance and frequency of L_A and L_B are constant. When a metal comes near a L_B circuit, the inductance L_B decreases and frequency of L_B is increased. This difference in frequencies of A and B produces beats which are amplified and the speaker produces a sound.

Q. No. 2 Part (xiv)

MAXIMUM POWER.

A Source (battery or cell) gives maximum power output if the load resistance R is equal to the internal resistance r of the battery. In case the R is greater or lesser than r, power will not be maximum. This is explained by power transfer theorem.



$$P = I^2 R$$

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

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

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

Adding and subtracting $2Rr$.

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

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

If $R = r$ (maximum power)

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

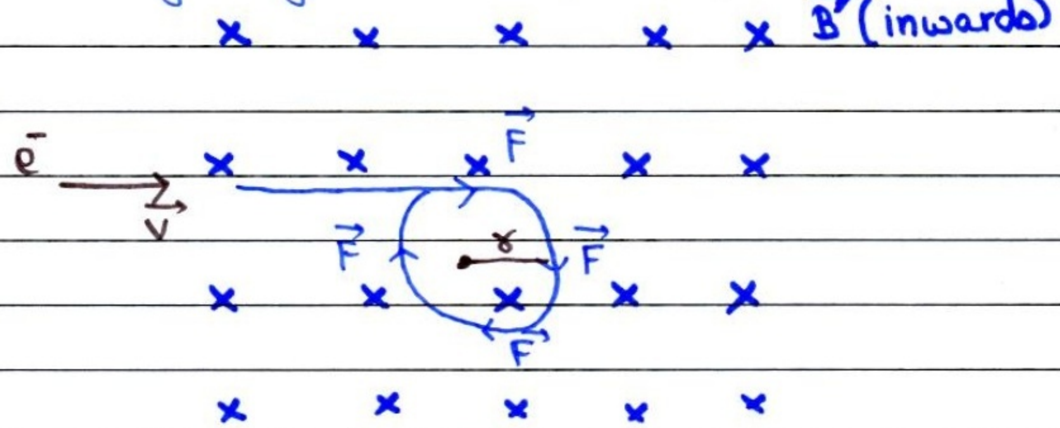
$$P = \frac{\varepsilon^2 \cancel{R}}{4\cancel{R}r}$$

$$P = \frac{\varepsilon^2}{4r} \quad \text{OR} \quad \frac{\varepsilon^2}{4R}.$$

Q. No. 3 (Page 1)

$\frac{e}{m}$ Ratio of electron.

When an electron enters a magnetic field, it is deflected. This deflection and direction of motion of electron can be calculated by Flemming's left hand Rule (in reverse direction). or Flemmings right hand rule.



Centripetal Force:

Thus, the force acting on the electron makes it rebolve in a circular path.
This magnetic force provides the necessary centripetal force.

$$\vec{F}_B = \vec{F}_c$$

$$\frac{mv^{\not 2}}{r} = q\not{v}B$$

As electron motion is perpendicular to $\vec{B}$ $\sin 90^\circ = 1$

$$\frac{mv}{r} = qB$$

$$\frac{v}{Br} = \frac{q}{m} \quad \text{— (3)}$$

Q. No. 3 (Page 2)

Magnetic field: The magnetic field of the area is known.

Radius: The radius can be calculated by using gas in the discharge tube. During the excitation and de-excitation of gas molecules, the radius is calculated.

Velocity: The velocity can be calculated as:

$$K.E = \frac{1}{2} mv^2 \quad \text{— ①}$$

And,

$$K.E = qV \quad \text{— ②}$$

By combing ① and ②.

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

$$mv^2 = 2qV$$

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

Taking sq root.

$$\sqrt{v^2} = \sqrt{\frac{2Vq}{m}}$$

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

Putting value in eq ③.

$$\frac{q}{m} = \frac{\sqrt{\frac{2Vq}{m}}}{Br}$$

Taking sq.

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

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

Calculating Value:

Charge of $e^- = 1.66 \times 10^{-19}$ C.

Mass of $e^- = 9.11 \times 10^{-31}$ kg.

$$\frac{e}{m} = \frac{1.66 \times 10^{-19}}{9.11 \times 10^{-31}} \, C kg^{-1}$$

$$\boxed{\frac{e}{m} = 1.758 \times 10^{11} \, C kg^{-1}}$$

Photoelectric Effect.

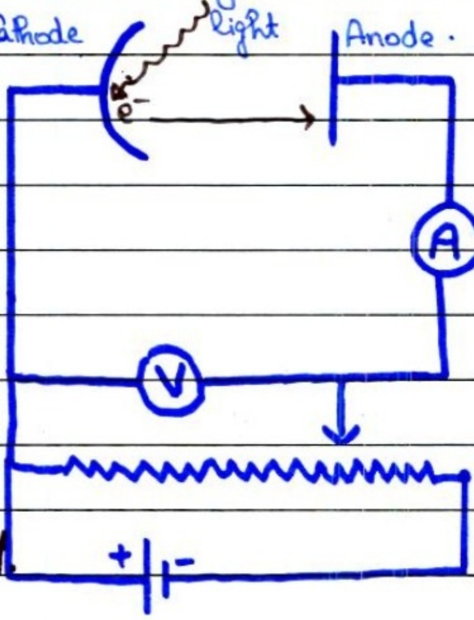
Photoelectric effect proves particle nature of light.

"When light falls on the surface of metal, a photon is emitted. This phenomenon is called photoelectric effect and the current is called photoelectric current."

Explanation:

The photoelectric effect was observed by Hurtz and explained by Einstein.

When light falls on a concave cathode, it emits an electron which is detected as current in the ammeter. The rheostat is used to change the voltage.



FAILURE OF CLASSICAL PHY

FIRST PUZZLE:

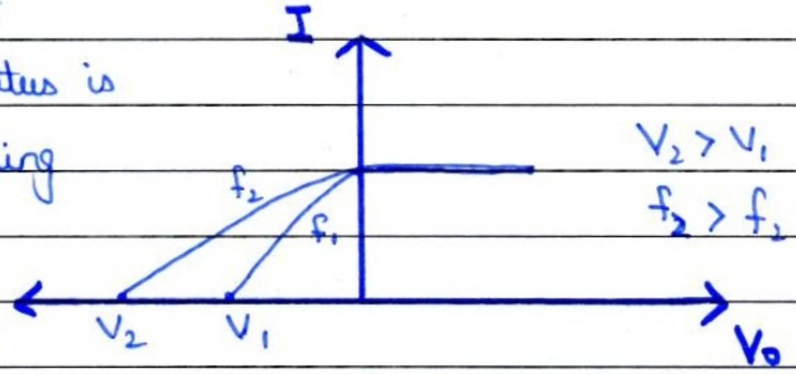
To measure the kinetic energy of electrons, the polarity of battery is reversed. At a certain point, the voltage is kept on increasing. With increase in voltage the electon number reduces. When no electron is emitted further, the voltage is called stopping potential. Stopping Potential is the voltage at which no more electrons will be emitted.

$$K.E = qV_o$$

$$V_o = \frac{K.E}{q}$$

According to Photoeletric effect, if the voltage is increased by increasing K.E and frequency, the photoelectric current remains same.

The voltage of appratus is increased by increasing frequency, $V \propto f$ but the photoelectric current remains same.

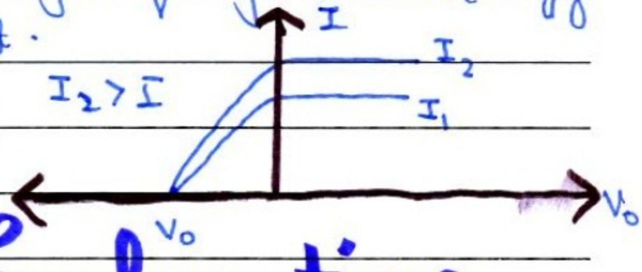


Classical physics fails to explain this. As according to classical physics, with increase in amplitude, the intensity of current increases.

SECOND PUZZLE: Classical physics states that their must be time dilation in emission of electrons but the electrons are emitted continuously.

THIRD PUZZLE: According to Photoelectric effect, if the frequency is kept constant with increase in no. of photons i.e. the intensity of photons, the current increases. This is failure of classical physics as classical physics suggests that with increase in intensity, frequency increases (energy increases) but here voltage is constant.

Only after a certain frequency, the current will be emitted.



Einstein's Explanation

Einstein in 1905 explained the photoelectric effect and solved the puzzles.

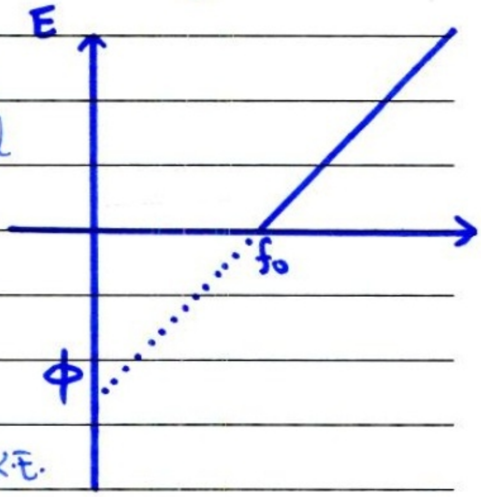
According to Photoelectric effect, only after a certain frequency, the current i.e. electrons will be emitted. This was failure of Classical theory as according to classical theory, photons will emit electrons at all frequencies.

THRESHOLD FREQUENCY: The minimum amount of frequency required to emit an electron is threshold frequency. (f_o)

Einstein explained this by using the Plank's quantization of energy. According to Einstein, the energy that is given by photon is converted into work function and rest is converted into K.E of electron.

WORK FUNCTION: It is the minimum amount of energy required to remove an electron.

When electron absorbs a photon, it is excitated. Absorbing work function ionizes the electron. If energy greater than work function is given, the electron moves to surface and travels with K.E.



This work function ϕ is characteristic of metal. Metal having more ϕ will have less K.E.

$$hf = \phi + K.E_{max}$$

$$hf = hf_o + K.E_{max}$$

work function $\phi = hf_o$.

It can also be used to calculate K.E.

$$K.E_{max} = hf - hf_o$$

If $f = f_o$ i.e. the energy of photon is equal to threshold frequency, there will be no K.E.

$$K.E_{max} = hf_o - hf_o = 0.$$

Wavelength $\frac{hc}{\lambda} = \frac{hc}{\lambda'} + K.E_{max}$

Gauss's Law

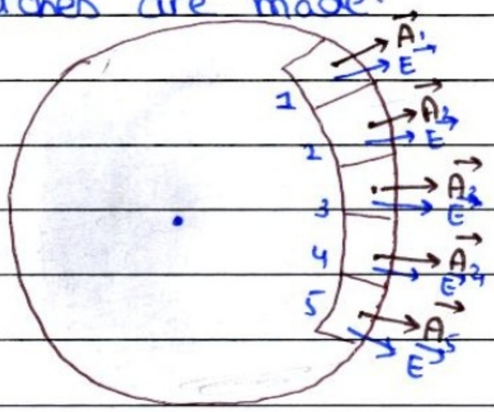
Gauss's law is used to find the electric flux of a closed, arbitarary path.

STATEMENT:

According to gauss's law, the flux of a closed path is $\frac{1}{\varepsilon_0}$ the charge enclosed in the path.

EXPLANATION:

Patches: To find the electric flux of a closed surface having irregular shape, small patches are made.



Flux of each patch:

The flux of each patch is calculated separately.

$$\phi_1 = \vec{E}_1 \cdot \vec{A}_1$$

$$\phi_1 = E_1 A_1 \cos\theta$$

As Angle b/w $\vec{A}$ and $\vec{E}$ is $0°$ $\cos\theta = 1$

$$\phi_1 = E_1 A_1$$

Similarly,

$$\phi_2 = E_2 A_2$$

$$\phi_3 = E_3 A_3.$$

For n-patches.

$$\phi_n = E_n A_n.$$

Addition of flux:

To calculated the total flux of the path, the flux of each patch is added.

$$\sum_{i=1}^{n}\phi = \phi_1 + \phi_2 + \phi_3 + \cdots\cdots + \phi_n$$

$$\sum_{i=1}^{n}\phi = E_1A_1 + E_2A_2 + E_3A_3 + \cdots\cdots + E_nA_n.$$

As, the electric field intensity is same for all patches.

$$E = E_1 + E_2 + E_3.$$

$$E = \frac{kq}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$\sum_{i=1}^{n}\phi = E\,(A_1 + A_2 + A_3 + \cdots\cdots + A_n).$$

$$\phi = \frac{kq}{r^2}\Sigma\Delta A.$$

For a closed loop, the area is $A = 4\pi r^2$ (circle).

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

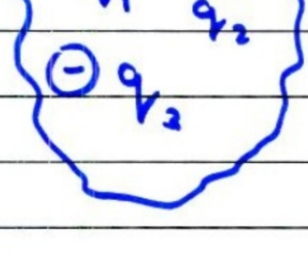
$$\phi = \frac{q}{\varepsilon_0}$$

For Arbitarary Surface:

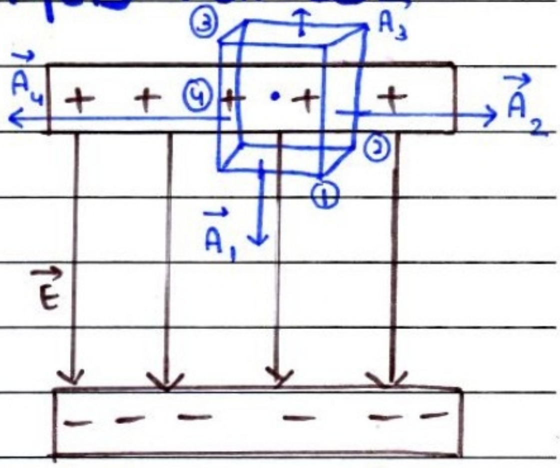
$$Q = q_1 + q_2 + \cdots\cdots + q_n$$

For arbitrary surface having multiple charges, gauss's law is the sum of total charge enclosed in the surface divided by permitivity of free space.

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



OPPOSITELY CHARGED PLATES.



Consider two oppositely charged plates of infinite length. By taking the length of infinite, the fringing effect can be reduced and the electric field is uniform traveling from high potential to low potential.

Gaussian Surface: Gauss's law can be used to measure electric field intensity. Imagine a gaussian surface. In this case, a cube or rectangular shape having one loop above the positively charged plate.

Flux by definition: In all four loops, the flux is calculated.

Loop 1: $\phi = E_1 A_1$. $\cos 0° = 1$ $\theta = 0°$

Loop 2 and 4: As angle is $90°$ $\phi = 0$.

Loop 3: Though, it has angle $180°$, but it is outside the plate $\phi = 0$.

$$\phi = \phi_1 + \phi_2 + \phi_3 + \phi_4 = EA + 0 + 0 + 0.$$

$$\phi = E_1 A_1$$

Let $E_1 = E$ and $A_1 = A$ $\phi = EA$ — ①.

Flux by Gauss's law: According to gauss's law.

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

The charge density δ is calculated as $\delta = \frac{Q}{A} \Rightarrow Q = \delta A$.

Putting value of Q.

$$\phi = \frac{\delta A}{\varepsilon_0} \quad — ②$$

By comparing eq ① and ②.

$$\frac{\delta A}{\varepsilon_0} = EA$$

$$\boxed{E = \frac{\delta}{\varepsilon_0}}$$

Half Life

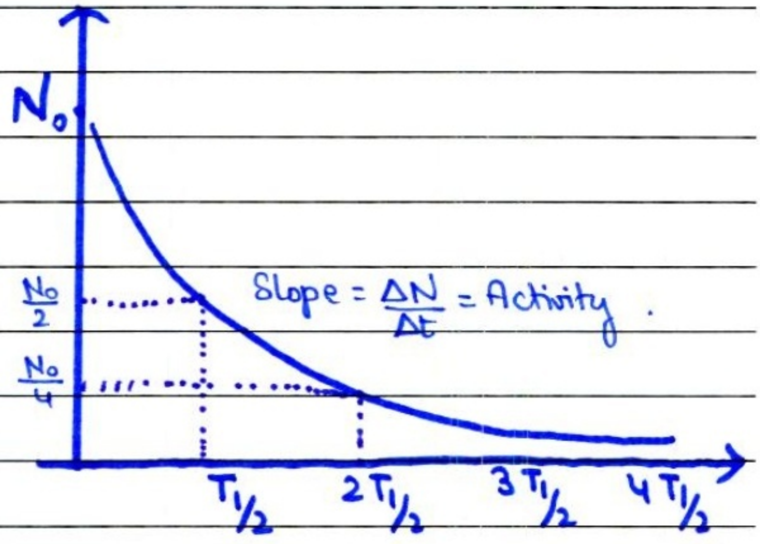
"Half-life is the amount of time by which a radioactive element decays to $\frac{1}{2}$ of its original mass."

EXPLANATION:

Radioactive elements decays by means of emission of α, β or γ rays at a time and converts into another atom or atoms. The half-life is a spontaneous, random process and depends only on the nature material.

EXAMPLE: Every material has its own half-life. This is used to detect the presence of materials in an object. The half-life is the time in which an atom is reduced to its half-amount.

Carbon-14 has half life of 15730 years. In 15730 years. Carbon-14 having initial No will remain $\frac{N_o}{2}$. In another 15730 years, $\frac{N_o}{4}$ will be left.



COMPLETE DECAY:

No element can be completely decayed, as the time for complete decay is infinity. With each half-life, the number of decaying elements decrease.

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

The number of atoms decayed is directly proportional to the initial atoms.

$$\Delta N \propto N \quad -① $$

The number of atoms decayed is directly proportional to the time interval.

$$\Delta N \propto -\Delta t \quad -②$$

negative sign shows that the number of decaying atoms decrease with increase in time.

By combining one and ②.

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

$$\Delta N = \text{con.} - N\Delta t$$

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

$$\frac{\Delta N}{\Delta t} = -\lambda N. \quad -③.$$

λ is called decaying constant and have units of s^{-1} and dimension of frequency.

Activity: The number of decaying atoms per second is called Activity.

$Bq = dps$ **SI unit:** Bacquerel.

$$A = -\lambda N.$$

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

1 Curie = 3.7×10^{10} Bq

1 Ruderford = 10^6 Bq

According to eq ③.

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

Now, if $N = \frac{N_0}{2}$ and $t = T_{1/2}$

$$\frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}}$$

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$$\frac{1}{2} = e^{-\lambda T/2}$$

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

Taking $\ln$ on both sides.

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

$\ln 2 = 0.693.$

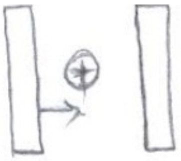
$$(\ln e = 1) \quad \lambda T_{1/2} = 0.693$$

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

$$\text{Undecayed atoms} = \frac{N_0}{2^n}$$

$$\text{Decayed atoms} = N - \frac{N_0}{2^n}.$$

The stability of an element is inversely proportional to decay constant and stability depends on the ratio of radioactive decay.



$\frac{1}{2}$

$E = F/q$

$\frac{F}{2} = \frac{Eq}{2} V/2$

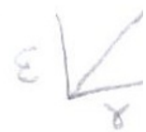
$E = \delta/\varepsilon$ F/q

$F = kq_1q_2$ $Q/2$

$\frac{\delta \downarrow}{\varepsilon_0^2}$

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

Eq $Q/$ $F = Eq$



$E = F/q$ $V/2$

$\downarrow \delta = \frac{Q}{2} / \frac{A}{2} \downarrow$

$I = V/R$

$R = 100\,\text{ohm}$

$L = 32 \times 10^{-3}\,H$ CEC

speed $X_L = 10.05 \downarrow$ back emf

$\frac{kq_1q_2}{r^2 q}$

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

$\frac{V^{I_C}}{I_B}$

$w = Fd$ $\sqrt{X_L^2 + R^2}$

$F\Delta r$

$= qE\Delta r$

$N_S > N_P$

$N_S < N_P$

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

$E = \frac{\delta}{E}$

$\uparrow \theta \propto 1/C_{NAB} \downarrow$

$N_S = N_P$

$\frac{n(n-1)}{2}$

$5(\frac{5}{2}$

$P = w/t$

$Q = CV$

$\frac{60}{50} \times 100^2$

$w = Q\Delta V$

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

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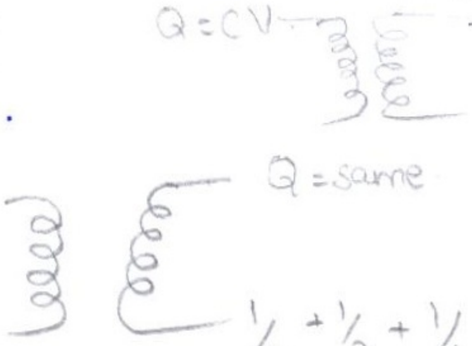
$Q = \text{same}$



$N_S > N_P$

$P = w/t$

$N_S < N_P$

$I = \max$

$Z = \min$

Ideal $\frac{N_S}{N_P} = 1$ $N_P = N_S$

$\frac{1}{2} + \frac{1}{3} + \frac{1}{6}$

ΔV

Δr

$Wb\,m^{-2}$

$\Delta Q = w/Q$

N

$F = \frac{kq_1q_2}{r^2}$

ΔV

ΔV

$\downarrow \lambda = \frac{h}{m\,2v\uparrow}$

$w = \Delta QV$

$\frac{2l - l}{l} = \frac{l}{l} \cdot 2$

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

$2V$

$\downarrow \lambda \propto 1/v\uparrow$

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

$\frac{(6.624 \times 10^{-34}) \times (3 \times 10^8)}{(500 \times 10^{-9})}$

$\frac{1}{1.6}$ $1J$

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