Al-Abbas Notes Physics 2nd year

(Volume-1 Chapter 12 to 16)

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An Easy approach to objective as well Subjective

This booklet contain

- Short and Extensive Questions & Answers from topics
- Solved Exercise Short Questions
- Solved Numerical Problems
- Tid bits/useful information from text book in mcqs form and short Questions form
- Solved BISE Past Papers Topic wise Mcqs

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PHYSICS 2ND YEAR CHAPTER 12 ELECTROSTATICS

INTRODUCTION

*Electrostatics: "**The branch of Physics which deals with the study of charges at rest under the action of electric force is called Electrostatics**".

Electric charge: "An intrinsic property of fundamental particles which takes parts in conduction process is called electric charge. Either they repel or attract each other".

Kinds of charges

There are **two** types of charge, **positive** and **negative**, charge on proton is positive and charge on electron is negative.

SI unit of charge:SI unit of charge is **coulomb**

How many electrons one Coulomb: 6.25*10^{18} electrons

Electric force: The force which holds the positive and negative charges to make up atoms and molecules is called electric force.

***Types of electric force**

Repulsive force: The force b/w two same charges(The force b/w two electrons)

Attractive force: The force b/w two different charges(The force b/w electron and proton)

***Basic law of electrostatics for knowing the nature of charge**

"Like/same charges **repel** each other, while unlike/different charges **attract** each other"

Q. STATE AND EXPLAIN COLOMB LAW. DISCUSS ITS VECTORIAL FORM AND GIVE EFFECT OF MEDIUM ON IT.

In **1784**, French military engineer **Charles Coulomb** deduced a law known as Colomb law which measures the force b/w two charges.

Statement: - "**The force of attraction or repulsion b/w two charges is directly proportional to the product of the magnitude of charges and inversely proportional to the square of distance b/w them**".

Mathematically: - $F \propto q_1 q_2$ and $F \propto \frac{1}{r^2}$ ……..> $F = K\frac{q_1 q_2}{r^2}$

K (Colomb Constant): K is called Colomb constant, whose value is **$9*10^9$ Nm^{2}C^{-2}**.

The value of K depends upon: - a) the system of units b) Nature of medium b/w charges

If medium is free space then $K=\frac{1}{4\pi\varepsilon_o}$, ε_o is permittivity of free space its value in SI unit is

$8.85*10^{-12}\ N^{-1}m^{-2}c^{2}$, so Colomb law becomes **F=** $\frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}$,

This is mathematical form of Colomb law.

Vectorial form of Colomb law: Let us consider two point charges q_1 and q_2, if q_1 exert a for on q_2 then q_2 also exert a force on q_1 which is equal in magnitude but opposite in direction as shown in fig

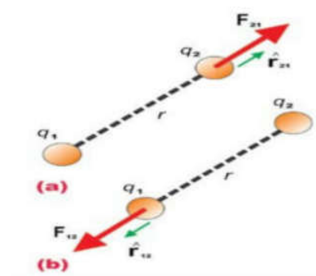
$$\vec{F}_{12}=\frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}\hat{r}_{12}-----(1$$

$$\vec{F}_{21}=\frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}\hat{r}_{21}-----(2$$

Both forces are equal but opposite in direction so

$$\vec{F}_{12}=-\vec{F}_{21}$$

This is called Vectorial form of Colomb Law. this is mutual force.



Effect of medium on Colomb force: Coulomb force is reduced when medium is placed b/w two charges. The insulating medium placed b/w two charges is called dielectric like Teflon etc. so formula for Colomb force becomes **F=**$\frac{1}{4\pi\varepsilon_o\varepsilon_r}\frac{q_1q_2}{r^2}$ **ε_r** is relative permittivity, its value is different for different dielectrics, and its value is **greater than one** other than vacuum. For air ε_r=1.0006, for vacuum ε_r=1.

Limitation of Colomb law: Colomb law is applied only on point charges.

PRACTICE MCQS

1	SI unit of Coulomb constant	**Nm^2C^{-2}**	$C^2N^{-1}m^2$	$C^2N^2m^{-2}$	$Nm^{-2}C^2$
2	The electric force of repulsion between two electrons at distance of 1m is	1.8N	$1.5x10^{-9}$ N	**$2.3x10^{-28}$ N**	$2.3x10^{-30}$N
3	If the distance between two point charges is doubled then force between them will becomes	Half	Double	Four times	**One fourth**
4	If the distance between two charges is half then force becomes	Half	One fourth	Two times	**Four times**

5	Two point charges +2C and +6C repel each other if a charge of -2C is given to each of them then electric force will be	**Zero N**	$8x10^{9}$ N(attractive)	$108x10^{9}$N (repulsive)	$12x10^{9}$ N (attractive)
6	SI unit of Ɛo is	$Nm^{2}C^{-2}$	**$C^{2}N^{-1}m^{-2}$**	$C^{2}N^{2}m^{-2}$	$Nm^{-2}C^{2}$
7	The value of relative permittivity for all the dielectrics other than air or vacuum is unit:	Less than unity	**Greater then unity**	Equal to unity	Zero
8	Presence of dielectric other than air or vacuum always	Increase the electric force	**Decrease the electric force**	Does not affect electric force	Double the electric force
9	The force between two charges separated by air is 4N. When separated by a medium of relative permittivity 2. The force between them becomes	½ N	**2N**	4N	8N
10	Dielectric constant for Teflon is	1	2	**2.1**	2.94
11	One coulomb charge is created by	10 electron	$1.6x10^{-19}$ electron	**$6.25x10^{18}$ electrons**	$6.25x10^{21}$ electron
12	The force b/w two charges is 28N, if dielectric of value 2.8 is kept then force becomes	**10 N**	20 N	30 N	40 N
13	The value of coulomb constant in SI	$6.25x10^{-18}$	$8.85x10^{-12}$	**$9x10^{9}$**	$1.6x10^{-19}$
14	SI unit of charge	Ampere	Volt	eV	**Coulomb**

What is Electric field and electric field intensity? Derive its formula.

***Electric field**:"**The space or region around a charge within which another charge experience a force is called electric field**".

Michal Faraday introduced the concept of electric field.

***Electric field intensity:**

"The force experience by unit positive charge placed a point in electric field is called electric field strength or field intensity", its unit N/C and formula $\vec{E} = \frac{\vec{F}}{q}$

it is vector quantity and its direction along the direction of force.

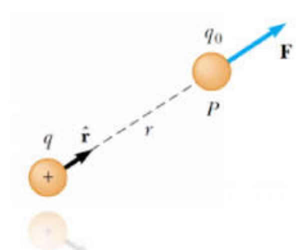
***Electric field intensity due to a point charge q:**

The force experienced by test charge qo placed in the field of charge q is calculated by Colomb law and electric field intensity is calculated by putting in formula of field intensity.

$$\vec{E} = \frac{\vec{F}}{q_o} \quad ------(1$$

$$\vec{F} = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}\hat{r} \quad ---(2 \quad \text{put this value in equation (1)}$$

$$\vec{E} = \frac{1}{q_o} * \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}\hat{r} \quad \text{also written as } \vec{E} = K\frac{q}{r^2}\hat{r}$$



Electric field intensity depends upon a) magnitude of charge b) medium c) distance from charge

What are Electric field lines? Write its properties.

Definition: "**The direction of electric field intensity is represented by lines which are called electric field lines"**.

- **Michal Faraday introduced the concept of field lines**.
- The field due to positive point charge is directed **radially outward**
- The field due to negative charge is directed **radially inward**
- The middle region b/w two same charges has no field due to repulsion of like charges, is called zero field sport or **neutral zone**.

Properties of Electric field lines: There are following properties field lines

i) Electric field lines starts from positive charges and end on negative charges.
ii) The tangent to a field line at any point gives the direction of the electric field intensity at that point.
iii) The lines are closer where the field is strong; the lines are farther apart where

the field is weak.

iv) No two lines cross each other because at a single point electric field has only one direction.

PRACTICE MCQS

1	Concepts of electric field lines was given by	Colomb	**Faraday**	Joule	Millikan
2	The field created by positive charge	**Radially outward**	Radially inward	Both A&B	None of these
3	The field created by negative charge	Radially outward	**Radially inward**	Both A&B	None of these
4	The value of field at middle region b/w two same charges	Maximum	Minimum	**Zero**	None
5	The lines which provide information about the electric force exerted on charged particle are	Magnetic field lines	**Electric field lines**	Tangent lines	Curved lines
6	Electric field lines are	Real	**Imaginary**	Perpendicular	Parallel
7	Electric field lines never –each other	Attract	**Intersect**	Repel	None
8	Electric lines are closer where the field	Weak	**Strong**	Negligible	Zero
9	Electric field lines due to a charge in	One D	Two-D	**Three-D**	Four-D
10	Closeness of field lines is the measure of	Direction of potential	Direction of field	**Strength of field**	Uniformity of field
11	A charge of 4 C is in the field of 4 N/C, the force on charge is	8N	**16N**	4 N	1 N
12	The force on an electron in a field of	$2.6*10^{-8}$ N	**$2.88*10^{-11}$ N**	$2.6*10^{-19}$N	$1.6*10^{-27}$ N

	$1.8*10^8$ N/C				
13	The unit of electric field intensity is	Newton	Coulomb	Joule/coulomb	**Newton/coulomb**
14	An electric field can deflect	Neutron	Gamma rays	**Beta particles**	Gamma particle
15	If the magnitude of charge and distance are both doubled then intensity of field	Doubled	**Halved**	Unaffected	One fourth

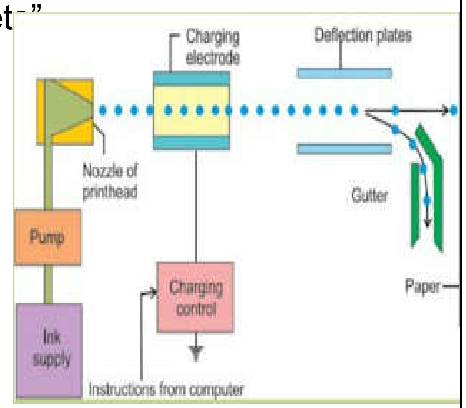
There are two applications of Electrostatics: a) Xerography b) Inkjet printers

What is inkjet printer? Write principle and working.

Inkjet printer: "**Such a printer which uses electric charge in its working is called inkjet printer**".

Principle: Inkjet printers works on the principle of Electrostatics.

"It eject a thin stream of ink when shuttling back and forth across the paper and ink is ejected from small nozzle and break into small droplets"



Working:

An inkjet print head eject a steady flow
Of ink droplets. The charging electrodes are used
To charge the droplet that are not need on the paper
Charged droplets are deflected into a gutter by the
Deflection plates, while uncharged droplets fly straight
Onto the paper.
Inkjet printer also produce colored images.

Q. Write A Note On Xerography?

Xerography (Photo copier): It is Greek word, Xero mean dry; graphos mean writing, and Xerography mean dry writing. "The copying process is called Xerography".

<u>Photocopier works on the following principle</u>: Photocopier works on the principle of Electrostatics.

"The lamp transfer image of page to the drum which leaves the static charge. The drum collects the toner dust and transfer it to the paper, the toner is melted on page".

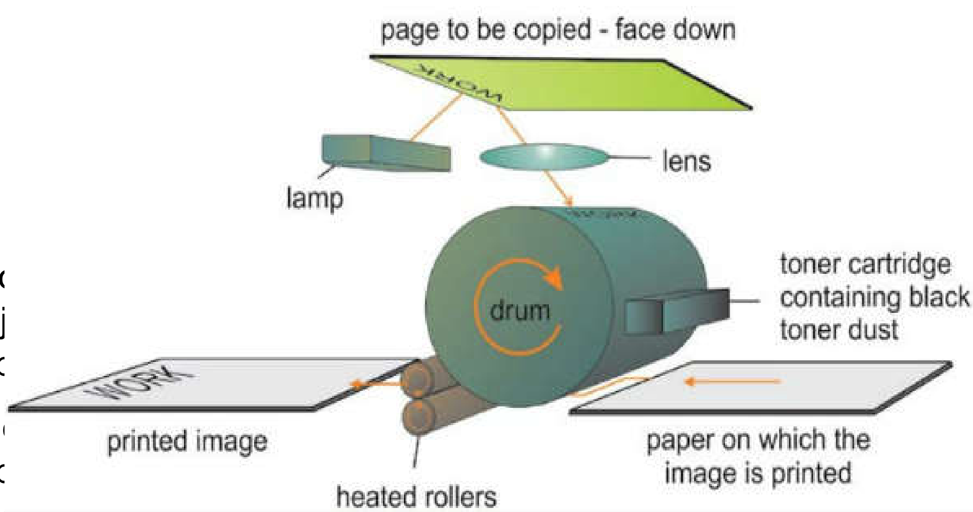
<u>Main parts of photocopier</u>: 1) Drum 2) toner 3) heated rollers

Drum is the heart of photocopier machine. Dum is an aluminum cylinder coated with layer of selenium.

Such materials which show conduction only when light falls on them, otherwise they are insulators in absence of light are called photoconductors like selenium.

<u>Working</u>: If the drum is exposed to an image of document to be copied, the dark and light areas of document produce same dark and light areas on the drum.

The dark areas retain their positive charge but light areas becomes conducting, in this way a positive charge image of document remains on the selenium surface, then a special dry black powder called "Toner" is given a negative charge and spread over the drum, where it sticks to the positive charge areas, the toner from the drum is transferred on to a sheet of paper on which document is to be copied, heated pressure rollers then melt the toner into the paper to produce permanent image of document.



1	Ph inkj app				**<u>Electrostatics</u>**
2	On app electrostatic induction is				WC chamber
3	Which one is photo conductor	Copper	**<u>Selenium</u>**	Mercury	Aluminum

4	word" Xerography " means	Writing by left hand	Writing be children	**Dry writing**	Writing by water colors
5	Photocopying process is called	photography	**Xerography**	Scanning	Holography
6	In photocopier special black powder called toner gives	Positive charge	**Negative charge**	Neutral charge	none

Q. DEFINE ELECTRIC FLUX. CALCULATE THE ELECTRIC FLUX THROUGH A SURFACE ENCLOSING A CHARGE

Definition: "**Total number of electric field line passing normally through certain area is called electric flux.**

OR: The scalar or dot product of electric field intensity and vector area is called electric flux"

Equation with unit: $\varphi_e = \vec{E}.\vec{A}$,= $EA\cos\theta$ its unit is Nm^{2}C^{-1},

it is scalar quantity. is Greek letter. Electric flux depends on electric field intensity, vector area and orientation of surface.

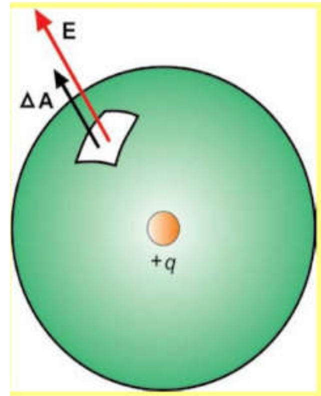
Cases of electric flux: When angle b/w electric field and vector area =0° =EAcos0°=EA= maximum electric flux

When angle b/w electric field and vector area =90°, =EAcos90°=0= minimum electric flux

Vector area: An area whose magnitude is equal to surface area A of the element but its direction is normal to this area is called vector area.

ELECTRIC FLUX THROUGH A SURFACE ENCLOSING A CHARGE

Consider a closed surface in the form of sphere of radius r having charge q. The surface is divided into n small patches of vector area are $\Delta \mathbf{A_1}$, ΔA_2,ΔA_3…..$\Delta \mathbf{A_n}$ so that each patch is a flat. Electric intensity for each patch are E_1, E_2, E_3,E_n respectively.



for first patch $\varphi_{e1} = \vec{E}_1.\Delta\vec{A}_1,$

for 2nd patch $\varphi_{e2} = \vec{E}_2.\Delta\vec{A}_2$

for 3rd patch $\varphi_{e3} = \vec{E}_3.\Delta\vec{A}_3$

and so on...similarly

for nth patch $\varphi_{e_n} = \vec{E}_n.\Delta\vec{A}_n$

Total electric flux through closed surface will be

$\varphi_{total} = \varphi_1 + \varphi_2 + \varphi_3 + ...\varphi_n$ putting values

$\varphi_{total} = \vec{E}_1.\Delta\vec{A}_1 + \vec{E}_2.\Delta\vec{A}_2 + \vec{E}_3.\Delta\vec{A}_3 + ...\vec{E}_n.\Delta\vec{A}_n$

$\varphi_{total} = E_1\Delta A_1 \cos\theta + E_2\Delta A_2 \cos\theta + E_3\Delta A_3 \cos\theta + ...E_n\Delta A_n \cos\theta$

As the direction of electric intensity and vector area is same at each patch so $\theta = 0^o$

$\varphi_{total} = E_1\Delta A_1 \cos 0^o + E_2\Delta A_2 \cos 0^o + E_3\Delta A_3 \cos 0^o + ...E_n\Delta A_n \cos 0^o$ $\cos 0^o = 1$

$\varphi_{total} = E_1\Delta A_1 + E_2\Delta A_2 + E_3\Delta A_3 + ...E_n\Delta A_n$ As we know that $E_1 = E_2 = E_3 ... = E_n = E$ for each patch

$\varphi_{total} = E(\Delta A_1 + \Delta A_2 + \Delta A_3 + ...\Delta A_n) = E(\text{Total Area of sphere})$

As $E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$ surface Area of sphere $= 4\pi r^2$

$$\varphi_e = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}(4\pi r^2) = \frac{q}{\varepsilon_o}$$

$\varphi_e = \frac{q}{\varepsilon_o}$...........Req Result,

This shows that electric flux through closed surface depends upon medium and charge enclosed.

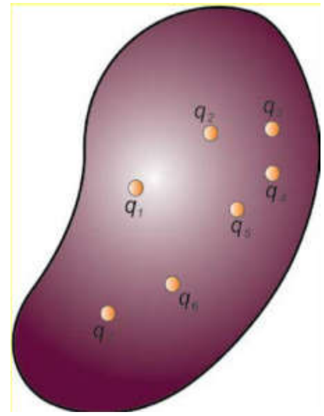
State and prove Gauss's law?

Statement:"**Electric flux through any closed surface is equal to $1/\varepsilon_o$ times the total charge enclosed in it**"

Mathematically it can be written as $\varphi_e = \frac{1}{\varepsilon_o} * Q$

Proof: consider a closed surface having n point charges

q_1,q_2,…on, total electric flux is calculated as



flux due to first point charge $q_1 = \varphi_1 = \frac{q_1}{\varepsilon_o}$ ------ (1)

flux due to2nd point charge $q_2 = \varphi_2 = \frac{q_2}{\varepsilon_o}$ ------ (2)

flux due to 3rd point charge $q_3 = \varphi_3 = \frac{q_3}{\varepsilon_o}$ ------ (3)

flux due to nth point charge $q_n = \varphi_n = \frac{q_n}{\varepsilon_o}$ ------ (n)

$$\varphi_{\text{total}} = \varphi_1 + \varphi_2 + \varphi_3 + ...\varphi_n$$

$$\varphi_{\text{total}} = \frac{q_1}{\varepsilon_o} + \frac{q_2}{\varepsilon_o} + \frac{q_3}{\varepsilon_o} + ...\frac{q_n}{\varepsilon_o}$$

$$\varphi_{\text{total}} = \frac{1}{\varepsilon_o} * (q_1 + q_2 + q_3 + ...q_n)$$

$$\varphi_{\text{total}} = \frac{1}{\varepsilon_o} * (\textit{Total}\text{ charge enclosed surface}) = \frac{1}{\varepsilon_o} * Q = \text{Req result}$$

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Applications of Gauss law

To calculate the electric field intensity we take following steps.

Step 01: Construct a Gaussian surface and charge enclosed by it.

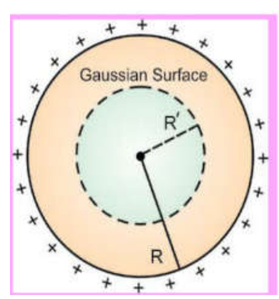
Gaussian Surface: "**An Imaginary closed surface which passes through point we want to calculate field is called Gaussian surface**".

Step 02: Calculate the electric flux through the surface

Step 03: Calculate the electric field by applying Gauss's law.

Q. Calculate the Intensity of field inside a hollow charged sphere?

To calculate the field intensity inside a charged sphere.



Step 01: Construct a Gaussian surface of R'

inside the sphere in which there is no charge q=0

Step 02: To calculate the flux use formula $\varphi_e = \vec{E}.\vec{A}$ ---------------- (1

Step 03: Using Gauss's law $\varphi_{\text{total}} = \frac{1}{\varepsilon_o} * q$ as there is no charge in surface so flux is zero then

Equation 1) $\varphi_e = \vec{E}.\vec{A}$ =0 so this result into $\bar{E}$=0 inside the sphere.

Q.CALCULATE THE ELECTRIC INTENSITY DUE TO AN INFINITE SHEET OF

CHARGE.

Consider an infinite sheet on which positive charge is uniformly distributed.

To calculate the electric intensity at any point

Step 01: consider a Gaussian surface in the form of cylinder passing through sheet having Area A and σ is uniform **surface charge density**, so the charge enclosed by it is **q=σA**

Step 02: For calculation of electric flux through each surface of Gaussian cylinder

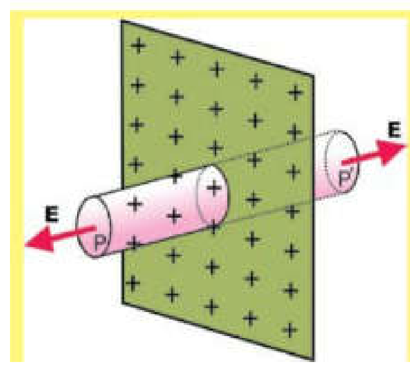
$$total\ flux = flux\ t\ \ roug\ \ \ rig\ \ t\ flat\ surface + flux\ t\ \ roug\ \ \ left\ flat + flux\ t\ \ roug\ \ \ curved\ surface$$

$$\varphi = \bar{E}.A + \bar{E}.A + no\ field\ lines\ passing\ t\ \ roug\ \ \ cuved\ surface$$

$\varphi = EAcos\theta + EAcos\theta + 0$ as E and A are parallel so angle Ө=0°

$\varphi e = EAcos0° + EAcos0°$ = $EA + EA$ =2EA ---------- (1

Step 03: According to Gauss's law $\varphi_{\text{total}} = \frac{1}{\varepsilon_o} * q$ ------------- (2



Comparing both eqs.

2EA=$\frac{1}{\varepsilon_o} * q$ putting the value of q so

2EA =$\frac{1}{\varepsilon_o}$(σA) $\mathrm{E} = \frac{\sigma}{2\varepsilon_o}$

In vectorial form $\vec{\mathrm{E}} = \frac{\sigma}{2\varepsilon_o}\hat{r}$

Q. CALCULATE THE ELECTRIC INTENSITY B/W TWO OPPOSITELY CHARGED PARALLEL PLATES

Consider two parallel plate of closely spaced having opposite uniform distributed charge.. Electric field lines start from positive plate and end on negative plate

Step 01: Consider a Gaussian surface in the form of hollow box having Area A and σ is uniform surface charge density, so the charge enclosed by it is q=σA

Step 02: For Calculating electric flux through each surface of hollow box we follow

Total electric flux= flux through upper surface of box**+** flux through lower surface of box**+** flux through sides of box

As there is no field through upper end of box so flux through it will be zero

Flux through lower surface= $\varphi = EAcos\theta = EAcos0° = EA$

Flux through side of box is zero because they are parallel to field lines

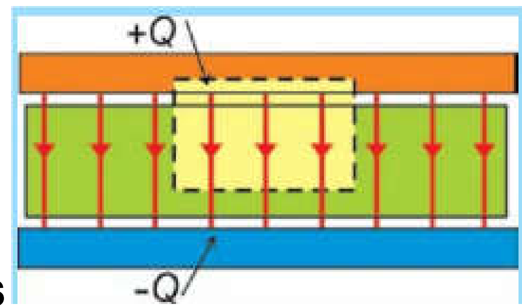
So total electric flux becomes= φ_e=0+EA+0=EA ------------(1)

Step 03: According to Gauss's law $\varphi_{total} = \frac{1}{\varepsilon_o} * q$ ----(2)

comparing both equations to get the result

$\text{EA} = \frac{1}{\varepsilon_o} * \text{q} \quad \Rightarrow \text{EA} = \frac{1}{\varepsilon_o} * \sigma\text{A} \quad \Rightarrow E = \frac{\sigma}{\varepsilon_o}$

in vectorial for $\vec{E} = \frac{\sigma}{\varepsilon_o}\hat{r}$



PRACTICE MCQS

1	For the computation of electric flux the surface should be	**Closed**	Curved	Inclined	Spherical
2	SI unit of electric flux is	Nm^2C^{-2}	**Nm^2C^{-1}**	NCm^{-2}	$Nm^{-2}C^{-3}$
3	When vector area L is held perpendicular to electric field lines then magnitude of electric flux is	Maximum	**Minimum**	Either maximum or minimum	Negative
4	Electric flux depends upon	Electric intensity	Area of surface	Orientation of area	**All of these**
5	Electric flux is a:	Vector, Nm^2C^{-1}	Scalar, Nm^2C	**Scalar ,Nm^2C^{-1}**	Vector,Nm^2C^{-2}
6	What does Nm^2C^{-1} stands for quantity	Electric field	Electric potential	**Electric flux**	Electric force
7	Equation Ø=**E.A** is applicable to surface	Spherical	Cylindrical	Conical	**Flat**
8	The value of	90°	**0°**	270°	180°

	maximum electric flux is obtained when angle between $\overline{\boldsymbol{E}}$ and $\overline{\boldsymbol{A}}$ is				
9	Which one of the following can be taken as measure of electric field intensity	$\frac{F}{A}$	**$\frac{\phi_e}{A}$**	$\frac{qA}{\varepsilon_o}$	$\frac{\varphi_e \varepsilon_o}{A}$
10	Electric field intensity inside a hollow charge sphere	$\frac{\sigma}{\varepsilon_o}$	$\frac{\sigma}{2\varepsilon_o}$	**Zero**	None
11	Electric field intensity due to infinite sheet of charge	$\frac{\sigma}{\varepsilon_o}$	**$\frac{\sigma}{2\varepsilon_o}$**	Zero	None
12	Electric field intensity between two oppositely parallel plates	**$\frac{\sigma}{\varepsilon_o}$**	$\frac{\sigma}{2\varepsilon_o}$	Zero	None
13	Electric field due to infinite sheet is ----of between two oppositely parallel plates	**Half**	Double	Four times	Same as
14	Surface charge density is equal to	**Charge/area**	Charge/field	Field/ charge	Force/ charge
15	SI unit of surface charge density	**C/m^2**	C/m	Nm	N/C
16	Special organ called ampullae of lonrenzini that are sensitive to E	Bats	Cats	Dogs	**Sharks**
17	Electric flux does not depend upon	Charge enclosed	Medium	Both A&B	**Shape of closed surface**
18	Statement $\varphi_e = \frac{Q}{\varepsilon_o}$ given by	Fermi	Coulomb	Farad	**Gauss**

19	Negative sign in electric potential gradient shows that electric intensity is along	Increasing potential	Increasing strength	**Decreasing potential**	Negative potential
20	Gauss law is applied only to a surface which is	Open	Straight	**Closed**	All of these
21	A rubber ball of radius 2cm has charge 5C on its surface, E at its center is	10 N/C	2.5 N/C	**Zero**	5 N/C

What is Electric potential and potential difference? Write SI unit with formula.

Electric potential: "The electric potential energy per unit charge is called electric potential". V=W/q. Its unit is J/C which is equal to volt.

Potential difference: "The amount of work done in moving a charge from one point to other against electric field keeping the charge in equilibrium is called potential difference". OR

The difference of potential energy per unit charge b/w two points is called potential difference $\Delta V = \frac{\Delta U}{q}$ and unit is volt.

Volt: SI unit of electric potential and potential difference is volt

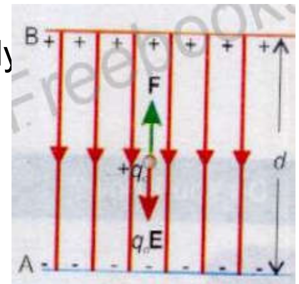
Definition of volt: "If one joule of work is done in carrying a unit positive charge of 1 coulomb from one point to other keeping the charge in rest position, then potential difference will be one volt".

1 joule/Coulomb=1 volt

Q. What is Potential gradient? Derive its relation.

Definition: "**The quantity $\frac{-\Delta V}{\Delta r}$ gives the maximum rate of change of potential with respect to distance which is called the potential gradient".** Its unit is **V/m.**

Relation: consider uniform Electric field E b/w two oppositely plates and charge is moved again field



The potential difference b/w two points

$$V_B - V_A = \frac{W_{AB}}{q_o} = \frac{\vec{F}.\vec{d}}{q_o} = \frac{q_o Ed\cos\theta}{q_o} = \frac{q_o Ed\cos 180^o}{q_o} = -Ed \qquad \cos 180^o = -1$$

as the distance b/w plates is small so d = Δr then above equation becomes

$$V_B - V_A = \Delta V = -E(\Delta r)$$

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

Prove that $\frac{1\,\text{newton}}{1\,\text{colomb}} = \frac{1\,\text{Volt}}{1\,\text{meter}}$

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

as we know that 1volt= 1J/C, and joule= Nm

$$\frac{V}{m} = \frac{J/C}{m} = \frac{J}{Cm} = \frac{Nm}{Cm} = \frac{N}{C} - - - -$$

Required result

Q. What is absolute potential? Calculate the Electric potential due to a point charge.

Definition: **"The work done in bringing a unit positive charge from infinity to that point keeping electrostatic equilibrium is called absolute potential or electric potential at a point".**

Calculation of potential: Consider a positive point charge q is moved from infinity to that point keeping it in equilibrium, since electric field intensity changes inversely to square of distance, so it does not remains same so taken two points A and B close to each other so that E remains same

The distance of point A from charge $q = r_A$

The distance of point B from charge $q = r_B$

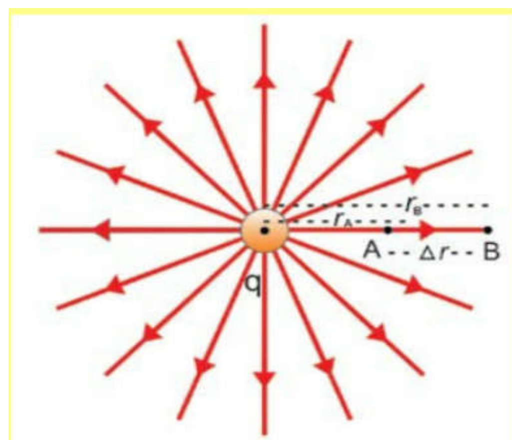
$\Delta r = r_B - r_A$ ---------------- (1)

The mid point b/w A and B is given as $r = \dfrac{r_A + r_B}{2}$, and the magnitude of field at this point

$E = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q}{r^2}$, since the points are close to each other so we take approximations

$r_A \approx r_B = r$ so we can say that $r^2 = rxr = r_A r_B$ so the field becomes

$E = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q}{r_A r_B}$



now using the formula of potential gradient $\Delta V = -E\Delta r$

$V_B - V_A = -E(r_B - r_A)$ it may also written as

$V_A - V_B = -E(r_A - r_B)$, applying minus inside the bracket

$V_A - V_B = E(r_B - r_A)$ putting the value of field

$V_A - V_B = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q}{r_A r_B}(r_B - r_A) = \dfrac{q}{4\pi\varepsilon_o}(\dfrac{r_B - r_A}{r_A r_B})$

$V_A - V_B = \dfrac{q}{4\pi\varepsilon_o}(\dfrac{r_B}{r_A r_B} - \dfrac{r_A}{r_A r_B}) = \dfrac{q}{4\pi\varepsilon_o}(\dfrac{1}{r_A} - \dfrac{1}{r_B})$

As the point B is at infinity so $r_B = \infty$ and $V_B = 0$ and $\dfrac{1}{r_B} = \dfrac{1}{\infty} = 0$

$V_A - 0 = \dfrac{q}{4\pi\varepsilon_o}(\dfrac{1}{r_A} - 0) = \dfrac{q}{4\pi\varepsilon_o}\dfrac{1}{r_A}$

in general $V = \dfrac{q}{4\pi\varepsilon_o}\dfrac{1}{r}$, this is electric potential due to a point charge.

What is eV? Prove that 1eV=1.6*10^{-19} J.

Electron volt: "The amount of energy acquired or lost by an electron as it moves through a potential difference of one volt is called electron volt". This change in potential energy appears as kinetic energy $q=e=1.6*10^{-19}$ C

$\Delta(K.E)=q\Delta V$

1eV=(1.6*10^{-19}C)(1volt)

1eV=1.6*10^{-19}(CV)   as we know that CV=joule (J)

1eV=1.6*10^{-19} J

1eV=1.6*10^{-19} J   **Electron Volt (eV) is the unit of energy**

Q. Write two similarities b/w electric force and gravitational force.

1) Both forces are conservative
2) Both obey inverse square law

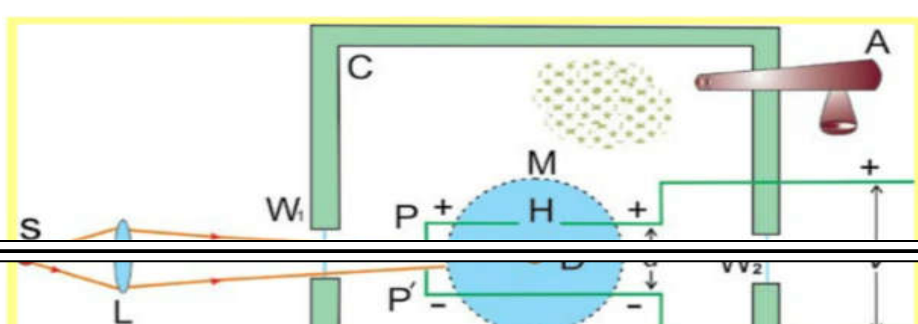
Q. Write four differences b/w electric and gravitational force.

Electric force	Gravitational force
Formula $F = K\frac{q_1 q_2}{r^2}$	**Formula** $F = G\frac{m_1 m_2}{r^2}$
It is explained by Coulomb law	It is explained by Gravitation law
It is stronger than gravitational force	It is weaker than electric force
It may be attractive or repulsive	It is attractive force only
It is medium dependent	It is medium independent
It is short range	It is long range

Q. DESCRIBE EXPERIMENT FOR FINDING THE CHARGE ON ELECTRON BY MILLIKAN OIL DROP METHOD.

__Definition__: **"Such a technique which is used for finding the charge on electron devised by Millikan in 1909".**

__Construction__: The apparatus of this experiment consists of a evacuated chamber in which two parallel plates P and P' are placed at separation d, upper plate has small hole H. A potential difference is applied b/w plates to produce E. An atomizer is used for spraying oil drops into the chamber and light source S make the drops visible.



Working: The tiny oil droplets are sprayed into the chamber through small nozzle of atomizer which get charged negatively due to friction b/w walls of atomizer and oil drops. A potential difference is applied in such a way that electric force F=qE becomes equal to gravitational force(mg).

Charge on droplet: When electric force is equal to weight of droplet then

$$F_e = F_g \quad \Rightarrow \text{ also we know } F_e = qE, \quad F_g = mg$$

$$qE = mg \qquad \text{also we know that } E = \frac{V}{d}$$

$$q\frac{V}{d} = mg$$

$$q = \frac{mgd}{V} \qquad \text{which is the result for charge on droplet}$$

Mass and radius of droplet: For calculation of mass of droplet the electric field is switched off so droplet falls under the action of gravity through air with terminal speed Vt. In this case weight must equal to drag force so

$$F = 6\pi\eta r v_t = mg \; --- (1), \text{ where r is radius of droplet, if } \rho \text{ is density then } \rho = \text{m/volume}$$

$$m = \rho * \text{volume} = \rho * 4/3\, \pi\, r^3 \qquad \text{putting the value in equation (1)}$$

$$6\pi\eta r v_t = \rho * 4/3\, \pi\, r^3 g$$

$$r^2 = \frac{18\eta v_t}{4\rho g} = \frac{9\eta v_t}{2\rho g}$$

$$r = \sqrt{\frac{9\eta v_t}{2\rho g}}, \text{ this is the value of radius by knowing it we can find the mass of droplet}$$

Conclusion: Millikan measured the charge on many droplets and found each droplet is the integral multiple of $1.6*10^{-19}$C and concluded that the minimum value of charge in nature is the charge on an electron

PRACTICE MCQS

1	An ECG records, between points on human skin generated by electrical process in the heart	Current	**Voltage**	Resistance	Capacitan
2	The amount of energy equal to $1.6x10^{-19}$J is called	One volt	One milli volt	**One electron volt**	One meg electron v
3	1 volt is equal to	$J^{-1}C^{-1}$	**JC^{-1}**	$J^{-1}C$	JC
4	Electron Volt is the unit of	Electricity	Voltage	Charge on electron	**Energy**
5	Electric potential at mid point in an electric dipole	**0 V**	5 V	1V	1.5 V
6	Electrical energy is measured in	Watt	Horse power	Killo watt	**Killo wat hour**
7	A particle having charge 2e falls through a potential difference of 5V. energy acquired by it is	2.5eV	20eV	0.4eV	**10eV**
8	If an electron of charge is accelerated through a potential difference V, it will acquire energy	**Ve**	V/2	E/2	Ve^2
9	Potential gradient is defined as	$\frac{V}{r}$	$\frac{E}{r}$	$\frac{V}{E}$	None of these
10	A particle carrying a charge of 2e falls through a potential difference of 3V, energy acquired by it	$9.6x10^{-16}$J	$9.6x10^{-20}$J	$9.6x10^{-15}$J	**$9.6x10^{-19}$J**

	is				
11	The amount of energy acquired or lost by an alpha particle as it moves through potential difference of 1V is	$3.2x10^{-19}$J	$6.4x10^{-19}$J	**$1.6x10^{-19}$J**	Zero
12	Absolute potential difference due to point charge of 1C at a distance of 1m	$9x10^{6}$ V	$9x10^{7}$V	$9x10^{8}$V	**$9x10^{9}$V**
13	1 joule is equal to	**$6.25x10^{18}$eV**	$6.25x10^{-18}$eV	$1.6x10^{-19}$eV	$9.1x10^{-31}$eV
14	A particle carrying a charge of 2e falls through a potential difference of 3V, energy acquired by it is	1.5 eV	0.66eV	**6eV**	3eV
15	Two opposite point charge of same magnitude separated by distance 2d, electric potential mid way between them is	1V	2V	0.5V	**0 V**
16	In Electroene Phalography the P.D by the electrical activity of --- are used for diagnose	Heart	Liver	**Brain**	Hands
17	The electrical activity of retina of eye generate—used in electro ritino graphy	Current	**Potential difference**	Resistance	Capacitance
18	1 N/C=?	1 mC	**1V/m**	V/C	C/N
19	SI unit of electric potential and potential difference are	joule	**Volt**	Colomb	Farad

20	SI unit of potential gradient is same as that of	Electric potential	**Electric field intensity**	Capacitance	None
21	1 joule/colomb is equal to	Farad	**Volt**	joule	Newton
22	If 5J of work done of an object having charge 5C than what will be potential	2 V	**1 Volt**	4 volt	25 Volt
23	Which is the property of electric force	Obey inverse square law	Conservative force	Short range than gravity	**All of these**
24	Charge on electron determined by Millikan in	1906	1907	1908	**1909**
25	Millikan and Fleter could find the charge on oil droplets in	Thermal equilibrium	**Electrical equilibrium**	Mechanical equilibrium	Unstable equilibriu
26	The name electron was suggested by	Thomson	Rutherford	Millikan	**Stoney**
27	The electrical activity of retina of eye generate—used in electro ritino graphy	Current	**Potential difference**	Resistance	Capacitance
28	minimum value of charge in nature is the charge on	**Electron**	Alpha particle	Neutron	Muon
29	The minimum charge on an object in nature cannot be less than	Zero	**$1.6x10^{-19}$ C**	$-1.6x10^{-19}$C	$\pm1.6x10^{-19}$
30	The unit of electric field intensity other than N/C is	V/A	**V/m**	V/C	N/V
31	$-\frac{\Delta V}{\Delta r}$ is called	Electric field	**Potential gradient**	Electric potential	Capacitance
32	SI unit of electric	Kgm^2s^{-1}/C	**Kgm^2s^{-2}/C**	Kgm^2/C	$Kgms^{-2}/C$

	potential is				
33	The charge on oil droplet in Millikan oil drop experiment is calculated using	q=mg/V	**mgd/V**	v/mgd	d/mgV
34	A charged conductor has charge on	**Outer surface**	Inner surface	Middle surface	None
35	If a charge is moved against electric field, will gain	**Electric potential energy**	Kinetic energy	Both A&B	None
36	Strength of field in order to suspend a charge q and mass m	**E=mg/q**	E=m/q	E=q/mg	Both A&B
37	In Millikan experiment, if the direction field is reversed then acceleration of particle	**2g**	g	g/2	4g

Q. WHAT IS CAPACITOR? CALCULAT THE CAPACITANCE OF PARALLEL PLATE CAPACITOR.

Definition: "A Device which is used to store charge as well as electrical energy is called capacitor".

Construction: A capacitor consists of two parallel plates having opposite charge connected to potential difference V. let the Q charge on either of plate. So
$Q \propto V \quad \Rightarrow Q = CV,\quad C$ is constant of proportionality called capacitance of capacitance

Capacitance: **The ability of capacitor to store charge is called capacitance**. C=Q/V, its unit is farad.

Farad: If a charge of one coulomb given to plates of capacitor produces a potential difference of one volt b/w them then capacitance is 1 farad.**1 Farad= 1C/1V.**

Capacitance of parallel plate capacitor: Let us consider a parallel plate capacitor consisting of two metal plates each of area A separated by small distance d as shown in fig

Case A: When medium is air or vacuum b/w plates

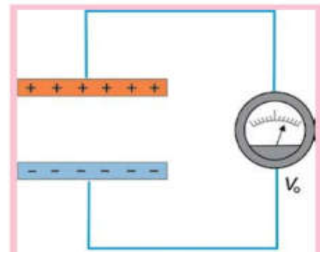
If Q is the charge on the capacitor and V is the potential difference then

$C_{vac} = \frac{Q}{V} --- (1)$, the magnitude of electric intensity E is related with distance and potential

$E = \frac{V}{d}, \quad V = Ed$ also we know that Electric field intensity b/w two oppositely plates is $E = \sigma/\varepsilon_o$

$V = \frac{\sigma}{\varepsilon_o} d$ also we know $\sigma = \frac{Q}{A}$

$Q = \sigma A$ putting these values in eq (1)



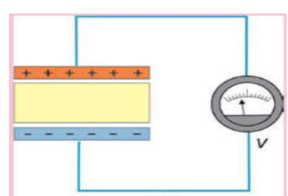
$$C_{vac} = \frac{\sigma A}{\frac{\sigma}{\varepsilon_o} d},$$

$C_{vac} = \frac{A\varepsilon_o}{d}$ this is the capacitance of parallel plate capacitor when air is placed b/w plates

case B : If insulating medium called dielectric of relative permitivity ε_r is placed b/w plates then capacitance is increased by the factor ε_r and the formula for this is $C_{med} = \frac{A\varepsilon_o \varepsilon_r}{d}$

<u>Dielectric constant</u>: "The ratio of capacitance of parallel plate capacitor with dielectric as medium to its capacitance when air as medium b/w plates is called dielectric constant".

Its formula is $\varepsilon_r = \frac{C_{med}}{C_{vac}}$ having no unit.



$$\frac{C_{med}}{C_{vac}} = \frac{\frac{A\varepsilon_o \varepsilon_r}{d}}{\frac{A\varepsilon_o}{d}} = \varepsilon_r$$

Q.What is ELECTRIC POLARIZATION OF DIELECTRIC and also define electric dipole.

<u>Electric Dipole:</u> "Two equal and opposite charges placed at small distance d formed an electric dipole".

<u>Polarization and polarized</u>: "A process in which the molecules of the dielectric under the action of external electric field become dipoles is called electric polarization" and dielectric is called polarized.

OR "The phenomenon in which negative and positive charges of atoms/molecules of dielectric are slightly displaced when a dielectric is placed in an electric field is called polarization".

Q. What is the effect of polarization on capacitance of capacitor?

Ans: When the dielectric is placed b/w plates then capacitance of capacitor is increased. Because dielectric material decrease surface charge density on plates which decrease electric field intensity $E = \sigma/\varepsilon_o$, with this potential difference V is decreased V=Ed and capacitance is increased C=Q/V.

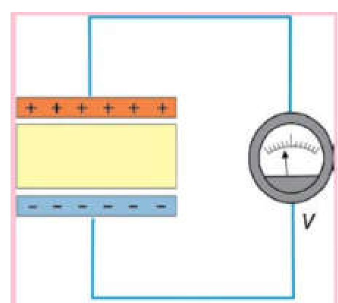
Q. CALCULATE THE ENERGY STORED IN CAPACITOR IN TERMS OF ELECTRIC FIELD.

Capacitor is device which is used for storing charge as well as electric energy".

When a capacitor is uncharged, the potential difference

b/w plates is zero and finally it becomes V when charge q

is deposited on each plate.



$$\text{Average potential} = \frac{0+V}{2} = \frac{V}{2}$$

electric potential energy = *Average* potential x charge

$$P.E = \frac{V}{2}q \qquad \text{Also we know that } q = CV$$

$$\text{Energy} = \frac{V}{2}(CV) = \frac{1}{2}CV^2 -------------(1)$$

Energy stored in an electric field

As we know that capacitance of capacitance C when medium is placed $C = \frac{A\varepsilon_o\,\varepsilon_r}{d}$, $V = Ed$

"

then Equation (1) becomes $\quad \text{Energy} = \frac{1}{2}\frac{A\varepsilon_o\,\varepsilon_r}{d}(Ed)^2 = \frac{1}{2}(E^2\varepsilon_o\,\varepsilon_r)(Ad)$

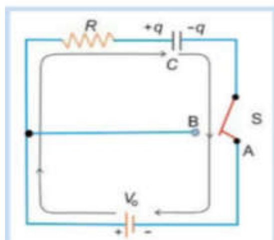
. $\text{Energy} = \frac{1}{2}(E^2\varepsilon_o\,\varepsilon_r)(volume)$

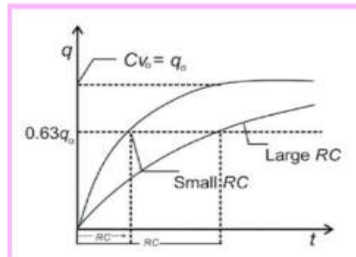
$\text{Energy/Volume} = \text{Energy density} = \frac{1}{2}E^2\varepsilon_o\,\varepsilon_r$, This is required result

Q. DISCUSS CHARGING AND DISCHARGING OF CAPACITOR

<u>RC circuit</u>: The circuit consists of capacitor of capacitance C and resistor of resistance R is called RC circuit.

<u>Charging of capacitor:</u> When the switch S is set at terminal A connected to battery V which starts charging the capacitor through R. capacitor is not charged immediately and charges take some time to attain maximum value on capacitor qo=CVo

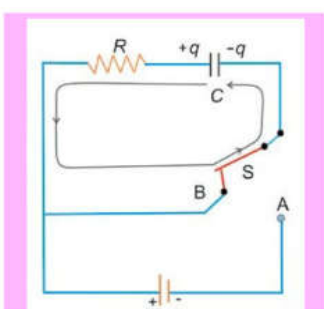


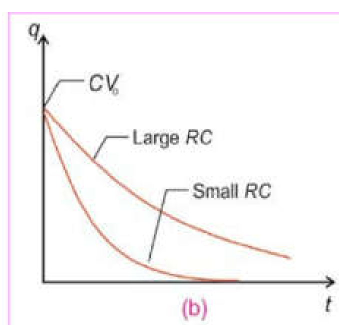


<u>Time constant</u>: "**The time required by capacitor to charge 63% of its maximum value is called time constant". OR "the product of resistance and capacitance is called time constant t=RC".** Its unit is second.

For small value of time constant capacitor rapidly/fastly charge and discharge.

<u>Discharging of capacitor</u>: When switch is set at a point B, charge on positive plate start to discharge through R and neutralize the negative plate and graph of discharging is shown in fig





Graph of charging and discharging of capacitor is exponential

USEFUL INFORMATION AND TID BITS

- ✓ **Write the principle of working of windshield wipers of cars?**

Charging and discharging of capacitor enable windshield wipers to be used. The time of the on-off cycle is found by the time constant of resistor capacitor combination.

- ✓ **If a surface encloses a positive as well as negative charge of same value. Then what is the value net flux?**

The net value of flux will be zero

- ✓ **Why electronic circuits such as T.V and computer are often enclosed within metal boxes?**

To eliminate stray electric field interference circuits of such devices are enclosed within metal boxes.

- ✓ **What is ECG?**

ECG stands for electro cardio gram. An ECG records the voltage b/w points on human skin generated by electrical process in the heart.

- ✓ **What is EEG?**

EEG stands for electro enephalo graph, in this potential difference created by the electrical activity of brain are used for diagnosing abnormal behavior.

- ✓ **What is ERG?**

ERG stands for Electro retino graphy, in which electrical activity of the retina of eye generates the potential difference.

- ✓ **How shark and other sea creatures locate their prey very precisely?**

Fish and other sea creatures produces electric field in variety of ways, sharks have special organ called ampullae of lorezini that are sensitive to field and can detect potential difference of **nanovolt** and can locate their prey very precisely

PRACTICE MCQS

1	Wind shield wipers of car to be used	**Charging/ Discharging**	Potential effect	Compton effect	Ohm law
2	A 5Mega ohm resistor is connected with 2 micro farad capacitor. Time constant	0.1 sec	1 sec	2.5 sec	**10 sec**
3	Net charge on a capacitor is	Infinity	q	2q	**0**
4	The energy stored in capacitor is given by the relation	$\frac{1}{2}\varepsilon_o\varepsilon_r E^2$	$\underline{\frac{1}{2}\varepsilon_o\varepsilon_r E^2(Ad)}$	$\frac{1}{2}\varepsilon_o\varepsilon_r E^2(A)$	$\frac{1}{2}\varepsilon_r E^2$
5	The product of resistance and capacitance is called	Force	**Time Constant**	Velocity	Current constant
6	The capacitance of a parallel plate capacitor is given by C=?	$\boldsymbol{\frac{A \in 0}{d}}$	$\frac{A \in 0}{q}$	$\frac{q \in 0}{d}$	None of these
7	If time constant in RC circuit is small, then capacitor is charged or discharged	**Rapidly**	Slowly	At constant rate	Nil
8	A charge of 10^{-10}C b/w two parallel plates 1cm apart experience a force of 10^{-5}N, the P.D is	10	100V	**1000V**	1V
9	Farad is defined as	**C/V**	A/V	C/J	J/C
10	The expression of energy stored in a capacitor is given by	$E=cV^2$	**$E=1/2\ CV^2$**	$E=1/2\ C^2V$	$E=1/2(CV)^2$
11	In capacitor, energy is stored in the	Magnetic field	**Electric field**	Gravitational field	Nuclear field
12	In the time constant of RC circuit, how much charge is	0.37qo	0.51qo	**0.63qo**	0.90qo

	stored out of maximum charge qo				
13	Energy density in case of capacitor is always proportional to	**E^2**	ε_o	V^2	C
14	The increase in capacitance of a capacitor due to presence of dielectric is due to ------ of dielectric	**Electric polarization**	Electrification	Ionization	Electrolysis
15	Energy stored per unit volume inside capacitor is called	Electric intensity	Electric flux	**Energy density**	Electrical energy
16	The unit of RC is	Volt	**Second**	Coulomb	Ampere
17	Product of resistance and capacitance is called	Gas constant	Resistivity	Boltzmann constant	**Time constant**
18	Farad is the unit of	Charge	Current	Electric flux	**Capacitance**
19	A capacitor is perfect insulator for	AC	**DC**	Both A&B	None
20	Sec/ohm is equal to	**Farad**	Coulomb	Joule	Ampere
21	If potential difference between plates of parallel plate capacitor is doubled then energy stored in it will	Two times	Eight times	**Four times**	Remains same
22	SI unit of energy density of electric field is	J/C	J/V	**J/m^3**	J/F^3
23	The term "RC" has same unit as that of	Potential	Capacitance	Energy	**Time**
24	A parallel plate capacitor with oil between plates dielectric constant=2 has capacitance C. if the oil removed than capacitance becomes	C	$C/\sqrt{2}$	2C	**C/2**
25	The capacitor stores energy in the form of	Magnetic field	Heat energy	Mechanical energy	**Electrical energy**

26	If the dielectric is inserted between the plates of a capacitor, the potential difference	Does not change	increase	Becomes zero	**Decrease**
27	Which material is used to increase the capacitance of	copper	Iron	Tin	**Mica**

EXERCISE SHORT QUESTIONS

1.The potential is constant throughout a given region of space. Is the electric field zero or non-zero in this region? Explain

Electric field will be zero in this region

We know that $E=\frac{-\Delta V}{\Delta r}$ for constant potential ΔV=0

Then E=0

2. Suppose that you follow an electric field line due to a positive point charge. Do electric field and the potential increases or decreases?

Both electric field and potential will decrease as we know that $E \propto \frac{1}{r^2}$ and $V \propto \frac{1}{r}$ when we move away r increase and E and V will be decreased.

3. How can you identify that which plate of capacitor is positively charged?

To identify the plate of a capacitor a gold leaf electroscope is used

If the positive charged disc of gold leaf electroscope is touched with any plate of the charged capacitor and the divergence of the leaves increases, the plate of capacitor is positively charged (due to repulsion of similar charged plates). If the divergence of leaves decreases, then that plate of capacitor is negatively charged (due to force of attraction b/w different charged plates).

4. Describe the force or forces on a positive point charge when placed between parallel plates'. with similar and equal charges ii. With opposite and equal charges?

i. Net force acting on the positive charge is zero as electric field intensity due to equal and opposite plate is zero so F=qE=0

ii. Net force acting on the positive charge will be maximum due to maximum value of field in this case F=qE

5. Electric lines of force never cross. Why?

Electric lines of force never cross each other. This is because of the reason that electric field intensity has only one direction at any given pint. If the lines cross, electric intensity could have more than one direction which is physically impossible.

6. If a point charge of mass m is released in a non-uniform electric field with field lines in the same direction pointing, will it make a rectilinear motion?

Yes, it will make a rectilinear motion, If a point charge q of mass m is placed at any point in the field, it will follow straight or rectilinear path along the field line due to repulsive force.

7. Is E necessarily zero inside a charged rubber balloon if the balloon is spherical?

Yes, E is necessarily zero inside a charged rubber balloon. Because there is no charge enclosed by it so electric field will be zero.

$$\varphi_e = \frac{q}{\varepsilon_o} = \frac{0}{\varepsilon_o} = 0$$

$$\varphi_e = EA, \text{so } EA = 0 \text{ then } E = 0 \text{ as } A \neq 0$$

8.Is it true that Gauss's law states that the total number of lines of force crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface?

Yes it is true statement, as Gauss's law states that number of electric field lines through any closed surface is 1/εo times the total charge enclosed in it as flux is directly proportional to charge so this statement is true.

9. Do electrons tend to go to region of high potential or of low potential?

The electrons being negatively charge particle when released in electric field moves from a region of lower potential (negative end) to a region of high potential (positive end).

NUMERICALS CHAPTER 12

12.1: Compare magnitudes of electrical and gravitational forces exerted on an object (mass = 10.0g, charge = 20.0μC) by an identical object that is placed 10.0cm from the first. $(G = 6.67\times10^{-11} Nm^2kg^{-2})$

Given Data : Mass $m_1 = m_2 = m = 10g = 10/1000\,kg = 0.1\,kg$, Charge $q_1 = q_2 = 20\mu C = 20*10^{-6}C$, $r = 10cm = 10/100 = 0.1m$

$$solution: \frac{F_e}{F_G} = ? \Rightarrow \frac{F_e}{F_G} = \frac{Kq_1q_2/r^2}{Gm_1m_2/r^2} = \frac{Kqq/r^2}{Gmm/r^2} = \frac{Kq^2}{Gm^2} = \frac{9*10^9(20*10^{-6})^2}{6.67*10^{-11}(0.1)^2} = 5.4*10^{14}$$

12.3: A point charge $q = -8.0\times10^{-8}\,C$ is placed at the origin. Calculate electric field at a point 2.0m from the origin on the z-axis.

Given Data : Charge = l = $-8*10^{-8}$ C, r = 2m, E = ?

$$\text{solution}: E = \frac{Kq}{r^2} = \frac{9*10^9*(-8*10^{-8})}{(2)^2} = -(1.8*10^2\,\hat{K})N/C, \qquad \vec{E} \text{ is along negative Z - axis}$$

12.4: Determine the electric field at the position $r = (4\hat{i} + 3\hat{j})m$ caused by a point charge $q = 5.0\times10^{-6}\,C$ placed at origin.

Given Data : $r = (4\hat{i} + 3\hat{j})m$, $q = 5*10^{-6}C$, E = ? $\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{(4\hat{i}+3\hat{j})}{\sqrt{4^2+3^2}} = \frac{(4\hat{i}+3\hat{j})}{\sqrt{16+9}} = \frac{(4\hat{i}+3\hat{j})}{5}$

$$\text{Solution : As } E = \frac{Kq}{r^2}\hat{r} = \frac{9*10^9*5*10^{-6}}{5^2} * \frac{(4\hat{i}+3\hat{j})}{5} = 360*(4\hat{i}+3\hat{j}) = (1440\hat{i}+1080\hat{j})\text{ N/C}$$

12.5: Two point charges, $q_1 = -1.0\times10^{-6}C$ and $q_2 = +4.0\times10^{-6}C$, are separated by a distance of 3.0m. Find and justify the zero-field location.

Given Data : $q_1 = -1*10^{-6}C, q_2 = 4*10^{-6}C$, r = 3m, Location at which $\vec{E} = 0 = ?$

solution : consider P be a point at a distance x from charge q_1 at which E is zero

$$E_1 = \frac{Kq_1}{x^2},\ \ E_2 = \frac{Kq_2}{(x+3)^2} \qquad As\ \ E_1 = E_2 \Rightarrow \frac{Kq_1}{x^2} = \frac{Kq_2}{(x+3)^2} \Rightarrow \frac{q_1}{x^2} = \frac{q_2}{(x+3)^2}$$

$$\frac{1*10^{-6}C}{x^2} = \frac{4*10^{-6}C}{(x+3)^2} \Rightarrow \frac{1}{x^2} = \frac{4}{(x+3)^2} \Rightarrow (x+3)^2 = 4x^2 \Rightarrow x+3 = 2x \Rightarrow x = 3m$$

12.6: Find the electric field strength required to hold suspended a particle of mass and $1.0\times10^{-6}kg$ charge $1.0\mu c$ between two plates 10.0cm apart.

Given Data : mass = $m = 1*10^{-6}$ kg, $q = 1\mu\mu = 1*10^{-6}C$, d = 10cm = 10/100 m = 0.1 m , $\vec{E} = ?$

$$\text{solution : As } \vec{F}_e = \vec{F}_g \Rightarrow q\vec{E} = mg \Rightarrow \vec{E} = \frac{mg}{q} = \frac{1*10^{-6}*9.8}{1*10^{-6}} = 9.8\text{N/C or } 9.8\text{V/m}$$

12.7: A particle having a charge of 20 electrons on it falls through a potential difference of 100 volts. Calculate the energy acquired by it in electron volts (eV).

Given data : Nof electrons = n = 20, charge on electron = $1.6*10^{-19}C$, $q = ne = 20*1.6*10^{-19}C$

$q = 3.2*10^{-18}C$, potential difference = $\Delta V = 100V$, $\Delta(K.E) = ?$

$$\Delta(K.E) = q\Delta V = 3.2*10^{-18}C*100V = 3.2*10^{-16}J \Rightarrow \text{or } \Delta(K.E) = \frac{3.2*10^{-16}}{1.6*10^{-19}}eV = 2*10^3 eV$$

12.8: In Millikan's experiment, oil droplets are introduced into the space between two flat horizontal plates, 5.00 mm apart. The plate voltage is adjusted to exactly 780V so that the droplet is held stationary. The plate voltage is switched off and the selected droplet is observed to fall a measured distance of 1.50 mm in 11.2s. Given that the density of the oil used is 900kgm^{-3}, and the viscosity of air at laboratory temperature is $1.80\times10^{-5}Nm^{-2}s$, calculate...(a) The mass, and (b) The charge on the droplet (Assume g = 9.8ms^{-2})

Given Data : d = 5mm = $5*10^{-3}$m, V = 780V, S = $1.55*10^{-3}$m, t = 11.2 sec, $\eta = 1.8*10^{-5}Nm^{-2}S$, $\rho = 900kgm^{-3}$

m = ? q = ? As we know that ρ = mass/Volume, $\Rightarrow m = \rho * volume = \rho * 4/3\,\pi r^3$ ––––(1)

$$\text{As } v = s/t = 1.55*10^{-3}/11.2 = 0.13*10^{-3}\ ms^{-1}, r = \sqrt{\frac{9\eta\eta}{2\rho\rho}} = \sqrt{\frac{9(1.8*10^{-5})0.13*10^{-3}}{2*900*9.8}} = 0.011*10^{-4}m, \text{putting in (1)}$$

$$m = \rho*4/3\,\pi r^3 = 900*4/3*3.14*(0.011*10^{-4})^3 = 5.01*10^{-15}kg$$

$$\text{charge} = q = \frac{mgd}{V} = \frac{5.01*10^{-15}*9.8*5*10^{-3}}{780} = 3.15*10^{-19}C$$

12.9: A proton placed in a uniform electric field of 5000 NC^{-1} directed to right is allowed to go a distance of 10.0cm from A to B. Calculate.

(a) Potential difference between the two points
(b) Work done by the field
(c) The change in P.E. of proton
(d) The change in K.E. of the proton
(e) Its velocity (mass of proton is $1.67\times10^{-27}kg$)

Given Data : $q = 1.6*10^{-19}$ C, $m = 1.67*10^{-27}$ Kg, E = 5000 N/C, d = 0.1 m,

(a) V = ? $V = -Ed = -5000*0.1 = -500\text{ V}$ (b) W = ? $W = qV = 1.6*10^{-19}\text{ C}*500\text{ V} = -500\text{eV}$

(c) ΔU = ? $\Delta U = qV = 1.6*10^{-19}\text{ C}*(-500\text{ V}) = -500\text{eV}$, (d) ΔK.E = ? $\Delta K.E = qV = 1.6*10^{-19}\text{ C}*500\text{ V} = 500\text{eV}$

(e) v = ? $\Delta K.E = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2\Delta K.E}{m}} = \sqrt{\frac{21.6*10^{-19}\text{ C}*500\text{ V}}{1.67*10^{-27}}} = 3.09*10^5\ m/s$

12.10: Using zero reference point at infinity, determine the amount by which a point charge of $4.0\times10^{-8}C$ alters the electric potential at a point 1.2m away, when (a) Charge is positive (b) Charge is negative.

Given Data : $q = 4*10^{-8}$ C, r = 1.2 m, V+ = ? V- = ?

$$V+ = \frac{K(+q)}{r} = \frac{9*10^9(4*10^{-8})}{1.2} = +300V,\ V- = \frac{K(-q)}{r} = \frac{9*10^9(-4*10^{-8})}{1.2} = -300V$$

12.11 In Bohr's atomic model of hydrogen atom, the electron is in an orbit around the nuclear proton at a distance of $5.29\times10^{-11}m$ with a speed of $2.18\times10^6 ms^{-1}$.

$\left(e = 1.60\times10^{-19}C,\quad mass\ \ of\ \ electron = 9.10\times10^{-31}kg\right)$.Find

(a) The electric potential that a proton exerts this distance
(b) Total energy of the atom in eV
(c) The ionization energy for the atom in eV

Given Data : $r = 5.29*10^{-11}$ m, $v = 2.18*10^6$ m/s, charge on electron = $q = e = 1.6*10^{-19}$ C

mass of electron = $m = 9.1*10^{-31}$ kg, V = ? Total energy in eV = ? Ionization energy = ?

$$\text{Electric potential} = V = \frac{Kq}{r} = \frac{9*10^9*1.6*10^{-19}\text{C}}{5.29*10^{-11}} = 27.22\text{ V}$$

$$\text{Total energy} = \frac{-Ke^2}{2r} = -\frac{9*10^9(1.6*10^{-19})^2}{2*5.29*10^{-11}} = -13.6eV$$

$$\text{Ionization Energy} = E_\infty - E_{ground} = 0-(-13.6eV) = 13.6eV$$

12.12 The electronic flash attachment for a camera contains a capacitor for storing the energy used to produce the flash. In one such unit, the potential difference between the plates of a 750μF capacitor is 330V. Determine the energy that is used to produce the flash.

Given Data : C = 750μ5 = $750*10^{-6}$ F, V = 330V, Energy = E = ?

$$E = \frac{1}{2}CV^2 = \frac{1}{2}(750*10^{-6})(330)^2 = 40.8\text{ J}$$

12.13: A capacitor has a capacitance of $2.5\times10^{-8}F$. In the charging process, electrons are removed from one plate and placed on the other one. When the potential difference between the plates is 450V, how many electrons have been transferred? $\left(e = 1.60\times10^{-19}C\right)$.

Given Data : $C = 2.5*10^{-8}$ F, V = 450V, $e = 1.6*10^{-19}$ C, n = ?

$$Q = CV = (2.5*10^{-8})(450) = 1125*10^{-8}\text{ C}$$

$$\text{no electrons} = n = \frac{Q}{e} = \frac{1125*10^{-8}\text{C}}{1.6*10^{-19}C} = 7*10^{13}$$

CHAPTER 13 CURRENT ELECTRICITY

<u>CURRENT ELECTRICITY</u>: "**The branch of physics which deals with the study of charges in motion through conductors is called current electricity. It is also called Electrodynamics**".

WHAT IS ELECTRIC CURRENT? GIVE ITS FORMULA, UNIT.

<u>ELECTRIC CURRENT</u>: "The time rate of flow of charges through any cross section of conductor is called electric current".

$I = \frac{\Delta Q}{\Delta t}$ And SI unit is ampere. It is scalar quantity.

Definition of "ampere": When one coulomb charge passes through any cross section of a conductor in one second, the current will be one ampere. 1 ampere= 1 Coulomb/ 1sec.

<u>Charge carriers</u>: Electric current is due to flow of charge particles, these charged particles are called charge carriers.

<u>Charge carriers in metals</u>: Negatively charged particle i.e electrons

<u>Charge carriers in electrolyte</u>: Positive and negative ions

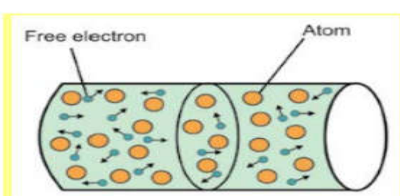
<u>Charge carriers in gases</u>: Electrons and ions

<u>Charge carriers in semiconductor</u>: Free electrons and holes

What is difference b/w electronic flow and conventional flow of electric current?

ELECTRONIC FLOW OF ELECTRIC CURRENT	CONVENTIONAL FLOW ELECTRIC CURRENT
The current which passes from a point of lower potential to high potential is called electronic flow of current	The current which passes from a higher potential to lower potential is called conventional flow of electric current
It is shown by the motion of negative particles	It is shown by motion of positive charges

<u>Current through metals when no battery is connected</u>: Current through the wire is zero in this case because free electrons passes through it from right to left is same as the rate at which pass from left to right.



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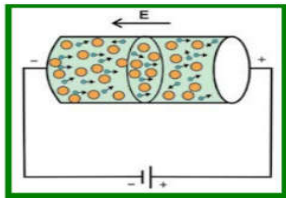
<u>Current through metals when battery is connected</u>: In this case Electric field is setup at every point in the wire and free electrons experience a force in the opposite the field, and move with drift velocity and a current begins to flow through conductor.



Drift Velocity:"Average constant velocity of free electrons inside the metallic conductors in opposite to electric field intensity is called drift velocity". Its value is 10^{-3} m/s.

Steady current: Steady current is maintained in wire when a constant potential difference is applied across it which produce necessary electric field along the wire.

WHAT ARE SOURCES OF CURRENT? DEFINE THEM.

Sources of current: A source which provides a constant potential difference across the conductor or ends of conductor is called source of current like generator, cell etc. OR A device which converts non electrical energy into electrical energy is called source of current. Some sources of current are as follows

- **Cell:** The device which convert chemical energy into electrical energy is called cell.
- **Electric generator:** The device which converts mechanical energy into electrical energy is called electric generator.
- **Thermocouple:** The device which converts heat energy into electrical energy is called thermocouple.
- **Solar cell:** The device which converts light energy into electrical energy is called solar cell.

EFECTS OF CURRENT

The presence of electric current is detected by various effects which are called effects of current namely

- **EXPLAIN HEATING EFFECT?**

The effect which is produced due to flow of current through metallic wire in which electrons collide with atoms of metals and give some their K.E to these atoms as result the kinetic energy of vibrations of atoms increased which generated heat is called heating effect $H=I^2Rt$, this effect is used in electric heater, kettles, toasters and in electrons iron.

- **EXPLAIN MAGNETIC EFFECT?**

An effect which is produce around the wire or coil when current flows through it is called magnetic effect and it is used in galvanometers, motors, fans, drill machines etc.

- **EXPLAIN CHEMICAL EFFECT?**

An effect that is produced by certain liquids like sulphuric acid solution conduct electricity due to some chemical reactions that placed within them is called chemical effect.

Chemical effect depend: It depends on a) nature of liquid b) quantity of electricity pass through it

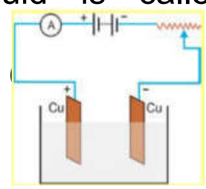
Electrolyte: The liquid which conduct electric current is called electrolyte.

Electrode: The material in the form of wire, rod or plate at which electric current enters or leave the electrolyte is called electrode.

Anode: The electrode connected with positive terminal of battery is called anode.

Cathode: The electrode connected with negative terminal of battery is called cathode

Voltammeter: The vessel containing two electrodes and liquid is called voltammeter.



Electroplating: A process in which a thin layer of an expensive metal is deposited on cheap metal is called electroplating.

STATE AND EXPLAIN OHM'S LAW.

Statement Of Ohm's Law: "Current flowing through a conductor is directly proportional to the potential difference across its ends provided physical state such as temperature remains same". V=IR,

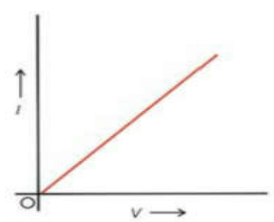
1/R is the constant in Ohm's law.

Resistance: The opposition to the flow of charge through conductor is called electrical resistance. R=V/I and unit is ohm.

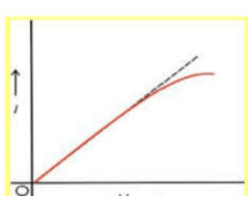
Ohm: If one ampere current is passed through a conductor by applying one volt potential difference, then resistance will be one ohm. 1ohm= 1volt/1 ampere

Factors upon resistance depends: Resistance of conductor depends upon nature, dimensions and physical state (temperature) of conductor.

Ohmic devices: The devices for which Ohm's law hold good and graph b/w V and I is straight line are called ohmic devices. For example metallic conductors silver gold etc.



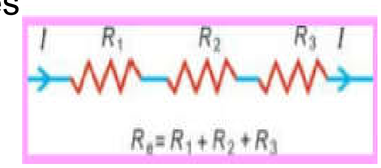
Non ohmic devices: The devices for which Ohm's law not hold good and graph b/w V and I is not straight line are called non ohmic devices. For example filament of bulb, semiconductor diode.



Graphical form of Ohm's law: Graphical form of Ohm law is Straight line.

EXPLAIN SERIES COMBINATION OF RESISTORS.

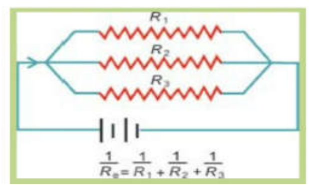
Definition: Such a combination in which resistors are connected end to end such that same current pass through it is called series combination of resistors. $R_e=R_1+R_2+R_3+$…………… They have following properties



i. In series combination total resistance is **increased**
ii. Current is **same** through each R
iii. Voltage is **different** through each R

EXPLAIN PARALLEL COMBINATION OF RESISTORS

Such a combination in which resistors are connected side by side with their end connected together at common point to voltage source is called parallel combination of resistor. $1/R_e=1/R_1+1/R_2+1/R_3+$………They have following properties



i. In parallel combination, total resistance is **decreased**
ii. Voltage is **same** through each R
iii. Current is **different** through each R

Practice Mcqs

1	1 ohm is defined as	1 V/C	**<u>V/A</u>**	C/V	VA
2	The graphical representation of Ohm law is	Hyperbola	Ellipse	Parabola	**<u>Straight line</u>**
3	Ohm law is	**<u>V=IR</u>**	V=R/I	$V=I^2R$	I=VR
4	A source of 10V is applied across 5ohm wire, the current through wire will be	1A	**<u>2A</u>**	10A	15A
5	Current flow in gases due to	Electron only	**<u>Electrons and ions</u>**	Positive and negative ions	Electrons and holes
6	A student has five resistances each of value 1/5 ohm. The minimum resistance that can be obtained by combining them in parallel is	1/50 ohm	**<u>1/25 ohm</u>**	1/10 ohm	5 ohm

7	The proportionality constant between current and potential difference is	P	R	**1/R**	V
8	In liquid and gases current is due to motion of	Negative charges	Positive charges	Neutral charges	**Electrons and positive and negative ions**
9	In which of these heating effect used	Electric heater	Kettles	Electric iron	**All of these**
10	Three resistances 5000,500 and 50 ohms are connected in series across 550V mains, the current through them	1A	**100mA**	10mA	1Ma
11	The magnitude of drift velocity is order	**10^{-3} m/s**	10^{6} m/s	10^{-6} m/s	10^{7} m/s
12	A battery of 50V is attached to a series combination of 5,10,10ohm , the current in circuit is	**2A**	5A	10A	20A
13	The flow of charge through a uniform cross section wire in a unit time is called	**Current**	charge	Power	Ampere
14	Electrical analog of mass in electricity is	Capacitance	Inductance	**Charge**	Resistance
15	The smallest resistance obtained by connected 50 resistance each of ¼ ohm	200 ohm	**1/200 ohm**	50/4 ohm	4/50 ohm
16	The heat produced by the passage of	**I^2Rt**	IR^2t	I/TR	HIR

	current through a resistor H=?				
17	The potential difference between head and tail of electric eel is	400 V	500V	**600V**	700V
18	A current of 1 A ampere passes through a wire in in 1 min, charge flowing	**60C**	30C	1 c	0.016 C
19	The current which flow from higher potential to lower potential is called	Electronic current	**Conventional current**	Directional current	Either of these

Write a note on RESISTIVITY AND ITS DEPENDANCE UPON TEMPERATURE

Resistivity or specific resistance: The resistance of a meter cube of material is called resistivity or specific resistance.

Mathematically $R \propto L$ $\quad R \propto \frac{1}{A}$ $\quad R \propto \frac{L}{A}$ its unit is ohm m (Ωm).

$$R = \rho \frac{L}{A} \qquad \Rightarrow \rho = R\frac{A}{L}$$

Difference b/w Resistance and Resistivity

Resistance	Resistivity
The measure of opposition to flow charge	Resistance of one meter of cube of wire
Unit of resistance is ohm(Ω)	Unit of resistivity is ohm meter (Ωm)
Resistance depends upon nature, temperature and geometry of wire	Resistivity depends upon nature and temperature only

Conductance: The reciprocal of resistance is called conductance. Its formula is G=1/R and unit is mho or Siemen

Conductivity: The reciprocal of resistivity is called conductivity, its formula is $\sigma=1/\rho$ and its unit is mho m^{-1}.

Effect of temperature on resistance of conductor: The resistance of conductor increased as the temperature of conductor rises, K.E of atoms increases and they vibrate with greater amplitude so electrons find it more difficult to pass through them.

R_o = Resistance of material at 0^oC

R_t = Resistance of material at t^oC

$R_t - R_o \propto R_o$ $\quad\quad$ $R_t - R_o \propto t$ $\quad\quad$ $R_t - R_o \propto R_o\, t$

$R_t - R_o = \alpha R_o\, t$ $\quad\quad$ $\alpha = \dfrac{R_t - R_o}{R_o\, t}$ $\quad$ α is temperature co - efficient of resistance

Temperature co-efficient of resistance: The fractional change in resistance per kelvin is called temperature co-efficient of resistance. Its formula is $\alpha = \dfrac{R_t - R_o}{R_o t}$ and unit is k^{-1}

Temperature co-efficient of resistivity: The fractional change in resistivity per kelvin is called temperature co-efficient of resistivity. Its formula is $\alpha = \dfrac{\rho_t - \rho_o}{\rho_o t}$ and unit is K^{-1}.

Positive and Negative temperature co-efficient of resistance α:
If resistance of conductor increase with increase of temperature then α is positive
If resistance of conductor decrease with increase of temperature then α is negative. Like Si, Ge etc

Explain COLOR CODE FOR CARBON RESISTOR

Carbon resistor: It consists of high grade ceramic rod or cone known as substrate on which thin resistive film of carbon is deposited.

Color code of carbon resistor: The numerical value of carbon resistors is indicated by a color code which consists of bands of different colors printed on body of the resistors.

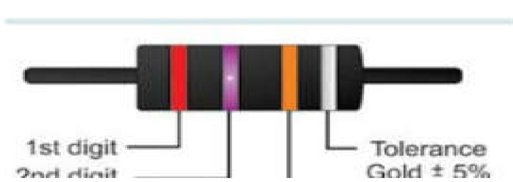
Bands in color code of resistor: There are four bands1st band: indicates 1st digit. 2nd band: indicates 2nd digit3rd band: indicates no of zeroes. 4th band: show tolerance

Tolerance: Possible variation from the marked value of resistance is called tolerance.

Tolerance of silver is ±10% and gold is ±5%. If there is no 4th band then tolerance will **±20%**

The color code

Color	Value	Color	Value
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Gray	8
Yellow	4	White	9



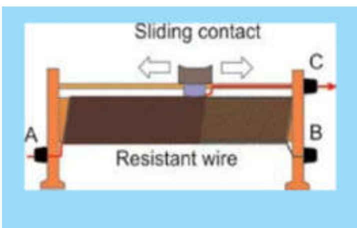
What is RHEOSTAT? Give its uses.

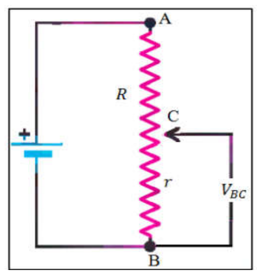
Rheostat: "A wire wound variable resistors which consist of bare mangnin wire over an insulating cylinder and its resistance can be changed is called Rheostat".
Uses of Rheostat: Rheostat can be used as

i. **Variable resistor**: A rheostat acts as variable resistor when terminal A and sliding terminal C are connected in circuit are used and this sliding terminal shifted increase or decrease the resistance. As shown in fig a
ii. **Potential divider:** A potential difference V is applied across the ends A and B of rheostat and R is the resistance of wire and r is the resistance b/w B and C then potential b/w the portion BC of wire AB will be

V_{BC}= V/R*r or V_{BC}=r/R*V this can be shown in fig b

a





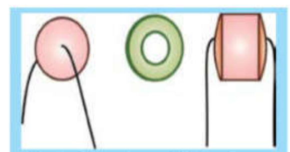


Fig. 13.15 Thermistors of different shapes

b

What is THERMISTOR? Write construction, advantage and uses.

Thermistor: A heat sensitive resistor is called thermistor. It is resistor whose resistance changes with temperature.
It has positive as well as negative temp. Co-efficient of resistance.
Construction: Thermistor are made from ceramics which are mixture of metallic oxides, manganese, nickel, cobalt, copper and iron etc. by heating them under high pressure.
Shapes of thermistor: They may be in the form of beads, rods or washers
Advantage of thermistor: Thermistor with high negative temperature co-efficient are very accurate for measuring low temperature especially near 10K.
Application/Use of thermistor: Thermistor are temperature sensors so they convert change in temperature into electrical voltage.

PRACTICE MCQS

1	If fourth band on a carbon resistor is of silver color then its tolerance is	±1%	±5%	**±10%**	±20%

2	A rheostat can be used as	Variable resistor	Potential divider	**Both A&B**	None of these
3	The substance having negative temperature co-efficient is	**Germanium**	Aluminum	Copper	Cobalt
4	Temperature co-efficient of resistivity of a material is measured in	Ohm-K	Ohm-m	Kelvin	**Per kelvin**
5	The color code for carbon resistor usually consist of	2 bands	**4 bands**	5 bands	7 bands
6	Resistivity is reciprocal of	Conductance	**Conductivity**	Induction	None of these
7	Tolerance for gold color is	±1%	**±5%**	±10%	±20%
8	The numerical value of violet color in color code represents	0	3	5	**7**
9	A wire of uniform area of cross section A and length L cut into two equal parts	Doubled	**Remain same**	Half	Increase three times

	the resistivity of each part is				
10	Siemen is the unit of	Resistance	**Conductance**	Resistivity	Conductivity
11	Resistivity of conductor increase with	Increase in Length	Increase in area	**Increase in its temperature**	Decrease in length
12	The substance having negative temperature co-efficient is	**Carbon**	Iron	Tungsten	Gold
13	Resistivity at a given temperature depends on	Area of cross section	Length	**Nature of material**	Both length and area
14	If the conductivity of a material is small then it is	Conductor	**A poor conductor**	A good conductor	An insulator
15	A thermistor is	A resistor	**Thermal sensitive resistor**	An adiabatic resistor	An isothermal resistor
16	Color code for green color is	2	3	4	**5**
17	Mho m^{-1} is the SI unit of	Conductivity	**Conductance**	Resistance	Capacitance
18	A rheostat can be used as	**Potential divider**	Conductance	Rectifier	Amplifier
19	The numerical value of	0	**3**	5	8

	orange color in color code carbon resistor is				
20	When conductivity of material is high then it is	An insulator	A semiconductor	**A good conductor**	A superconductor
21	A thermistor is a heat sensitive	Capacitor	Diode	**Resistor**	Inductor
	A wire of uniform area of cross section A and length L is cut into two equal parts, the resistance of each part becomes	Double	**Half**	4 times	One fourth
22	The color of strips on a carbon resistor from extreme left are yellow, black and red respectively its resistance will be	**4 killo ohm**	400 ohm	40 ohm	40 killo ohm
23	The numerical value of black color is	1	**0**	2	3
24	When	**Increases**	Decreases	Remains	Vanish

	temperature increases, the resistance of conductor			same	
25	The numerical value of orange color in color code carbon resistor is	0	**3**	5	8
26	If resistance is 500 ohm have fourth band of silver color then its upper maximum resistance will be	600 ohm	450 ohm	**550 ohm**	400 ohm
27	Specific resistance of material depends	Length	Area	**Temperature**	Both A&B
28	If there is no fourth band in carbon resistor then tolerance will be	±1%	±5%	±10%	**±20%**
29	A zero ohm resistor is indicated by a	**Single black color**	Single red color	Single blue color	Single green color
30	What is resistance of carbon	**100 ohm**	150 ohm	200 ohm	250 ohm

	resistor which bands brown, black and brown				
31	What is the color code for 52MΩ±5%?	**Green,red,blue Gold**	Green, blue, red Violet	Yellow,green, blue, yellow	Violet, red,green, gray
32	If resistor is indicated by single black color then value of resistance is	**Zero ohm**	One ohm	10 ohm	100 ohm
33	If the length of conductor is doubled and area of cross section is halved, its conductance becomes	Increase four times	**Decrease four times**	Becomes half	Remain same
34	Which is an example of wire wound variable resistor	Potentiometer	**Rheostat**	Thermistors	Wheatstone bridge
35	SI unit of conductance is	Ohm	**Siemen**	Per ohm	Per Kelvin
36	Substance having negative temperature coefficient	**Carbon**	Iron	Tungsten	Gold
37	Reciprocal of resistance is	**Conductance**	Conductivity	Resistivity	None
38	Color code	**Brown black**	Black black	Brown black	Brown black

	of 10 ohm resistance with 5% tolerance	**black gold**	brown gold	silver	black silver
39	Thermistor convert temperature into	**Electrical voltage**	heat	Sound	Light energy

What is ELECTRICAL POWER AND POWER DISSIPATION IN RESISTORS

Electrical power: The rate at which battery is supplying energy is called electrical power. Its unit watt.

Power dissipations in Resistors: If a circuit consisting of battery and Resistance R the work done in moving a charge through potential difference V in time Δt.

$$W = V * \Delta Q$$

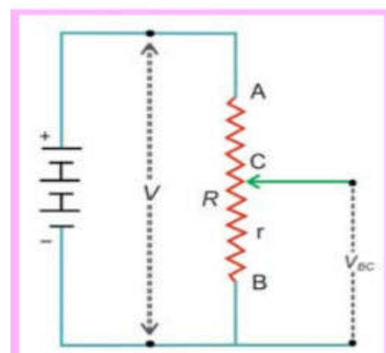
$$\text{Electrical power} = P = \frac{\Delta W}{\Delta t}$$

$$P = \frac{V * \Delta Q}{\Delta t} = V * \frac{\Delta Q}{\Delta t}$$

$$P = VI$$

$$P = (IR)I = I^2R \quad \text{or}$$

$$P = V(V/R) = V^2/R$$



Definition of watt : If one ampere current is passed through

wire by applying one volt potential then power will be one watt

1 watt= 1 volt x 1ampere

Explain ELECTROMOTIVE FORCE AND POTENTIAL DIFFERENCE

EMF: "The energy supplied by the battery to a unit positive charge is called emf".

Consider a battery which is connected across resistance to maintain steady current then

E=Energy supplied/ charge= ΔW/ΔQ, SI unit of emf is J/C also known as volt.

Terminal potential difference: The potential difference across the terminals of cell or battery when current is drawn from it is called terminal potential difference.

Internal Resistance: "The resistance officered by electrolyte present b/w the electrodes of cell are called internal resistance denoted by r".

Expression b/w terminal potential difference and emf:

Consider a cell of emf E having internal resistance r connected as shown in fig and V is the terminal potential difference across the external resistance R. The current flowing through circuit is

$$I = \frac{E}{R+r} \Rightarrow E = IR + Ir \Rightarrow E = V_t + Ir$$

$V_t = E - Ir$ This is the relation for terminal potential difference

if internal resistance $r = 0$ then $V_t = E$ in special case

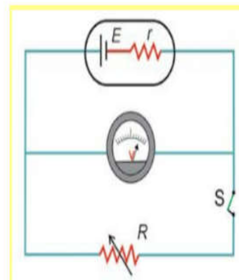


Fig. 13.19 The terminal potential difference V of a cell is E - Ir

Difference b/w emf and potential difference

Emf	Potential difference
Emf is cause	Potential difference is effect
Emf is always present even no current passes through battery	Potential difference across the conductor is zero when no current pass through it

MAXIMUM POWER OUT PUT

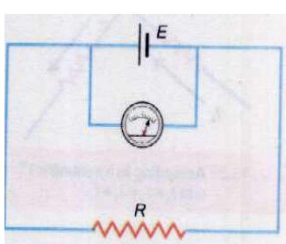
If current I flows through the resistance R, the charges flow from a point of higher potential to lower and loss of potential energy per second across R is VI. The loss of energy per second appear in the form of power delivered to R by current.

Power delivered to $R = \text{Pout} = VI = (IR)I = I^2R$

As we $I = \dfrac{E}{R+r}$

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

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



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

as $(a+b)^2 = (a-b)^2 + 4ab$

if $r = R$ then maximum power out put relation

$$P_{max} = E^2/4r$$

KIRCHOFF RULES

State Kirchhoff first rule:

Statement :"Sum of all the currents meeting at a point in a circuit is zero".
$\sum I=0$

Proof:

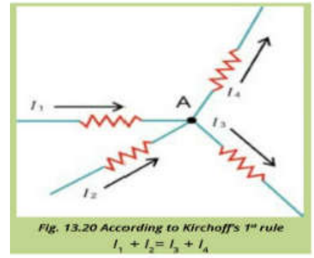


Fig. 13.20 According to Kirchoff's 1st rule $I_1 + I_2 = I_3 + I_4$

consider four wire carrying current I_1, I_2, I_3 and I_4
Current flowing towards point A which take as positive
is equal to current flowing away from the point A taken as
negative $I_1 + I_2 + (-I_3) + (-I_4) = 0$
$I_1 + I_2 = I_3 + I_4$, this law is accordance to law of conservation of charge

State Kirchhoff 2nd rule:

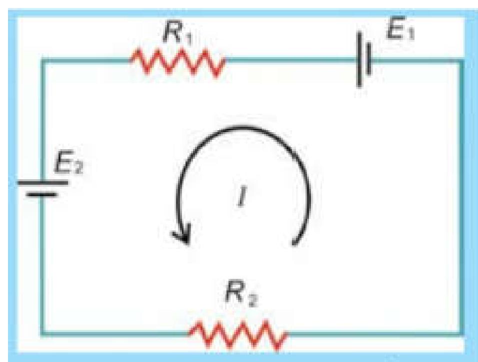
Statement: **"Algebraic sum of voltage changes in closed circuit or loop is equal to zero ∑V=0"**.

Explanation: Consider a circuit which consists of two cell of emf E1 and E2 and two resistors R1 and R2. The direction of current depends upon the cell of larger emf. If E1 is greater than E2 then current flow in anti clock wise direction.

First of all for finding potential changes following rules should be applied

i. Potential change is positive if source of emf is traversed from negative to positive terminal otherwise it negative
ii. Potential change is negative if resistor is traversed in the direction of current

Proof: As Kirchhoff 2nd rule is according to law of conservation of energy so across each terminal we find energy gain and lost and then adding to get the result



Energy gained across $E_1 = E_1\Delta Q$ ---------(1
Energy lost across $E_2 = -E_2\Delta Q$ ----------(2
Energy lost across $R_1 = -IR_1\Delta Q$ ----------(3
Energy lost across $R_2 = -IR_2\Delta Q$ ----------(4
Adding all equations
$E_1\Delta Q + (-E_2\Delta Q) + (-IR_1\Delta Q) + (-IR_2\Delta Q) = 0$
$\Delta Q(E_1 - E_2 - IR_1 - IR_2) = 0$
$E_1 - E_2 - IR_1 - IR_2 = 0$ This is required Result

PRACTICE MCQS

1	Maximum power delivered by battery is	**$E^2/4r$**	$4r^2E$	Vit	V^2R
2	Kirchoff first rule is based on conservation o f	Energy	Voltage	**Charge**	Mass
3	SI unit of electric power is	**Watt**	Killo watt sec	Joule	KWh

4	The terminal potential difference of battery of short circuit of emf E is equal	2E	**<u>E</u>**	E/2	0
5	Electromotive force is closely related to	Electric intensity	Magnetic intensity	**<u>Potential difference</u>**	Inductance
6	The power output of a lamp is 6W. how much energy does the lamp gives out in 2 minutes	3J	12J	120J	**<u>720J</u>**
7	Power output is given by	$\frac{E2R}{(R+r)2}$	$\frac{E2R}{(R \quad r)2+4Rr}$	I^2R	**<u>All of these</u>**
8	100W bulb is operated by 200V, the current flowing through bulb is	**<u>0.5A</u>**	1A	2A	2.5A
9	SI unit of emf is	Newton	Pascal	**<u>Volt</u>**	Ampere
10	Kirchoff 2nd rule is accordance to law of conservation of	**<u>Energy</u>**	Mass	Charge	Momentum
11	Potential difference between head and tail of electric eel	**<u>600V</u>**	700 V	800 V	900 V
12	When current is drawn from cell, its terminal potential difference and emf is equal	**<u>Different</u>**	Same	Zero	Negative
13	For open circuit, terminal potential difference Vt is	**<u>Vt=emf</u>**	Vt=2emf	Vt=3emf	Vt=emf/2

Write PROCEDURE OF SOLUTION OF CIRCUIT PROBLEMS

Following steps should be taken to solve the circuit problem

- Draw the circuit diagram
- Choose the loop which contain at least one resistance

- Assume a loop current in each loop which may be clock wise or anti clock wise
- Write the loop equations for selected loops according to Kirchhoff voltage rule
- Solve these equations for unknown quantities.

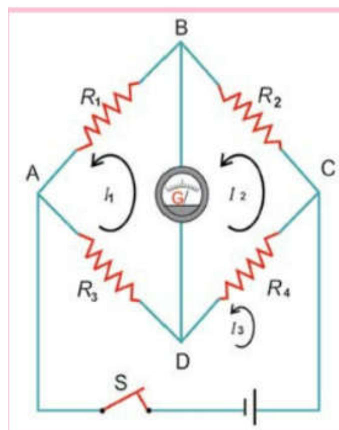
What is WHEAT STONE BRIDGE? Write its construction and working. Derive formula.

Definition: “An electrical circuit that is used to measure the value of unknown resistance is called Wheatstone bridge”.

Construction: This circuit consists of four resistance R_1, R_2,R_3 and R_4 connected in such a way that form a loop ABCDA. A battery of emf E is connected b/w A and C and sensitive galvanometer is connected b/w B and D.

Working: If the key is closed a current will flow through galvanometer. We are to find the under which no current will flow through galvanometer even the key is closed.

Derivation: Using Kirchhoff voltage rule we consider two loop ABDA and BCDB and assume clock wise current I1 and I2 through the loop



Across the loop ABDA $\quad -I_1R_1-(I_1-I_2)R_g-I_1R_3=0$ -------(1)

Across the loop BCDB $\quad -I_2R_2-(I_2-I_1)R_g-I_2R_4=0$ -------(2)

under the balance condition $I_1-I_2=0$ so $I_1=I_2$

Eq (1) becomes $\quad -I_1R_1-(0)R_g-I_1R_3=0 \Rightarrow -I_1R_1-I_1R_3=0$

$-I_1R_1=I_1R_3$ --------------(3)

Eq (2) becomes $-I_2R_2-(0)R_g-I_2R_4=0 \Rightarrow -I_2R_2-I_2R_4=0$

$-I_2R_2=I_2R_4$ --------------(4)

Dividing 3 and 4

$$\frac{-I_1R_1}{-I_2R_2}=\frac{I_1R_3}{I_2R_4} \Rightarrow$$

$$\frac{-I_1R_1}{-I_1R_2}=\frac{I_1R_3}{I_1R_4}$$

$$\Rightarrow \frac{R_1}{R_2}=\frac{R_3}{R_4}$$

$$R_4=\frac{R_2*R_3}{R_1} \qquad \Rightarrow X=\frac{R_2*R_3}{R_1}$$

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TID BITS/USEFUL INFORMATION

How electric eel save from danger?
When electric eel senses danger, it turns itself into a living battery, anyone who attacks this fish is likely to get a shock of **600V** and eel remains safe.

What is value of potential difference b/w head and tail of an electric eel: 600 volt

How inspectors can easily check the reliability of a concrete bridge made with carbon fiber?
Because the fiber conduct electricity, if sensors show that electrical resistance is increasing over time the fibers are separating because of cracks.

How zero ohm is indicated: A Zero ohm resistor is indicated by single black color band around the body of conductor

What measured by voltmeter across the terminals of cell: Emf of a cell on open circuit and Terminal potential difference on closed circuit

What is POTENTIOMETER? Explain its construction and working.

Definition: It is an electrical instrument which is used to measure and compare the potential difference b/w two points without drawing any current from the circuit is called potentiometer.

Principle: When a steady current flow through a wire then potential difference across any length of wire is directly proportional to its length $V \alpha l$.

Construction: A potentiometer consists of a resistor R in the form of wire on which terminal C can slide. As the sliding contact moves from A to B, the resistance b/w A and C changes from 0 to R.

Working as Potential divider: Let emf of cell is E, and current flowing through resistor R is $I=E/R$ ----(1)

If r is the resistance b/w A and C then potential drop b/w these points will be $V_{AC}=Ir$ putting the value of current

$V_{AC}=\frac{E}{R}r \quad =\frac{r}{R}E$

Potential drop can be changed by change the value of r.

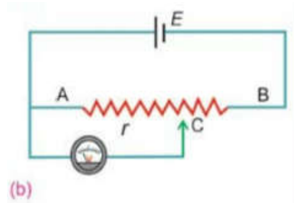
Measurement of unknown emf:

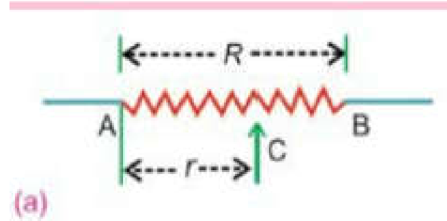
A potentiometer is used to measure the unknown emf of a cell by using

The relation

$V_{AC} = \left(\frac{r}{R}\right)E$

$Ex = \left(\frac{r}{R}\right)E$



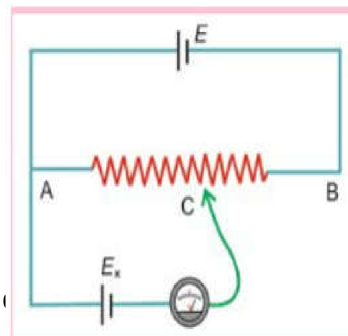


As resistance is directly proportional to length $R \propto L$ and $r \propto l$ so above equation can be written as

$Ex = \left(\frac{l}{L}\right)E$ as($R = \rho L/A$ $r = \rho l/A$ ....$r/R = l/L$)

L is the length of total wire and l is length of wire b/w A and C.

Comparison of emf of cells: let l_1 and l_2 are balancing lengths for emf of two cells E_1 and E_2 respectively then



$E_1 = E\frac{l_1}{L}$ and $E_2 = E\frac{l_2}{L}$

Dividing both equations, we get

$\frac{E_1}{E_2} = \frac{l_1}{l_2}$

This shows that ratio of emfs is equal to ratio of balancing lengths

Uses of potentiometer: There are following uses of potenti

- ✓ To measure the emf of a cell
- ✓ To compare the emf of two cells and as potential divider
- ✓ To measure the internal resistance of cell

Why potentiometer is preferred instead of voltmeter?

Because it draws no current from the circuit and potential difference is measured accurately with this so it is used.

PRACTICE MCQS

1	If resistance is traversed in the direction of current, the change in potential	Positive	**Negative**	Remains same	None
2	The resistance of open circuit is	Zero	**Infinity**	100 ohm	None of these
3	In open circuit the current flowing through circuit will	Infinite	Finite	Maximum	**Zero**
4	The emf is always	Zero	**Present**	Absent	Maximum

	--- even no current is drawn through the battery or cell				
5	Which one is used to find the internal resistance of cell?	Ammeter	Voltmeter	Galvanometer	**Potentiometer**
6	Wheatstone bridge is used to find unknown	Voltage	Current	Potential	**Resistance**
7	The ratio of emfs in potentiometer is proportional	Ratio of balancing voltage	**Ratio of balancing lengths**	Ratio of balancing current	Ratio of unknown resistances
8	Potentiometer can be used as	Galvanometer	**Potential divider**	Ammeter	All of these

Exercise short Questions

1.A potential difference is applied across the ends of a copper wire. What is the effect on the drift velocity of free electrons by i. increasing the potential difference ii. Decreasing the length and the temperature of the wire

i. Drift velocity of electron increases with increase in potential difference

ii. Drift velocity of electron also increases by decreasing the length and temperature of wire.

2.Do bends in a wire affect its electrical resistance? Explain**

The resistance of the conductor is described by the formula: $R = \rho \frac{L}{A}$, Where L is the length and A is the cross-section area of conductor. the electrical resistivity of the material which depends upon the nature of conductor. Hence the resistance of conductor depends upon the geometry and nature of conductor. Hence the bends in conducting wires don't affect its electrical resistance.

3. What are the resistances of the resistors given in the figure A and B. What is the tolerance of each?

Fig A	Fig B
Brown 1 (First Digit)	Yellow 4 (First Digit)
Green 5 (Second Digit)	White 9 (Second Digit)
Red 2 (Number of Zero)	Orange 3 (Number of Zero)

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Resistance = 1500 And Tolerance = T = 5%

Actual R= 1500±5%

therefore Resistance = 49000 And Tolerance = T = 10%

Actual R=49000±10%

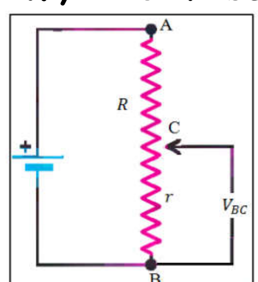
4. Why does the resistance of conductor rise with temperature?**

The resistance offered by a conductor to the flow of electric current is due to collisions which the free electrons encounter with atoms of the lattice. As the temperature of the conductor rises, the amplitude of vibration of atoms increases and hence the probability of their collision with free electrons also increases which result increase of resistance of conductor.

5.What are the difficulties in testing whether the filament of a lighted bulb obeys ohm's law?**

The main difficulty is the rise of temperature of filament with increase of in current. Because for obeying Ohm's law temperature must be remained constant and in filament temperature is changed so ohm's law is not applied on it.

6.Is the filament resistance lower or higher in a 500 W, 220 V bulb than in a 100 W, 220 V bulb?**



$$\text{1st case} \quad R = \frac{V^2}{P} = \frac{(220)^2}{500} = 96.8\Omega$$

$$\text{2nd case} \quad R = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\,\Omega$$

so 100watt bulb has greater resistance

7. **Describe a circuit which will give a continuously varying potential.

A potentiometer can be used as potential divider to give a
Continuously varying potential. It consists of resistor R in the Form of wire on which terminal C
Can slide and battery is connected In which current I=E/R So V_{AC}=Ir
Er/R .it varies from 0 to R

8. ** Explain why the terminal potential difference of a battery decreases when current drawn from itis increases.

The terminal potential difference of the battery of emf is described by the formula: $V_t = E - IR$ Where is the internal resistance of the battery and I is the current flowing through outer circuit. It is clear from equation that when I is large, the factor becomes large and becomes small. Hence terminal potential difference of a battery decreases when current drawn from it is increased.

9. **What is Wheatstone bridge? How can it be used to determine unknown resistance?

It is an electrical circuit which can be used to find the unknown resistance of a wire. By the following formula $\frac{R_1}{R_2} = \frac{R_3}{R_4}$, $X = \frac{R_2 * R_3}{R_1}$ X is unknown resistance.

NUMERICALS CHAPTER 13

13.1: How many electrons pass through an electric bulb in one minute if the 300mA current is passing through it?

$\text{Given Data : charge on an electron} = e = 1.6*10^{-19}\,C, \text{time} = t = 1\text{min} = 60\text{sec}, I = 300m = 300*10^{-3}\,A, n = ?$

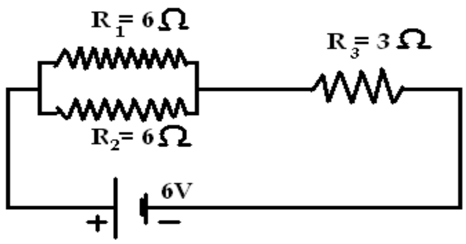
$$\text{As we know that } I = \frac{Q}{t} = \frac{ne}{t} \Rightarrow n = \frac{I*t}{e} = \frac{300*10^{-3}*60}{1.6*10^{-19}} = 1.125*10^{20}\,\textit{electrons}$$

13.2: A charge of 90C passes through a wire in 1 hour and 15 minutes. What is the current in the wire?

$\text{Given data : Charge} = Q = 90C, \text{ time} = t = 1\,\text{hr}\,15\,\text{min} = 3600\,\text{sec} + 900\text{sec} = 4500\,\text{sec}, \text{Current} = I = ?$

$$I = \frac{Q}{t} = \frac{90}{4500} = 0.02A = 2*10-2 = 2*10^{-2}\,A \text{ also written as } I = 20mA$$

13.3: Find the equivalent resistance of the circuit (Fig.P.13.3), total current drawn from the source and the current through each resistor.



$\text{Data : } R_1 = 6\Omega\Omega R_2 = 6\Omega\Omega R_3 = 3\Omega\Omega V = 6V, \; Re' = ?, I = ?, \; I_1, I_2, I_3 = ?$

$$\text{Eq.Resistance for first two R } \frac{1}{Re} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{Re} = \frac{1}{6} + \frac{1}{6} \Rightarrow \frac{1}{Re} = \frac{2}{6} \Rightarrow \frac{1}{Re} = \frac{1}{3} \Rightarrow Re = 3\Omega$$

$$Re' = Re + R_3 = 3 + 3 = 6\Omega$$

$$\text{Total Current} = I = \frac{V}{Re'} = \frac{6}{6} = 1 \text{ ampere}$$

$$I_1 = \frac{V}{R_1} = \frac{3}{6} = 0.5A, \; I_2 = \frac{V}{R_2} = \frac{3}{6} = 0.5\,A, \; I_3 = \frac{V}{R_3} = \frac{3}{3} = 1\,A$$

13.4: A rectangular bar of iron is 2.0cm by 2.0cm in cross section and 40cm long. Calculate its resistance if the resistivity of iron is $11\times10^{-8}\,\Omega m$.

$\text{Given Data : Length} = L = 40\text{ cm} = 40/100 = 0.4\text{ m, Area} = A = 2*2\,cm^2 = 4*10^{-4}\,m^2, \rho = 11*10^{-8}\,\Omega m$

$$\text{Solution : } R = \frac{\rho L}{A} = \frac{11*10^{-8}*0.4}{4*10^{-4}} = 1.1*10^{-4}\,\textit{ohm}$$

13.5: The resistance of an iron wire at $0^\circ C$ is $1\times10^4\,\Omega$. What is the resistance at $500^\circ C$ the temperature coefficient of resistance of iron is $5.2\times10^{-3}\,K^{-1}$?

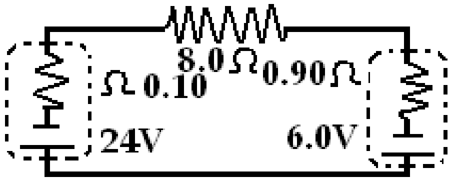
$\text{Given Data : Ro} = 1*10^4\,\Omega, t_1 = 0^o C = 273K, t_2 = 500^o C = 773K, t = t_2 - t_1 = 773 - 273 = 500K,$

$R_t = ? \quad \alpha = 5.2*10^{-3}\,K^{-1}$

$$\text{As we know that } \alpha = \frac{R_t - R_o}{R_o t} \Rightarrow \alpha R_o t = R_t - R_o \Rightarrow \alpha R_o t + R_o = R_t \Rightarrow R_t = R_o(\alpha\, t + 1)$$

$$R_t = 1*10^4\,\Omega(5.2*10^{-3}*500+1) = 3.6*10^4\,\text{ohm}$$

13.6 Calculate terminal potential difference of each of cells in circuit of Fig.



solution :

Given Date : $r_1 = 0.1\Omega, r_2 = 0.9\Omega, R = 8.0\Omega$

$R_e = r_1 + r_2 + R = 0.1 + 0.9 + 8 = 9\Omega$

Effective voltage in circuit = $v_{ef} = E_2 - E_1 = 6 - 2.4 = 3.6V$

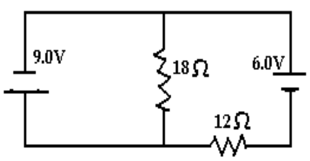
current through circuit = $I = V_{ef}/R_e = 3.6/9 = 0.4A$

from fig battery E_2 current flow through battery from - to + terminal

$V_{t1} = E_1 - Ir_1 = 2.4 - (0.4)(0.1) = 2.36V$

$V_{t2} = E_2 - (-I)r_2 = E_2 + Ir_2 = 6 + (0.4 * 0.9) = 6.36V$

13.7: Find the current, which flows in all the resistances of the circuit



Let I_1 & I_2 are the current flowing through loop in CW direction

first : Applying KVL on loop abcda

$-E_1 + (I_2 - I_1)R_1 = 0 \quad \Rightarrow -9 + (I_1 - I_2)18 = 0$, taking 9 common

$2I_1 - 2I_2 = 1$ ------------------------ (1)

second applying KVL on loop becfb

$-E_2 + I_2R_2 + (I_2 - I_1)R_1 = 0$

$-6 + 12I_2 + 18I_2 - 18I_1 = 0$, taking 6 common and solving

$-3I_1 + 5I_2 = 1$ ------------------------(2)

solving equation (1) and (2) simultaneo usly we get

$I_1 = 1.75$ A and $I_2 = 1.25$ A

Current th rough $R_1 = I_1 - I_2 = 1.75 - 1.25 = 0.5$ A

Current th rough $R_2 = I_2 = 1.25A$

CHAPTER 14 ELECTROMAGNETISM

<u>Electromagnetism: “</u>The branch of Physics which deals with observation and laws relating to electricity and magnetism is called electromagnetism”.

Magnetic field: "The space or region around a magnet where the effect of its magnetism can be detected is called magnetic field". Its SI unit is tesla.
Hans Oersted was discovered magnetic field around moving charge in 1820

The magnetic field due to current in a long wire

To find the existence of magnetic field due to moving charge consider a thick copper wire that passed vertically through a hole inside a cardboard and Compass needle is placed around the conductor. When current I is passed through wire the needles are deflected along the tangent to the circle. Which show the existence of field. We can conclude from this

i. Magnetic field is setup only in the region around the current carrying wire
ii. Magnetic lines of force are circular and direction depends on current
iii. Magnetic field exists as long as the current is passing through wire
iv. Strength of field is larger near the wire.

<u>Right hand rule for find direction of magnetic field</u>: "If wire is grasped in right hand with the thumb pointing in the direction of current and the curled finger indicate the direction of magnetic field".

Explain and calculate Force On A Current Carrying Conductor In A Uniform Magnetic Field

Let us consider a current carrying wire that is moving on a pair of conducting copper rails lying b/w the poles of horse shoe magnet inside a field pointing vertically upward. When the current is passed through the copper rod, it starts moving under the action of magnetic force which is perpendicular to plane containing rod and field. Following results can be made from it.

Copper rod experience a force when it is placed at right angle to magnetic field

so Force is directly proportional to $\sin\alpha$

$F \propto \sin\alpha$ -----(1)

Force is directly proportional to current flowing

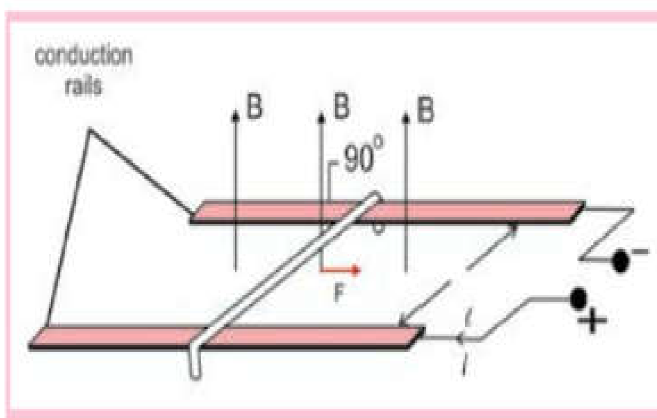
$F \propto I$ --------(2)

Force is directly proportional to lenght of conductor

$F \propto L$ --------(3)

Also Force is proportional to field

$F \propto B$ --------(4)



by combining all the equations we can write

$F \propto ILB\sin\alpha$, which is also written as

$F = ILB\sin\alpha$ and in vector form it can be written as

$\vec{F} = ILB\sin\alpha\,\hat{n} = I(\vec{L} \times \vec{B})$. --------------(A)

Case 01: If α=0° or 180° i.e. rod is parallel or anti parallel to field then force acting on it zero, F=0

Case 02: If α=90° i.e. when rod is perpendicular to field then force will maximum. F=ILB

Equation (A) also provide the definition of strength of magnetic induction

Magnetic Induction: The magnetic force on one meter length of a conductor carrying one meter length of a conductor, carrying one ampere current placed at right angle to the magnetic field is called magnetic induction. Its SI unit is tesla.
If I=1A, L=1m and α=90°, then F=B
Tesla: A magnetic field is said to be one tesla if it exert one newton force on conductor of length one meter placed at right angle to the field, when one ampere current passes through it. B=F/IL= 1 tesla= 1 $NA^{-1}m^{-1}$, 1 tesla=10^4 gauss.
Right hand rule for finding the direction of magnetic force: Curl the fingers of right hand **L** to **B** through smaller possible angle. Then erect thumb will be point in the direction of force.
Convention: It is convention to represent current flowing towards the reader by small dot (**.**) and flowing away from him by (x).

What is Magnetic Flux and Flux Density?

Magnetic flux: "**Total number of magnetic field lines passing through certain area is called magnetic flux**". **OR** scalar product of magnetic field and vector area is called magnetic flux
Formula: $_m$=BAcos , Unit of magnetic flux is weber, 1 weber= Nm/A= NmA^{-1}
At =0° =BAcos0°=EA= maximum angle is b/w vector area and field
At =90°, =BAcos90°=0= minimum
Magnetic flux density: The magnetic flux per unit area of a surface perpendicular to magnetic field is called magnetic flux density. B= m/A its SI unit is $NA^{-1}m^{-1}$=$webm^{-2}$= tesla.

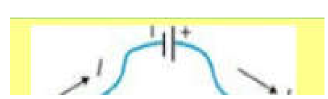
State Ampere Law And Determination Of Flux Density.

Statement of Ampere law: The sum of quantities $\bar{B}.\Delta\bar{L}$ for all path elements into which the complete loop has been divided equal to μo times the total current enclosed by the loop. $\sum_{i=1}^{n}(\vec{B}.\Delta\vec{L}) = \mu_o I$ This is called Ampere law.
Permeability of free space: μ_o is called permeability of free space, whose value is $4\pi\times10^{-7}$ $WbA^{-1}m^{-1}$.

Calculate the Magnetic field inside a current carrying solenoid.

Solenoid: "**A long tightly cylindrical coil of wire is called solenoid, field due to solenoid**". B=μ_onI
Field due to solenoid: When the current passes through solenoid, then it behave as bar magnet. The field inside the solenoid is strong and uniform as compared to the field outside the solenoid is weak so neglected.
Let us consider a rectangular loop abcd as shown in fig. divide it into four elements of length
$ab = l_1, bc = l_2, cd = l_3$ and $da = l_4$

Using Ampere Law, we get $\sum_i^4(B. \; L)$=μ_o(current enclosed)



Using Ampere law we can find magnetic field $\sum_{i}^{4}(\vec{B}.\Delta\vec{L}) = \mu_o$ x (Current enclosed)

$(\vec{B}.\Delta\vec{L})_1 + (\vec{B}.\Delta\vec{L})_2 + (\vec{B}.\Delta\vec{L})_3 + (\vec{B}.\Delta\vec{L})_4 = \mu_o$ x (Current enclosed) also written as

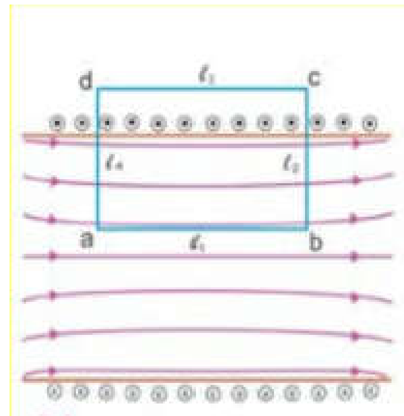
$(\vec{B}.\Delta\vec{L})_{ab} + (\vec{B}.\Delta\vec{L})_{bc} + (\vec{B}.\Delta\vec{L})_{cd} + (\vec{B}.\Delta\vec{L})_{da} = \mu_o$ x (Current enclosed) ---(1)

$(\vec{B}.\Delta\vec{L})_{ab} = Bl_1 \cos\theta = Bl_1 \cos 0^o = Bl_1$

$(\vec{B}.\Delta\vec{L})_{bc} = Bl_2 \cos\theta = Bl_2 \cos 90^o = 0$

$(\vec{B}.\Delta\vec{L})_{cd} = Bl_3 \cos\theta = (0)l_3 \cos 0^o = 0$ As this lenght lies outside the solenoid

$(\vec{B}.\Delta\vec{L})_{da} = Bl_4 \cos\theta = Bl_4 \cos 90^o = 0$



Putting these values in equation (1)

$Bl_1 + 0 + 0 + 0 = \mu_o$ x (Current enclosed)

$Bl_1 = \mu_o$ x (Current enclosed) -------------(2)

$Bl_1 = \mu_o$ x (Current enclosed) -------------(2)

as Number of turns per unit length of solenoid = n

Number of turns in length l_1 of solenoid = n l_1

current enclosed by the loop = I

current enclosed by n l_1 loops = n $l_1 I$ putting in eq(2)

$Bl_1 = \mu_o$ x (n l_1I) = also written as as n = N/L

$B = \mu_o$ n I OR $B = \mu_o$ (N/L) I This is the value of field due to solenoid

Right hand rule: "Hold the solenoid in right hand with fingers curling in the direction of current, the thumb will point in the direction of field".

PRACTICE MCQS

1	Unit of magnetic flux is	**Weber**	Gauss	Tesla	Amper/m^2
2	Magnetic flux through an area A is	Ø=E.A	Ø=ExA	**Ø=B.A**	Ø=BxA
3	1 tesla is equal to	**1 $NA^{-1}m^{-1}$**	1NA^{-1}m	1NAm^{-1}	1Nam
4	Right hand palm rule is used to find the direction of	Current	Emf	**Force**	Temperature
5	Magnetic induction in a solenoid is	**$B=\mu_o nI$**	$B=\mu_o NI$	B=μon	None
6	The mathematical	Lenz law	**Ampere law**	Gauss's law	Faraday law

	expression $\Sigma(B.dl)= \mu_o I$ is known as				
7	A magnetic field acts on a charged particle so as to change its	Speed	Energy	**Direction of motion**	All of these
8	Magnetic field B=4i^+18k^ webm^{-2} passes through 5k^m^2 area net flux is	20 web	90x10^{-4} web	**90 web**	Zero
9	For a current carrying conductor the term "n" has unti as	No unit	**m^{-1}**	m^{-2}	m^{-3}
10	Magnetic field inside the turns of toroid of radius r and N turns carrying current I is given by	μo 2πr/NI	**μoNI/2πr**	μonI/2πr	None
11	Two parallel wires current in opposite direction	No effect	**Repel each other**	Attract each other	Neither attract no repel
12	A 5m wire carrying current 2A at right angle to field 0.5T, the force	**5N**	10N	20N	25N
13	Best magnetic material is made up of	**Alnico V**	Iron	Nickel	Cobalt

14	The direction of vector LxB is same as	**Force**	Mag. Field	Electric field	Length
15	Electric current produces magnetic field was suggested by	Faraday	**Oersted**	Henry	Lenz
16	One weber is equal to	N/A	Nm-1A	**Nm/A**	N/Am
17	The magnetic force acting on a unit positive charge moving at right angle to the magnetic field with unit velocity is called	Magnetic flux	Induced emf	Motional emf	**Magnetic induction**
18	SI unit of magnetic induction is	Weber	**Tesla**	Gauss	Farad
19	Which one is correct relation?	Webm^2=N/Am	1 tesla=10^{4}gauss	1 webm^2=1 tesla	**All of these**
20	The unit of magnetic field in SI is	Weber	**Tesla**	Gauss	Newton
21	If 0.5T field over an area of 2m2 which lies at an angle of 60 with field, then resulting flux	0.50 T	**0.50 Web**	0.25Web	0.25T
22	If the number of turns become doubled but length remains same, then magnetic field in	Half	**Double**	Remains same	Zero

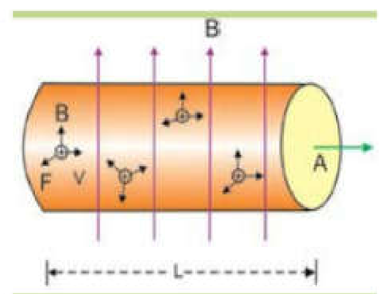
	the solenoid become				
23	In current carrying solenoid the magnetic field does not depends upon	**Radius of solenoid**	Number of turns per unit length	Current	All of these
24	Magnetic lines of force are	**Imaginary**	Real	Perpendicular	Plane to field
25	Ampere law is magnetic equivalent of	Newton law	**Gauss law**	Faraday law	Ohm law
26	If current flowing through solenoid becomes double then magnetic field inside	Becomes half	**Becomes two times**	No effect	Becomes zero
27	Ampere circuital law is given by	μo 2πr/NI	**μoI/2πr**	μonI/2πr	None
28	SI unit of magnetic flux density is	Web m-1	**Web m^{-2}**	web	Joule/sec
29	A power line 10m high carries a current of 200A. the magnetic field of wire at ground	$40*10^{-8}$T	**$40*10^{-6}$T**	$4*10^{-4}$T	$4*10^{-3}$T
30	Magnetic flux density at a point is calculated using	Gauss law	**Ampere law**	Faraday law	Ohm law
31	Magnetic field inside a long solenoid carrying current	Weak	**Uniform and Strong**	Zero	Both A&B

	I				
32					

Calculate the formula for Force on moving charge placed in a magnetic field

A force is experienced by current carrying conductor placed in uniform magnetic field. As this is the force which is acted upon by magnetic field on charged particles moving in conductor.

To calculate this force consider a wire of length L and area of cross section A



Then no charge carriers in unit volume=n

Length of wire=L,   area of wire=A

volume of wire of length L and Area A=AL

Total no of charge carriers in the wire of volume AL=

Charge on a single charge carrier=q

total charge moving due to nAL charge carriers=nALq

Let v is the velocity of single charge q and Δt is the time by charge b/w two ends of wire then

S=vΔt or L=v/Δt   because in this case s=L

Current flowinig through wire is $I = \frac{\Delta Q}{\Delta t} = \frac{nALq}{L/v} = nAqv$

using the formula for force on current carrying conductor $\vec{F} = I(\vec{L}x\vec{B}) = nAqv(\vec{L}x\vec{B}) ----(1)$

Since the direction of segment L of wire is along the direction of velocity of charge carriers therefore

$\hat{L} = \hat{v}$ so we can write $v\vec{L} = vL\hat{L} = vL\hat{v} = L\vec{v}$ as we know that $(\vec{v} = v\hat{v})$

putting in eq (1)   eq (1) $\Rightarrow$ $\vec{F} = nAqv(\vec{L}x\vec{B}) = nAq(v\vec{L}x\vec{B}) = nAq(L\vec{v}x\vec{B}) = nALq(\vec{v}x\vec{B})$

This is the magnetic force acting on conductor due to nAL charge carriers. The force on single is $\vec{F}' = \vec{F}/nAL$.

so $F' = nALq(\vec{v}x\vec{B})/nAL = q(\vec{v}x\vec{B}) = qvB\sin\theta$

This is the force on a moving charge placed in magnetic field

Case 01: If charge is electron then $q = -e$ then $F = -e(\vec{v} \times \vec{B})$

and electron is deflected vertically downward into $\vec{B}$

Case 02: If charge is proton then $q = +e$ then $F = +e(\vec{v} \times \vec{B})$

and proton is deflected in verticall upward into $\vec{B}$

Minimum Force: When charge is moving parallel to field then $\theta = 0^o$ $F = qvB\sin 0^o = 0$ Minimum force

Maximum Force: When charge is moving perpendicular to field then $\theta = 90^o$ then $F = qvB\sin 90^o = qvB$ Max force

Direction of Force: Direction of force is found by right hand rule "Rotate the fingers of your right hand through v towards $\bar{B}$ through smallest possible angle then erect thumb will show the direction of force".

Explain Motion of charge particle in electric and magnetic field. What is Lorentz force & formula.

Acceleration of charge particle: When a charge q is placed in electric field b/w two oppositely charged plates then the force acting on it will F=q$\bar{E}$
then by using Newton 2nd law a=F/m =q$\bar{E}/m$, this is uniform acceleration.
Lorentz force: "**Sum of electric force q$\bar{E}$ and magnetic force q($\bar{v}x\bar{B}$) is called Lorentz force**". When a charge particle q is moving with velocity v in region having electric field E and field B, formula for Lorentz force is $\vec{F}=q(\vec{v}*\vec{B})+q\vec{E}$
Only electric force work, magnetic force is simply deflecting force. Magnetic force does not work.

Explain the Determination of e/m of an electron

JJ Thomson was first person who determined the charge to mass ratio of an electron in 1897.

Principle: When a beam of electron is deflected when it passed through magnetic field.

Explanation: let us consider a beam of electrons moving through uniform magnetic field $\bar{B}$ with velocity$v$.

The force acting on the electron is F=-e(vx$\bar{B}$) and in magnitude form it is F=evBsinϴ

As v and B are perpendicular to each other so ϴ=90°, so F=evBsin90°=evB ------- (1)

This force provides necessary centripetal force Fc=mv^2/r ------------------- (2)

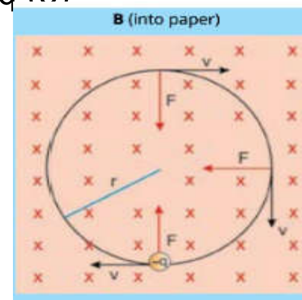
Comparing both equations Fe=Fc evB= mv^2/r

$\frac{e}{m}=\frac{v}{Br}$ --------- (3)

Determination of radius: We can measured the radius of circular path followed by electron by making its path visible by filling the glass tube with hydrogen gas at low pressure placed in known uniform magnetic field. When electrons are projected inside the tube and they began to move along a circle and collide with gas thus the atom become excited, on de excitation of the atoms emit light to make the path of electron visible and it looks like a glowing circle. The diameter of ring can be measured easily.

Determination of velocity by potential difference method: In this method, the electron is accelerated through a potential difference V_o. The energy gained during this acceleration is eV_o which appear as K.E of electrons.

K.E=eVo ……> $\frac{1}{2}mv^2 = eVo$ ………> $v = \sqrt{\frac{2eVo}{m}}$ putting in eq (3)



$\frac{e}{m} = \frac{1}{Br}\left(\sqrt{\frac{2eVo}{m}}\right)$ squaring both sides we get $\frac{e^2}{m^2} = \frac{1}{B^2r^2}\left(\frac{2eVo}{m}\right)$

$\frac{e}{m} = \frac{2V_o}{B^2r^2}$ Value of e/m for electron=$1.7588*10^{11}$ C/kg

PRACTICE MCQS

1	Magnetic force is simply a	**Deflecting force**	Reflecting force	Restoring force	Gravitational force
2	The value of e/m of electron is C/kg	**1.75×10^{11}**	1.75×10^{-11}	1.6×10^{-19}	Zero
3	e/m of an electron	$B^2r^2/2V$	$Br^2/2V$	**$2V/B^2r^2$**	$2V^2/B^2r^2$
4	Magnetic force on a moving charged particle is perpendicular to the	Magnetic field	Electric field	Velocity of particle	**Both A&C**
5	For an electron e/m is given by	B/Vr	**V/Br**	Br/V	VBr
6	The unit of E is N/C and B is N/Am the unit of E/B is	ms^{-2}	Ms	**ms^{-1}**	$m^{-1}s^{-1}$
7	Two long parallel wires carrying current to same direction will --- each other	Repel	**Attract**	Remains at rest	Start rotating
8	A charged particle moving in a magnetic field experience a	Field	Motion	Opposite to its motion	**Perpendicular to field and its motion**

	resulting force in the direction of				
9	Beam of electron is also called	Positive rays	X-rays	**Cathode rays**	Cosmic rays
10	An electron of mass m and charge e is moving in circle of radius r with speed v in uniform magnetic field B then	**r proportional to m**	r proportional to B	r proportional to 1/v	r proportional to 1/m
11	Force on a moving charge in a uniform magnetic field will be maximum when angle between v and B is	0°	**90°**	60°	30°
12	The sum of electric and magnetic force is	Maxwell force	**Lorentz force**	Newton force	Centripetal force
13	Work done on charge particle moving in uniform magnetic field	Maximum	**Zero**	Negative	Infinity
14	e/m of neutron	Less than electron	Greater then electron	**Zero**	The same as electron
15	The magnetic force on electron travelling at 10^6 m/s perpendicular to the field of strength 1T is	$16*10^{12}$ N	**$1.6*10^{-13}$ N**	0 N	Infinity
16	In expression e/m=v/Br, the radius is	Elliptical	**Visible**	Dark	Hyperbolic

	measured by making electronic trajectory				
17	F=Fe+Fm is called	Electric force	**<u>Lorentz force</u>**	Magnetic force	Weak force
18	When a charge particle perpendicular to uniform magnetic, then path follow will	Straight line	**<u>Cicle</u>**	ellipse	Helix
19	Lorentz force is given by	$\vec{F} = I(\vec{L}x\vec{B})$	$\vec{F} = I(\vec{L}x\vec{B}) + q\vec{E}$	<u>$\vec{F} = q(\vec{v}x\vec{B}) + q\vec{E}$</u>	$\vec{F} = q(\vec{v}) + q\vec{E}$
20	Electronic path in e/m experiment visible if gas is filled at	**<u>Lower pressure</u>**	High pressure	Infinite pressure	Zero pressure
21	e/m is smallest for	**<u>Proton</u>**	Electron	Beta particle	Positron

Write a note on Cathode ray oscilloscope

<u>Definition</u>:" An electronic device which is used for plotting the graphs at a very high speed is called CRO".

<u>Principle of working of CRO</u>: A beam of electrons is deflected while passing through uniform electric field present b/w two sets of plates. This beam falls on screen and makes a spot.

<u>Construction</u>: A CRO consist of following parts and their functions is as follows

<u>Electron gun</u>: Electron gun consists of an indirectly heated cathode, a grid and three anodes and it provides beam of electrons.

Cathode provide electronic beam when heated and anodes cause the electronic beam to accelerate.

<u>Grid:</u> It is at negative potential relative to cathode. It controls number of electrons and brightness of spot on screen.

<u>Sweep or time base generator</u>: The voltage that is applied across X-plates provided by a circuit that is built in CRO is called time base generator. It display saw tooth wave.

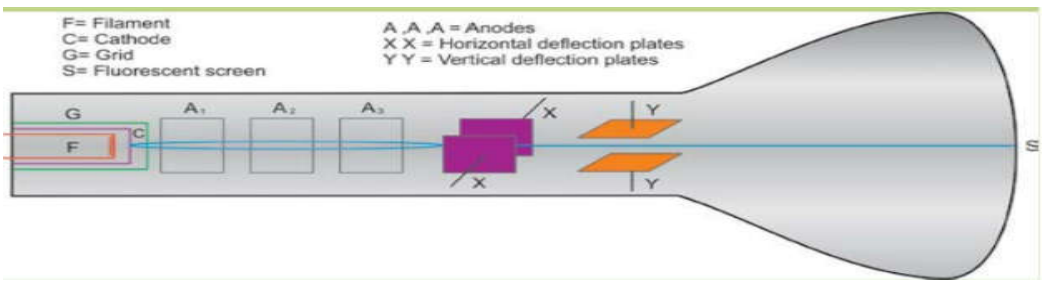
<u>Trace on CRO if voltage is applied across y plates</u>: Sinusoidal trace will appear when voltage is applied across y plates.

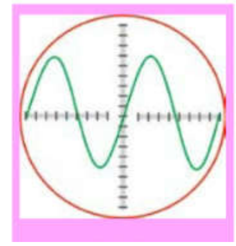
<u>Screen</u>: This is fluorescent screen where it makes a visible spot of deflected beam.

<u>Synchronization control</u>: The frequency of voltage at y plates is adjusted by synchronization control provided on the front panel of the CRO

<u>Uses of CRO</u>: There are following uses of CRO

i. It display the waveform of given voltage
ii. It measure the voltage, frequency and phase of input signal
iii. It measure time period of AC signal and phase difference b/w two phase



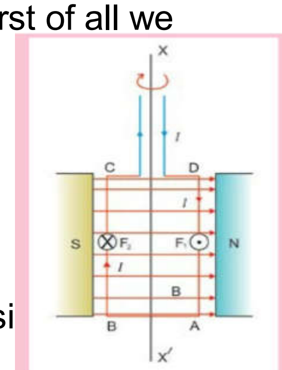


Calculate the Torque on current carrying coil in uniform magnetic field

Consider a rectangular coil of length L and width a carrying current I is placed inside a magnetic field B. Coil is capable of rotating about an axis due to which torque is produced which is calculated here.

Force acting on conductor of length L is F=I($\bar{L}$x$\bar{B}$) =ILB sinϴ, where ϴ is angle b/w $\bar{L}$and$\bar{B}$.

As there are four sides of rectangular coil AB, BC, CD, DA and first of all we calculate the force on each side



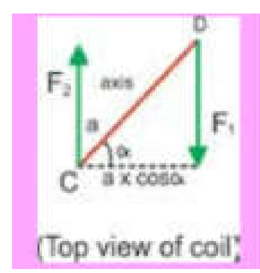
In case of side AB and CD of the coil angle ϴ=0° or 180°

so the force acting these sides

F=ILB sin0° or sin180°=0

In case of sides DA and BC the angle is 90° and force on these si

F_1=F_2=ILB sin90°=ILB



Both forces F_1 and F_2 are equal and opposite form a couple

Which rotate the coil due to which torque is produced

Torque=Force x moment arm= ILB x a=IB (Lxa)

As L x a=area of coil=A

Ʈ= IBA, if the field makes angle α with plane of the coil as shown in fig cosα

Ʈ= IBAcosα, this is the formula for torque on current carrying coil in uniform magnetic field.

What is Galvanometer? Explain its principle, construction and working.

<u>Galvanometer</u>: "Such an electrical instrument which is used to detect the passage of current through circuit is called galvanometer".

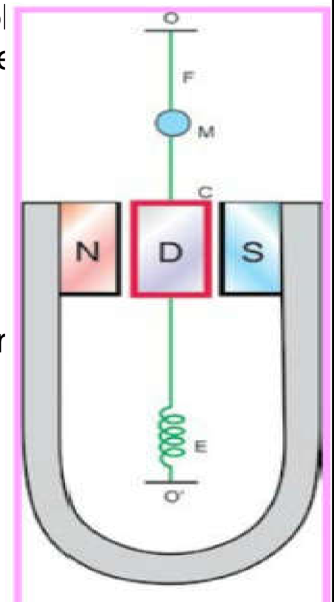
<u>Working Principle of galvanometer</u>: It works on principle "**torque acts on a current coil when placed in uniform magnetic field** $\tau = NIBA\cos\alpha$ **".**
<u>Construction</u>: A galvanometer consists of a rectangular coil C suspended b/w the concave pole piece magnet of U shaped by suspension wire made enameled copper wire. The suspension wire F acts as one current lead while the other terminal of coil is connected to loosely spiral spring E
which act as 2^{nd} current lead. The mirror M attached to suspension wire used to find angle of deflection.
<u>Working</u>: When the current is passed through the coil, two equal and opposite forces acting on different points of coil which form couple due to magnetic force. Such couple is known as deflecting coupl and its produce torque due to number of turns N and A is the are
Deflecting torque=τ= NIBAcosα=NIBAcos0°=NIAB ---(1)
As the coil turns und the action of deflecting torque then couple produced is restoring couple which is proportional to angle of deflection Θ so by using Hook's law
Restoring torque $\propto \Theta$ so Restoring torque=CΘ------ (2)
C is called torsional or twisting constant defined as Restoring Couple per unit twist produced in coil of galvanometer
Comparing equation (1) and (2)

$$NIAB = C\Theta$$

$$I = \frac{C\theta}{NBA} \quad \text{or}$$

$$I \propto \Theta$$

$$\text{As } \frac{C}{NBA} = \text{constant}$$



(a)

This shows that current passing through the coil of galvanometer is proportional to angle of deflection.

How can we Measure of angle of deflection?

: There are two methods for measuring angle of deflection

i. **<u>Lamp and scale arrangement</u>**: In this method a beam of light from the lamp is directed towards the mirror M attached to the coil of galvanometer. After reflecting from the mirror, it produce a sport on transparent scale placed at 1m distance from galvanometer. When the coil rotates the attached to the coil also rotates and spot of light on scale is proportional to angle of deflection.

ii. **<u>Pivoted type galvanometer</u>**: In this type of galvanometer coil is rotated b/w two jeweled bearings. The restoring torque is provided by two hair springs which also act as current lead. An aluminum pointer is attached to the coil which moves over a scale such galvanometer is called Weston type galvanometer.

What is Current sensitivity of galvanometer and the factors upon which it depends

A galvanometer is said to be sensitive if it give one millimeter deflection on scale when microampere current is passed through it. For galvanometer $I = \frac{C\theta}{NAB}$,

Galvanometer can made more sensitive if $\frac{C}{NAB}$ is made small

<u>Sensitivity of galvanometer can be increased by</u>:

i. Increasing number of turns and area of coil
ii. Increasing flux density B
iii. Decreasing C by using wire of large length and small radius

Types of galvanometer/ What is dead beat galvanometer and unstable galvanometer?

<u>Stable or dead beat galvanometer: "</u>A galvanometer in which the coil comes to rest quickly after passage of current through it is called stable or deadbeat galvanometer".

<u>unstable galvanometer: "</u>Such a galvanometer in which the coil of galvanometer is not come to rest and keep on oscillating about its mean position or shoot beyond its fixed position if current is suddenly passed through it is called unstable galvanometer".

What is ammeter? How galvanometer is converted into ammeter?

<u>Ammeter:"</u>An electrical device which is used to measure the current in amperes is called ammeter". It is low resistance galvanometer".

Meter movement: The portion of galvanometer whose motion cause the needle to move across the scale is called meter movement.

<u>Conversion</u>: A galvanometer is converted into ammeter by connecting a low resistance Rs shunt in parallel with galvanometer.

<u>Shunt/bypass resistor</u>:

Small value of resistance connected in parallel with galvanometer to convert into ammeter is called shunt.

<u>Calculation of shunt resistance</u>: shunt resistance is adjusted so that current which give full scale deflection pass through galvanometer and remaining current passes through shunt

Potential difference across galvanometer Rg=Vg=IgRg ---- (1)

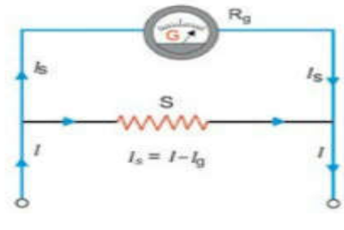
Potential difference across shunt Rs=Vs= (I-Ig)Rs --------(2)

Since the both resistances are parallel so have same P.D so,

Putting the values

(I-Ig)Rs=IgRg

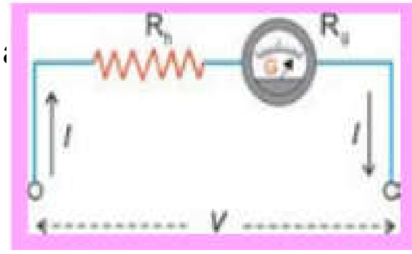
Rs=$\frac{\text{IgRg}}{(\text{I}-\text{Ig})}$, this is the formula for shunt resistance which of few



Ammeter is connected in series with circuit so that maximum current can be measured by it.

What is voltmeter? How galvanometer is converted into voltmeter?

<u>Voltmeter</u>: "An electrical device which is used to measure the potential difference b/w two points is called voltmeter".
It is high resistance galvanometer. An ideal voltmeter has infinite resistance.
<u>Conversion of Galvanometer</u>: Galvanometer is converted into voltmeter by connecting high resistance R_h in series with coil of galvanometer which give a full scale deflection when connected across P.D V.



As same current Ig is flowing through Rg and R_h so by

$V=I_g(R_g+R_h)$

$\frac{V}{I_g}=R_g+R_h$

$R_h=\frac{V}{I_g}-R_g,$

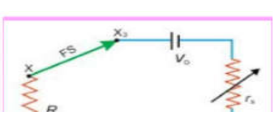
By connecting the proper value of R_h in series with meter movement,
Voltage can be measured.Voltmeter is connected in parallel with circuit.

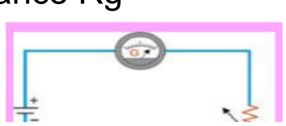
What is Ohmmeter? How galvanometer is converted into ohmmeter?

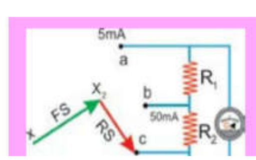
<u>Ohmmeter</u>: "**An electrical device which is used for rapid measurement of resistance is called ohmmeter**".
It consists of a galvanometer, an adjustable resistance rs and cell in series.
<u>Conversion</u>: A galvanometer is converted into ohmmeter by connecting
An adjustable resistance r and a cell in series with galvanometer.
To measure the unknown resistance, it is connected b/w two terminals c and d
And deflection of scale gives R.

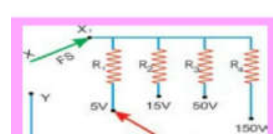
What is AVO METER/MULTIMETER?

<u>Definition</u>: "An electrical device which can measure current in ampere, potential difference in volt and resistance in ohm is called AVO meter or multi meter".
<u>Function switch</u>: It is Function selector switch which connects the galvanometer with relevant measuring circuit.
<u>Voltage measuring part of AVO meter</u>: It is actually multi range voltmeter which consists of Number of resistances each connected in series with moving coil galvanometer with function switch. The value of each resistance depends upon the range of Voltmeter which it controls.
Alternating voltages are also measured by AVO meter. AC voltage is first converted into DC voltage by using diode as rectifier and then measured.
<u>Current measuring part of AVO meter</u>: It is actually called multi range ammeter consists of a number of low resistances connected in parallel with galvanometer.
<u>Resistance measuring part of AVO meter</u>: It is multi range ohmmeter for each range of this. Meter consists of a battery of emf V_O and variable resistance rs connected in series with Galvanometer of resistance Rg









Digital multimeter(DMM):"An electronic instrument which is used to measure the current, resistance and voltage in circuit. It is digital version of an AVO meter".

Advantages of DMM: There are following advantages of DMM

Fig. 14.26

i. It is digital version of AVO meter
ii. It is very accurate device
iii. It is easy to operate
iv. It removes the reading error

PRACTICE MCQS

1	In CRO the output waveform of time base generator is	Circular	Square	Sinusoidal	**Saw tooth**
2	The maximum torque on a current carrying coil of N turns is t=?	**NIBA**	IBA	IBAsinϴ	NIBAcosϴ
3	Brightness of the spot of the CRO on the screen is controlled by	Cathode	Anode	**Grid**	Plate
4	A current carrying coil placed in a magnetic field experience torque maximum when angle is	**0 °**	90 °	180 °	45°
5	An AVO meter is also called	An ammeter	A voltmeter	**A multimeter**	An ohmmeter
6	The anode in CRO	Control the no. of waves	Control the brightness of spot formed	**Accelerate and focus beam**	At negative potential w.r.t cathode
7	Torque on current carrying coil is t=?	**NIABcosϴ**	BILsinϴ	NIABsinϴ	BIL
8	CRO works by deflecting beam of	Neutrons	Protons	**Electrons**	Positrons

9	In CRO the number of electrons is controlled by operating	anodes	Cathode	**Grid**	Filament
10	Grid in CRO	Control the number of waves	**Control the brightness**	Has positive potential w.r.t cathode	Accelerate electrons
11	AVO meter measure	Current	voltage	Resistance	**All of these**
12	An advantage of AVO meter	Digital version	Easy to operate	Remove error of reading	**All of these**
13	At what angle the value of torque acting current carrying coil becomes half	0	45	90	**60**
14	Output waveform of built in voltage of CRO is	Sinusoidal	Square	Rectangular	**Saw tooth**
15	An electric circuit in CRO that provides voltage to x plates is called	Tweet	Sleep	Cheap	**Sweep**
16	Beam of electrons is also called	Canal rays	Gamma rays	X rays	**Cathode rays**
17	CRO is used to display the waveform of	Current	frequency	amplitude	**Voltage**
18	Work done on a charged particle moving in uniform magnetic field	Minimum	Maximum	Infinite	**Zero**
19	Filament in CRO is	***Conductor***	Insulator	Perfect conductor	Perfect insulator
20	High resistance Rh that connected in series with galvanometer of resistance Rg to convert into voltmeter of range V volts is given	$\frac{V}{Ig}$+Rg	**$\frac{V}{Ig}$- Rg**	$\frac{V}{Ig}$+IRg	None of these
2	Galvonometer can be made	Made	**Made**	Remains	None of

1	more sensitive if the value of factor C/NAB is	large	**small**	constant	these
22	In order to increase the range of voltmeter the series resistance is	Kept constant	Decreased	**Increased**	Made zero
23	Which of the following is likely to have least resistance	**Ammeter**	Galvanometer	VTVM	Voltmeter
24	Voltmeter is always connected in circuit	**Parallel**	Series	Both A&B	None
25	To measure the current ammeter is always connected	Parallel	**Series**	Both A&B	None
26	To convert galvanometer into ammeter the parallel shunt resistance Rs equal	**IgRg/I-Ig**	I-Ig/IgRg	IR	None
27	Shunt resistance is also called	**By pass resistor**	Specific resistance	Reactance	Impedance
28	Shunted galvanometer is called	**Ammeter**	Voltmeter	Ohmmeter	Potentiometer
29	In case of conversion of galvanometer into ammeter the shunt resistance is connected	**In parallel**	In series	Neither series nor parallel	Both A&B
30	The pointer of dead beat galvanometer gives a --- deflection because of eddy current	Variable	**Steady**	Continuous	Slow

EXERCISE SHORT QUESTIONS

1.A plane-conducting loop is located in a uniform magnetic field that is directed along the x-axis. For what orientation of the loop is the flux a maximum? For what orientation is the flux a minimum?**

Case 1 When vector area of the conducting loop is in the direction of magnetic field strength =0° then the magnetic flux will maximum:

At =0° =BAcos0°=EA= maximum

Case 2 When vector area of the conducting loop is perpendicular to magnetic field strength then the magnetic flux will minimum:

At =90°, =BAcos90°=0= minimum

2. A current in a conductor produces a magnetic field, which can be calculated using Ampere's law. Since current is defined as the rate of flow of charge, what can you conclude about the magnetic field due to stationary charges? What about moving charges?

a. Magnetic field due to stationary charges is zero: because in this case the value of current is zero so field will be zero. $B = \frac{\mu o I}{2\pi r} = \frac{\mu o(0)}{2\pi r} = 0$

b. Moving charge produce magnetic field: because moving charge produce current which produces magnetic field

3. Describe the change in the magnetic field inside a solenoid carrying a steady current I, if (a) the length of the solenoid is doubled, but the number of turns remains the same and (b) the number of turns is doubled, but the length remains the same.

a..In this case magnetic field is reduced to half

As magnetic field due to solenoid $\mathrm{B} = \frac{\mu\mathrm{oNI}}{\mathrm{L}}$ as in this case L'= 2L so $\mathrm{B'} = \frac{\mu\mathrm{oNI}}{2\mathrm{L}}, \mathrm{B'} = \frac{1}{2}B$

b. In this case magnetic field increased to double:

$\mathrm{B} = \frac{\mu\mathrm{oNI}}{\mathrm{L}}$ as in this case N'= 2Nso $\mathrm{B'} = \frac{\mu\mathrm{o2NI}}{\mathrm{L}}, \mathrm{B'} = 2B$

4.**At a given instant, a proton moves in the positive x direction in a region where there is magnetic field in the negative z direction. What is the direction of the magnetic force? Will the proton continue to move in the positive x direction? Explain**

a. Magnetic force is directed along positive y-axis: Because magnetic force on proton is $\vec{F} = q(\vec{v} * \vec{B})$, according to right hand rule F is perpendicular to v and B along y axis

b. No, the proton will not continue to move in the positive x-direction. Since the magnetic force is acting at the right angle to motion of conductor, therefore it will move along a circular path in xy-plane

5.**Two charged particles are projected into a region where there is a magnetic field perpendicular to their velocities. If the charges are deflected in opposite directions, what can you say about them?**

The two particles are oppositely charged: Because the magnetic force acting on charged particle is $\vec{F} = +e(\vec{v} * \vec{B})$ for positive charge and $\vec{F} = -e(\vec{v} * \vec{B})$ for negative charge and force is deflecting so if q is positive it is deflected in one direction and q is negative then it will be deflected in other direction.

6. Suppose that a charge q is moving in a uniform magnetic field with a velocity V. Why is there no work done by the magnetic force that acts on the charge q?**

As we know that magnetic force acting on charge particle $\vec{F} = q(\vec{v} * \vec{B})$ is always perpendicular to velocity so angle b/w F and d is 90°,W=Fdcos90°=0 so no work is done by magnetic force.

7.** **If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero?**

No, it may or may not be zero: Because the magnetic force acting on a charge particle $\vec{F} = q(\vec{v} * \vec{B})$=qvBsin , Force will be zero in the following cases

i. If field is zero
ii. Charge particle move parallel to field =0°
iii. Charge particle movie anti parallel/opposite to field =90°

8.**Why does the picture on a TV screen become distorted when a magnet is brought near the screen?**

As the picture on TV screen is formed due to the beam of electrons. When a magnet is brought near the screen the path of electrons is disturbed due to magnetic force so the picture on TV screen is distorted

9.**Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? Explain.**

Yes it is possible: we know that torque acting on current loop in uniform magnetic field is $\tau = NIBA\cos\theta$ It is clear from expression that when plane of the coil makes an angle of 90° with magnetic field, the torque on the coil will be zero. In this condition, the coil will not tend to rotate.

10.**How can a current loop be used to determine the presence of a magnetic field in a given region of space?**

We know that torque acting on current carrying loop is $\tau = NIBA\cos\theta$ so, if current loop is deflected in given region of space then it shows the presence of magnetic field otherwise not.

11.**How can you use a magnetic field to separate isotopes of chemical element?**

For this purpose the ions of elements are passed through a uniform and perpendicular field, magnetic force act on them so under the action of this force the ions move along circular path of different radii due to their different masses and $qvB = \frac{mv^2}{r}$, and $r \propto m$

12.** **What should be the orientation of a current carrying coil in a magnetic field so that torque acting upon the coil is (a) maximum (b) minimum?**

As we know that $\tau = NIBA\cos\theta$

When plane of the coil is parallel to magnetic field, the torque acting on the coil will be maximum given by:

$\tau = NIBA\cos 0$=NIBA= maximum

When plane of the coil is perpendicular to magnetic field, and the torque acting on the coil will be minimum,

$\tau = NIBA\cos 90$=0= minimum

13.**A loop of wire is suspended between the poles of a magnet with its plane parallel to the pole faces. What happens if a direct current is put through the coil? What happens if an alternating current is used instead?**

As the plane of the coil is parallel to the pole faces, therefore, it is perpendicular to the magnetic field,
i.e. α = 90°. Torque acting on coil $\tau = NIBA\cos 90$=0. Therefore, for both A.C. and D.C., the coil will not rotate.

14.**Why the resistance of an ammeter should be very low?**

An ammeter is connected in series with a circuit to measure the current. It is connected in series so that total current passing through the circuit should pass through it. If the resistance of the ammeter will be large, it will decrease the current of the circuit that's why resistance of ammeter should be very low so maximum and accurate current measured by it.

15.**Why the voltmeter should have a very high resistance?**

A voltmeter is connected in parallel with circuit to measure potential difference across it. It should have very high resistance so that practically, a very little current should pass through it and the current of the circuit should almost remain constant, so that it might measure the potential difference across a circuit accurately.

NUMERICALS CHAPTER 14

14.1: Find the value of the magnetic field that will cause a maximum force of $7.0\times10^{-3}\,N$ on a 20.0cm straight wire carrying a current of 10.0A.

Given : $F = 7*10^{-3}$ N, L = 20cm = 20/100 = 0.20 m, I = 10A, B = ?

$$F = ILB \Rightarrow B = \frac{F}{IL} = \frac{7*10^{-3}}{10*0.20} = 3.5*10^{-3}\ T$$

14.2: How fast must a proton move in a magnetic field of $2.50\times10^{-3}T$ such that the magnetic force is equal to its weight?

Given Data : Magnetic field = $B = 2.5*10^{-3}$ T, $mp = 1.673*10^{-27}$ Kg, $q = 1.6*10^{-19}$ C v = ?

as Magnetic force is equal to weight so $F = W \Rightarrow qvB = mg$

$$v = \frac{mg}{qB} = \frac{1.673*10^{-27}*9.8}{1.6*10^{-19}*2.5*10^{-3}} = 4*10^{-5}\,\text{m/s}$$

14.3: A velocity selector has a magnetic field of 0.30T. If a perpendicular electric field of 10,000 Vm^{-1} is applied, what will be the speed of the particle that will pass through the selector?

Given Data : Magnetic field = B = 0.30 T, E = 10,000 V/m, speed = v = ?

As Magnetic force = electric force, $qvB = qE \Rightarrow vB = E$

$$v = \frac{E}{B} = \frac{10000}{0.30} = 3.3*10^{4}\,\text{m/s}$$

14.4: A coil of $0.1m\times0.01m$ and of 200 turns carrying a current of 1.0mA is placed in a uniform magnetic field of 0.1T. Calculate the maximum torque that acts on the coil.

Given Data : Area = A = 0.1*0.1 = 0.01 m, N = 200, I = 1mA = $1*10^{-3}$ A, B = 0.1 T, τ = ?

$$\tau = NIAB = 200*1*10^{-3}*0.01*0. = 2*10^{-4}\,Nm$$

14.5: A power line 10.0m high carries a current 200A. Find the magnetic field of the wire at the ground.

Given Data : Height of power line = h = r = 10m, I = 200A, B = ?

$$\text{Using Ampere law } B = \frac{\mu_o I}{2\pi r} = \frac{4\pi*10^{-7}*200}{2*3.14*10} = 4*10^{-6}\,T$$

14.6: You are asked to design a solenoid that will give a magnetic field of 0.10T, yet the current must not exceed 10.0A.Find the number of turns per unit length that the solenoid should have.

Given Data : $B = 0.1T, I = 10A, n = ?$

$$\text{Using } B = \mu_o nI \Rightarrow n = \frac{B}{\mu_o I} = \frac{0.1}{4\pi * 10^{-7} * 10} = 7.96 * 10^3 \text{ turn/length}$$

14.7: What current should pass through a solenoid that is 0.5m long with 10,000 turns of copper wire so that it will have a magnetic field of 0.4T?

Given Data : Length $= L = 0.5$ m, $B = 0.4$ T, $N = 10000$, $n = N/L = 10000/0.5 = 20000$, current $= I = ?$

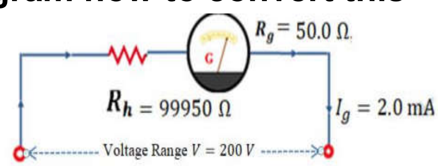
$$\text{Using } B = \mu_o nI \Rightarrow I = \frac{B}{\mu_o n} = \frac{0.4}{4\pi * 10^{-7} * 20000} = 15.9 \text{ ampere}$$

14.8: A galvanometer having an internal resistance R_g= 15.0Ω gives full scale deflection with current I_g= 20.0mA. It is to be converted into an ammeter of range 10.0A. Find the value of shunt resistance R_s.

Given Data : $Rg = 15\Omega \quad Ig = 20 \text{ mA} = 20 * 10^{-3} \text{ A}, \quad I = 10 \text{ A}, \quad Rs = ?$

$$Rs = \frac{IgRg}{I - Ig} = \frac{20 * 10^{-3} * 15}{10 - 20 * 10^{-3}} = 0.03 \text{ ohm}$$

14.9: The resistance of a galvanometer coil is 50.0Ω and reads full scale deflection with a current of 2.0mA. Show by a diagram how to convert this galvanometer into voltmeter reading 200V full sca



Given Data : $Rg = 50\Omega \quad Ig = 2\text{mA} = 2 * 10^{-3} \text{ A}, V = 200\text{V}, R_h = ?$

$$R_h = \frac{V}{Ig} - Rg = \frac{200}{2 * 10^{-3}} - 50 = 99950 \text{ ohm}$$

14.10: The resistance of a galvanometer coil is 10.0Ω and reads full scale with a current of 1.0 mA. What should be the values of resistances R_1, R_2 and R_3 to convert this galvanometer into a multi range ammeter of 100, 10.0 and 1.0A?

Given Data : $Rg = 10\Omega \quad Ig = \text{mA} = 1 * 10^{-3} \text{ A}$, Ranges of current $= I_1 = 100\text{A}, I_2 = 10\text{A}, I_3 = 1\text{A}$

$$R_1 = \frac{IgRg}{I_1 - Ig} = \frac{1 * 10^{-3} * 10}{100 - 10 * 10^{-3}} = 0.0001 \text{ ohm}$$

$$R_2 = \frac{IgRg}{I_2 - Ig} = \frac{1 * 10^{-3} * 10}{10 - 10 * 10^{-3}} = 0.001 \text{ ohm}$$

$$R_3 = \frac{IgRg}{I_3 - Ig} = \frac{1 * 10^{-3} * 10}{1 - 10 * 10^{-3}} = 0.01 \text{ ohm}$$

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CHAPTER 15 ELECTROMAGNETIC INDUCTION

In 1820 Oerested discovered the electric current produce magnetic field.

In 1831, Joseph Henry and Michal Faraday observed that when field is changed then emf is produced.

Electromagnetic induction: "If the magnetic field through a circuit changes, an emf and current are induced in the circuit, this phenomenon is called Electromagnetic induction".

Induced current and induced emf: If a conductor moves through a magnetic field then due to change of magnetic flux current flows through circuit which is called induced current and emf produced is called induced emf

Factors induced current depends: Induced current depends upon

i. Speed of loop
ii. Resistance of loop

Factors which increased the induced current: Induced current can be increased by

i. Using a stronger field
ii. Moving the loop faster
iii. Using a coil of many turn
iv. Increasing the area of loop

Induced current can be produced: The induced current can be produced by the relative motion of the magnet or loop i.e. by moving either the loop or the magnet.

Methods to produce induced emf: There are following methods to produce induced emf

i. Relative motion of bar magnet and coil of wire:
ii. Changing area of coil
iii. Rotating the coil
iv. Mutual induction and electromagnet

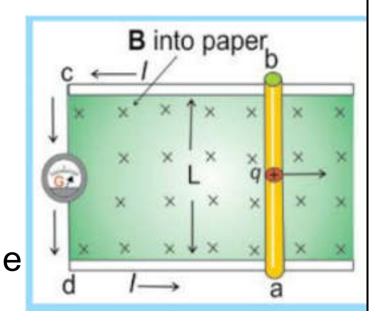
What is Motional emf? Derive its relation.

Definition:"The emf induced by the motion of conductor across the magnetic field is called motional emf".

Formula: $\varepsilon = -vBL\sin\theta$.

Explanation: Consider a conducting rod of length 'L' placed on two parallel metals rails separated by a distance L.

A galvanometer is connected b/w its ends of rails. This forms a complete conducting loop as shown in fig.



A uniform magnetic field is applied directed into the paper, when the rod is pulled to the right with constant velocity v, the galvanometer indicates a current flowing through loop.
Moving rod is acting as a source of emf $E=V_b-V_a=\Delta V$.
When the rod moves, a charge q within rod also moves with same velocity v and experience force
$F=q(v \times \bar{B})$ =qvB sinΘ= qvBsin90°=qvB, by using right hand rule
Force is directed from a to b in rod

And electric field is induced along the rod $E = \frac{F}{q} = \frac{qvB}{q}$ =vB ……………….. (1)

Also we know that electric field intensity $E = \frac{-V}{r} = \frac{-V}{L} = \frac{-\varepsilon}{L}$ ……………….(2)

Comparing eq(1) and eq(2) $\frac{-\varepsilon}{L}$=vB

We get ε =-vBL, if Θ is angle b/w v and B then ε =-vBLsinΘ, this is relation for motional emf.

Motional emf can be increased by:

(a) Increasing the speed of rod

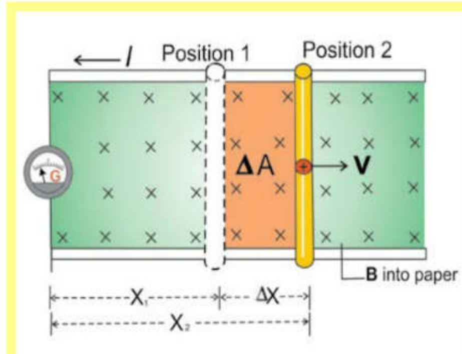
(b) Using the stronger magnetic field

State and explain Faraday Law of Electromagnetic induction

Statement: "The average emf induced in a conducting coil of N loops is equal to the negative of the rate at which magnetic flux through the coil is changing with time"

Equation: $\varepsilon = -N\frac{\Delta\varphi}{\Delta t}$.

Explanation: Consider a conducting rod of length L moves from a position 1 to position 2 and covers a distance



$\Delta x = x_2 - x_1$

the velocity of rod is given $v = \frac{\Delta x}{\Delta t}$

the emf produced in rod is $\varepsilon = -vBL$, putting the value of v

$\varepsilon = -\frac{\Delta x}{\Delta t}BL = -\frac{(\Delta x.L)}{\Delta t}B$ as we $\Delta x.L = \Delta A$

$\varepsilon = -\frac{(\Delta A)}{\Delta t}B = -\frac{(B\Delta A)}{\Delta t}$ $\Delta\varphi = B\Delta A$

$\varepsilon = -\frac{\Delta\varphi}{\Delta t}$, if coil has N turns then emf is $\varepsilon = -N\frac{\Delta\varphi}{\Delta t} \Rightarrow$ Faraday law of electromagnetic induction

Reason of negative sign in Faraday law: Negative sign shows that the direction of induced emf is such that it oppose the change it.

State and explain Lenz's law.

Statement: "**The direction of induced current is always such as to oppose the change which causes the current**"

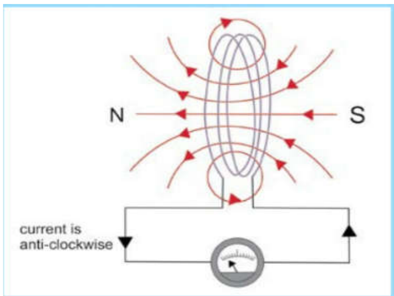
Lenz's law is used to find the direction of induced current which was given by Heinrich Lenz in 1834.

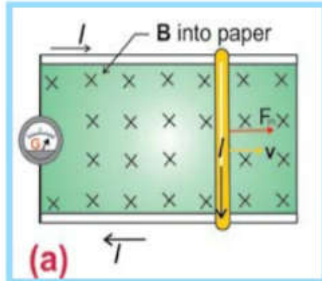
Experiment: let us consider a coil in which current is induced by the movement of bar magnet due to magnetic effect of current. One face of the coil acts as North Pole while the other one as the South Pole. If the coil is to oppose the motion of bar magnet, the face of the coil towards the magnet must become a north pole, the two north poles will repel each other, and then by using right hand rule direction of induced current is anti-clock wise.

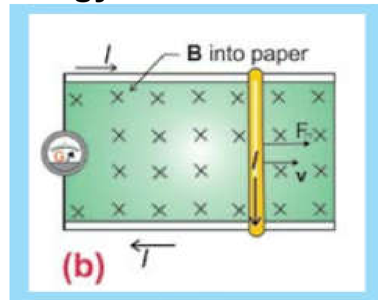
According to Lenz law the "push" of magnet is the "Change" that produces the induced current which tend to oppose the "push". Similarly if we "pull" the magnet away from the coil, the induced current oppose the "pull" by creating South Pole towards the bar magnet. As shown in fig a

Lenz's law and law of conservation of Energy: Let us consider rod moves towards right in uniform magnetic field, emf is induced it and induced current flows through the loop in anti-clock direction and rod experience a magnetic force whose direction is opposite to v, so it tend to stop the rod. If we consider the direction of current in clock wise direction then magnetic force will in the direction of v so this force would accelerate the rod increasingly. Hence the process becomes self-perpetuating which is against the law of conservation of energy.As shown in fig b and c

Lenz's law is in accordance to law of conservation of energy.







<u>PRACTICE MCQS</u>

1	Lenz law is actually the law of conservation of	Charge	Mass	**<u>Energy</u>**	Momentum
2	If velocity of a conductor moving through a magnetic field B is made zero then motional emf is	-vBL	-v/BL	-BL/v	**<u>Zero</u>**
3	"The direction of induced current is always so as to oppose the change which causes the current" is statement of	Faraday law	**<u>Lenz law</u>**	Ohm law	None
4	If we make the magnetic field stronger then value of induced current is	Decreased	**<u>Increased</u>**	Vanished	Kept constant
5	A metal rod of length 1m is moving at a speed of 1m/s in a direction making an angle of 30°with 0.5T the emf produced	0.25N	**<u>0.25V</u>**	2.5V	25V

6	When a loop of wire is moved across a magnetic field. The current produced in it which is called	Eddy current	DC current	Photo electric current	**Induced current**
7	A rod of length 20m is moving with velocity 20m/s in a direction perpendicular to magnetic field of 20T what is value of emf	2000V	4000V	6000V	**8000V**
8	SI unit of induced emf is	Ohm	Tesla	Henry	**Volt**
9	When a conductor is moved across magnetic field then emf produced is called	Variable emf	Constant emf	**Induced emf**	Back emf
10	Heater operates on the principle of	conduction	Electrostatic Induction	**Electromagnetic Induction**	None
11	Max motional emf is vBL. At what angle conductor moves in field so that it becomes half maximum value	0	45	**30**	60
12	Web/sec is equal to	Ampere	Tesla	**Volt**	Henry
13	Lenz law is used to find the direction of	Induced emf	**Induced current**	Force	Acceleration

What is Mutual Induction and derive the relation for mutual inductance.

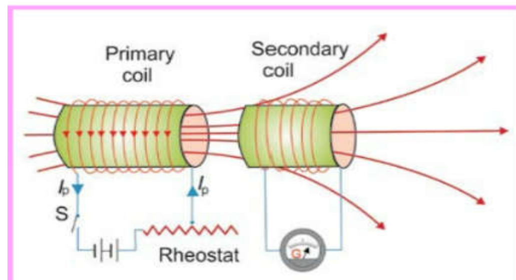
Definition:"**The phenomenon in which changing the current in one coil induces an emf in another coil, is called mutual induction".**

Explanation: Lets us consider two coils placed to each other as shown in fig

Primary coil and Secondary coil: A coil connected with a battery through a switch and rheostat is called primary coil and the coil connected to a galvanometer is called secondary coil.

If the current in primary coil is changed by the changing the resistance by rheostat then magnetic flux through primary coil changes and emf is induced in secondary coil whose value is $\varepsilon_s = -N_s \frac{\Delta\varphi_s}{\Delta t}$

Mutual inductance: If φ_s = flux across secondary and N_s = No of turns across secondary



Magnetic flux φ_s and N_s is directly proportional to I_p

$N_s\varphi_s \propto I_p$

$N_s\varphi_s = M\, I_p$

Where M = Constant of proportionality known as mutual inductance

Now by Using Faraday law $\varepsilon = -Ns\frac{\Delta\varphi s}{\Delta t} = -\frac{\Delta(Ns\varphi s)}{\Delta t}$

$\varepsilon_s = -\frac{\Delta(M\, Ip)}{\Delta t} = -M\frac{\Delta Ip)}{\Delta t}$, This shows that induced emf is proportional to rate of change of current current in primary coil

$M = \frac{\varepsilon_s}{\frac{\Delta Ip}{\Delta t}}$ = Mutual inductance

Mutual inductance: The ratio of average of induced emf in the secondary to the time rate of change of current in the primary coil is called mutual inductance. $M = \frac{\varepsilon_s}{\Delta I_p / \Delta t}$ Its unit is henry.

Henry: If the rate of change current one ampere per second in primary coil produces the emf of one volt in the secondary then mutual inductance will be one henry. VsA^{-1}= henry (H).

Factors on which mutual inductance depend:

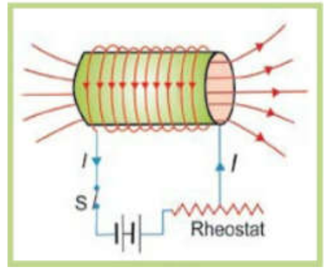
i. No of turns of the coils
ii. Area of cross section of coils
iii. Closeness and orientation of coils
iv. Nature of core material

What is Self-induction? Derive its relation.

Self-induction: "**The phenomenon in which changing current in a coil induces an emf in itself is called self-induction**".

Explanation: Consider a coil connected in series with a battery and a rheostat as

If the current is changed by varying the rheostat, magnetic flux through coil changes that caused an induced emf in coil such an emf is called self-induced emf or back emf.



Magnetic flux φ and N is directly proportional to I

$N\varphi \propto I$

$N\varphi = LI$

Where L = Constant of proportionality known as self inductance

Now by Using Faraday law $\varepsilon = -N\frac{\Delta\varphi}{\Delta t} = -\frac{\Delta(N\varphi)}{\Delta t}$

$\varepsilon = -\frac{\Delta(LI)}{\Delta t} = -L\frac{(\Delta I)}{\Delta t}$, This shows that induced emf is proportional to rate of change of current current in primary coil

$L = \frac{\varepsilon}{\frac{\Delta I}{\Delta t}}$ = Self inductance

Self-inductance: The ratio of induced emf produced in a coil to the rate of change of current in the same coil. $L = \frac{\varepsilon_L}{\Delta I / \Delta t}$ Its unit is henry (VsA^{-1}).

As induced emf must oppose the change that produced it, so according to Lenz's law self-induced emf is called back emf.By winding the coil around a ferromagnetic (iron) core, the magnetic flux and inductance can be increased.

PRACTICE MCQS

1	If an inductor has N turns of a coil and Ø is magnetic flux through each turn when current I is flowing in it, then self inductance is given by	I/N Ø	**N Ø/I**	NI/ Ø	Ø/NI
2	In choke of inductance L and resistance R	**L is large and R is small**	L is small and R is large	Both R&L are large	Both R&L are small
3	Inductance is measured in	volt	Ampere	**Henry**	Ohm
4	The ratio of average induced emf to rate of change of current in a	**Self-inductance**	Mutual inductance	Self-induction	Mutual induction

	coil is called				
5	One henry is equal to	VSA	VSA^2	**<u>VSA^{-1}</u>**	None
6	Mutual inductance depends upon	Density of coil	Material	**<u>Geometry</u>**	Stiffness
7	Self inductance of long solenoid with n turns per unit length is L=?	μonA/l	$\mu o n^2 A/l$	**<u>$\mu o n^2 A l$</u>**	$\mu o n^2 l/A$
8	The practical application mutual induction is	Electric motor	**<u>Transformer</u>**	Generator	None
9	SI unit of mutual and self-induction are	**<u>Same</u>**	Different	No unit	None of these
10	Inductance is more in self-induction in	Air cored coil	**<u>Iron cored coil</u>**	Tungsten cored	Steel cored
11	Mutual induction between two coils depends upon	Area of coils	Number of turns	Distance between coils	**<u>All of these</u>**
12	The inductance can be increased by winding the wire around a core made of	Copper	Silicon	**<u>Iron</u>**	Aluminum
13	Henry is the SI unit of	Current	Resistance	Flux	**<u>Self-inductance</u>**
14	SI unit of mutual inductance is	VSA	VSA^2	**<u>VSA^{-1}</u>**	None

15	The self-induction is given by	NL=φI	NI=Lφ	**Nφ=LI**	N=LI
16	The current in one coil changes from 0 to 2A in 0.05s, if the induced emf is 80V, self inductance will	1H	0.5 H	**2H**	1.5
17	What is mutual inductance when magnetic flux changes by $2*10^{-2}$web and change in current is 0.01 A and emf is 1 volt	**½ henry**	2 henry	Zero henry	10 henry
18	If coil is wound on an iron core, magnetic flux will	**Increase**	Zero	Decrease	Infinite
19	A coil has self inductance 5H, if current changes at the rate of 5A/s, self induced emf	**25V**	50 V	75V	2.5 V
20	Induction in coil can be increased by using	**Ferromagnetic substance**	Paramagnetic Substance	Diamagnetic Substance	Ferromagnetic substance

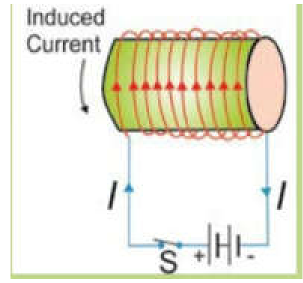
Calculate the Energy stored in an Inductor in terms of magnetic field.

Inductor: **"Such a device which store energy in magnetic field is called inductor".**

Derivation: Consider a coil connected to a battery and a switch in series as shown in fig. when the switch is turned on voltage is applied across the ends of coil and current increases from zero to maximum value. Due to change of current, an emf is induced, which is opposite to that of battery, work is done by battery to move charges against the induced emf.

Work done by the battery in moving small charge Δq

$$\Delta W = \varepsilon_L \Delta q \text{ --------------- (1)} \quad \text{as } \varepsilon_L = \frac{\Delta W}{\Delta q}$$



in case of self induced emf in inductor $\varepsilon_L = L\frac{\Delta I}{\Delta t}$ putting in eq (1)

$$\Delta W = L\frac{\Delta I}{\Delta t}\Delta q = L\frac{\Delta q}{\Delta t}\Delta I \text{ ------ (2)}$$

As average current is $I = \frac{\Delta q}{\Delta t} = \frac{I_{max} + I_{min}}{2} = \frac{I+0}{2} = \frac{I}{2}$

$\Delta I = I_{max} - I_{min} = I - 0 = I$ putting in eq (2)

$\Delta W = L(\frac{I}{2})(I) = \frac{1}{2}LI^2$ This work is stored in form of P.E inductor which is

$U_m = \frac{1}{2}LI^2$ --------(a) This is energy stored in inductor

<u>Energy in terms of magnetic field/Energy density</u>: As inductor stored energy in magnetic field so the above equation (a) can be written in form of magnetic field B. As inductor is like solenoid of n turn per unit length of area A

For calculation of L consider Magnetic field inside solenoid $= B = \mu_o nI$, $n = N/L$

flux through coil is $= \phi = BA = \mu_o nI\,A$

as we know that $N\phi = LI$

$$L = \frac{N\phi}{I} = \frac{N\mu_o n I A}{I} = (nL)\mu_o n\ A = \mu_o n^2 (AL) \text{----(2)}$$

and I for solenoid $I = \frac{B}{\mu_o n}$ -----(3) putting the values of 2 and 3 in (a)

$$U_m = \frac{1}{2}\mu_o n^2 (AL)(\frac{B}{\mu_o n})^2 = \frac{1}{2}\mu_o n^2 (AL)(\frac{B^2}{\mu_o^2 n^2}) = \frac{1}{2}\frac{B^2}{\mu_o}(AL) = \text{Energy stored in terms of } \vec{B}$$

Energy density : Energy stored in inductor per unit volume is called energy density.

$$\frac{U_m}{AL} = \frac{1}{2}\frac{B^2}{\mu_o} \Rightarrow$$

$u = \frac{1}{2}\frac{B^2}{\mu_o}$ this is the formula for energy density in magnetic field, which is proportional to square of field.

What is AC Generator? Describe its principle construction and working. Also derive equation of induced current and induced emf.

<u>Definition</u>: "**A device which converts mechanical energy into electrical energy and output is in alternating current form is called AC generator**".

<u>Principle of AC generator</u>: AC generator works on the principle of Faraday law of electromagnetic induction.

When a coil is rotated in magnetic field, magnetic flux through coil changes so an emf is induced in coil.

<u>Construction</u>: let us consider a rectangular wire of AC generator which has three major parts of AC generator

Armature: Number of coils wounded on an iron cylinder is called armature. The magnetic field is usually provided by an electromagnet.
Slip rings: slip rings are concentric with axis of loop and rotate with it.
Carbon brushes: carbon brush connected the slips rings to external circuit.
Working and Expression for induced emf and induced current of AC generator: consider the position of coil which is rotating anti clock wise. The vertical side ab and cd of loop is moving with velocity v and and field $\bar{B}$ and angle b/w is Θ, same value of current is flowing through both sides.

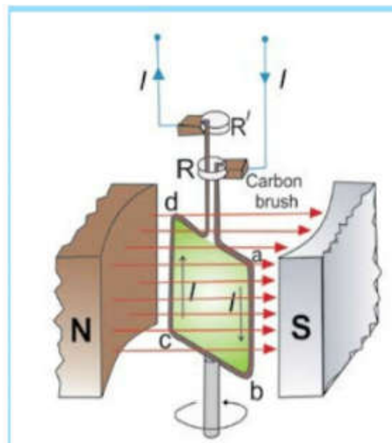
$\varepsilon_{ab} = vBL\sin\theta, \quad \varepsilon_{cd} = vBL\sin\theta$

And no contribution of sides $\varepsilon_{bc} = \varepsilon_{da} = 0$ because the force acting on the charges is not along the wire

$\varepsilon = \varepsilon_{ab} + \varepsilon_{cd} = vBL\sin\theta + vBL\sin\theta = 2vBL\sin\theta$

If the loop is replaced by N turns, the total emf in coil is

$\varepsilon = 2NvBL\sin\theta$



The linear speed of vertical wire is related to angular speed ω, $v = r\omega$

$\varepsilon = 2N(\omega r)BL\sin\theta = N\omega(2rL)B\sin\theta$ As $A = 2rL$

$\varepsilon = N\omega AB\sin\theta$ $\theta = \omega t$

$\varepsilon = N\omega AB\sin(\omega t)$ ------(1)

This show that induced emf changes sinusoidally with time

for maximum value $\sin 90^\circ = 1$ $\varepsilon = N\omega AB\sin 90^\circ = N\omega AB$

$\varepsilon_o = N\omega AB$

equation (1) is $\varepsilon = \varepsilon_o \sin(\omega t)$,

if the resistance of coil then by Ohm.'s law induced current will be

$I = \frac{\varepsilon}{R} = \frac{\varepsilon_o \sin(\omega t)}{R} = \frac{\varepsilon_o}{R}\sin(\omega t) = I_o \sin(\omega t)$ if angular speed $\omega = 2\pi f$

$\varepsilon = \varepsilon_o \sin(2\pi ft)$, $I = I_o \sin(2\pi ft)$ shows that variation of emf and current as function of $\theta = 2\pi ft$

As current alternates its direction once in one cycle so such current is called alternating current.

PRACTICE MCQS

1	If magnetic field is doubled then magnetic energy density becomes	**Four times**	Two times	Three times	Six times
2	A 50mH coil carries a current of 2A. The energy stored in B is	0.05 J	**0.1 J**	10 J	50 J
3	The value of emf induced in armature of N turns and area	**2πf NAB**	2πfN2AB	NIfAB	4πf2NAB

	A rotating in magnetic field B with frequency f is given by				
4	Energy stored in inductor is given by	½ cV^2	**½ LI^2**	½ BL^2	None
5	Which converts the mechanical energy into electrical energy	Transformer	Galvanometer	**Ac generator**	D.C motor
6	An inductor may store energy in its	Electric field	**Magnetic field**	Coils	Neighboring circuit
7	Maximum value of induced emf in the coil of A.C generator is	NBA/W	**NωAB**	BA	NIAB
8	Energy density of inductor is	$B^2/2\mu o^2$	μo/2B	$\mu o/2B^2$	**$B^2/2\ \mu o$**
9	The principle of AC generator is	Coulomb law	Ampere law	**Faraday law**	Lenz law
10	Energy stored per unit volume inside a solenoid is called	Electric flux	**Energy density**	Work	Volume charge density
11	Alternating current generator converts which type of energy into electrical energy	**Mechanical energy**	Chemical energy	Solar energy	Potential energy
12	Magnetic potential energy	Under root	Cube root of	**Square of**	None

	stored in an inductor depends upon	of current	current	**current**	
13	The work stored in inductor as a	Kinetic energy	Elastic potential energy	**Magnetic potential energy**	Gravitational potential energy
14	Which of the following is not present in alternating current generator	Armature	Magnet	Slip rings	**Commutator**
15	The most common source of AC voltage is	Motor	Cell	**Generator**	Thermocouple
16	AC generator uses	Coiled rings	Split rings	**Slip rings**	Solenoid rings
17	In AC inductor behaves as	Capacitor	**Resistor**	Commutator	Transistor
18	A device which convert mechanical energy into electrical energy is called	Dc motor	**Generator**	Capacitor	Inductor
19	Principle of AC generator is	Self induction	**Electromagnetic induction**	Mutual induction	All of these
20	If 10A current passes through 100mH inductor, then energy stores is	100 J	**5J**	20J	Zero
21	If magnetic field/current is doubled then energy stored in inductor	Becomes two times	**Becomes four times**	Becomes half	Becomes zero

22	Assembly of coil and cylinder is called	Generator	**Armature**	Router	Solenoid
23	If speed of rotation of AC generator becomes double, then output voltage	Remains same	**Becomes double**	Becomes half	Becomes zero

What is DC generator? Write its principle, construction and working.

DC generator: "A device which converts mechanical energy into electrical energy and gives direct current at its output is called DC generator".

Principle of DC generator: DC generator works on the principle of Faraday law of electromagnetic induction.

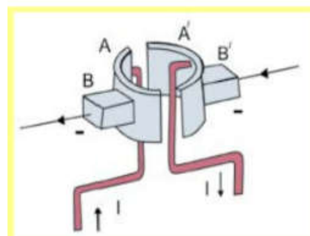
Major parts of DC generator: There are following major parts

i. Armature

ii. Split rings (commutator):

Two halves of a rings/split rings which prevents
The direction of current from changing is called commutator.
William Sturgeon invented the commutator In 1834

iii. Carbon brushes



Working: When the current in the coil is zero and is about to change the direction, the split rings also changes the contact with carbon brushes, in this way the output remains in same direction although the current is not constant in magnitude, the curve is similar to sine curve with lower half inverted.

Fluctuations in output of DC can be reduced by: It can be reduced by using many coils rather than a single coil and each coil is connected to separate commutator to get maximum output.

What is Difference b/w AC generator and DC generator?

Both generators convert mechanical energy into electrical energy differences are following

AC generator	DC generator
Its output in AC form	Its output in DC form
It uses slip rings	It uses split rings

Both workon same principle "Faraday law of electromagnetic induction".

What is Back motor effect in generator?

How a turbine run : In order to run a turbine, the shaft of turbine is attached to the coil which rotates in magnetic field, it converts the mechanical energy of driven turbine to electrical energy. the generator supplies current to external circuit.

Back motor effect:

An effect produced by the forces acting on the coil placed in the magnetic field that opposes the rotational motion of coil is called back motor effect.

Load:

The generators supplies current to devices in external circuit is called load, greater the load, larger is the current supplied by generator. For open circuit generator does not supply electrical energy, for closed circuit current is drawn.

Write a note on DC Motor.

DC motor: "An electrical device which converts electrical energy into mechanical energy is called DC motor".

Principle: DC motor works on the principle "A current carrying conductor placed in magnetic field experience a force".

Construction: A DC motor is similar to DC generator in construction having magnetic field, commutator and armature, instead of rotating coil electric current is applied to coil which rotate in magnetic field. In DC motor, the brushes are connected to DC supply or battery.

Working: When current flows in the coil the force on the conductor produce a torque that rotate the coil. The amount of torque depends upon the current, the strength of field, the area of coil and number of turns. The magnetic field in motor is provided by a permanent magnet or electromagnet.

Field coils: The windings of electromagnet are called field coils. It may be series or in parallel to armature coils.

How jerks in smooth running of armature can be reduced: It is overcome by using more than one coil wrapped around a soft iron core which produces more steady torque.

What is DIFFERENCE B/W MOTOR AND GENERATOR?

Generator	Motor
It converts mechanical into electrical energy	It converts electrical into mechanical energy
It may uses slip and split rings	It uses only split rings
Mechanical work is input	Mechanical work is output
Electric current is output	Electric current is input

What is BACK EMF IN MOTOR

Back emf in motor: An emf induced in the motor which opposes the actual emf is called back emf in motor.

Relation b/w back emf and current: Since V and ε are opposite in polarity, then net emf will be V-ε so the value of current will be $I = \frac{V - \varepsilon}{R}$, $IR = V - \varepsilon$, $V = \varepsilon + IR$

Why induced emf is called back emf of motor: When the coil of motor rotates across the magnetic field by applied potential difference, an emf induced in it, this induced emf is in such a direction to oppose the applied emf, that's why induced emf is called back emf.

Important points about back emf:

- ✓ If motor is just started back emf is almost zero and large current pass through coil.
- ✓ If motor is running at normal speed back emf becomes maximum and current becomes minimum.
- ✓ If motor is overloaded back emf decreases and allow the motor to draw more current
- ✓ If motor is overloaded beyond its limit the current could be so high that it may burn out the motor.

What is Transformer? Explain its principle, construction and working.

Definition: "**An electrical device which changes a given AC voltage into larger or smaller AC voltage is called transformer**".

Principle of transformer: Transformer works on the principle of **Mutual induction** b/w two coils. A changing current in the primary coil induce an emf in the secondary coil.

Construction: There are two coils used in transformer

Primary coil: The coil to which AC power is supplied

Secondary coil: The coil which delivers power to output. Both coils are magnetically linked.

Working: When an alternating emf is supplied to primary the, if at the some instant t the flux in primary is change then there will be back emf induced in primary which oppose the applied voltage.

Self induced emf $= -N_p \dfrac{\Delta\phi}{\Delta t}$, If resistance of coil is negligible then

Vp = -back emf

$$Vp = -\left(-N_p \frac{\Delta\phi}{\Delta t}\right) \Rightarrow Vp = \left(N_p \frac{\Delta\phi}{\Delta t}\right) ----------(1)$$

As change of flux in primary coil and secondary coil is same so

$$Vs = \left(N_s \frac{\Delta\phi}{\Delta t}\right) ---------------(2)$$

For transformation ratio dividing (2) by (1)

$$\frac{Vp}{Vs} = \frac{\left(N_p \frac{\Delta\phi}{\Delta t}\right)}{\left(N_s \frac{\Delta\phi}{\Delta t}\right)} = \frac{Np}{Ns} \Rightarrow or \frac{Vs}{V_P} = \frac{Ns}{Np}, \text{This is transformation ratio equation}$$

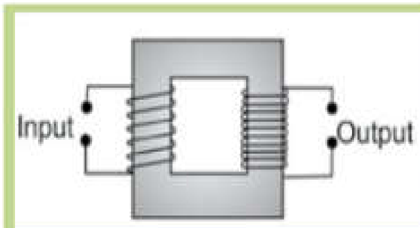


Fig.15.21 (a) Step up transformer

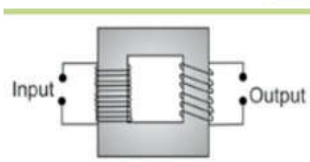
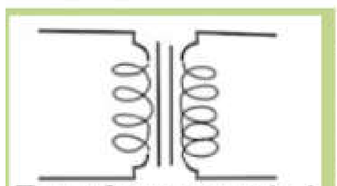


Fig.15.21 (b) Step down transformer


Transformer symbol

Types of Transformer: There are following types of transformer

Step-up transformer: Such a transformer in which voltage across the secondary is greater than primary voltage is called step up transformer as Ns>Np so Vs>Vp.

Step-down transformer: Such a transformer in which voltage across the secondary is less then primary voltage is called step down transformer. Ns<Np, Vs<Vp.

In Ideal transformer: The out power is equal to input power Power input= power output $V_pI_p=V_sI_s$ $V_p/V_s=I_s/I_p$

For an actual transformer the output power is always less than input power due to power losses.

Main causes of power loss in transformer: There are two main causes of power loss in transformer.

Eddy currents: The induced current which is setup in direction perpendicular to flux so as oppose the cause that produce them is called eddy current Eddy current cause the energy loss in core due to heat produced in it.

Such a loss can be reduced by using laminated core with insulation b/w layers of lamination sheets

Hysteresis loss: The energy used to magnetize and demagnetize the core material in each cycle of Ac is called hysteresis loss.This loss can be reduced by using soft iron core

Efficiency of transformer: $E=\frac{outputpower}{inputpower}*100$

Practice mcqs

1	An ideal transformer obey the law of conservation of	Flux	Momentum	**Energy**	Charge
2	The device which converts electrical energy into mechanical energy is called	Transformer	Galvanometer	Ac generator	**D.C motor**
3	The core of transformer is made of iron because of	High melting point	Good conductor of electricity	Good conductor of heat	**Magnetic material**
4	The frequency of AC in Pakistan is	30Hz	40Hz	**50Hz**	100Hz
5	Which one is correct relation for transformer is	Ns/Np=Vp/Vs	Is/Ip=Vs/Vp	Ns/Np=Ip/Is	**$I_s/I_p=V_p/V_s$**
6	The power loss in transformer due to	Eddy current	Magnetic field	Hysteresis	**Both A&C**
7	When motor is just started, back emf is almost	Maximum	**zero**	Minimum	Infinite
8	Turn ratio of transformer is 50 if the 220V is applied to its primary coil . voltage in secondary coil will be	44V	**4.4V**	220V	1100V
9	A transformer works on	**A.C only**	D.C only	Both A&B	Has no

					loss
10	Eddy current produced in the core of transformer are responsible for	**Heat loss**	Step up process	Step down process	Induction phenomenon
11	In non ideal transformer, which quantity remains unchanged?	Power	**Frequency**	Current	Voltage
12	The practical application mutual induction is	Electric motor	**Transformer**	Generator	None
13	To construct a step down transformer	**Ns<Np**	Ns>Np	Ns=Np	None
14	Inductance of coil in transformer is increased by using	Paramagnetic core	Diamagnetic core	**Ferromagnetic core**	Anti-ferromagnetic core
15	Hysteresis produced in transformer is responsible for	**Energy loss**	Step up process	Step down process	EM induction
16	If motor is overloaded then the magnitude of back emf	Increases	**Decrease**	Constant	Becomes zero
17	Which of the following is not present in alternating current generator	Armature	Magnet	Slip rings	**Commutator**
18	When back emf is zero it draws current	Minimum	**Maximum**	Zero	Steady
19	When back emf in the generator is maximum it draw	Maximum current	Steady current	**Zero current**	None
20	Eddy current are produced in a material when it is placed in	**Time varying field**	Moving	At rest	None
21	Which of the following is correct step up transformer?	Np>Ns	**Np<Ns**	Np=Ns	None
22	Commutators are used in	**DC generator**	AC generator	AC motor	AC rotator
2	Commutator was invented in	1736	**1834**	1935	1885

23					
24	Working principle of transformer is	Self induction	Faraday law	**Mutual induction**	EM induction
25	The winding of electromagnet in motor are usually called	Magnetic coils	**Field coils**	Electric coils	None
26	A simple device which prevents the direction of current from changing is	Capacitor	Resistor	**Commutator**	Inductor
27	If a step up transformer were 100% efficient, the primary and secondary windings would have same	Current	**Power**	voltage	Direction

EXERCISE SHORT QUESTIONS

1.Does the induced emf in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?**

a)No, induced emf does not depend upon the resistance of circuit. Because According to Faraday law $\varepsilon = -N\frac{\Delta\varphi}{\Delta t}$ induced emf depends upon rate of change of flux.

b)Yes, induced current depends upon resistance of circuit, as I=ε/R so induced current is inversely proportional to resistance.

2. A square loop of wire is moving through a uniform magnetic field. The normal to the loop is oriented parallel to the magnetic field. Is a emf induced in the loop? Give a reason for your answer.

No, emf is not induced in square loop. Because in this case the magnetic flux through loop is constant so rate of change of flux is zero and induced emf is directly proportional to rate of change of flux, so it will be zero.

$\varepsilon = -N\frac{\Delta\varphi}{\Delta t} = -N\frac{(0)}{\Delta t} = 0$

3. A light metallic ring is released from above into vertical bar magnet viewed for above for above, does the current flow clockwise or anticlockwise in the ring?

When viewed from above, the current in the ring is clockwise: and according to Lenz's law direction of induced current is opposing the downward motion of ring so face of ring towards magnet acts as north pole, so according to right hand rule induced current must be clock wise

4.*What is the direction of the current through resistor R when switch S is (a) closed (b) opened

a) The direction of current through Resistor R is from left to right when switch is closed the primary coil increases from zero to maximum steady value.

b) In this case direction of current through R from right to left.

5.Does the induced emf always act to decrease the magnetic flux through a circuit?**

No, it always opposes the change in magnetic flux through a circuit. According to Lenz's law the induced emf always opposes the cause that produces it. So if magnetic flux is decreasing through circuit induced emf acts to increase the magnetic flux through circuit and vice versa.

6. When the switch in the circuit is closed a current is established in the coil and the metal ring jumps upward why? Describe what would happen to the ring if the battery polarity were reversed?

The induced magnetic field in the ring opposes the magnetic field of the coil (according to Lenz's law). Therefore the ring experience a force of repulsion and jumps up. The same event occurs even if the polarity of the battery is reversed.

7. The Fig shows a coil of wire in the xy plane with a magnetic field directed along the y-axis. Around which of the three coordinate axes the coil should be rotated in order to generate an emf and a current in the coil?

If the coil is rotated about x-axis, then there is a change of magnetic flux passing through a coil. So only in this case, an emf is induced in the coil.

8. **How would you position a flat loop of wire in a changing magnetic field so that there is no emf induced in the loop?

If the plane of loop of wire is placed parallel to changing magnetic field i.e.,, then no flux through it will change. Hence no emf will be induced through the loop as

$$\varepsilon = -N\frac{\Delta\varphi}{\Delta t} = -N\frac{(0)}{\Delta t} = 0$$

9.In a certain region the earth's magnetic field point vertically down. When a plane flies due north, which wingtip is positively charged?**

When the plane flies due north in the earth magnetic field directed vertically downward, then electrons will experience force in east direction. Thus west wingtip of the plane is positively charged.

10. Show that ε and $\frac{\Delta\Phi}{\Delta t}$ have the same units?**

$$\text{unit of } \varepsilon = \text{volt} = \frac{\text{J}}{\text{C}} ----(1)$$

$$\text{unit of } \frac{\Delta\varphi}{\Delta t} = \frac{\text{web}}{\text{sec}} = \frac{\text{NmA}^{-1}}{\text{sec}} = \frac{Nm}{A\,\text{sec}} = \frac{J}{C} --(2)$$

$$\text{As Nm} = \text{J and Asec} = \text{C} \qquad \text{Hence, proved.}$$

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11. When an electric motor, such as an electric drill, is being used, does it also act as a generator? If so what is the consequence of this?

Yes it acts like a generator.

When the coil of motor rotates in magnetic field, the magnetic flux through coil changes so emf is induced which oppose the applied emf. It limits the current flowing through coil of motor.

12. Can a D.C motor be turned into a D.C generator? What changes are required to be done?**

Yes, a DC motor be turned into a DC generator

In order to convert DC motor into a DC generator, two changes are to be done

i. Electromagnet is replaced by permanent magnet
ii. An arrangement to rotate the coil armature should be provided

13. Is it possible to change both the area of the loop and the magnetic field passing through the loop and still not have an induced emf in the loop?

Yes. If the plane of the loop is kept parallel to the direction of the magnetic field, no emf will be induced in the loop either by changing its area or by changing the magnetic field.

14. Can an electric motor be used to drive an electric generator with the output from the generator being used to operate the motor?**

No it is not possible. Because if it is possible, it will be a self-operating system without getting energy from some external source and this is against the law of conservation of energy.

15. A suspended magnet is oscillating freely in a horizontal plane. The oscillations are strongly damped when a metal plate is placed under the magnet. Explain why this occurs?

When the metal plate is placed under the magnet, a changing magnetic flux passes through the plate which produces an emf, according to Lenz law these eddy current oppose the free oscillations of magnet hence the oscillations of magnets are damped strongly.

16. Four unmarked wires emerge from a transformer. What steps would you take to determine the turn's ratio?**

There are following steps to find turn ratio

i. Coils are separated as primary and secondary by ohmmeter
ii. AC voltage is supplied to primary coil and induced emf is measured
iii. The turn ratio is determined by $\frac{Ns}{Np} = \frac{Vs}{Vp}$

15.17 (a) Can a step-up transformer increase the power level?**

No it cannot increase power level. In case of an ideal transformer, the power output is equal to the power input. In actual transformer, due of dissipation of energy in the coil, the output power is always less than input power. Therefore, a step-up transformer can't increase power level

b) Transformer, there is no transfer of charge from the primary to the secondary. How is, then the power transferred?

The two coils of transformer are magnetically linked i.e., the change of flux through one coil is linked with the other coil.

18. When the primary of a transformer is connected to a.c mains the current in it. (a) Is very small if the secondary circuit is open, but (b) increases when the secondary circuit is closed. Explain these facts.

a) In a transformer power input=power output

$V_pI_p=V_sI_s$ if secondary circuit is open $I_s=0$ then $V_p=0$.

a) When the secondary circuit is closed, the output power increases. To produce this power, transformer will draw large current from the A.C. mains to increase its primary power (V_pI_p).

NUMERICALS CHAPTER 15

15.1: An emf of 0.45V is induced between the ends of a metal bar moving through amagnetic field of 0.22T. What field strength would be needed to produce an emf of 1.5V between the ends of the bar, assuming that all other factors remain the same?

Given Data : $\varepsilon_1 = 0.45\text{V}, B_1 = 0.22\text{T}, \varepsilon_2 = 1.5\text{V}, B_2 = ?$

Using the formula $\varepsilon_1 = vB_1L\sin\theta -----(1)$ $\varepsilon_2 = vB_2L\sin\theta -----(2)$ Dividing both eqs.

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{vB_1L\sin\theta}{vB_2L\sin\theta} = \frac{B_1}{B_2} \Rightarrow B_2 = \frac{B_1 * \varepsilon_2}{\varepsilon_1} = \frac{0.22*1.5}{0.45} = 0.73T$$

15.2: The flux density B in a region between the pole faces of a horseshoe magnet is 0.5 Wbm^{-2} directed vertically downward. Find the emf induced in a straight wire 5.0 cm long, perpendicular to B when it is moved in a direction at an angle of 60^{o}with the horizontal with a speed of 100 cms^{-1}.

Given data : $B = 0.5\text{ web/m}^2, L = 5\text{ cm} = 5*10^{-2}\text{m}$, Angle $= \theta_h = 60^o, \theta_v = 90^o - 60^o = 30^o, v = 100cm/s = 1m/s$

$$\varepsilon = vBL\sin\theta \Rightarrow \varepsilon = (1)(0.5)(5*10^{-2})\sin 30^o = 1.25*10^{-2}V$$

15.3: A coil of wire has 10 loops. Each loop has an area of $1.5\times10^{-3}m^2$. A magnetic field is perpendicular to the surface of each loop at all times. If the magnetic field is changed from 0.05T to 0.06T in 0.1, find the average emf induced in the coil during this time.

Given Data : $N = 10, A = 1.5*10^{-3}\text{m}^2, B_1 = 0.05\text{T}, B_2 = 0.06\text{T}, \Delta B = 0.06 - 0.05 = 0.01\text{T}, \Delta t = 0.1\text{ sec}, \varepsilon = ?$

$$\varepsilon = \frac{N\Delta\varphi}{\Delta t} = \frac{N\Delta BA}{\Delta t} = \frac{10*0.01*1.5*10^{-3}}{0.1} = 1.5*10^{-3}V$$

15.4: A Circular coil has 15 turns of radius 2cm each. The plane of the coil lies at 40^{o}to a uniform magnetic field of 0.2 T. If the field is increased by 0.5T in 0.2s, find the magnitude of the induced emf.

Given Data : $N = 15, r = 2\text{cm} = 2*10^{-2}\text{m}$, Angle b/w B and plane of coil $= \theta = 40^o$, Angle b/w A and B $= 90^o - 40^o = 50^o$

$B_1 = 0.2\text{T}, B_2 = 0.5\text{T}, \Delta B = 0.5 - 0.2 = 0.3\text{T}, \Delta t = 0.2\text{sec}$, induced emf $= \varepsilon = ?$

$$\varepsilon = \frac{N\Delta\varphi}{\Delta t} = \frac{N\Delta\Delta B}{\Delta t} = \frac{N\Delta B(\pi r^2)}{\Delta t} = \frac{N\Delta\Delta B(r^2)}{\Delta t} = \frac{15*0.3(3.14*(2*10^{-2})^2)}{0.2} = 1.8*10^{-2}V$$

15.5: Two coils are placed side by side. An emf of 0.8 V is observed in one coil when the current is changing at the rate of 200 As^{-1} in the other coil. What is the mutual inductance of the coils?

Given Data : emf $= \varepsilon_s = 0.8\text{V}$, Rate of change of current $= \frac{\Delta Ip}{\Delta t} = 200\text{A/sec}, M = ?$

$$M = \frac{\varepsilon}{\frac{\Delta Ip}{\Delta t}} = \frac{0.8}{200} = 40*10^{-3}H = 4mH$$

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15.6: A pair of adjacent coils has a mutual inductance of 0.75 H. If the current in the primary changes from 0 to 10A in 0.025 s, what is the average induced emf in the secondary? What is the change in flux in it if the secondary has 500 turns?

Given Data : $M = 0.75\,H, \Delta Ip = 10A - 0A = 10A, \Delta t = 0.025sec, N = 500, \varepsilon_s = ?\Delta\varphi = ?$

$$\varepsilon_s = M\frac{\Delta Ip}{\Delta t} = 0.75 * \frac{10}{0.025} = 300V$$

Using Faraday's law, $\varepsilon = N\frac{\Delta\varphi}{\Delta t} \Rightarrow \Delta\varphi = \frac{\varepsilon * \Delta t}{N} = 300 * \frac{0.025}{500} = 0.015web = 1.5 * 10^{-2}\,weber$

15.7: A solenoid has 250 turns and its self-inductance is 2.4 mH. What is the flux through each turn when the current is 2 A? What is the induced emf when the current changes at 20As^{-1}?

Given Data : $N = 250$, Self inductance $= L = 2.5mH = 2.5 * 10^{-3}\,H, I = 2A, \frac{\Delta I}{\Delta t} = 20A/sec, \varphi = ?, \varepsilon = ?$

Using equation $N\varphi = LI \Rightarrow \varphi = \frac{LI}{N} = \frac{2.5 * 10^{-3} * 2}{250} = 1.92 * 10^{-5}\,web$

$$\varepsilon = L\frac{\Delta I}{\Delta t} = 2.5 * 10^{-3} * 20 = 48 * 10^{-3}\,V = 48mV$$

15.8: A solenoid of length 8.0cm and cross sectional area 0.5cm^2 has 520 turns. Find the self-inductance of the solenoid when the core is air. If the current in the solenoid increases through 1.5A in 0.2s, find the magnitude of induced emf in it.

Given Data : length $= l = 8\,cm = 8 * 10^{-2}\,m, A = 0.5cm^2 = 0.5 * 10^{-4,}\,m^2\; N = 520, \Delta I = 1.5A, \Delta t = 0.2\,sec, L = ?\;\varepsilon = ?$

Using Equation $L = \mu_o n^2 lA = \mu_o (N/l)^2 lA = \mu_o (N^2/l)A = 4\pi * 10^{-7}(520)^2 * 0.5 * 10^{-4,}/8 * 10^{-2} = 2.12 * 10^{-4}\,H$

$$\varepsilon = L\frac{\Delta I}{\Delta t} = 2.12 * 10^{-4} * \frac{1.5}{0.2} = 1.6 * 10^{-3}\,volt$$

15.9: When current through a coil changes from 100 mA to 200 mA in 0.005s, an induced emf of 40 mV is produced in the coil. (a) What is the self-inductance of the coil? (b) Find the increase in the energy stored in the coil.

Given Data : $I_1 = 100mA, I_2 = 200mA, \Delta I = 200mA - 100mA = 100 * 10^{-3}\,A, \varepsilon = 40mV = 40 * 10^{-3}\,V, \Delta t = 0.005sec$

Self inductance $= L = ?$ Increase in energy stored $= \Delta E = ?$

$$L = \frac{\varepsilon}{\Delta I/\Delta t} = \frac{40 * 10 - 3}{0.1/0.005} = 2 * 10^{-3}\,H = 2mH$$

$$\Delta E = \frac{1}{2}L(\Delta E)^2 = \frac{1}{2}2 * 10^{-3}(100 * 10^{-3})^2 = 0.03 * 10 - 3J = 0.03mJ$$

15.10: Like any field, the earth's magnetic field stores energy. Find the magnetic energy stored in a space where strength of earth's fields is $7\times10^{-5}T$, if the space occupies an area of $10\times10^{8}m^2$ and has a height of 750m.

Given Data : $B = 7 * 10^{-5}\,T, A = 10 * 10^{8}\,m^2,\; L = 750m, Um = ?$

$$Um = \frac{1}{2}\frac{B^2}{\mu_o}(AL) = \frac{1}{2}\frac{(7 * 10^{-5})2}{4\pi * 10^{-7}}(10 * 10^{8} * 750) = 1.5 * 10^{9}\,J$$

15.11: A square coil of side 16cm has 200 turns and rotates in a uniform magnetic field of magnitude 0.05T. If the peak emf is 12V, what is the angular velocity of the coil?

Given Data : Side of square coil = 16cm, Area = $A = 16*16cm^2 = 256*10^{-4} m^2$, N = 200, B = 0.05T, $\varepsilon_o = 12V, \omega = ?$

$$\varepsilon_o = N\omega\omega A \Rightarrow \omega = \frac{\varepsilon_o}{NAB} = \frac{12}{200*256*10^{-4}*0.05} = 46.9 \text{rad/sec} = 47 \text{rad/sec}$$

15.12: A generator has a rectangular coil consisting of 360 turns. The coil rotates at420 rev per min in 0.14 T magnetic field. The peak value of emf produced by the generator is 50V. If the coil is 5.0 cm wide, find the length of the side of the coil.

given Data : $N = 360, \omega = \frac{420*2\pi}{60} = 43.96$ rad/sec, B = 0.14T, $\varepsilon_o = 50V$, width = b = 5cm = 5/100 = 0.05m

length of coil = L = ? using the formula $\varepsilon_o = N\omega\omega A = N\omega\omega(*b)B$

$$L = \frac{\varepsilon_o}{N\omega\, bB} = \frac{50}{0.14*360*43.96*0.05} = 0.45m$$

15.13: It is desired to make an a.c generator that can produce an emf of maximum value 5kV with 50 Hz frequency. A coil of area 1m^2 having 200 turns is used as armature. What should be the magnitude of the magnetic field in which the coil rotates?

Given Data : emf = ε_o = 5KV = 5000V, f = 50Hz, A = $1m^2$, N = 200, B = ?

$$\varepsilon_o = N\omega AB \Rightarrow B = \frac{\varepsilon_o}{N\omega A} = \frac{\varepsilon_o}{N(2\pi f)A} = \frac{5000}{200(2\pi*50)*1} = 0.08T$$

15.14: The back emf in motor is 120 V when the motor is turning at 1680 rev per min.What is the back emf when the motor turns 3360 rev per min?

Given Data : $\varepsilon_1 = 120V, \omega_1 = 1680$rev/min, $\omega_2 = 3360$ rev/min, $\varepsilon_2 = ?$

As $\varepsilon_1 = N\omega_1 AB$ – – – –(1) $\varepsilon_2 = N\omega_2 AB$ – – – –(1) Dividing both eqs

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{N\omega_1 AB}{N\omega_2 AB} \Rightarrow \frac{\varepsilon_1}{\varepsilon_2} = \frac{\omega_1}{\omega_2} \Rightarrow \varepsilon_2 = \frac{\omega_2}{\omega_1}*\varepsilon_1 = \frac{3360}{1680}*120 = 240V$$

15.15: A D.C motor operates at 240 V and has a resistance of 0.5Ω. When the motor is running at normal speed, the armature current is 15A. Find the back emf in the armature.

Given Data : V = 240V, R = 0.5Ω, I = 15A, $\varepsilon = ?$

$$\varepsilon = V - IR = 240 - (15(0.5) = 232.5 \text{ V}$$

15.16: A copper ring has a radius of 4.0 cm and resistance of 1.0mΩ. A magnetic field is applied over the ring, perpendicular to its plane. If the magnetic field increases from 0.2T to 0.4T in a time interval of, what is the current in the ring during this interval?

Given Data : radius = r = 4cm = $4*10^{-2}$m, R = 1mΩ = $1*10^{-3}$Ω, $B_1 = 0.2T, B_2 = 0.4T, \Delta t = 5*10^{-3}$ sec

$N = 1, \Delta B = B_2 - B_1 = 0.4 - 0.2 = 0.2T$, I = ? As $I = \frac{\varepsilon}{R}$ – – – – – –(1)

$$\varepsilon = N\frac{\Delta\varphi}{\Delta t} = N\frac{\Delta BA}{\Delta t} = N\frac{\Delta B(\pi r^2)}{\Delta t} = 1*\frac{0.2*(3.14*(4*10^{-4})^2)}{5*10^{-3}} = 2.01*10^{-1} V, \text{put in}(1)$$

$$I = \frac{\varepsilon}{R} = \frac{2.01*10^{-1}}{1*10^{-3}} = 201A$$

15.17: A coil of 10 turns and 35cm^2 area is in a perpendicular magnetic field of 0.5T.The coil is 1.0s. Find the induced emf in the coil as it pulled out of the field.

Given Data : $N = 10, A = 35cm^2 = 35*10^{-4} m^2, \Delta B = 0.5 - 0 = 0.5T, \Delta t = 1 sec, \varepsilon = ?$

$$\varepsilon = N\frac{\Delta\varphi}{\Delta t} = N\frac{\Delta BA}{\Delta t} = 10*\frac{0.5*35*10^{-4}}{1} = 175*10^{-4}V = 1.75*10^{-2}V$$

15.18: An ideal step down transformer is connected to main supply of 240V. It is desired to operate a 12V, 30W lamp. Find the current in the primary and the transformation ratio?

Given Data : Vp = 240 V, Vs = 12V, powerPo = 30W, Ip = ?, Ns/Np = ?

Ns/Np = Vs/Vp $\Rightarrow$ 12/240 = 1/20

For an ideal transformer input power = output power $\Rightarrow$ so $P_o = IpVp \Rightarrow Ip = Po/Vp = 30/240 = 0.125A$

CHAPTER 16 ALTERNATING CURRENT

Alternating Current: "Such a current whose polarity keeps on reversing with time is called alternating current".

Why AC is widely used? It is widely used because it can be transmitted to long distance easily and at a very low rate.

Main common source of AC voltage: AC generator is most common source of AC voltage

Time period of AC: The time interval T during which the voltage source change its polarity once is called time period

Frequency of AC: The number of cycles completed in one second is called frequency of AC. f=1/T SI unit of frequency is Hz. The frequency of AC in Pakistan is 50 Hz.

Instantaneous value of AC: The value of AC current or voltage that exists in circuit at any instant of time t is called instantaneous value. $V = V_o \sin(2\pi ft)$.

Peak value of AC: The highest value reached by the voltage or current in one cycle is called peak value.

Peak to peak value: Sum of positive and negative peak values is called p-p value p-p value of voltage is 2Vo.

Root mean square (RMS) value: The effective value of AC over complete cycle **OR** square root of average values of V^2 and I^2 is called rms value.

$$V^2_{rms} = \frac{0^2 + V_o^2}{2} \Rightarrow V^2_{rms} = \frac{V_o^2}{2} \Rightarrow V_{rms} = \frac{V_o}{\sqrt{2}} \Rightarrow V_{rms} = 0.707V_o$$

$$I^2_{rms} = \frac{0^2 + I_o^2}{2} \Rightarrow I^2_{rms} = \frac{I_o^2}{2} \Rightarrow I_{rms} = \frac{I_o}{\sqrt{2}} \Rightarrow I_{rms} = 0.707I_o$$

Most of the meters measured Rms values of current and voltage. Average value of current or voltage over a cycle is zero.AC changes its polarity one time in one cycle.

Phase of AC: The angle which specifies the instantaneous value of alternating voltage or current is called phase. The formula for this $V = V_o \sin\theta = V_o \sin(\omega t)$.

Phase lag and phase lead: "The phase difference b/w two alternating quantities is called phase lag or phase lead".
Vector representation of Alternating quantity: Alternating voltage or current can be graphically represented by counter clock rotating vector and satisfies following conditions

1. Its length on scale show peak value of quantity
2. When the alternating quantity is zero, it is in horizontal position.
3. Angular frequency of rotating vector is same as angular frequency of alternating quantity.

What are the basic elements of AC& DC circuits?

Basic element of DC circuit: Resistor is the basic element of DC circuit.
Basic elements of AC circuit: There are three components of AC circuits.

i. Resistor R
ii. Inductor L
iii. Capacitor C

PRACTICE MCQS

1	A sinusoidal current has rms value of 10A, its maximum value	7.7A	10 A	**14.14A**	20A
2	The average value of AC over one period with peak value Vo is	$V_o/\sqrt{2}$	V_o	$\sqrt{2}Vo$	**Zero**
3	The rms value of AC supply is 220V its peak value Vo is	150V	**311V**	110V	440V
4	The frequency of AC in Pakistan is	30Hz	40Hz	**50Hz**	60Hz
5	The highest value reached by the voltage or current in one cycle is called	Peak to peak value	**Peak value**	Instantaneous value	Root mean square value
6	If Io is the peak value of an AC supply then rms value is given as Irms=?	**$Io/\sqrt{2}$**	Io/0.707	$\sqrt{2}\,Io$	Io/2
7	The basic circuit element in AC circuit which controls the current	Resistor only	Capacitor only	Inductor only	**All of these**
8	If Vrms=$10\sqrt{2}$ V the peak value Vo=?	10 V	**20V**	40V	$10/\sqrt{2}$
9	The peak value of AC source is 20A, then rms value will be	**14.2 A**	10 A	20 A	28.2 A
1	The phase of AC at positive	**π/2**	π/3	2π	Π

0	peak from origin				
11	AC changes its polarity in once cycle	**Once**	Twice	Thrice	Four time
12	All voltmeters and ammeters measures	**Rms value**	Peak value	Average value	None
13	Main reason for the worldwide use of Ac is that it can be transmitted to	Short distance at very low cost	Long distance at very high cost	Short distance at very high cost	**Long distance at very low cost**
14	Peak to peak value of an alternating voltage is	0	Vo	Vo/2	**2Vo**
15	An AC varies as a function of	Displacement	Current	Voltage	**Time**
16	The peak value of alternating current is $5\sqrt{2}$ A. the mean square value of current will	**5A**	2.5A	25 A	$10\sqrt{2}$ A
17	The device which permit flow of DC but not AC	**Inductor**	Capacitor	Both A&B	None
18	The sum of positive and negative peak values of ac	**P-P value**	Peak value	Rms value	Instantaneous value
19	Most common source of AC voltage is	**Ac generator**	Motor	Transformer	Battery

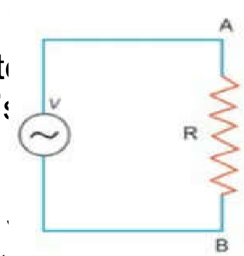
AC through Resistor

Consider a resistor of resistance R connected with an alternating voltage source as shown in fig.

Instantaneous voltage: At any instant of time the potential difference across the terminals

Of resistors is given by $V=V_o\sin\omega t$ whereV_O is the peak value of alt

Instantaneous current: This is given by the relation by using Ohm's



$I=\frac{V}{R}=\frac{V_o\sin\omega i}{R}=I_o\sin\omega in$ As $I_o=\frac{V_o}{R}$, I_o = peak value of current ,

Graphical representation: both instantaneous voltage and current

can be shown graphically in fig. So in purely resistive AC circuit, instantaneous

values of voltage and current are in phase. So phase difference is zero.

Resistance: The measure of opposition of to flow of current is called resistance, R=V/I, its unit is ohm.

Electrical power: The electrical power supplied by the source or power dissipated in resistor is given as

$P=VI=(IR)I=I^2R$ or $P=V^2/R$. SI unit power is watt.

Explain the behavior of AC through capacitor?

Let us consider a capacitor of capacitance C is connected in series with voltage source, alternating current flows in circuit and plates are continuously charged and discharged.

Charge: At any instant of time charged stored in capacitor due to voltage V is q=CV Also we know that V=Vosinωt, so charge q=CVosinωt,

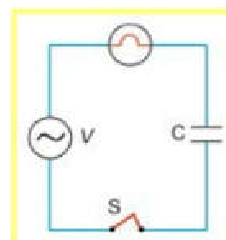
q and V are sine function and in phase.

Electric current: As the rate of flow of charge is equal to current which is $I=\frac{\Delta q}{\Delta t}$.So at any instant the slope of q-t curve represent electric current.

When slope of q-t curve is maximum it means current is maximum across capacitor.

Phase: In AC through capacitor current is leading the voltage by 90° or π/2.

Reactance: The measure of opposition offered by capacitor to flow of AC is called reactance of capacitor.



$$Xc=\frac{V_{rms}}{I_{rms}}$$

$$Xc=\frac{V_{rms}}{CV_{rms}\omega}=\frac{1}{\omega C}$$

$$Xc=\frac{1}{2\pi\pi C}\Rightarrow Xc\propto\frac{1}{f}\text{, this is the relation of reactance, SI unit of reactance is ohm.}$$

Reactance depends upon **frequency**, when frequency is large reactance will be small and vice versa.

$$\therefore I=\frac{\Delta q}{\Delta t}=\frac{\Delta CV}{\Delta t}=\frac{\Delta CVo\sin\omega t}{\Delta t}=\frac{\Delta}{\Delta t}(CV_o\sin\omega t)=CV_o(\omega\cos\omega t)=CV_o\omega\quad\text{, as }\cos\omega t=1$$

Explain the behavior of AC through Inductor?

"A coil or solenoid wound form a thick wire having large of self-inductance and negligible resistance is called inductor".

Flow of AC through inductor: Let us consider an inductor which is connected with alternating voltage source, As the self-inductance of coil oppose the change of current, so inductor must oppose the flow of AC which is continuously changing.

Electric current: current flowing through inductor is $I=I_o\sin\omega t=I_o\sin(2\pi f)t$.

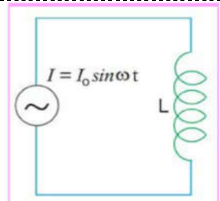
Voltage: If L is the inductance of coil, the changing current setup a back emf in coil which is

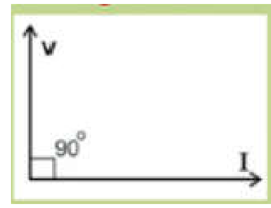
$\varepsilon_L=L\frac{\Delta I}{\Delta t}$. To maintain the current,

Applied voltage must be equal to back emf so applied voltage $V=L\frac{\Delta I}{\Delta t}$, so $V\propto\frac{\Delta I}{\Delta t}$,

thus slope of I-t curve at any instant of time gives the value of voltage. It means when slope of I-t curve is maximum V is maximum.

Phase: In AC through inductor voltage is leading the current by 90° or π/2.
Inductive Reactance: "The measure of opposition offered by inductance coil to flow of AC is called inductive reactance".





$$X_L = \frac{V_{rms}}{I_{rms}}$$

$$X_L = \frac{LI_{rms}\omega}{I_{rms}} = \omega L$$

$X_L = 2\pi f L \Rightarrow X_L \propto f$, this is the relation of reactance, SI unit of inductive reactance is ohm.

Inductive Reactance depends upon **frequency**, when frequency is large inductive reactance is large.

Power in inductor: No power is dissipated in inductor, so inductor does not consume energy.

$$\therefore V = L\frac{\Delta I}{\Delta t} = L\frac{\Delta I_o \sin\omega t}{\Delta t} = \frac{\Delta L I_o \sin\omega t}{\Delta t} = \frac{\Delta}{\Delta t}(LI_o \sin\omega t) = LI_o(\omega\cos\omega t) = LI_o\omega \quad , \text{as } \cos\omega t = 1$$

PRACTICE MCQS

1	In inductor the voltage	Leads the current 90°	**Lags current by 90°**	Is in phase with current	Changes independently
2	The net reactance of a dc circuit is zero the circuit may consist of	**An inductor only**	A capacitor only	Both inductor and capacitor	None of these
3	The phase angle between the voltage and current AC through a resistor is	**0**	45	180	270
4	Power dissipation in a pure inductive or in a pure capacitance circuit is	Infinite	**Zero**	Minimum	Maximum
5	A capacitor is perfect insulator for	AC	**DC**	Both A&B	None
6	In pure resistive AC circuit, instantaneous value of voltage or current	Current lags behind voltage	Current leads voltage by 90	**Both are in phase**	Voltage leads current by 90
7	At high frequency, the current through a capacitor of AC circuit will be	**Large**	Small	Infinite	Zero
8	The capacitive reactance to	Zero	**Infinite**	Variable	Equal to

	pure DC is				reactance
9	If frequency of AC supply is doubled then reactance of capacitor is	**Half**	Two times	Four times	One fourth
10	The inductive reactance is	X_L=Wc	**X_L=ωL**	Xc=1/Wc	XL=1/WL
11	The reactance of an inductor at 50Hz is 10Ω its reactance at 100Hz becomes	**20 ohm**	5 ohm	2.5 ohm	1 ohm
12	In AC inductor behave like	Semiconductor	Inductors	Resistor	**Insulator**
13	DC cannot flow through	Resistor	**Capacitor**	Inductor	Voltmeter
14	Capacitive reactance Xc=?	X_L=Wc	X_L=WL	**Xc=1/Wc**	XL=1/WL
15	In pure inductive AC circuit the current	**Lags behind voltage 90**	Lead the voltage by 90	In phase with voltage	Lead the voltage 270
16	In pure capacitive circuit current and charge are	In phase	**Out of phase**	Parallel to each other	None
17	X_L is low for low frequency but Xc is	Low	**High**	Zero	None
18	Inductive reactance is directly proportional to	Frequency	Resistance	Inductance	**Both A&C**
19	SI unit of reactance is	Joule	Ampere	Volt	**Ohm**
20	At high frequency, the value of reactance of capacitor will	large	Infinite	Zero	**Small**
21	In RL series circuit, phase angle is given by	$\theta = \tan^{-1}(\frac{L}{R})$	$\theta = \tan^{-1}(LR)$	$\theta = \tan^{-1}(R/L)$	**$\theta = \tan^{-1}(\frac{\omega L}{R})$**
22	Slope of q-t curve at any instant of time give	Voltage	Charge	Resistance	Current

What is Impedance. Write its formula and unit.

Definition: "**The combined effect of resistance and reactance's in AC circuit is called impedance**". Its formula is $Z = \frac{V_{rms}}{I_{rms}}$. The unit of impedance is **ohm**.

Admittance: Reciprocal of impedance is called Admittance. Y=1/Z, unit of admittance is Ω^{-1}

Write a note on RC and RL Series Circuit.

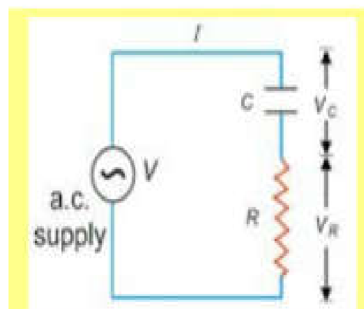
RC series circuit:"**A circuit in which resistor and a capacitor are connected in series combination across an alternating voltage is called RC series circuit**".
Consider a circuit in which resistor R and capacitor C in series with voltage source, if I is the value of current then potential difference across resistance is V_R=IR, but potential difference across the capacitor will be $V_c=IX_c$.
Impedance: Impedance can be calculated by using the formula

$$V_{rms} = \sqrt{V_R^2 + Vc^2} = \sqrt{(I_{rms}R)^2 + (\frac{I_{rms}}{\omega C})^2}$$

$$V_{rms} = \sqrt{I_{rms}^2[(R)^2 + (\frac{1}{\omega C})^2]} = I_{rms}\sqrt{(R)^2 + (\frac{1}{\omega C})^2}$$

$$\frac{V_{rms}}{I_{rms}} = \sqrt{(R)^2 + (\frac{1}{\omega C})^2}$$

$$Z = \sqrt{(R)^2 + (\frac{1}{\omega C})^2}$$

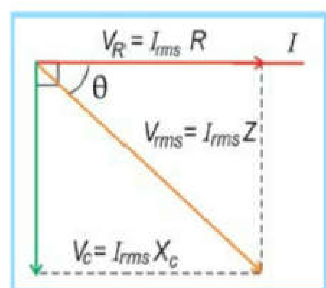


Which is required relation for the impedance of RC circuit as shown in fig.
Phase: voltage and current are not in phase, Current leads the applied voltage 90° or π/2.

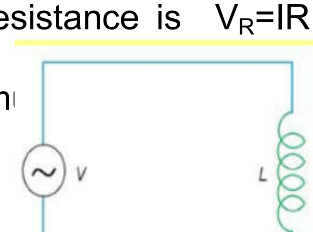
$$Tan\theta = \frac{Xc}{R}$$

$$\theta = Tan^{-1}\left(\frac{Xc}{R}\right) = Tan^{-1}\left(\frac{1/\omega C}{R}\right)$$

$$\theta = Tan^{-1}\left(\frac{1}{\omega CR}\right)$$



RL series circuit:"**A circuit in which resistor and an inductor are connected in series combination across an alternating voltage source is called RL series circuit**".
Consider a circuit in which resistor R and inductor L in series with voltage source, if I is the value of current then potential difference across resistance is V_R=IR, but potential difference across the capacitor will be $V_L=IX_L$.
Impedance: Impedance can be calculated by using the form



$$V_{rms} = \sqrt{V_R^2 + V_L^2} = \sqrt{(I_{rms}R)^2 + (I_{rms}\omega L)^2}$$

$$V_{rms} = \sqrt{I_{rms}^2[(R)^2 + (\omega L)^2]} = I_{rms}\sqrt{(R)^2 + (\omega L)^2}$$

$$\frac{V_{rms}}{I_{rms}} = \sqrt{(R)^2 + (\omega L)^2}$$

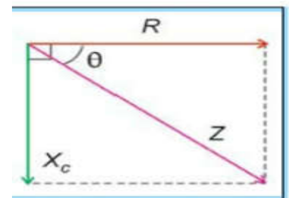
$$Z = \sqrt{(R)^2 + (\omega L)^2}$$

Phase: voltage and current are not in phase, voltage leads the current by 90° or π/2.

$$Tan\ \theta = \frac{X_L}{R}$$

$$\theta = Tan^{-1}\left(\frac{X_L}{R}\right) = Tan^{-1}\left(\frac{X_L}{R}\right)$$

$$\theta = Tan^{-1}\left(\frac{X_L}{R}\right) = Tan^{-1}\left(\frac{\omega L}{R}\right)$$



What is Power in AC circuit?

Power in AC circuit: The formula for power $P=V_{rms}I_{rms}$, this relation is true when resistive the voltage V and current I are in phase. The power dissipation in pure inductive or in a pure capacitive circuit is zero, if the phase difference b/w applied voltage V and current I is Θ, so power dissipation in AC circuit is $P=V_{rms}I_{rms}Cos\Theta$, CosΘ is power factor.
For pure capacitor or inductor phase is Θ=90°, $P=V_{rms}I_{rms}Cos90°=0$
Power factor: The ratio of consumed power to applied power is called power factor.

What is Series Resonant circuit/RLC series circuit? Derive formula for resonance frequency and write its properties.

RLC/Series resonant circuit:"Such a circuit in resistor R, capacitor C and inductor L are connected in series with alternating voltage source is called RLC series or resonant circuit".

Explanation: Let us consider RLC series circuit connected with voltage source in which Resistance R, capacitive reactance Xc=1/ωC and inductive Reactance X_L=ωL. As X_L and Xc are opposite in direction.
At high frequency X_L>> Xc, so behave as RL circuit, at low frequency Xc >> X_L so behave as RC circuit.

Resonance frequency: The frequency at $X_L=X_c$ across the circuit and maximum current flow through it called resonance frequency. Its formula is $f_r = \frac{1}{2\pi\sqrt{LC}}$.

$X_L = X_c$

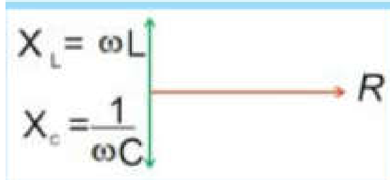
$\omega L = \frac{1}{\omega C}$

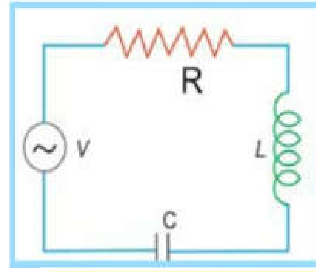
$\omega^2 = \frac{1}{LC}$,

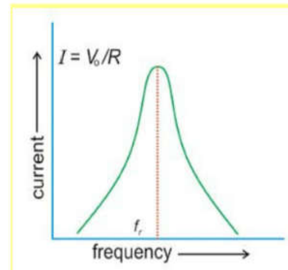
$\omega = \frac{1}{\sqrt{LC}}$ As $\omega = 2\pi f$

$2\pi f = \frac{1}{\sqrt{LC}}$

$f_r = \frac{1}{2\pi\sqrt{LC}}$, This is the formula for resonance frequency







Properties of Series Resonant circuit

1. The resonance frequency is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$.
2. The impedance of circuit at resonance is resistive so voltage and current are in phase and power factor is 1.
3. The impedance of circuit is minimum at resonance and is equal to R.
4. If source voltage V_o is constant, the current is a maximum at resonance I=Vo/R.
5. At resonance, voltage drop across inductance and capacitance may be larger than source voltage.

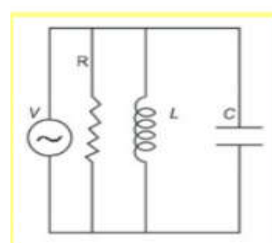
It is called acceptor circuit because this circuit accept the maximum flow of current due to minimum impedance.

What is Parallel Resonance circuit/LC parallel circuit. Write its properties.

LC/parallel resonant circuit: "Such a circuit in which inductor is connected parallel with capacitor then it is called parallel resonant circuit".

Let us consider LC parallel circuit in which inductance coil L and negligible resistance r. at resonance frequency $X_L=X_c$

Current drawn from the source is zero. Practically current is not zero but is very small due to small resistance r of coil.



Properties of Parallel resonant circuit

1. The resonance frequency is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$.
2. At resonance frequency the circuit impedance is maximum whose value is L/CR.
3. At resonance the current is minimum and in phase with applied voltage so power factor is one.
4. At resonance branch current I_L and Ic may be larger than the source current Ir.

It is called rejecter circuit because it rejects the maximum flow of current due to maximum impedance.

PRACTICE MCQS

1	The power dissipated in AC circuit is given by $P=I_{rms}V_{rms}\cos\Theta$, in relation $\cos\Theta$ is called	Phase factor	Gain factor	Loss factor	**Power factor**
2	Impedance Z can be expressed by	**$Z= V_{rms}/I_{rms}$**	$Z=V_{rms}I_{rms}$	Z=RI	None
3	In RLC series circuit the true condition for resonance takes place when	**$X_L=Xc$**	$X_L>Xc$	$X_L<Xc$	None of these
4	SI unit of impedance is	Henry	Hertz	Ampere	**Ohm**
5	In RLC series circuit the current at resonance frequency will	Minimum	Zero	**Maximum**	Infinite
6	The formula for resonance frequency is fr=	$\frac{1}{T}$	**$\frac{1}{2\pi\sqrt{LC}}$**	$\frac{1}{2\pi\sqrt{C}}$	None of these
7	At resonance RLC series circuit shows the behavior of	**Pure resistive**	Pure inductive circuit	Pure capacitive circuit	Pure RLC circuit
8	The impedance of RC series AC circuit is given by Z=?	$\sqrt{R^2-(wC)^2}$	$R^2+(wC)^2$	$\sqrt{R^2+(wC)^2}$	**$\sqrt{R^2+(\frac{1}{wC})^2}$**
9	The total reactance of a series RLC circuit at resonance is	**Equal to R**	Zero	Infinity	1
10	At higher frequencies, which of the following plays a dominant role in RLC	Resistor	**Inductor**	Capacitor	Transistor

	series circuit				
11	At resonance frequency, the impedance of RLC series circuit is	Zero	**Minimum**	Maximum	Moderate
12	The impedance of RLC series circuit at resonance is given as	$\sqrt{R^2+(X_L-Xc)^2}$	$\sqrt{R^2+X_L{}^2}$	**Z=R**	$\sqrt{R^2+X_c{}^2}$
13	Power factor of an AC series circuit is	Always greater than one	Always less than one	**Always equal to one**	Zero
14	EM waves have frequency of range of	10^4 Hz	10^5 Hz	**10^6 Hz**	10^2 Hz
15	Resistance of choke is	Zero	**Very small**	Large	Infinite
16	At resonance the value of current in RLC series circuit is equal to	**Vo/R**	VoR	I/2	Zero
17	Which one is most energetic	**Gamma rays**	X-rays	UV rays	Visible light
18	In tunning a circuit if capacitance is doubled and inductance is halved then frequency	Doubled	Halved	**Remain same**	Increase 4 times
19	Reciprocal of impedance is called	Resistance	Deflection	**admittance**	Coherence
20	The unit of $\sqrt{LC}$ is	**Second**	Ampere	Hertz	Farad
21	With increase in frequency of an AC supply, the impedance of RLC series circuit	Decrease	Increase	Remains same	**1^{st} decrease becomes min than increase**

22	The unit of ωL/R in RLC series circuit is	Ohm	Volt	Henry	**Unitless**
23	When 10V are applied to AC circuit, current flowing in it 100 mA, its impedance	10 ohm	1000 ohm	**100 ohm**	1 ohm
24	In AC circuit, R is connected in series with inductance L, if the Phase angle b/w voltage and current is 45, inductive reactance will be	R/2	2R	**R**	R/4
25	The capacitance required to construct a resonance circuit of frequency 1000 KHz with inductor 5mH is	**5.09PF**	5.09μF	5.09mF	5.09KF
26	In RL series circuit the phase angle is	$\theta = Tan^{-1}\left(\frac{\omega L}{R}\right)$	$\theta = Tan^{-1}\left(\frac{\omega}{R}\right)$	$\theta = Tan^{-1}\left(\frac{1}{\omega CR}\right)$	None
27	The dimension of L/R is	**[T]**	[ML]	[LT]	None
28	At resonance, the behavior of RLC series circuit is	**Resistive**	Capacitive	Inductive	All of these

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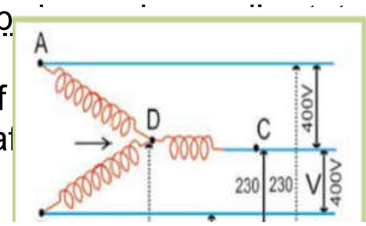
What is Three phase AC supply? Write is construction and working with advantages.

Three phase AC supply: "In three phase AC generator there are three coils inclined at 120° to each other, each connected to its own pair of slip rings and three alternating voltages are generated across its own pair of slip in field".



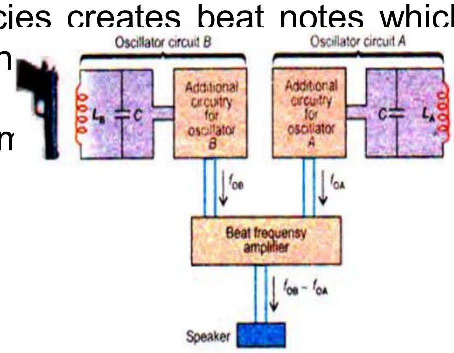
Three phase has only four terminals because starting point of all three coils has common junction which is earted to the shaft generator and three ends of coils are connected to three separate terminals on the machine

Advantages of Three phase AC supply: There are following advantages

i. Total load is divided into three parts and none of line is overloaded.
ii. Some special devices operate at 400 V so this supply provides 400V to those Devices.

What is Principle of Metal detector and uses.

Metal detector: Metal detector consists of two oscillators A and B having inductances L_A and L_B, the inductances varies in the presence of metal that change the frequency of oscillator, the difference of frequencies creates beat notes which can be heard with help of speaker that tells about th s shown in figure below.



Uses of metal detector: There are following uses of m

i. The detectors are used at security checks
ii. They are used to detect buried metal objects.

What is Choke? Write its uses.

Choke: Such a coil which consists of thick copper wire wound Closely in Large no of turns over soft iron laminated core is called Choke. Its inductance is very large and R is very small.

Uses: It is used to control or limits the current with very small Wastage of energy.

Explain Principle, Generation, Transmission And Reception Of Electromagnetic Waves

Electromagnetic waves: "The waves which require no medium for transmission and rapidly propagate through vacuum are called electromagnetic waves".

Maxwell equations: In 1864 James Clark Maxwell formulated a set of equations which explained the various electromagnetic phenomenons are called Maxwell equations.

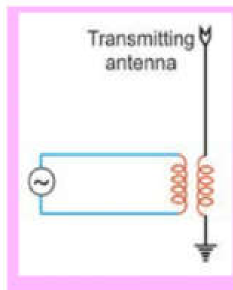
- According to Maxwell equation, a changing magnetic flux creates electric field and changing electric flux produces magnetic field. It means each field generates the other fields and both the fields' moves in a direction of its propagation through space and waves produced are called electromagnetic field.
- Speed of EM waves is equal to speed of light in vacuum $3*10^8$ m/s.
- EM waves are periodic. EM spectrum starts from low frequency Radio waves and end on high frequency Gamma rays.

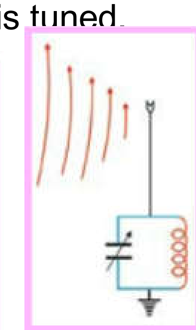
Principle: According to Maxwell equation, a changing magnetic flux creates electric field and changing electric flux produces magnetic field. It means each field generates the other fields and both the fields' moves in a direction of its propagation through space and waves produced are called electromagnetic field.

Generation: The electromagnetic waves are generated when electric or magnetic flux is changing through a region of space, it means when we accelerate the electrical charges radiate electromagnetic waves.

Transmission: The piece of wire along the charges is made to accelerate is called transmitting antenna. A radio transmitting antenna is a good example of generating the electromagnetic waves by accelerating charges. It is charged by alternating source of potential V frequency f, the frequency with which the field alternate is always equal to the frequency of source generating them in free space with the speed of light.

Reception: The voltage of one particular frequency can be picked up by connecting an inductor L and variable capacitor C in parallel with one end of receiving antenna as shown in fig. In order to pick the required signal capacitance of capacitor is so adjusted that natural frequency of LC circuit is same as that of required transmitting station. At this frequency the circuit will resonate under the driving action of antenna. So, LC circuit will build up a large response to radio waves to which it is tuned.





What is Modulation and carrier wave?

Modulation: The process of combining the low freque
Signal with a high frequency is called modulation.

Carrier wave: The high frequency radio wave in modu
Is Called carrier wave.

Modulation signal: Low frequency signal in modulation is
Called modulation signal.

What is Difference b/w A.M and F.M?

Amplitude modulation (A.M)	**Frequency modulation (F.M)**
In this type of modulation, the amplitude of the carrier wave is increased or decreased as the amplitude of the superposing modulating signal increases or decreases	In this type of modulation, the frequency of the carrier wave is increased or decreased as the amplitude of the superposing modulating signal increases or decreases. But the carrier wave amplitude remains constant.
The range of A.M is **540 KHz to 1600 KHz**	The range of F.M is **88 MHz to 108 MHz**
Advantage of A.Mis better to transmit the signal for large range.	F.M are less affected by electrical interference then A.M and it provide higher quality transmission of sound
Disadvantage of A.Mhave low quality transmission of sound	They are less able to travel around obstacles such as hills and high building.

PRACTICE MCQS

1	Pure choke consumes	Minimum power	Maximum power	**No power**	Average power

2	In a choke of inductance L and resistance R	**L is large and R is small**	L is small and R is large	Both L and R are large	Both L and R are small
3	Power dissipated in pure inductor and pure capacitor is	Large	Small	Infinite	**Zero**
4	In three phase AC supply the phase difference between each pair of coil is	45°	**120°**	90°	180°
5	Electromagnetic waves emitted from an antenna are	**Transverse**	Longitudinal	Stationary	All of these
6	Three phase AC supply uses	No terminals	Two terminals	**Four terminals**	Six terminals
7	The velocity of an oscillating charge as it moves to and fro along wire is	**Changing**	Constant	Infinite	Zero
8	Metal detector consist of circuit	**LC**	RL	RC	RLC
9	Shake an electrically charged object to and fro and produce	Mechanical waves	Transverse waves	Longitudinal waves	**EM waves**
10	When electrons in the transmitting antenna vibrate 94000 times then produce radio wave of	94 Hz	940 KHz	**94 KHz**	94 MHz
11	Which one is in the order of increasing frequency?	X-rays,. Radio waves, infrared waves	UV rays, visible light , X-rays	Yellow, green, red	**Infrared rays, visible light, X-rays**
12	In three phase AC supply, phase difference between	45°	**240°**	90°	180°

	first and third coil is				
13	Resistance of choke is	Zero	**<u>Very small</u>**	Large	Infinite
14	The process of combining low frequency signal with high frequency radio wave is called as	**<u>Modulation</u>**	Amplification	Demodulation	Resonance
15	The range of A.M is	**<u>540 KHz to 1600 KHz</u>**	54 KHz to 1600 KHz	50 KHz to 1600 KHz	5 MHz to 1600 KHz
16	The range of F.M is	540 KHz to 1600 KHz	88 KHz to 108 KHz	50 KHz to 1600 KHz	**<u>88 MHz to 108 MHz</u>**

EXERCISE SHORT QUESTIONS

1. **A sinusoidal current has r.m.s value of 10A. What is the maximum or peak value?

$I_{rms} = 10A \qquad I_o = ?$

$I_{rms} = \frac{I_o}{\sqrt{2}}, \qquad I_o = \sqrt{2}\, I_{rms}$

$I_o = 1.41(10) = 14.14A$

maximum current $= 14.14$ A

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2.** **Name the device that will (a) permit flow direct current but oppose the flow of alternating current (b) permit flow of alternating current but not the direct current.**

a) An inductor (choke) is a device which permits flow of direct current but opposes the flow of alternating current

b) A capacitor is a device which permits flow of alternating current but not the direct current

3. ****How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50 Hz source?**

It reaches the maximum brilliance 100 times per second.

The brilliance of the lamp will become maximum twice in one AC cycle because the current also becomes maximum two times in a cycle so

Maximum brilliance shown by lamp=2f=2*50=100 Hz

4. A circuit contains an iron-cored inductor, a switch and a D.C. source arranged in series. The switch is closed and after an interval reopened. Explain why a spark jumps across the switch contacts?

When switch is reopened, the current in circuit decreased from its maximum value to zero, this changing current produce an emf across the inductor which produce spark across the switch contacts.

5. How does doubling the frequency affect the reactance of (a) an inductor (b) a capacitor?**

a) The reactance of inductor becomes double

$$X_L = \omega L = 2\pi f L$$
$$X'_L = 2\pi(2f)L$$
$$X'_L = 2(2\pi f L)$$
$$X'_L = 2X_L$$

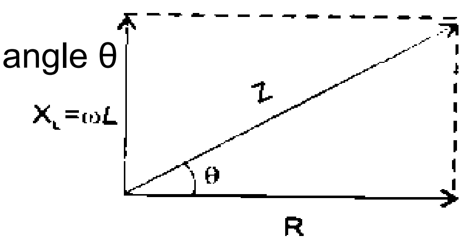
b)The reactance of capacitor becomes half

$$Xc = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$
$$X'_c = \frac{1}{2\pi(2f)C}$$
$$X'_c = \frac{1}{2}X_c$$

6.In a R – L circuit, will the current lag or lend the voltage? Illustrate your answer by a vector diagram.**

In R-L circuit current lags the voltage by an angle θ

$$\theta = \tan^{-1}(\frac{\omega L}{R})$$



7. **A choke coil placed in series with an electric lamp in an A.C. circuit causes the lamp to become dim. Why is it so? A variable capacitor added in series in this circuit may be adjusted until the lamp glows with normal brilliance. Explain, how this is possible?**

a)When the choke coil is connected in series with an electric lamp in L.C circuit, the impedance Z of circuit is increased so current is reduce and lamp becomes dim.

b)At resonance X_L=Xc, impedance becomes minimum and current becomes maximum and lamp glows with normal brilliance.

8.** **Explain the conditions under which electromagnetic waves are produced from a source?**

Electromagnetic waves are generated, when electric or magnetic flux is changing through a certain region of space. This is possible only when electrical charges are accelerated by AC source. For example when electrons in the radio transmitting antenna vibrate it produce changing flux which setup electromagnetic waves propagated in space from antenna.

9.How the reception of a particular radio station is selected on your radio set?**

A particular radio station can be selected on a radio set by tuning it. When the frequency of the LC oscillator in the radio set is equal to the frequency of the radio wave from a particular radio station, a resonance is produced. The current of this signal becomes maximum and can detected and amplified $f_r = \frac{1}{2\pi\sqrt{LC}}$.

10. What is meant by A.M. and F.M.?**

Amplitude modulation (A.M)

In this type of modulation, the amplitude of the carrier wave is increased or

Frequency modulation (F.M)

In this type of modulation, the frequency of the carrier wave is increased or

decreased as the amplitude of the superposing modulating signal increases or decreases	decreased as the amplitude of the superposing modulating signal increases or decreases. But the carrier wave amplitude remains constant.
The range of A.M is **540 KHz to 1600 KHz**	The range of F.M is **88 MHz to 108 MHz**
Advantage of A.M is better to transmit the signal for large range.	F.M are less affected by electrical interference then A.M and it provide higher quality transmission of sound

NUMERICALS CHAPTER 16

16.1: An alternating current is represented by the equation I=20sin100π t. Compute its frequency and the maximum and r.m.s values of current.

$\text{solution : Given Equation, } I = 20\text{Sin}100\pi\ t \ \text{ compare with general equation } \ I = I_o\text{Sin}2\pi\ f\ t$

$I_o = 20\text{A} \qquad 2\pi f = 100\pi \Rightarrow \ f = 50\text{Hz}, \qquad I_{rms} = I_o/\sqrt{2} = 20/\sqrt{2} = 14A$

16.2: A sinusoidal A.C. has a maximum value of 15A. What are its r.m.s values? If the time is recorded from the instant the current is zero and is becoming positive, what is the instantaneous value of the current after 1/300s, given the frequency is 50Hz.

$\text{Given Data : } I_o = 15\text{A}, t = 1/300\text{ sec}, f = 50\text{Hz}, I_{rms} = ?\ I = ?$

$\text{sol : } I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{15}{\sqrt{2}} = 10.6\text{A} \qquad I = I_o\sin 2\pi\ f\ t = 15\sin 2\pi(50)(1/300) = 15\sin(\pi/3) = 12.96A$

16.3: Find the value of the current and inductive reactance when A.C. voltage of 220V at 50Hz is passed through an inductor of 10H.

$\text{Given Data : } V = 220\text{V}, f = 50\text{ Hz}, L = 10\text{ H}, I = ?\ X_L = ?$

$X_L = \omega L = 2\pi f L = 2 * 3.14 * 50 * 10 = 3140\text{ohm}, \ \ I = \frac{V}{X_L} = \frac{220}{3140} = 0.07\text{ ampere}$

16.4: A circuit has an inductance of 1/π H and resistance of 2000Ω. A 50 Hz A.C. is supplied to it. Calculate the reactance and impedance offered by the circuit.

$\text{Given Data : } L = \frac{1}{\pi}\text{H}, \ R = 2000\,\Omega, \ f = 50\text{Hz}, X_L = ? \ Z = ?$

$X_L = \omega L = 2\pi f L = 2 * \pi * 50 * 1/\pi = 100\text{ ohm}$

$Z = \sqrt{R^2 + {X_L}^2} = \sqrt{2000^2 + 100^2} = 2002.5\text{ ohm}$

16.5: An inductor of 3/π H is connected in series with a resistance of 40Ω. Find (i) the peak value of the current (ii) the r.m.s value, and (iii) the phase difference between the current and the applied voltage V=350sin(100π t).

Given Data : $L = 3/\pi$ H, $R = 40$ ohm, $V = 350\sin(100\pi t)$, $I_o = ?$ $I_{rms} = ?$ $\theta = ?$

comparing voltage by orignal eq, $V = V_o\sin(2\pi f)t$, $V_o = 350V$, $f = 50Hz$

$$A = \sqrt{R^2 + X_L{}^2} = \sqrt{R^2 + (2\pi fL)^2} = \sqrt{40^2 + (2*3.14*50)^2} = 302.65\ \text{ohm}$$

$$I_o = \frac{V_o}{Z} = \frac{350}{302.65} = 1.16A, \quad I_{rms} = 0.707\, I_o = 0.707*1.16 = 0.81A$$

$$\theta = \tan^{-1}(\frac{X_L}{R}) = \tan^{-1}(\frac{2\pi fL}{R}) = \tan^{-1}(\frac{2*3.14*50*3/3.14}{R}) = 82.4^o$$

16.6: A 10 mH, 20Ω coils is connected across 240V and 180/π Hz source. How much power does it dissipate?

Given Data : $L = 10mH = 10*10^{-3}$ H, $R = 20$ ohm, Vrms = 240 V, $f = 180/\pi$ Hz $P = ?$ $P = V_{rms}I_{rms}\cos\theta$ ---(1)

$$X_L = \omega L = 2\pi f L = 2\pi*180/\pi*10*10^{-3} = 3.6\ \text{ohm} \quad Z = \sqrt{R^2 + X_L{}^2} = \sqrt{20^2 + 3.6^2} = 20.32\text{ohm}$$

$$I_{rms} = \frac{240}{20.32} = 11.81A \qquad \theta = \tan^{-1}(X_L/R) = \tan^{-1}(3.6/20.32) = 10.2^o \quad \text{putting in (1)}$$

$$P = 240*11.81\,\text{Cos}10.2^o = 2778\ W$$

16.7: Find the value of the current flowing through a capacitance $0.5\mu F$ when connected to a source of 150V at 50Hz.

Given Data : $C = 0.5\mu.F = 0.5*10^{-6}$ F, V = 150 V, f = 50 Hz, I = ? As circuit is capacitive so I = V/Xc

$$Xc = \frac{1}{\omega C} = \frac{1}{2\pi\pi f} = \frac{1}{2*3.14*50*0.5*10^{-6}} = 6369.4\ \text{ohm} \quad I = V/X_c = 150/6369.4 = 0.02A$$

16.8: An alternating source of emf 12V and frequency 50Hz is applied to a capacitor of capacitance $3\mu F$ in series with a resistor of resistance 1kΩ. Calculate the phase angle.

Given Data : V = 12V, f = 50Hz, $C = 3*10^{-6}$ F, R = 1 ohm $\qquad \theta = ?$

$$\theta = \tan^{-1}(\frac{Xc}{R}) = \tan^{-1}\frac{1}{2\pi f\,CR} = \tan^{-1}\frac{1}{2*3.14*50*3*10^{-6}*1} = 46.7^o$$

16.9: What is the resonant frequency of a circuit, which includes a coil of inductance 2.5H and a capacitance $40\mu F$?

Given dAta : L = 2.5 H, $\quad C = 40\mu F = 40*10^{-6}$ F $\quad f_r = ?$

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2*3.14\sqrt{2.5*40*10^{-6}}} = 15.9Hz$$

16.10: An inductor of inductance $150\mu H$ is connected in parallel with a variable capacitor whose capacitance can be changed from $500PF$ to $20PF$. Calculate the maximum frequency and minimum frequency for which the circuit can be tuned.

Given Data : $L = 150\mu H = 150*10^{-6}$ H, $C_1 = 500PF = 500*10^{-12}$ F, $C_2 = 20PF = 20*10^{-12}F$

$$f_{min} = \frac{1}{2\pi\sqrt{LC_1}} = \frac{1}{2*3.14\sqrt{150*10^{-6}*500*10^{-12}}} = 2.91*10^6\,Hz = 2.91MHz$$

$$f_{max} = \frac{1}{2\pi\sqrt{LC_2}} = \frac{1}{2*3.14\sqrt{150*10^{-6}*20*10^{-12}}} = 0.58*10^6\,Hz = 0.58MHz$$

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Chapter 17 Physics of Solids

<u>What is Solid state physics</u>?"The branch of Physics which deals with structure & properties of solids is called solid state physics".

Difference b/w crystalline, amorphous and polymeric solids.

Crystalline solids	Amorphous solids	Polymeric solids
Those solids in which there is regular arrangement of atoms or molecules are called crystalline solids.	The word amorphous means "without form or structure". So, "such solids in which there is no regular arrangement of molecules are called amorphous solids"	Such type of solids which are more or less solid materials with a structure which is intermediate b/w order and disorder are called polymeric solids.
For examples copper, NaCl, zirconia's etc.	For example ordinary glass	For example Plastics, synthetic rubber, polythene and nylon.
Properties of crystalline solids	**Properties of amorphous solids**	**Properties of polymeric solids**
i. The atoms, molecules or ions in crystalline solids are in state of vibratory motion about fixed points i. Cohesive force b/w atoms maintain strict long range order ii. They have definite melting point	i. They have no definite melting point ii. On heating it gradually soften into paste and becomes very viscous liquid at 800°C	i. Polymeric solids consists wholly or partly combination of carbon with oxygen, hydrogen, nitrogen or nonmetallic elements. Natural rubber $(C_5H_6)_n$. ii. The materials have low specific gravity compared to lightest of metals.

A crystalline solid consists of three dimensional patterns that repeat itself again and again.
<u>What is Specific gravity</u>? The ratio of density of substance to density of a reference substance (usually water) is called specific gravity.
<u>What is Unit cell</u>? The smallest three dimensional basic structures is called unit cell.
<u>What is Crystal lattice</u>? The whole structure which is obtained by the repetition of unit cell is called crystal lattice. e.g NaCl has cubic.
Practice MCQs

Describe Mechanical properties of solids.

What is Deformation? Any change which is produced in length, volume or shape of object when external force is applied is called deformation. For example when we hold a rubber ball in our hand it compresses shape and volume changes.
What is Elasticity? The ability of a body to return to its original shape when stress is removed is called elasticity.
What are stress and strain? Write their formulas and units as well as types.

Stress: The force applied on unit area to produce change in length, volume or shape is called stress. Its unit isNm^{-2}

$stress = \frac{Force}{Area} = \frac{F}{A}$ And dimension is $[ML^{-1}T^{-2}]$

Types of stress: There are three types of stress

i. **Tensile stress**: A stress that changes the length of body is called tensile stress
ii. **Volumetric stress**: A stress that changes the volume of body is called volumetric stress.
iii. **Shear stress**: When the stress changes the shape of body is called shear stress.

Strain: The measure of deformation of solid material when stress is applied on it is called strain. It has no unit.

Types of strain

i. **Tensile strain**: Fractional change in length is called tensile strain which is $=\Delta L/L$
ii. **Volumetric strain:** fractional change in volume is called volumetric strain which is$=\Delta V/V$
iii. **Shear strain**: Change in shape by shear stress, it is in angle , y=tan $=\Delta a/a$,for small values y=

State Hook's law

Within elastic limit, stress is directly proportional to strain. Stress ∝ strain, stress=constant (strain)

What is elastic modulus? Give its types.

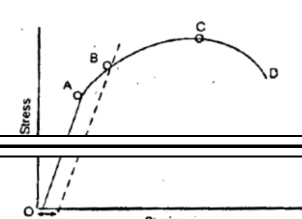
Elastic modulus or modulus of elasticity: The ratio of stress to strain remains constant which is called elastic modulus or modulus of elasticity. Its unit is Nm^{-2} or Pascal.

Types of modulus of elasticity

i. **Young's modulus**: The ratio of tensile stress to tensile strain is called young modulus.
$Y = \frac{\text{tensil stress}}{\text{tensile strain}} = \frac{F/A}{\Delta l/l} = \frac{Fl}{\Delta l A}$. Its unit is Nm^{-2} or Pascal.
ii. **Bulk modulus**: The ratio of volumetric stress to volumetric strain is called bulk modulus.
$B = \frac{\text{volumetric stress}}{\text{volumetric strain}} = \frac{F/A}{\Delta V/V} = \frac{FV}{\Delta V A}$. Its unit is Nm^{-2} or Pascal.
iii. **Shear modulus:** The ratio of shear stress to the shear strain is called shear modulus.
$G = \frac{\text{shear stress}}{\text{shear strain}} = \frac{F/A}{\tan\theta}$, it is also called modulus of rigidity. Its unit is Nm^{-2} or Pascal.

Draw a stress strain curve for ductile material. Discuss the term related to this tensile test.

Tensile test: In this test metal wire is extended at a specified deformation rate and stresses generated in the wire during deformation are continuously measured by a suitable electronic device fitted in the mechanical test machine. Force elongation graph for ductile material is shown in fig.



Proportional limit: Proportional limit is the greatest stress
That a material can endure without losing straight line

Proportionality between stress and strain. Hooks law applicable.
This limit is from O to An in graph.
Elastic limit: Elastic limit is the greatest stress that a material can endure without any permanent deformation. This limit is from A to B.
Yield stress: Maximum value of applied stress within its elastic limit is called yield stress.
Plasticity: If the stress is increased beyond elastic limit, the specimen becomes permanently changed and does not regain its original state even if applied stress is removed which is called plasticity.
UTS (ultimate tensile stress): The maximum stress that a material can withstand is called UTS.
Fracture stress: Once UTS is cross, the material breaks at this point and is called fracture stress.

What are ductile and brittle substances? Give examples.

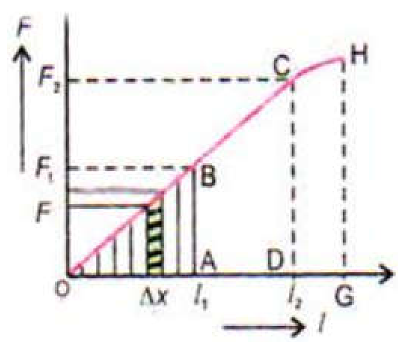
Ductile substance: "The substances which undergo plastic deformation until they break are called ductile substance" e.g. lead copper.
Brittle substance: "The substances which break just after the elastic limit is reached are called brittle substance". Like glass, high carbon steel etc.

What is strain energy? Derive the relation for strain energy in deformed material from graph.

Strain energy: "The work done in deforming the material which is stored in the form of potential energy is called strain energy".

$$\text{Strain energy} = \frac{1}{2}\left[\frac{EA * l_1^2}{L}\right].$$

Explanation: Consider a wire whose one end is attached to the fixed support and stretched vertically connected a weight at its lower end which acts as a stretching force. The extension l of the wire can be increased by increasing the stretching force F. The graph is plotted b/w extension l and stretching force F.
Work can be calculated by area under the force extension graph. Let us find the work done on the wire when extension is l_1 and force is F_1.



$$\text{Work done} = \text{Area of } \Delta AOAB$$

$$W = \frac{1}{2}(OA)(AB)$$

$$W = \frac{1}{2}(F_1)(l_1) = \frac{1}{2}F_1 l_1$$

This work is stored in the form of potential energy in the wire.

$$P.E = \frac{1}{2}F_1 l_1 \text{ --------------(1)}$$

Strain energy in terms of elastic modulus: The energy can be calculated in terms of elastic modulus.

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$$E = \frac{Stress}{Strain} = \frac{F_1/A}{l_1/L} = \frac{F_1 L}{A l_1}$$

$$F_1 = \frac{EAl_1}{L}, \text{ putting in equation (1)}$$

$$P.E = \frac{1}{2}\left[\frac{EAl_1}{L}\right]l_1 =$$

$$P.E = \frac{1}{2}\left[\frac{EAl_1^{\,2}}{L}\right]$$, This is the result for strain energy in deformed material.

DESCRIBE ELECTRICAL PROPERTIES OF SOLIDS

There are three types of solids according to the conduction ability.

Conductors

The substance which can easily conduct electricity having conductivity **$10^7\ \Omega^{-1}m^{-1}$** e.g. metals like copper gold, silver etc.

Insulator

The materials have very low conductivity of ranging **10^{-20} to $10^{-10}\ \Omega^{-1}m^{-1}$** like wood, plastic, glass etc

Semiconductor

The materials have intermediate conductivity ranging from **10^{-6} to $10^{-4}\ \Omega^{-1}m^{-1}$** like Ge, Si etc.

Practice MCQs

1	SI unit of strain is	N/m2	N/m	Nm	<u>**No unit**</u>
2	The ratio of stress to strain is called	Electricity	Resistivity	Conductivity	<u>**Elastic modulus**</u>
3	The conductivity of material is of the order of	10^1 (ohm m)-1	10^{10} (ohm m)-1	<u>**10^7(ohm m)-1**</u>	10^{15} (ohm m)-1
4	The substance with conductivity of the order of 10-6 (ohm m)$^{-1}$ to 10-4 (Ωm)$^{-1}$	Conductor	Insulator	<u>**Semiconductor**</u>	Super conductor
5	Shear modulus is expressed as G=?	$\frac{\tan\theta}{F/A}$	$\frac{\tan\theta}{A}$	<u>**$\frac{F/A}{\tan\theta}$**</u>	$\frac{\tan\theta}{F}$
6	The resistivity of conductor are of	10^3(Ωm)-1	10^7(Ωm)	<u>**10^{-7}(Ωm)**</u>	10^{-6}(Ωm)-1
7	The SI unit of stress is the same that of	Momentum	<u>**Pressure**</u>	Force	Length
8	Nm^{-2} is also called	Tesla	Weber	<u>**Pascal**</u>	Gauss
9	Dimension of strain are	$[L^2]$	$[L^{-2}]$	$[ML^{-1}T^{-2}]$	<u>**No dimension**</u>
10	The atoms, ions and molecules of crystalline materials maintains their long range order due to	Adhesive forces	<u>**Cohesive forces**</u>	Electrostatic force	Van der wall forces
11	The substance with conductivity of the order of	Conductor	<u>**Insulator**</u>	Semiconductor	Super conductor

	10^{-10} (ohm m)-1 to 10^{-20} (Ώm)-1				
12	Glass and high carbon steel are example of	Ductile substance	**<u>Brittle substance</u>**	Soft material	Hard material
13	Reciprocal of bulk modulus is	Elasticity	Young modulus	**<u>Compressi bility</u>**	Shear modulus
14	Substance which break just after the elastic limit is reached are called	Ductile substance	Hard substance	Soft substance	**<u>Brittle substance</u>**
15	The ratio of applied stress to volumetric strain is called	Young modulus	Shear modulus	Tensile modulus	**<u>bulk modulus</u>**
16	When a stress changes the shape of a body it is called	Volumetric stress	**<u>Shear stress</u>**	Tensile stress	Compressio nal stress
17	The ability of a body to return to its original shape is called	Strain	Stress	**<u>Elasticity</u>**	Plasticity
18	Which type of solids have definite melting point are called solids	**<u>Crystalline</u>**	Amorphous	Both A&B	None of these
19	The stress that produces in shape is	Tensile stress	**<u>Shear stress</u>**	Volume stress	All of these
20	Which one of the following is crystalline solid	**<u>Zirconia</u>**	Glassy solids	Natural rubber	Polystrene
21	The young modulus of steel is	<u>$20x10^{11}\,Nm^{-2}$</u>	$3.9x10^{-9}\,Nm^{-2}$	$2x10^{9}\,Nm^{-2}$	$1.5x10^{9}\,Nm^{-2}$
22	A solids having regular arrangements of molecules	Britlle	**<u>Crystalline</u>**	Amorphous	Polymeric
23	There are--- different crystal systems based on geometrical arrangement of atoms	2	5	**<u>7</u>**	9

What is band theory of solids? Differentiate b/w conductor insulator and semiconductor on the basis of Band theory of solids.

Concept of Band theory of solids was given by Felix Bloch in 1928.

<u>Energy band/states</u>: A group of such energy sublevels when the number of atoms are brought together and interacts one another and each energy level splits up into many sublevels are called energy band. The Theory which explain the difference b/w conductor, insulator and semiconductor on the basis this energy band or states is called band theory of solids. There are three types of bands

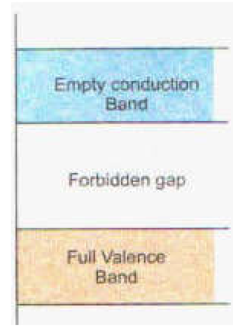
<u>Forbidden band</u>: The energy bands are separated by gaps in which there are no electrons. Such energy gaps are called forbidden band.

<u>Valence band</u>: The electrons in the outermost shell of an atom are called valance electrons. Therefore, the energy band occupied by valance electrons is called the valance band.

<u>Conduction band</u>: The band above the valence band and in which electrons move freely and conduct electric current is called conduction band.

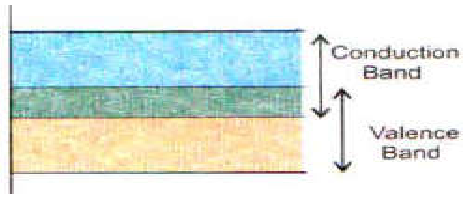
Insulators: Insulators are those materials in which valence electrons are bound very tightly to their atoms having

i. An empty conduction band
ii. A filled valance band
iii. A large energy gap of several eV



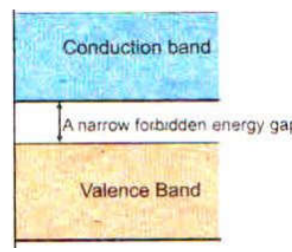
Conductors: Conductors are those materials in which have large number of free electrons having

i. Partially filled conduction band
ii. Partially filled valance band
iii. No energy gap



Semiconductor: Semiconductors have electrical property lies b/w insulator and conductors having

i. Partially filled valance band
ii. Partially filled conduction band
iii. A narrow energy gap(1eV)



At 0 K semiconductor is pure insulator and at room temperature Ge and Si crystal is semiconductor.

What is Intrinsic and extrinsic semiconductor? How P type and N type semiconductors are formed?

Intrinsic semiconductor: A semiconductor in its extremely pure form is called intrinsic semiconductor as pure Si or Ge.
Extrinsic semiconductor: A doped and impure semiconductor is called extrinsic semiconductor. Like p type or n type substances.
Doping and dopant: The process of adding the small impurity atom in pure semiconductor is called doping. And impurity materials itself is called dopant.
The impurity atoms are added in semiconductor in the ratio 1 to 10^6 atoms.
Types of Extrinsic Semiconductor: There are two types of extrinsic semiconductor
(i): N- type Semiconductor: The semiconductor which is formed by adding pentavalent impurity to a pure semiconductor is called N-type semiconductor.
Pentavalent impurity: An atom belongs to 5^{th} group have five valence electrons like antimony, phosphorous and arsenic etc.
(ii) P- type semiconductor: The semiconductor which is formed by adding trivalent impurity to pure semiconductor is called P-type semiconductor.
Trivalent impurity: An atom belonging to third group has three valence electrons like aluminum, boron, gallium, and indium.
Acceptor and donor impurity:
As pentavalent impurity donates a free electrons so it is called donor impurity

Trivalent impurity accepts a free electron so it is called accepter impurity.

Electrical conduction by electrons and holes in semiconductor

When a battery is connected to a semi-conductor, it establishes an electric field across it due to which a directed flow of electrons and holes takes place. The electrons drift towards the positive end whereas the holes drift towards the negative end of the semiconductor. The current flowing through the semiconductor is carried by both electrons and holes.

PRACTICE MCQS

1	To make a n type semiconductor a pure SI should be doped with atoms of	Ge	**P**	C	Al
2	The substance which have partially filled conduction band are called	Insulator	**Semiconductor**	Conductor	Super conductor
3	When a silicon is doped with pentavalent element it becomes	P type semiconductor	**N type semiconductor**	Intrinsic semiconductor	Extrinsic semiconductor
4	What type of impurity is to be added to the semiconductor material to provide holes	Mono valent	**Trivalent**	Tetra valent	Pentavalent
5	In n type materials minority carrier are	Free electrons	**Holes**	Protons	Mesons
6	A well-known example of an intrinsic semi conductor is	**Germanium**	Phosphorus	Aluminium	Cobalt
7	Majority carriers in p type substance	**holes**	Neutrons	Electrons	Positrons
8	Majority carriers in n type substance	Protons	Neutrons	**Electrons**	Positrons
9	If the conductivity of a material is high then it is	An insulator	A semi-conductor	**A good conductor**	A super conductor
10	Which of the following has least energy gap ?	**Conductor**	Insulator	Semi-conductor	None of these
11	A substance having empty conduction band is called	Conductor	**Insulator**	Semi-conductor	All of these
12	According to band theory of solids the band in atom containing conductive electrons is	**Conduction band**	Valence band	Forbidden band	First conduction then forbidden band
13	Which pair belongs to acceptor impurity	Arsenic, phosphrous	**Boron, gallium**	Antimony, indium	Arsenic, antimony
14	Which one is pentavalent?	Boron	Gallium	**Antimony**	Indium
15	At 0k semiconductor are	Conductors	Insulators	Perfect	**Perfect**

				conductor	**insulator**

Write a note on Super conductors.

Superconductor: "The materials whose resistivity becomes zero below a certain temperature are called superconductors".
Critical temperature: The temperature at which the resistivity of a material becomes zero is called critical temperature.
Superconductivity: "The process of reducing the resistance of material with low temperature to immeasurable low value is called superconductivity".
As resistance of material is zero, so no energy is dissipated.
First superconductor was discovered by Kmaerlingornes 1911.
Critical temperature for different materials: Mercury= 4.2 K, aluminum= 1.18 K, Tin= 3.72 K, lead= 7.2 K
Critical temperature of yttrium barium copper oxide ($YBa_2Cu_3O_7$):163 K or -110°C
Uses of superconductor: Superconductors are used in

i. Magnetic resonance imaging(MRI)
ii. Magnetic levitation trains
iii. Powerful electric motors
iv. Faster computer chips

Explain the types of magnet and give their Magnetic properties .

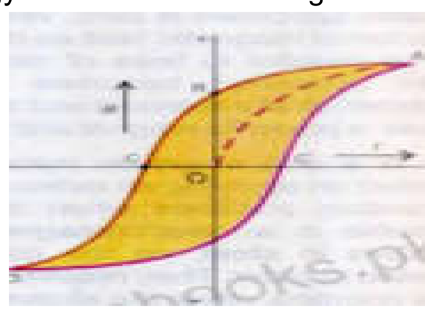
Origin of magnetism: Magnetism is the property of all substance due to their orbital and spin motion of electrons.
Magnetic dipole: An atom in which there is resultant magnetic field behave like a tiny magnet is called magnetic dipole.
Types of magnets: There are three type of magnetic substance

i. Paramagnetic substance
ii. Diamagnetic substance
iii. Ferromagnetic substance

Paramagnetic substance: The substance in which magnetic field produced by the orbital and spin motion of electrons support each other and atoms behave like tiny magnet are called paramagnetic substance. Like Al, Pt, Mn etc.
Diamagnetic substance: The substance in which magnetic fields produced by orbital and spin motion of electrons cancel each other and no resultant field is produced are called diamagnetic substance like Cu, Bi, Sb, atoms of water.
Ferromagnetic substance: The substances in which atoms co-operate with each other in such a way that they show a strong magnetic effect are called ferromagnetic substance. Like iron, nickel, cobalt, Alnico V etc.
Domains: The small magnetized regions in ferromagnetic substance are called domains. They have the microscopic size of 10^{12} to 10^{16} atoms.
Soft ferromagnetic substance: The ferromagnetic substance whose domains can be easily oriented on applying an external magnetic field and return to original position when field is removed are called soft ferromagnetic substance like iron.
Hard ferromagnetic substance: The ferromagnetic substance whose domains cannot be easily oriented on applying an external magneticfield and return to original position when field is removed are called hard ferromagnetic substance, steel is an example.
Curie temperature: The temperature above which a ferromagnetic substance becomes paramagnetic substance is called Curie temperature. Like curie temp of iron is 750°C.

What is Hysteresis loop. Explain the terms related to hysteresis loop.

Hysteresis loop: The graph b/w flux density and magnetization of specimen of for different values of magnetizing current in the form of loop is called hysteresis loop.
Hysteresis: The value of flux density for any value of current is always greater when the current is decreasing, then when it is increasing, i.e., magnetism lags behind the magnetizing current. This is called hysteresis.
Hysteresis loss: when a ferromagnetic substance is placed in an alternating current solenoid, the energy is needed to magnetize or demagnetize the material during each cycle of magnetizing current. This energy is need to do work again frictions of domains, this work is loss as heat which is called hysteresis loss. It is useful to decide either the material is suitable for construction of transformer
Saturation: When the magnetic flux density increase from zero to maximum value, then is magnetically saturated.
Remanence or retentivty: When the current is reduced to zero, material is still remains magnetized due to tendency of domains to stay partly in line, this property is called remanence.
coercivity and coercive current: Todemagnetize the material, the magnetizing current is reversed and increased to reduce the magnetization to zero. This is known as coercive current and this property is called coercivity.
Coercivity of steel is more than that of iron, as more current is needed to demagnetize it.
Area of loop: The area of loop is proportional to the energy which is used in magnetization, it describe about hysteresis loss, it also describe about the energy which is used to magnetize or demagnetize the material.



- For hard magnetic materials the area of loop is large as compared to soft magnetic materials so energy dissipated per second for iron is less than steel.
- Materials with high retentivity and large coericivity Are most suitable for making permanent magnet.
- The materials with low retentivity and large coercivity are suitable for making core of electromagnet.

Tid bits

- ✓ **Range:** The range of glassy solids is Short range and range of crystalline solids is Long range.
- ✓ **Seven crystal system:** .i. cubic system ii. Tetragonal system.iii. Hexagonal iv.trigonal system. v. rhombic system. vi. Monoclinic vii. triclinic system
- ✓ **Glass** is known as solid liquid because its molecules are irregularly arranged as in a liquid but fixed in their relative positions.
- ✓ Superconductors are alloys that conduct electricity at certain temperature with no resistance.
- ✓ **MRI stands for magnetic resonance imaging**. It uses strong magnetic field produced by super conducting materials for scanning computer processing produces the image identifying tumors and inflamed tissues.
- ✓ **Squids stand for super conducting quantum interference devices**. It is used to detect very weak magnetic field such as produce by brain.
- ✓ Magnet made out of organic materials could be used in optical disks and components in computers, mobile phones, TVs, motors, generators and data storage devices.
- ✓ **A bullet train** is lifted above the rails due to magnetic effect which reduced friction and speed can be increased to 500 kmh^{-1}

PRACTICE MCQs

1	Squids are to detect very weak magnetic field produced by	Heart	Liver	Tongue	**Brain**
2	MRI use field	Very weak	**Strong**	Weak	Zero
3	MRI used for image identifying of	Tumor	Inflamed	**Both A&B**	None

			tissues		
4	A Bullet train speed can be enhanced upto	300 Km/h	400 Km/h	**500 Km/h**	600 km/h
5	Curie temperature for iron is	450 C	550 C	**750 C**	850 C
6	Soft magnetic material is	**Iron**	Sodium	Steel	Copper
7	Critical temperature for mercury is	7.2 K	**4.2K**	1.18K	3.7k
8	The material below which resistivity of some materials become zero is called	Kelvin temperatur e	**Critical temperature**	Absolute temperature	Limiting temperature
9	Which one is not a ferromagnetic substance?	Cobalt	**Copper**	Nickel	Iron
10	which of the following has the least hysteresis loop area	Steel	Wrought iron	**Soft iron**	Cobalt
11	The substance in which the atoms do not form magnetic dipole are called	Ferromagn etic	Paramagnetic	**Diamagnetic**	Conductor
12	Critical temperature for lead	1.18 K	**7.2 K**	4.2 K	3.72 K
13	Best magnetic material is made up of	**Alnico V**	Iron	Nickel	Cobalt
14	Curi temperature for iron is	0K	570 K	**1023 K**	378 K
15	The substance in which the atoms do not form magnetic dipole are called	Ferro magnetic	Para magnetic	**Diamagnetic**	Conductor
16	The magnetism produced by electrons within an atom is due to	Spin motion	Orbital motion	**Spin motion and orbital motion**	Vibratory motion
17	Critical temperature for Aluminum	**1.18 K**	4.2 K	7.2 K	3.72 K
18	A magnetic field acts charged particle so as to change its	Speed	Energy	**Direction of motion**	All of these
19	Eddy current produced in the core of transformer are responsible for	**Heat loss**	Step up process	Step down process	Induction phenomenon
20	The temperature at which a ferromagnetic material becomes paramagnetic is called	Critical temperatur e	Absolute temperature	**Curi's temperature**	All of these
21	Critical temperature of yttrium barium copper oxide ($YBa_2Cu_3O_7$)	143 K	**163 K**	183 K	110 K
22	The number of atoms in domains of macroscopic size of a ferromagnetic substance are	10^4 to 10^6	10^6 to 10^8	**10^{12} to 10^{16}**	10^{21} to10^{23}

23	At curie temperature iron becomes	ferromagnetic	Diamagnetic	**<u>Paramagnetic</u>**	Super conductor
24	It is used to detect very weak magnetic field such as produce by brain.	Magnetic material	MRI	**<u>SQUIDS</u>**	None
25	Critical temperature for tin	1.18 K	4.2 K	7.2 K	**<u>3.72 K</u>**
26	Which one is not a ferromagnetic substance	Cobalt	**<u>Copper</u>**	Nickel	Iron
27	Magnetism lags behind the magnetization current this phenomenon is called	Saturation	Rententivity	**<u>Hysteresis</u>**	Coercivity
28	The most suitable material for making permanent magnet is	Iron	**<u>Steel</u>**	Aluminum	Copper

<u>Note: Exercise short Questions are solved in Theory of this chapter.</u>

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<u>Numerical problems</u>

17.1: A 1.25cm diameter cylinder is subjected to a load of 2500kg. Calculate the stress on the bar in mega Pascal's.

$$\text{Given Data : d} = 1.25\text{cm} = 1.25*10^{-2}\text{ m, r} = \text{d}/2 = 1.25*10^{-2}/2 = 0.625*10^{-2}\text{ m, m} = 2500\text{kg, Stress} = ?$$

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{\text{mg}}{\pi \text{r}^2} = \frac{2500*9.8}{3.14*(0.625*10^{-2})^2} = 200*10^6\text{ Pa} = 200\text{ MPa}$$

17.2: A 1.0m long copper wire is subjected to stretching force and its length increases by 20cm. calculate the tensile strain and the percent elongation which the wire undergoes.

$$\text{Given data : } l = 1\text{m}, \Delta l = 20cm = 20/100 = 0.20m, \text{Tensil strain} = ?\ \%\text{ elongation} = ?$$

$$\text{Tensil strain} = \frac{\Delta l}{l} = \frac{0.20}{1} = 0.20,\ \ \%\text{ elongation} = \frac{\Delta l}{l}*100 = 0.20*100 = 20\%$$

17.3: A wire 2.5 m long and cross-section area 10^{-5}m^2 is stretched 1.5mm by a force of 100N in the elastic region. Calculate (i) the strain (ii) Young's modulus (iii) the energy stored in the wire.

$$\text{Given Data : l} = 2.5\text{m, A} = 10^{-5}\text{ m}^2, \Delta\text{l} = 1.5\text{ mm} = 1.5*10^{-3}\text{ m, F} = 100\text{ N, Strain} = ?\ \text{Y} = ?\ \text{E} = ?$$

$$\text{Strain} = \frac{\Delta \text{l}}{\text{l}} = \frac{1.5*10^{-3}}{2.5} = 6*10^{-4} \qquad \text{Y} = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{strain} = \frac{100/0^{-5}}{6*10^{-4}} = 1.66*10^{10}\ Nm^{-2}$$

$$Energy = E = \frac{1}{2}\left[\frac{YA(\Delta l)^2}{l}\right] = \frac{1}{2}\left[\frac{1.66*10^{10}*10^{-5}(1.5*10^{-3})^2}{2.5}\right] = 7.5*10^{-2}\ J$$

17.4: What stress would cause a wire to increase in length by 0.01% if the Young's modulus of the wire is $12\times10^{10}\,Pa$. What force would produce this stress if the diameter of the wire is 0.56mm?

$$\text{Given Data : \%elongation} = \text{strain} = 0.01\% = 0.01/100 = 10^{-4}, Y = 12*10^{10}\,\text{Pa}, d = 0.56\text{mm}$$

$$r = d/2 = 0.56/2 = 0.28\text{ mm} = 0.28*10^{-3}\text{ m}, F = ?\ \text{As Stress} = F/A \text{ then } F = \text{Stress}*\text{Area} --- (1)$$

$$Y = \frac{\text{stress}}{\text{strain}} \Rightarrow \text{Stress} = Y*\text{strain} = 12*10^{10}*10^{-4} = 12*10^{6}\,\text{Pa} \quad \text{putting in eq (1)}$$

$$F = \text{Stress}*\text{Area} = 12*10^{6}*\pi r^{2} = 12*10^{6}*3.14(0.28*10^{-3})^{2} = 2.95\text{N}$$

17.5: The length of a steel wire is 1.0m and its cross-sectional area is $0.03\times10^{-4}\,m^{2}$. Calculate the work done in stretching the wire when a force of 100N is applied within the elastic region. Young's modulus of steel is $3.0\times10^{11}\,Nm^{-2}$.

$$\text{Given Data : } l = 1\text{ m}, A = 0.03*10^{-4}\text{ m}^{2}, F = 100\text{ N}, Y = 3*10^{11}\text{ Nm}^{-2}, \text{work } W = ?$$

$$W = \frac{1}{2}F*\Delta l --(1)$$

$$\text{To find } \Delta l \quad Y = \frac{F/A}{\Delta l/l} \Rightarrow \Delta l = \frac{F*l}{A*Y} = \frac{100*1}{0.03*10^{-4}*3*10^{11}} = 1.1*10^{-4}\,m, \text{putting in (1)}$$

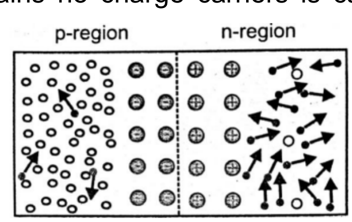
$$W = \frac{1}{2}F*\Delta l = \frac{1}{2}100*1.1*10^{-4} = 5.55*10^{-3}\,J$$

Chapter 18 Electronics

<u>Electronics</u>:"A Branch of science and technology that deal with flow of charge carriers through semiconductors is called Electronics".
<u>Main applications of Electronics</u>: Electronics has widely applications in every field of like TV, microwave oven, washing machine, cameras, digital watches, mobile and digital phones, calculators, computers, medical equipment's, industrial etc.

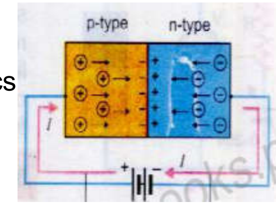
Brief review of PN Junction and its characteristics

<u>What is PN junction or semiconductor diode</u>? A crystal of silicon or germanium is grown in such a way that one half is doped with trivalent impurity (p type) and other half is doped with pentavalent impurity (n type), it is called pn junction.
<u>Name Majority charge carriers in n & p type substance</u>? In n type substance electrons are majority carriers. In p type substance holes are majority carriers
<u>Name Minority charge carriers in n and p type substance</u>? In n type substance holes are minority carriers. In p type substance electrons are minority carriers.
<u>What is Depletion region</u>? The region across the junction which contains no charge carriers is called depletion region.
<u>what is Potential barrier</u>? Due to formation of depletion region, a potential difference develops across the junction which stop further diffusion of electrons in p-type region.
This potential difference is called potential barrier.
Potential barrier for **silicon is 0.7 V and for Germanium is 0.3 V.**



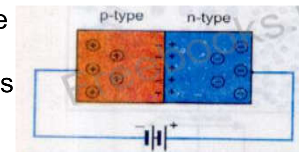
<u>What is Biasing? Describe forward and reverse biased pn junction.</u>
The process of connecting the battery to any device i.epn junction is called biasing. There are two types of biasing

i. Forward biasing
ii. Reverse biasing



Forward biased pn junction: A junction is forward biased when potential difference is applied in such a way that p-side is connected to positive terminal of battery and n-type is connected to negative terminal of battery. It has following characteristics

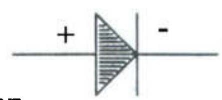
- Width of depletion is decreased in forward biasing.
- Resistance in forward biased is Very few ohm
- Formula for forward resistance is $r_f = \frac{\Delta V_f}{\Delta I_f}$.
- The graph b/w forward current and forward voltage is called forward characteristics



Reverse biased pn junction: A junction is reverse biased when potential difference Is applied in such a way that p-side is connected to negative terminal of battery and n-side is connected to positive terminal of battery. It has following characteristics

- The width of depletion region is increased in reverse biasing
- Resistance of high (mega ohm) is in reverse biasing.
- The graph b/w reverse current and reverse voltage is called reverse characteristics.

Symbol for DIODE

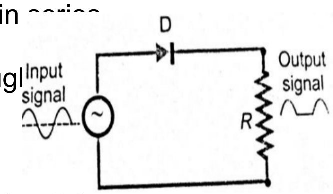


Symbolic representation of diode: Arrow head represents P region and also called anode. Vertical line shows n region and Called cathode
It is property to conduct current in one direction only in forward biased condition.

What is Rectification? Explain half wave and full wave rectification.

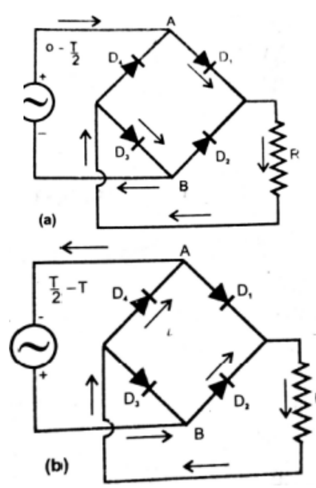
Rectification and rectifier:"The process of converting AC wave from into DC wave form is called rectification". And the device which converts AC waveform into DC waveform is called rectifier. It has two types

Half rectification: Such type of rectification in which only half of input AC is converted into DC is called half wave rectification.



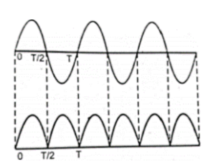
Consider an alternating voltage applied to diode D connected with resistance R in series
During the positive half cycle 0 to T/2 of input cycle,
The diode is forward biased so it will offer low resistance and current flows through
During the negative cycle T/2 to T of input cycle, the diode is reverse biased
And it offer very high resistance and current flow through R is almost zero
The same process continues for next cycles and so on for AC input,
Current will flow in one direction, so it is called direct current.This is called pulsating DC output.

Full wave rectification: Such type of rectification in which both input cycles of AC are converted into DC is called full wave rectification.



Let us consider a full wave rectifier circuit consists of four diodes
In the form of bridge that's why it is called bridge wave rectifier
Circuit.
During the positive half cycle 0 to T/2 of ac input, the terminal A of bridge
Is positive with respect to B, so diodes D1 and D3 becomes forward biased
And conducts
During the negative half cycle T/2 to T of ac input. The terminal A of bridge
Is negative with respect to B, so diodes D1 and D4 becomes forward biased
And conduct.
From the output of both half cycles current through R flows in the same direction
The output is pulsating dc. The pulsed can be removed by filter circuit
Filter circuit: such a circuit which is the combination of capacitors and inductors
Used to remove the pulses is called filter circuit.

Specially designed PN junction diodes



There are following most commonly used diodes

i. Light emitting diode(LED)
ii. Photo diode
iii. Photo voltaic cell

What is LED (Light emitting diode).write its two uses.

Such type of diode which is made up of gallium arsenide/phosphide in which potential barrier b/w p and n side is such that when electron combine with hole during forward biased a photon of visible light is emitted, is called LED.

Uses: There are following uses of LED

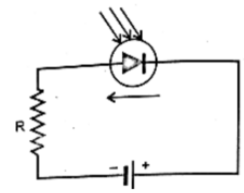
i. It is used as small light source as indicator
ii. A specially array of LEDs for displaying digits in electronic devices which is called seven segment display
iii. They are used in calculators and digital watches

What is Photo diode? Write applications.

The diode which convert light energy into electrical energy is called photo diode. It is used for detection of light and operated in reverse biased only. A photo diode can switch on and off in **nano seconds**.

Applications of photodiode: There are following applications of photodiode

i. Detection of visible and invisible light
ii. Automatic switching
iii. Logic circuits
iv. Optical communication devices



What is Photovoltaic cell? Write its one use.

It is pn junction in which potential barrier b/w p and n region is used to derive current through external circuit when light is incident on junction.. A single photovoltaic cell produces a small voltage0.6V and current of few mA.

They are in satellite to converts the solar energy into electrical power.

Practice MCQs

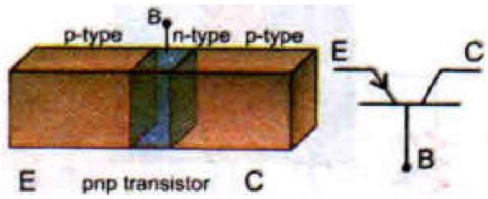
1	The reverse current through a semiconductor diode is due to	Holes	Electrons	Majority carriers	**Minority carriers**
2	The potential barriers for silicon at room temperature is	0.9V	0.3V	**0.7V**	0.5V
3	Process of conversion of AC into DC	**Rectification**	Amplification	Oscillation	Modulation
4	process of conversion of DC into AC	Rectification	Amplification	**Oscillation**	Modulation
5	The device used for rectification is called	**Rectifier**	Transformer	Thermistor	Wheat stone bridge
6	The diode characteristics curve is the graph between	Time and current	**Voltage and current**	Forward voltage and reverse current	None of these
7	Potential barrier for germanium is	0.9V	**0.3V**	0.7V	0.5V
8	The diode cannot be used as	**Amplifier**	Detector	Rectifier	Modulator
9	Photo diode is used for detection of	**Light**	Heat	Current	Magnet
10	Pulsating DC can be made smooth by using a circuit known as	**Filter**	Tank	Acceptor	All of these
11	The number of diodes in bridge rectifier is	2	3	**4**	5
12	The no. of LEDs needed to display all the digits is	4	6	**7**	8
13	The potential barrier in a diode stops the movement of	Holes only	Electrons only	**Both electrons and holes only**	None of these

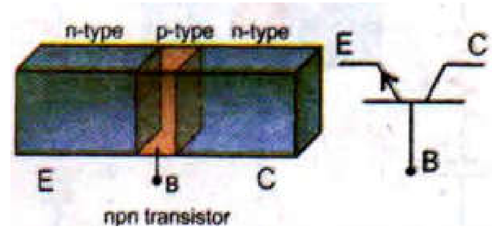
14	In n type minority carrier are	Free electrons	**Holes**	Protons	Mesons
15	A potential barrier of 0.7V exist across pn junction made from	**Silicon**	Germanium	Indium	Gallium
16	When a PN junction is reverse biased the depletion region is	**Widened**	Narrowed	Normal	No change
17	The output voltage of a rectifier is	Smooth	**Pulsating**	Perfectly direct	Alternating
18	A LED emits light only when it is	Reverse biased	**Forward biased**	Unbiased	None
19	Which factor does not affect the conductivity of PN junction diode	Doping	Temperature	Voltage	**Pressure**
20	The size of depletion region is of the order of	**10^{-6}m**	10^{-4} m	10^{-3}m	10^{-2} m
21	Minority carriers in p type substance	Protons	Holes	**Electrons**	Neutrons
22	Photo diode can turn its current on and off in	Micro second	Milli second	**Nano second**	Pico second
23	Reverse current through PN junction is	Infinite	Zero	**Less than forward current**	Greater than forward current
24	Holes can exist in	Super conductor	Conductor	**Semi-conductor**	Insulator
25	In forward biasing, the value of resistance is	Large	Very large	Small	**Very small**
26	Light emitting diodes (LEDs) are made from semiconductor	Silicon	Germanium	Carbon	**Gallium arsenide**
27	Potential difference across the two terminal of silicon diode is	0.3V	**0.7V**	0.9V	1.2V
28	In photovoltaic cell, current is directly proportional to	Wavelength of light	**Intensity of light**	Frequency of light	Energy
29	For an ideal diode resistance in forward biased	**Zero**	Infinity	Negative	None
30	For an ideal diode resistance in reverse biased	Zero	**Infinity**	Negative	None
31	The mobility of electrons ---- the mobility of holes therefore npn devices are fast and preferred	**2 to 3 times**	5 to 7 times	9 to 11 times	10 to 12 times
32	The magnitude of voltage gain of an amplifier having r_{ie}=1 ohm, β=100, R_c=200 ohm	**20000**	1000	50	5

What is Transistor? Give the types of transistor.

The word transistor is derived from "Transfer resistor". It is multi electrode semiconductor device that amplifies the electrical signal when transferred through it from its input terminal to output terminal. Transistor was firstly invented by John Bardeen in 1948.

Definition: A transistor consists of a single crystal of Ge or Si which is grown in such a way that it has three regions (base, emitter and collector). OR Two back to back pn junctions made in a single piece of semiconductor crystal is called transistor





Types: There are two types of transistor

i. p-n-p transistor
ii. n-p-n transistor

p-n-p transistor: Such type of transistor in which n type substance is sandwiched b/w two p type substances is called p-n-p transistor.

n-p-n transistor: Such type of transistor in which p type substance is sandwiched b/w two n type substances is called n-p-n transistor.

Main parts of transistor: There are three main parts of transistor

Base: the central region which is very thin of size **10^{-6} m** is called base. It control the flow of electrons from emitter to collector.

Emitter: the region has greater concentration of impurity than collector. The width of emitter is slightly smaller than in size as compared to collector

Collector: it is larger than emitter and used to collect charge carriers through base. Collector is comparatively larger in size than the emitter and has less concentration of impurity as compared to emitter.

What are the Junctions in transistor and biasing requirement under normal operation.

There are two junctions in transistor

i. Emitter base junction
ii. Collector base junction

Biasing requirements under normal operation of transistor:

Emitter base junction is **forward biased** Collector base junction is **reverse biased**

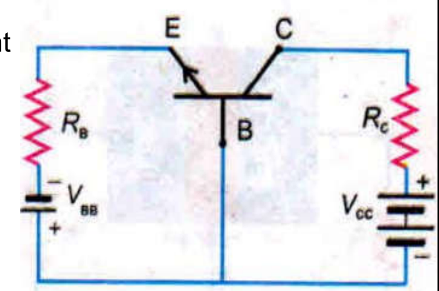
Explain the Current flow through npn transistor.

Let us consider the flow of current in an npn transistor as shown in fig.

In this emitter base junction is forward biased, so emitter injects a larger number of electrons in base region. The free electrons in the base can flow in either flow out of base to positive terminal of V_{BB} or they can be attracted towards the collector due to V_{CC}.

Electronic current I_E flow from emitter to base, a very small part of current I_B flow out of the base and remaining current I_C flow out of the collector

$I_E = I_C + I_B$ --- (1)



Current gain: The ratio of collector I_C to base current I_B is called current gain.

$\beta = \dfrac{I_C}{I_B}$. It value ranges from 30 to 500.

What are the advantages& disadvantages of transistor?

Advantages of transistor: Transistors have small size, light weight, low cost, Longer life.

Disadvantages: transistor is highly sensitive for temperature and low current Handling.

What is amplifier? How Transistor is used as an amplifier? Derive the formula for gain.

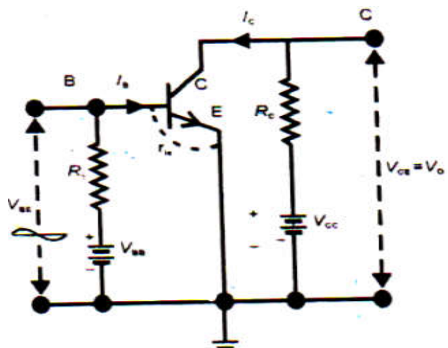
Amplifier: A device for reproducing a small value electrical signal into large value of signal is called amplifier.

Transistor as an amplifier: In maximum electronic circuits, transistors are basically used as an amplifier. An amplifier is thus the building block of every complex electronic circuit so that study of transistor is very important.

Construction: In normal operation of transistor emitter base is used as input terminals and base collector is used as output terminals. V_{BB} forward biased the emitter base junction and V_{CC} reverse biased the base collector junction. Vcc is very greater than V_{BB}. V_{BE} and V_{CE} are the input and output voltages respectively as shown in fig.

Gain of amplifier:

The base current is $I_B = \frac{V_{BE}}{r_{ie}}$, r_{ie} is base emitter resistance and transistor amplifies the base current β times



$$Ic = \beta I_B$$

$$Ic = \beta \frac{V_{BE}}{r_{ie}} ------------(1)$$

output voltage $Vo = V_{CE}$

$$V_{CC} = I_C R_C + V_{CE}$$

$V_{CE} = V_{CC} - I_C R_C$ putting the value of I_C

$$V_{CE} = Vo = V_{CC} - \beta \frac{V_{BE}}{r_{ie}} R_C ----------------(2)$$

When a small voltage signal ΔV_{in} is applied at input terminals

V_{BE} changes to $V_{BE} + \Delta V_{in}$ I_B changes to $I_B + \Delta I_B$

I_c changes to $I_c + \Delta I_c$ V_o changes to $V_o + \Delta V_o$

putting the above values into in equation (2)

$$V_o + \Delta V_o = V_{CC} - \beta \frac{(V_{BE} + \Delta V_{in})}{r_{ie}} R_C -----------(3)$$

subtract equation (3) from equation (2)

$$V_o + \Delta V_o - Vo = V_{CC} - \beta \frac{(V_{BE} + \Delta V_{in})}{r_{ie}} R_C - V_{CC} + \beta \frac{V_{BE}}{r_{ie}} R_C$$

$$\Delta V_o = -\beta \frac{(V_{BE})}{r_{ie}} R_C - \beta \frac{(\Delta V_{in})}{r_{ie}} R_C + \beta \frac{V_{BE}}{r_{ie}} R_C$$

$$\Delta V_o = -\beta \frac{R_C}{r_{ie}}$$

$\frac{\Delta V_o}{\Delta V_{in}} = -\beta \frac{R_C}{r_{ie}}$, As the ratio of output voltage to input voltage is called voltage gain denoted by G so

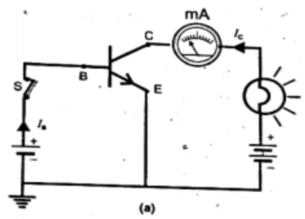
$G = -\beta \frac{R_C}{r_{ie}}$, - ive sign shows there is phase shift of 180° b/w input and output signals..

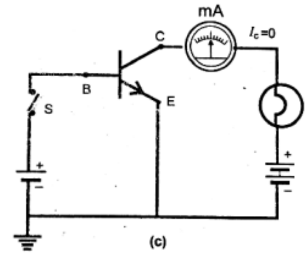
How Transistor is used as switch?

Transistor is used as switch in many electronic circuits. The emitter and collector behave as the terminals of switch.

The circuit in which the current is to be turned off and on is connected across these terminals.
To turn on the switch, small potential V_B is applied across the base to emitter terminals
As shown in fig. so increase in base current I_B, heavy current IC starts flow in common
Emitter circuit, large collector current is possible only when there is small resistance b/w
Collector and emitter and potential drop across CE is nearly 0.1 V.
To turn off switch: In this the base current I_B by opening the circuit is zero
So collector current is also zero, at this stage the resistance b/w C and E is nearly infinity

As shown in fig



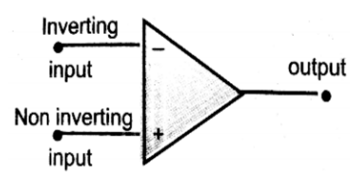


Practice MCQs

1	If I_E,I_B and I_C are emitter,base and coller current respectively in a transistor then	**$I_E=I_C+I_B$**	$I_C=I_E+I_B$	$I_B=I_C+I_E$	None of these
2	SI unit of current gain is	Ampere	Volt	Ohm meter	**No unit**
3	Central region of transistor is called	**Base**	Emitter	Collector	Neutral
4	In n-p-n transistor current does not flow in the direction from	Emitter to collector	Emitter to base	Base to collector	**Collector to emitter**
5	A circuit which converts low voltage to high voltage is called	**Amplifier**	Rectifier	Transistor	Inductor
6	When emitter base junction of transistor is reverse biased collector current	Reveres	Increase	Decrease	**Stops**
7	In npn transistor p works as	Collector	emitter	**Base**	Any of these
8	Base of transistor is very thin of the order of	10^{-2} m	10^{-4}m	**10^{-6} m**	10^{-8} m
9	An expression for current gain of transistor is given by ß=?	I_B/I_C	**I_C/I_B**	I_B+I_C	I_C-I_E

What is Operational amplifier? Write the characteristics of op-amp?

Operational amplifier: "Such an integrated amplifier silicon chip which is enclosed a capsule and pins are connected with working terminals such as input output and power supply is called operational amplifier".
Symbolic representation of Op-amp:
Two input terminals

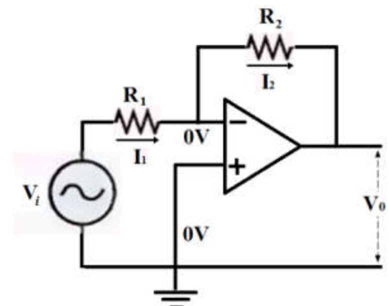


Inverting input: A signal applied at inverting input terminals has Phase shift of 180°.
Non inverting input: A signal applied at non-inverting has no phase Shift.
Characteristics of op-amp: There are following characteristics of op-amp
Input resistance: The resistance b/w positive and negative inputs of amplifier whose value is several mega ohm
Output resistance: The resistance b/w output terminal and ground. Its value is few ohm
Open loop gain: The ratio of output voltage to voltage differences b/w inverting and non-inverting inputs when no external connection is made $AoL = \frac{Vo}{Vi}$, open loop gain is 10^5.

What is inverting amplifier? Explain Operational amplifier as inverting amplifier.

<u>Inverting amplifier: </u>“Such an amplifier in which output amplified signal has phase shift of 180° with respect to input signal is called inverting amplifier”. Its gain is $G = -\frac{R_2}{R_1}$.

Gain of inverting amplifier: Let us consider a circuit in input signal V_{in} which is to amplified, is applied at inverting terminals (-) through resistor R1 and Vo is its output. Non inverting terminal (+) is grounded, its potential is zero, As Vo may have any value b/w +Vcc 12V and –Vcc (-12V) as shown in fig



$$\text{Current through } R_1 = I_1 = \frac{V_{in}}{R_1} ------------(1)$$

$$\text{Current through } R_2 = I_2 = \frac{V_- + (-Vo)}{R_2} = \frac{0 - Vo}{R_2} = \frac{-Vo}{R_2} ------(2)$$

Using Kirchoff current rule $I_1 = I_2$

$$\frac{V_{in}}{R_1} = \frac{-Vo}{R_2}$$

$$\frac{Vo}{V_{in}} = -\frac{R_2}{R_1},$$ As the ratio of output to input voltage is called voltage gain so

$$G = -\frac{R_2}{R_1}$$, This is called gain of inverting amp. $-$ive sign shows the phase shift of 180° w.r.t input signal

WHAT IS NON INVERTING AMP? EXPLAIN OP-AMP AS NON INVERTING AMPLIFIER.

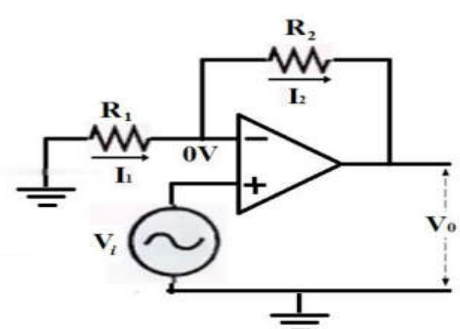
<u>Non-inverting amplifier</u>: Such an amplifier in which output amplified signal and input signals are in same phase is called non inverting amplifier, its gain is $G = 1 + \frac{R_2}{R_1}$.

Gain of non-inverting amplifier: let us consider a circuit of non-inverting amplifier. The input voltage Vi is applied across the non- inverting terminal (+). Open loop gain is high of the order of 10^5.
Gain:

$$\text{Current through } R_1 = I_1 = \frac{0 - V_{in}}{R_1} = \frac{-V_{in}}{R_1} ------------(1)$$

$$\text{Current through } R_2 = I_2 = \frac{V_- + (-Vo)}{R_2} = \frac{V_i - Vo}{R_2} ------(2)$$

Using Kirchoff current rule $I_1 = I_2$



$$\frac{-V_i}{R_1} = \frac{Vi - Vo}{R_2}$$

$$\frac{-V_i}{R_1} = \frac{Vi}{R_2} - \frac{Vo}{R_2}$$

$$\frac{Vo}{R_2} = \frac{V_i}{R_2} + \frac{V_i}{R_1} = V_i[\frac{1}{R_2} + \frac{1}{R_1}]$$

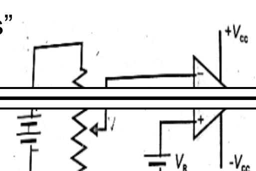
$$\frac{Vo}{V_{in}} = R_2[\frac{1}{R_2} + \frac{1}{R_1}]$$

$$G = \frac{R_2}{R_2} + \frac{R_2}{R_1}$$

$$G = 1 + \frac{R_2}{R_1}$$ This is called gain of non-inverting amp. $+$ive sign shows that input and output signals are in phase

What is comparator? How Operational amplifier is used as comparator?

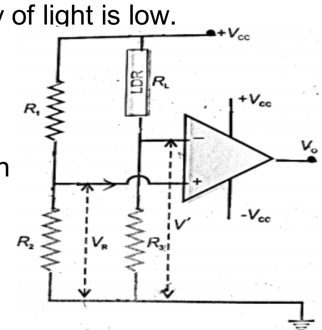
<u>Comparator</u>: “An electrical circuit which is used to compare the voltage signal levels”
In op-amp two inputs of equal but opposite polarity are required



Most op-amp operates with V_{CC}=±12V.
As open loop gain of op-amp is high so small change in potential b/wive and positive inputs produces such a large amplified out put that gets saturated.
VR=reference voltage is connected with + terminal
V= Compared voltage is connected with –ive terminal.
When V->V+ or V>V_R then Vo= -Vcc
When V- < V+ or V<V_R then Vo= +Vcc

What is night switch and LDR? How OP- AMP is used AS A NIGHT SWITCH?

Automatic night switch: It remains closed when the intensity of light is sufficient and it switches ON the light when the intensity of light falls below a required level.
Light dependent resistor (LDR): It is light dependent resistance whose resistance depends on light. It has low resistance when intensity of light is high and high resistance when intensity of light is low.



During day time, when light falls on LDR, R_L is small so from equation

$V_R = \frac{R_2}{R_1 + R_2} Vcc$ V will be large V>VR so that Vo=-Vcc

The output of op-amp is connected with relay system which switches only when Vo=+Vcc
Relay switch: This is system which switches on only whenVo=+Vcc.

Digital system

Digital system: A system that deal with quantities or variables which has two values Or states is called digital system.
Logic gates: The circuits which are used to perform switching action are called logic gates.
What are Fundamental logic gates? There are three fundamental logic gates
(1) OR gate (2) AND gate (3) NOT gate

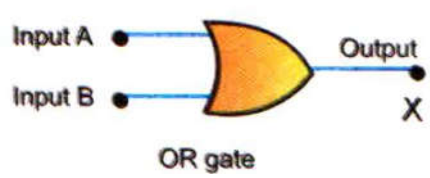
What is OR gate? Write its equation and truth table.

OR gate consists of two or more input but single output and it perform the function of addition when all inputs or either input is 1 then it show 1 other wise zero $X = A + B$

Truth table of OR gate.

2 input OR gate

A	B	X=A+B
0	0	0
0	1	1
1	0	1
1	1	1



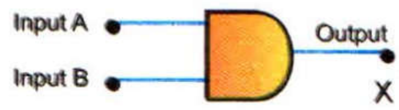
What is AND Gate? Write its equation and truth table?

AND gate consists of two or more inputs and one output and perform the function of multiplication, if all input are 1 then it shows 1 other wise zero.
$X = A.B$

Truth table of AND gate

2 input AND gate

A	B	X=A.B
0	0	0
0	1	0
1	0	0
1	1	1



AND gate

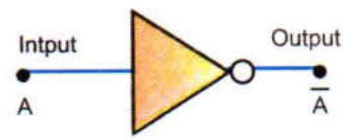
What is NOT gate? Write its equation and draw its truth table.

The gate which perform the operation of inversion is called NOT gate. $X = \overline{A}$

Truth table of NOT gate

NOT gate

A	$X = \overline{A}$
0	1
1	0



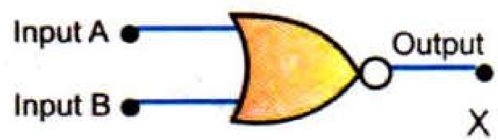
NOT gate

What is NOR gate? Write its equation and draw its truth table.

The combination of NOT gate and OR gate is called NOR gate.
$X = \overline{A+B}$

2 input NOR gate

A	B	$X = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0



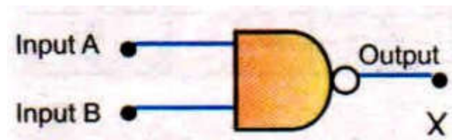
NOR gate

What is NAND gate? Write its equation and draw its truth table.

The combination of NOT and AND gate is called NAND gate.
$X = \overline{A.B}$ Symbol
Truth table of NAND gate

2 input NAND gate

A	B	$X = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0



NAND gate

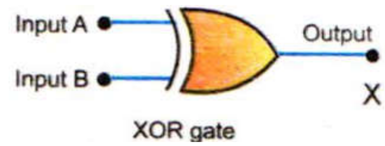
NAND and NOR gates are called universal gates.

What is Ex OR gate? Write its equation and draw its truth table?

A gate which is constructed by AND,OR and NOT gate is called Ex-OR gate. $X = A.\overline{B} + \overline{A}.B$

Truth table of XOR.

2 input XOR gate



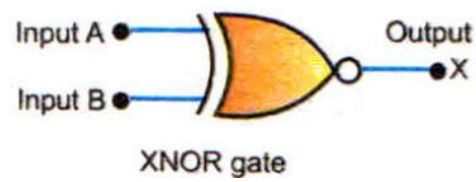
A	B	$X = A.\overline{B} + \overline{A}.B$
0	0	0
0	1	1
1	0	1
1	1	0

What is X NOR gate? Write its equation and draw its truth table?

The gate which is obtained by inverting the output of XOR gate is called XNOR gate $X = \overline{A.\overline{B} + \overline{A}.B}$

Truth table of XNOR gate.

2 input XNOR gate



A	B	$X = \overline{A.\overline{B} + \overline{A}.B}$
0	0	1
0	1	0
1	0	0
1	1	1

DESCRIBE THE APPLICATIONS OF LOGIC GATES.

Sensors: The device which converts various physical quantities into electrical voltage is called sensor. For example LDR, microphone thermistor etc.

- Logic gates are widely used in control system.
- They control the temperature, pressure or some other physical quantities of the system.
- As gates only operate with electrical voltage so they require sensor.

ICs:ICs are integrated circuits chips are manufactured on wafers of semiconductor material.

Practice MCQs

1	The term inverter is used for	NOR gate	NAND gate	**NOT gate**	AND gate
2	Mathematical notation for NOT gate is	**X=$\overline{A}$**	X=$\overline{A}.B$	X=$\overline{A.B}$	X=$\overline{A+B}$
3	Which one of the following is called fundamental gate?	NOR gate	**NOT gate**	NAND gate	Ex-OR gate
4	Two input NAND gate with inputs A and input B has an output zero if	B=0	**A=B=1**	A=B=0	None of these
5	The mathematical notation for NAND gate is	X=$\overline{A}$	X=$\overline{A}.B$	**X=$\overline{A.B}$**	X=$\overline{A+B}$
6	The electric circuit which gives the inversion process	XNOR gate	OR gate	AND gate	**NOT gate**
7	Any logical expression can be	AND gate	NAND gate	**AND,OR,NOT**	NOT gate

	realized using only			**gate**	
8	If both inputs are low the output is high for	OR gate	AND gate	XOR gate	**NOR gate**
9	Universal gate is the gate which can perform the function of switching	Buffer gate	**Any logic gate**	Any basic	Any exclusive gate
10	Gain of operational amplifier as inverting amplifier is given as G=?	R1/R2	R1xR2	**-R2/R1**	-R1/R2
11	The magnitude of open loop gain of operational amplifier is of the order	10^3	**10^5**	10^7	10^9
12	The device which keeps to work on the input with amplification is called	**Op-amp**	Inverter	Diode	None of these
13	LDR is abbreviated for	**Light dependent resistance**	Light depositing resistance	Light doped resistance	All of these
14	For non-inverting amplifier if R1=infinity and R2=0 then gain of amplifier is	-1	**+1**	Zero	Infinite
15	Gain of operational amplifier is the independent of	**Internal structure**	External structure	Batteries	Potential changes
16	Logic gates can control some physical parameters like	**Temperature, pressure**	Current, voltage	Resistance, inductance	Capacitance, impedance
17	The basic logic gate whose output is 1 when input are different	AND	**OR**	NOT	NAND
18	Integrated amplifier is known as	Power amplifier	Push pull amplifier	**Operational amplifier**	Current amplifier
19	Automatic function of street light can be one by use of	Inductor	Capacitor	Emf	**Comparator**
20	An op-amp can be used as	Comparator	Inverting amplifier	Non inverting amplifier	**All of these**
21	Automatic working of street light is due to	Inductor	Capacitor	**Comparator**	Rectifier
22	Gain of op amplifier in the R=infinity and R2=0	Infinity	**One**	Zero	-1
23	A NAND gate with two input A&B has an output zero if	A is zero	B is zero	Both A&B zero	**Both A&B are 1**
24	The output of AND gate will be one if	Both input are 1	Either input is one	**Both input are one**	None of these

25	A complete amplifier circuit made on a silicon chip and enclosed in a small capsule is used as	Diode	Inductor	Resistor	**Operational amplifier**
26	Which one can be used as temperature sensor in electric circuit	Capacitor	Diode	LDR	**Thermistor**
27	The circuit which compare two voltages	LDR	Sensor	**Comparator**	Logic gate

EXERCISE SHORT QUESTIONS

1.How does the motion of an electron in an n-type substance differ from the motion of holes in a p-type substance?**

In n-type material, the electrons are the majority carriers. They move from lower potential to higher potential. In p-type materials, the holes are the majority carriers. They move from higher potential to lower potential.

2.What is the net charge on an n-type or a p-type substance?**

Net charge on n type or p type substance is zero. They have only charge when they are connected to battery. Otherwise all the atoms in an n type or p type substance are electrically neutral as doping does not change the proportion of negative and positive charges.

3.The anode of a diode is 0.2 V positive with respect to its cathode. Is it forward biased?**

Yes , it forward biased as anode is positive with respect to cathode, but potential barrier for silicon is 0.7 V and Ge is 0.3 V so diode will no conduct in both.

4.Why charge carriers are not present in the depletion region?**

As during the formation of pn junction free electrons near the junction in the n region begin to diffuse across the junction into the p-type region where they combine with holes near the junction, and neutralize holes in p-type. As a result, a charge less region is formed across the junction in which charge carriers are not present. This region is known as depletion region.

5. **What is the effect of forward and reverse biasing of a diode on the width of depletion region?

When the diode is forward biased, the width of depletion region is decreased. When the diode is reversed biased, the width of depletion region is increased.

6.**Why ordinary silicon diodes do not emit light?**

Ordinary silicon diodes do not emit light because

i. It is opaque to light
ii. When electrons from n-side cross the junction and recombine with holes on p side most of energy is released in the form of heat, that's why they do not emit light

7.Why a photo diode is operated in reverse biased state?**

Basically Photo diode is used for detection of light. It is operated in the reverse biased condition because

i. When no light is incident on the junction, the reverse current is almost negligible.
ii. When a photo diode is exposed to light, the reverse current increases with intensity of light.

8. ** Why is the base current in a transistor very small?

The base current in transistor is very small due to

i. Base is very thin as compared to emitter and base
ii. Base is very lightly doped
iii. very few charge carriers (electrons or holes)from emitter may combine with electrons or holes of base

9. What is the biasing requirement of the junctions of a transistor for its normal operation

Emitter base junction is forward biased
Collector base junction is reverse biased

10. What is the principle of virtual ground?**

As open loop gain of op-amp is very high of the order of 10^5. So the input voltage is reduced to such a small value that it may be assumed to be at the ground, this is called virtual ground mean not really grounded.

11. **The inputs of a gate are 1 and 0. Identify the gate if its output is (a) 0, (b) 1...

a) The gate may be AND, NOR or XNOR

b) The gate may be OR, NAND, XOR

Chapter 18

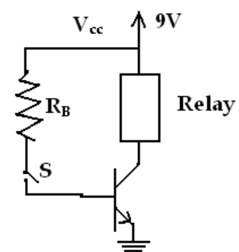
18.1: The current flowing into the base of a transistor is $100\,\mu A$. Find its collector current I_C, its emitter current I_E and the ratio I_C/I_E , if the value of current gain β is 100.

Given Data : $I_B = 100*10^{-6}$ A current gain $= \beta = 100$, Ic = ?I_E = ? Ration Ic/I_E = ?

$$\beta = \frac{Ic}{I_B} \Rightarrow Ic = \beta I_B = 100*100*10^{-6} = 10^{-2}\,A, \quad I_E = Ic + I_B = 10^{-2} + 100*10^{-6} = 10.1*10^{-3}\,A$$

$$\frac{Ic}{I_E} = \frac{10^{-2}}{10.1*10^{-3}} = 0.99$$

18.2: Fig. shows a transistor which operates a relay as the switch S is closed. The relay is energized by a current of 10mA. Calculate the value R_B which will just make the relay operate. The current gain β of the transistor is 200. When the transistor conducts, its V_{BE} can be assumed to be 0.6V.



Given Data : Ic = 10mA $= 10*10^{-3}$ A, gain $= \beta = 200$, $V_{BE} = 0.6$V, $V_{CC} = 9$V, R_B = ?

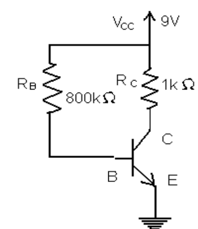
As we know that $R_B = V/I_B$ so first of all value calculate I_B and V

$$\beta = Ic/I_B \Rightarrow I_B = Ic/\beta = 10*10^{-3}/200 = 0.5*10^{-4}\,A$$

$V = V_{cc} - V_{BE} = 9 - 0.6 = 8.4\,volt$ Putting in R_B

$$R_B = \frac{V}{I_B} = \frac{8.4}{0.5*10^{-4}} = 168*10^3\,ohm = 168K\Omega$$

18.3: In circuit (Fig.P.18.3), there is negligible potential drop between B and E, where β is 100, calculate (i) base current (ii) collector current (iii) potential drop across R_C (iv) V_{CE}.



Given data : Vcc = 9V, $V_{CE} = 7.875$V, Rc = 1KΩ $= 10^3\,\Omega$, $R_B = 100K\Omega = 100*10^3\,\Omega$, $\beta = 100$, I_B = ? Ic = ?, Vc = ?

$$Ic = \frac{Vcc - V_{CE}}{Rc} = \frac{9 - 7.875}{10^3} = 1.125*10^{-3}\,A = 1.125mA$$

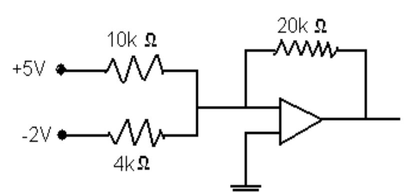
$$\beta = \frac{Ic}{I_B} \Rightarrow I_B = \frac{Ic}{\beta} = \frac{1.125*10^{-3}}{100} = 11.25*10^{-6}\,A = 11.25\mu A$$

$$Vc = IcRc = 1.125*10^{-3}*10^3 = 1.125volt$$

18.4: Calculate the output of the op-amp circuit shown in Fig.P.18.4.

Given Data : R1 = 10KΩ $= 10*10^3\,\Omega$, $R_2 = 4K\Omega = 4*10^3\,\Omega$, output of op – amp = Vo = ?

Using Kirchoff current rule, current through R_1 + Current through R_2 = Current through R_3



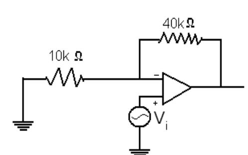
$$\text{Current through } R_1 = I_1 = \frac{5}{10*10^3} = 0.5*10^{-3}\,A - - - - - - - (1)$$

$$\text{Current through } R_2 = I_2 = \frac{-2}{4*10^3} = -0.5*10^3\,A - - - - - - - (2)$$

$$\text{Total current} = I = I_1 + I_2 = 0.5*10^{-3} + (-0.5*10^3) = 0$$

So output voltage is also = Vo = 0

18.5: Calculate the gain of non-inverting amplifier shown in Fig.P.18.5.



Given Data : $R_1 = 10K\Omega = 10*10^3\,\Omega$, $R_2 = 40K\Omega = 40*10^3\,\Omega$, Gain = ?

$$Gain = G = 1 + \frac{R_2}{R_1} = 1 + \frac{40*10^3}{10*10^3} = 1 + 4 = 5$$

CHAPTERS 19 DAWN OF MODERN PHYSICS

WHAT IS MODERN PHYSICS? The study physics after 1900 AD is called modern physics. Max Planks is pioneer of it.

Write the Phenomenon's which could not explain by the laws of classical physics?

i. Black body radiations
ii. Photo electric effect
iii. Compton effect
iv. Emission of spectral line by atoms
v. Invariance of speed of light

Relative motion: The change of position of an object with respect to another object is called relative motion.

What is Frame of reference? Define inertial and non-inertial frame of reference.

Frame of reference: Any co-ordinate system according to which measurements are taken is called frame of reference

There are two types of frame of reference

i. Inertial frame of reference
ii. Non inertial frame of reference

Inertial frame of reference: A co-ordinate system in which law of inertia hold good is called inertial frame of reference, for example Earth may be considered as inertial.

Non- inertial frame of reference: A co-ordinate system in which law of inertia is no valid is called non inertial frame of reference. When a moving car is suddenly stopped is an example of non-inertial.

What is general and Special Theory Of Relativity? Write the postulates of STR.

Theory of relativity: The theory of relativity deals with those cases in which observer are in state of relative motion, it has 2 types

i. General theory of relativity
ii. Special theory of relativity

General theory of relativity: The theory of relativity which deals with problems involving non inertial frame of reference is called general theory of relativity.

Special theory of relativity: The theory of relativity deals with problems involving inertial frame of reference is called specially.

Postulates of special theory of relativity: There are following two postulates of special theory of relativity

i. The laws of physics are same in all inertial frame of references
ii. The speed of light in free space has constant value

Explain the Results of special theory of relativity.

There are following results of special theory of relativity. STR results can be applied on all timing processes like physical, chemical and biological processes.

Time dilation: According to STR time is not absolute quantity. It depends upon the motion of frame of reference and time has dilated due to relative motion of observer and frame of reference.

Proper time and relativistic time: The time interval which is measured when observer is at rest is called proper time and the time which is measured when observer is moving with frame of reference is called relativistic time. $t = \frac{t_o}{\sqrt{1-v^2/c^2}}$. Where $\sqrt{1-v^2/c^2}$ is called Lorentz factor whose value is always less than one. Aging process is slowed by motion at very high speed.

Length contraction: The relative motion of two points the distance b/w two points appears to be shorter than when you were at rest relative to them, this effect is called length contraction.

Proper length and relativistic length: The length of an object or distance measured by an observer who is at rest is called proper length and if an observer and object are in relative motion with speed v ten contracted length is called relativistic length. $l = l_o\sqrt{1-v^2/c^2}$.

Mass variation: According to STR result mass of an object is varying quantity

Proper mass and relativistic mass: The mass of an object measured by observer which is at rest is called proper mass. And the mass when the object move relative to the frame of reference. $m = \frac{m_o}{\sqrt{1-v^2/c^2}}$.

Energy mass relation: According to STR results mass and energy are interconvert able by using equation $E = mc^2$.

What is NAVSTAR?

NAVSTAR stands for Navigation satellite and ranging, it is used to find the position and speed of an object anywhere on earth upto accuracy of **2cm/sec** but if relativity affects are not taken into account the speed could not be determined closer to **20 cm/sec** and position with upto **50m** as compared to **760m** without use of relativistic affects.

Practice MCQs

1	By using NAVSTAR speed of an object can now be determined to an accuracy	20 cm/sec	760cm/sec	50 cm/sec	**2 cm/sec**
2	Einstein presented special theory of relativity in	1850	1920	**1905**	1932
3	Aging process of human body is slowed by motion at very high speed according to	Newton	**Einstein**	Faraday	Coulomb
4	In 1905 special theory of relativity was proposed by	Maxwell	De-Broglie	Bohr	**Einstein**
5	If rest mass of particle is mo and relativistic mass is m then kinetic energy of particle is	mc^2	½ mv^2	**$(m-m_o)c^2$**	m_oc^2
6	All motions are	Absolute	Uniform	**Relative**	Variable
7	Einstein mass energy equation is	**$E=mc^2$**	$E=mc^3$	E=mc	$E=m^2c^2$
8	Einstein was awarded Nobel prize in Physics	1905	1911	1918	**1921**
9	The mass of an object will be doubled at speed	**$2.6*10^8$ m/s**	$1.6*10^8$ m/s	$3.6*10^8$ m/s	$0.6*10^8$ m/s
10	Aging process of human body is – by motion at very high speed	Fast	**slowed**	Remains same	None

What are BLACK BODY RADIATIONS? Give example.

Thermal radiations: When the body is heated, it emits radiations which are called thermal radiations. Nature of thermal radiation depends upon Temperature.
Black body radiations: The radiations emitted from a hollow black coated having small hole due to temperature are called black body radiations. The wave length of such radiations decrease with increase of temperature.
Ideal/ perfect black body: A body which absorbs the entire radiations incident upon it is called an ideal/perfect black body.
Example: When platinum wire is heated, it appears **dull red at 500°C**, **cherry red at 900°COrange red at 1100°C**, **yellow at 1300°CWhite at 1600°C.**

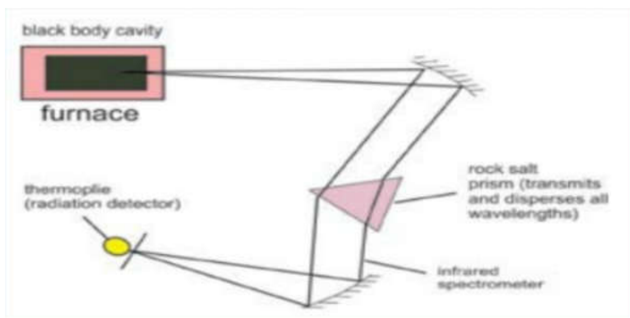
Explain Intensity distribution diagram facts.

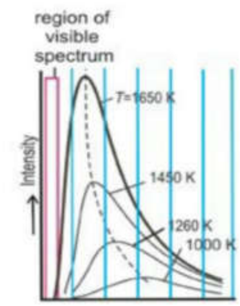
Lummer and Prinshiem measured the intensity of emitted energy with wavelength radiated from black body at different temperatures by the apparatus as shown in fig.
Facts/Results of energy distribution curves: There are following facts.

1. The energy is not uniformly distributed in the radiation spectrum of body at a given temperature.

2. **Wien displacement law:** At a given temperature T, wavelength corresponding to maximum energy is inversely proportional to absolute temperature. $\lambda_m \propto \frac{1}{T}$, $\lambda_m T = \text{constant}$ .The value of constant 0.0029 m K.
3. For all wavelengths, an increase in temperature causes an increase in energy emission. The ration intensity increase with increase in wavelength at a particular wavelength λ_{max} with further increase in wavelength, the intensity decreases.
4. Area under energy distribution curve represents total energy E radiated per second per square meter. "The amount of energy of all wavelengths radiated per second per unit area of black body is proportional to fourth power of absolute temperature"

$E \propto T^4$, $E = \sigma T^4$ $\sigma = \text{Stephen constant} = 5.67 * 10^{-8}\ Wm^{-2}K^{-4}$.





EXPLAIN PLANK'S ASSUMPTION ABOUT NATURE OF RADIATIONS.

Plank's assumption about nature radiation: Emission of energy from a matter is not continuous but it is emitted or absorbed by atom in black surface in the form of indivisible packet is called quanta. Energy of each quantum is proportional to the frequency. $E \propto f$, $E = hf$, $h = \text{planks constant} = 6.63 * 10^{-34}\ Js$.
He received Nobel Prize in 1918 for discovery of energy quanta.
Einstein photon theory: He postulated that light energy consist of packets or tiny bundles or tiny packets of energy which is integral part of all electromagnetic radiations that cannot be subdivided , these indivisible small particles are called photon by $E=mc^2$.
Practice MCQs

1	Platinum wire becomes yellow at temperature	500˚C	900˚C	1100˚C	**1300˚C**
2	In black body radiations at low temperature a body emits radiation of	**Long wavelength**	Small wave length	Medium wavelength	High wave length
3	Momentum of moving photon is	Zero	H	**h/λ**	λ/h
4	Radiation emitted by a human body at normal temperature 37˚ lies in	X-ray region	Visible region	**Infrared region**	UV region
5	If platinum wire is heated to 500˚C then it appears as	White	Yellow	Cherry red	**Dull red**
6	When platinum wire is heated, then it becomes --- at temperature about 1600˚C	**White**	Yellow	Green	Dull red
7	Joule second is the unit of	Energy	Wein constant	**Planks constant**	Boyle law
8	Which light photon has the least momentum	**Red**	Blue	Yellow	Green
9	In Stephen boltzman law $E=\sigma T^4$ "σ" is called	Plank constant	Stephen Boltzmann	**Stephen constant**	Boltzman constant

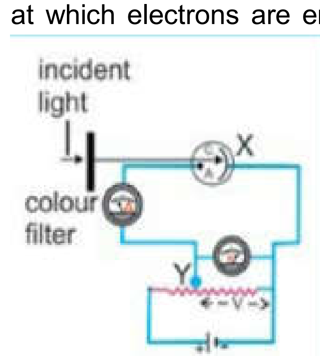
			constant		
10	The value of planks constant is	Zero	$6.63x10^{-34}$Js	**$6.63x10^{34}$Js**	$9x10^{9}$Js
11	0.1 kg mass will be equal to energy	**$9x10^{15}$J**	$9x10^{10}$J	$9x10^{12}$ J	$9x10^{16}$J
12	Planks constant has the same unit as that of	Linear momentum	**Angular momentum**	Torque	Power
13	Total amount of energy radiated per unit area of cavity radiator per unit time is directly proportional to	T	T^2	T^3	**T^4**
14	The name of photon for a quanta of light energy was first introduced by	Max plank	Wein	Bohr	**Einstein**
15	Platinum wire at 1300 C becomes	White	Cherry red	**Yellow**	Orange red
16	The value of Wein constant	**$2.9x10^{-3}$mK**	$2.9x10^{3}$mK	$5.67x10^{-8}$mK	0
17	Ratio of energies of two photons is same as the ratio of their	**Momentums**	Wavelengths	Range	None

WHAT IS PHOTO ELECTRIC EFFECT, STOPPING POTENTIAL AND THRESHOLD FREQUENCY.

Photo electric effect: When the light of a suitable frequency is incident on metal surface, the electrons are emitted from surface which are called photo electrons and this process is called photoelectric effect.
Photo electric current: the current produced by these photo electrons is called photoelectric current.
Explanation: Apparatus of photoelectric effect is shown in fig. An evacuated glass tube X contain two electrodes. The electrode A connected to the positive terminal of battery is known as anode. The cathode C connected to negative terminal is called cathode. When monochromatic light is allowed to shine on cathode, it starts to emit electrons. These photoelectrons are attracted by the positive anode and resulting current is measured by ammeter. The current stops when light is cut off which shows that current flows because of incident light. Frequency of incident light is proportional to maximum kinetic energy of photoelectrons.
Stopping potential: The negative potential of anode at which photoelectric current becomes zero is called stopping potential.Photoelectric current increase with intensity of light.
Threshold frequency: The minimum value of frequency of incident light at which electrons are emitted from a metal surface is called threshold frequency.

Important experimental results of photoelectric effect.

i. Photoelectrons are emitted with different energies
ii. Maximum energy of photoelectrons depends upon surface metal
And frequency of light
iii. Number of emitted electrons depends upon intensity of light.



Give the Einstein photo electric effect explanation.

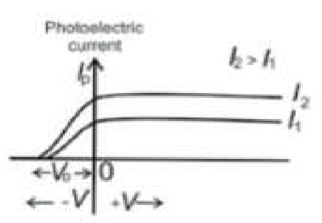
Einstein explains the photoelectric effect on the basis of plank's photon theory. He used the concept of work function
Work function: "The minimum energy required to escape the electrons from metal surface is called work function" $\varphi = hf$. SI unit of work function is joule.

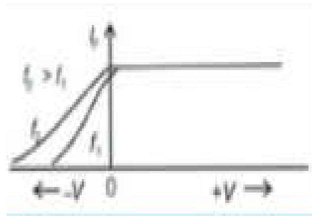
Einstein photoelectric effect equation:

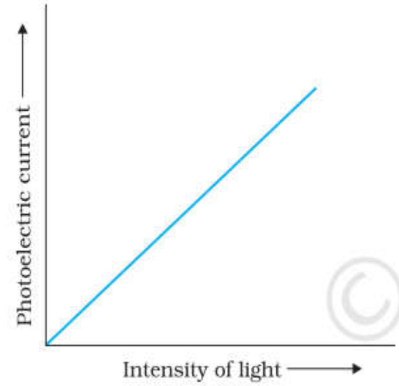
Energy of incident photon = Work function + Max K.E of electrons

$hf = \varphi + \frac{1}{2}mv^2$

$hf - \varphi = \frac{1}{2}mv^2$ This is called photoelectric effect equation



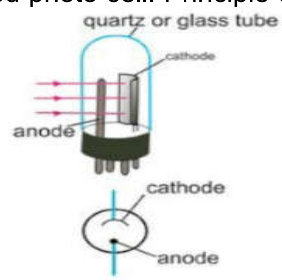




Einstein got Nobel Prize in 1921 for his explanation of photoelectric effect.

What is Photo cell? Write its uses.

Definition: A device convert's light energy into electrical energy is called photo cell. Principle of photocell is photoelectric effect.



Uses of photocell. There are following uses of photocell

i. Automatic door system
ii. Security system
iii. Counting system
iv. Exposure meter for photography
v. Sound track for movies
vi. Automatic street lightening

What is COMPTON EFFECT? Explain Compton shift formula.

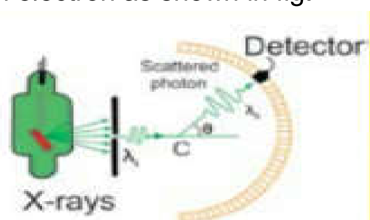
Compton Effect: The phenomenon in which the wavelength of scattered X-rays is larger than wavelength of incident rays is called Compton Effect. It was observed by Holy Compton in 1923.

Formula for Compton shift: The change in wavelength is called Compton shift. $\Delta\lambda = \frac{h}{m_o c}(1-\cos\theta)$.

Compton suggests that X-rays consists of photons when they collide with electron like billiards balls. In this collision, a part of incident photon energy and momentum is transferred to an electron as shown in fig.

Calculation of Compton shift:

Put Θ=90°, m_o =9.1*10^{-31}kg C=3*10^{8} m/s in formula $\Delta\lambda = \frac{h}{m_o c}(1-\cos\theta)$



$\Delta\lambda = \frac{6.63*10^{-34}}{9.1*10^{-31}*3*10^{8}}(1-\cos 90^o)$=2.43*10^{-12}m. $\frac{h}{m_o c}$ Has the dimension of length. This is called Compton wavelength. This confirms the particle like nature of electromagnetic radiation with matter.Holy Compton received Nobel Prize in 1927.

What is Pair production?

Pair production: When a high energy of gamma ray photon is converts into an electron and positron pair by collision of heavy nucleus is called pair production.

Materialization of energy: Because According to Einstein equation E=mc^2 energy (light) is converted into matter (electron, positron). It is called materialization of energy.

Positron: It is a particle having mass and charge equal in magnitude to that of electron but charge being of opposite nature. It is anti-electron. The existence of positron predicted by Dirac in 1928 and discovered by Anderson in 1932 and received Nobel Prize in 1935.

Minimum energy is required for pair production is 1.02 MeV. Pair production applied the law of conservation of charge, energy and momentum.

Prove that $2m_oc^2$=1.02 MeV

Put $m_o=9.1*10^{-31}$kg $c=3*10^8$ m/s$=2*9.1*10^{-31}$kg $(3*10^8)^2$
$=163.8*10^{-18}= 163.8*10^{-15}/1.6*10^{-19}=1.02*10^6$eV

What is ANNIILATION OF MATTER?

Definition: When electron and positron come close enough so that they destroy each other and converted into two photons in the range of gamma rays is called Annihilation of matter. It is Reverse process of pair production.

Particle and anti-particle theory: It states that every particle has a corresponding antiparticle with same mass and opposite charge. A particle and its anti-particle cannot exist together at one place, because when they meet and annihilate each other. Proton and anti-proton annihilation has been observed at Lawrence Barkley laboratory.

Practice MCQs

1	Momentum of photon is given by	hf/λ	**hf/c**	fλ	Hλ
2	Compton effect is observed with	**X-rays**	Visible light	Radio waves	All of these
3	Photon with energy greater then 1.02 MeV can interact with matter as	Photo electric effect	Compton effect	**Pair production**	All of these
4	Maximum Compton shift in the wavelength of scattered photon will at	**180˚**	90˚	45˚	60˚
5	The rest mass of X-ray photon is	Infinite	**Zero**	$9.1x10^{-31}$kg	None
6	Photo electric current depends on	Frequency of light	**Intensity of light**	Speed of light	Polarization of light
7	Electron is an anti particle of	Proton	Photon	**Positron**	Deuteron
8	The minimum energy required by a photon to produce electron positron pair is	2MeV	**1.02MeV**	0.51MeV	Zero
9	Due to annihilation of electron and positron the number of photons produced is	1	**2**	3	4
10	Compton effect prove nature of light	Wave nature of light	**Particle nature of light**	Dual nature of light	All of these
11	Photo diode can be used as	**Light**	Heat	Current	Magnet
12	The rest mass of photon is	m	Infinity	**Zero**	C
13	Compton shift is equal to Compton wavelength when scattered X-ray photon are observed at angle of	0˚	**90˚**	45˚	60˚
14	Maximum kinetic energy of photo electrons depends upon --- of incident light	**Frequency**	Intensity	Brightness	Power
15	In photo electric effect, which factor increases by increasing the intensity of incident photon	Kinetic energy of electrons	Stopping potential	Work function	**No. of emitted electrons**
16	The reverse process of photo electric effect is	Compton effect	**X-ray production**	Pair production	Annihilation

17	Free electrons are	Tightly bound	Fixed	**Loosely bound**	Tightly fixed
18	A positron is a particle having	**Mass equal to electron**	Charge equal to electron	Equal mass but opposite to electron	Mass equal to proton
19	The number of electrons emitted depends upon	Color of target surface	Shape of surface	Frequency of incident light	**Intensity of incident light**
20	The pair production is also called	Pair production	**Materialization of energy**	Fusion reaction	Fission
21	Wavelength associated with particle of mass m and moving with velocity v is	mv/h	hv/m	**h/mv**	m/hv
22	Photo diode can turn its current on and off in	Milli second	Micro second	**Nano second**	Pico second
23	Photo electric effect was explained by	Hertz	**Einstein**	Ruther ford	Bohr
24	Rest mass energy of an electron in MeV is equal to	**0.51**	0.61	0.902	1.02
25	Which one is the most energetic photon	**Gamma rays**	X rays	Uv rays	Visible light
26	When an electron combine with a positron we get	One photon	**Two photon**	Three photon	Four photon
27	The light of suitable frequency falling on a metal surface eject electrons this phenomenon is called	X-rays emission	Compton effect	**Photo electric effect**	Nuclear fission
28	Compton shift will be equal to Compton wavelength at angle of	0°	**90°**	45°	60°
29	Einstein was awarded Nobel prize in Physics	1905	1911	1918	**1921**
30	Potassium cathode in photocell emit electrons for a light	**Visible**	Infrared	Ultra violet	X-rays

What is de-Broglie hypothesis about Wave Nature Of Particle?

De Broglie hypothesis: "Electromagnetic waves as well moving electrons sometimes behave like wave and sometimes like particles" this is called de-Broglie hypothesis. He proposed this hypothesis in 1924.

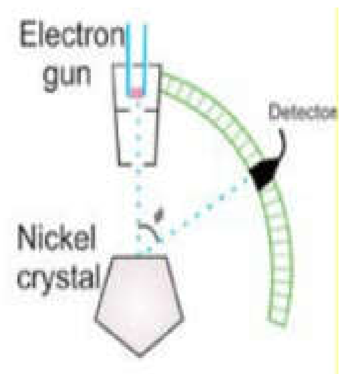
De-Broglie wavelength: The formula for de-Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$ holds only for microscopic particle.

De-Broglie wavelength for electron: $\lambda = \frac{h}{mv} == \frac{6.63*10^{-34}}{9.1*10^{-31}*1*10^{6}}$ $=7*10^{-10}$ m .

De- Broglie wavelength associated in X-rays range

DESCRIBE DAVISSON AND GERMER EXPERIMENT.

First experimental proof of de-Broglie wavelength was given by Davisson and Germer in 1926.
Experimental arrangement: The apparatus used in this experiment is shown in fig, in which the electron from a heated filament are accelerated by an adjustable applied voltage. Electron beam is incident on a nickel crystal and diffracted from crystal surface enters a detector and recorded as current I. The detector can move on a circular scale and Θ is the angle at which diffracted beam of electron is recorded and wavelength is calculated as follows.
The gain in K.E of electron as it accelerated by potential difference V in electron gun



$K.E = eV_o$

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

$mv^2 = 2eV_o$ Multipling both sides by m

$m^2v^2 = 2meV_o$

$mv = \sqrt{2meV_o}$

Using de - Broglie equation $\lambda = \frac{h}{mv}$

$$\lambda = \frac{h}{\sqrt{2meV_o}} = \frac{6.63*10^{-34}}{\sqrt{2(9.1*10^{-31})(1.6*10^{-19})(54)}} = 1.66*10^{-10} m = 1.66 A^o \; ----- (1)$$

Now by using Bragg's equation $2d\sin\theta = m\lambda \quad \theta = 65^o, d = 0.91*10^{-10}$ m, $m = 1$

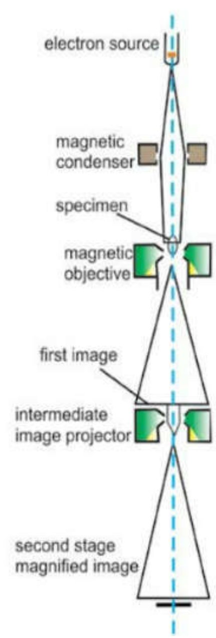
$(1) \lambda = 2*0.91*10^{-10}*\sin 65^o$

$\lambda = 1.65*10-10m = 1.65 A^o \; -------------- (2)$

Equation (1) and (2) shows that wavelength has same value.
For this work of dual nature of particle, de Broglie received nobel prize in 1929 and in 1937 Davisson and Germer shared the prize for this confirmation of hypothesis.
wave particle duality: Light behave as stream of particles/photons from a source when propagated act as wave and when it strike anything and exchange energy it acts as particle, interference and diffraction confirms its wave nature and photoelectric effect, Compton effect prove its particle nature.

WRITE A NOTE ON ELECTRON MICROSCOPE.

Definition: The device which is used for highly magnified and resolved image of object by means of highly energetic electrons is called electron microscope.
Principle: An electron microscope works on the principle of wave behavior of an electron.
Construction: Electron microscope has following main parts
Electron gun: This provide the beam of electrons by a potential difference of 30KV to several mega volt.
Magnetic condenser: This focus the electron beam on specimen.
In this microscope electric and magnetic field are used to focus.
Magnetic objective: Electrons falling on specimen are scattered out from thicker part of specimen enter the magnetic objective and first image of specimen is formed.
Intermediate image projector: This image projector is a magnetic coil which produces a real intermediate image.
Fluorescent screen: It is used to receive the highly magnified image of extremely small object under examination.
Image can be displayed on a special film is called electron micrograph.
Scanning electron microscope: A three dimensional image of very high quality can be Achieved by modern version, called scanning electron microscope.
Advantages of electron microscope: Electron microscope has following advantages



1) Electron microscope produces much higher magnification than optical microscope.
2) It has higher resolving power than optical microscope

3) A resolution of 0.5 nm to 1 nm is possible with 50 KV electron microscope while an optical microscope has best resolution has best optical resolution 0.2μm.

STATE AND EXPLAIN HEISENBERG UNCERTAINTY PRINCIPLE.

Statements: Uncertainty principle has two forms

Position- momentum uncertainty

i. Position and momentum of a particle cannot be measured at same time with perfect accuracy. $\Delta p \Delta x = h$ Where h is Plank's constant h=6.63*10^{-34}Js

Energy time uncertainty:

ii. The product of uncertainty in a measured amount of energy and time interval is equal to plank's constant. $\Delta E \Delta t = h$.

For more careful calculations we can use

$$\Delta x \Delta P \geq \hbar$$

$$\text{where } \hbar = \frac{h}{2\pi} = \frac{6.63*10^{-34}}{2*3.14} = 1.05*10^{-34}\,Js$$

Heisenberg received Nobel Prize in 1932 for the development of quantum mechanics.

Practice MCQs

1	Uncertainty principle related uncertainties in the measurement of energy and	Velocity	Momentum	**Time**	Mass of particle
2	Momentum of moving photon is	Zero	H	**h/λ**	λ/h
3	Davisson and Germer experiment indicates the	Interference	Polarization	**Electron diffraction**	Refraction
4	Free electrons are	Tightly bound	Fixed	**Loosely bound**	Tightly fixed
5	Who gave the idea of matter waves?	**De Broglie**	Plank	Einstein	Huygen
6	X-rays diffraction implies that radiation has a	Particle nature	**Wave nature**	Wave particle nature	None of these
7	The value of ħ in uncertainty principle	Zero	1.05x10^{-34}Js	**1.05x10^{34}Js**	9x10^{9}Js

Exercise short questions

1. **What are the measurements on which two observers in relative motion will always agree upon?

There are following measurements on two observer agree

i. Speed of light in free space
ii. Force on moving particle

2. **Does the dilation means that time really passes more slowly in moving system or that it only seems to pass more slowly?

According to special theory of relativity, time is relative Time seems to pass more slowly when an observer in one system in relativistic motion takes the measurement of the other system. $t = \frac{t_o}{\sqrt{1 - v^2/c^2}}$

3.If you are moving in a spaceship at a very high speed relative to the Earth, would you notice a difference (a) in your pulse rate (b) in the pulse rate of people on Earth?**

The pulse rate of a person who is travelling in a spaceship is not changed with respect to clock inside the spaceship.

But the person in spaceship will experience the change in pulse rate of the people on earth.

4. **If the speed of light were infinite, what would the equations of special theory of relativity reduce to?

If speed of light $C=\infty$ then $\frac{v^2}{c^2}=0$

$t=\frac{t_o}{\sqrt{1-v^2/c^2}}$, $t=t_o$ no time dilation

$m=\frac{m_o}{\sqrt{1-v^2/c^2}}$ $m=m_o$ no mass variation

$l=l_o\sqrt{1-v^2/c^2}$, $l=l_o$ no length contraction occur

$E=mc^2$ so $E=\infty$

5. since mass is a form of energy, can we conclude that a compressed spring has more mass than the same spring when it is not compressed?**

Yes, the compressed spring will have more mass because work done in compressed spring is converted into energy according to Einstein eq. $E=mc^2$

6. **As a solid is heated and begins to glow, why does it first appear red?

At lower temperature, a body emits radiation of low energy (longer wavelength). Since longest visible wavelength is red, so it appears red first.

7. What happens to total radiation from a blackbody if its absolute temperature is doubled?**

Total energy radiated per second is increased 16 time because according to Boltzmann law

$E=\sigma T^4$, in this case $T'=2T$, so $E'=\sigma(2T)^4$

$E'=\sigma(16T^4)=16\sigma T^4=16E$

8. **A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?

Beam of red light contain greater number of photons because when they have same energy then according to relation E=hf=hc/λ, number of photons is directly proportional to wavelength so red light has greater wavelength then blue light so it has greater no of photons.

9. Which photon, red, green, or blue carries the most (a) energy and (b) momentum?**

Blue light has most energy and momentum according to relation E=hc/λ, as blue light has shorter wavelength. And for momentum p=h/λ so it has maximum momentum due to shorter wavelength of blue light.

10. **Which has the lower energy quanta? Radiowaves or X-rays?

According to relation E=hc/λ radio waves have larger wavelength so it has lower quanta as compared to x rays.

11.****Does the brightness of a beam of light primarily depend on the frequency of photons or on the number of photons?**

The brightness of a beam depends upon intensity (number of photons) and not on the frequency of light. Thus brightness increases with intensity of light

12. When ultraviolet light falls on certain dyes. Visible light is emitted. Why does this not happen when infrared light falls on these dyes?

When ultra violet light falls on the dyes, the atoms of dyes are excited to higher energy states, on de excitation electrons return to lower energy level in steps so they emit visible light

In case of infrared light, photons emitted by atoms of dyes have frequency less than the least frequency of visible light

13. Will bright light eject more electrons from a metal surface than dimmer light of the same color?**

Since "number of electrons" ejected from metal surface depend upon the intensity of light (number of photons). Therefore, bright light being more intense will eject more electrons from a metal surface than dimmer light of same color.

14. **Will higher frequency light eject greater number of electrons than low frequency light?

No, the higher frequency light will not eject greater number of electrons than low frequency light. It is because of the reason that number of electrons emitted from metal surface depends upon intensity of light (number of photons) and not frequency of light.

15. When light shines on a surface, is momentum transferred to the metal surface?**

Yes momentum is transferred to metal surface. Because according to Einstein light photon behave like particles so when it is incident on metal surface, it transfer both its momentum and energy. For example in photo electric effect this occurs.

16. Why can red light be used in a photographic dark room when developing films, but a blue or white light cannot?**

As the frequency of red light is less as compared to blue light, so red light has less energy as compared to blue so cannot affect the photographic film. That's why red light can be used when developing films.

17. **Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B.?

Momentum of photon A is twice the momentum of photon B,

$$E = mc^2 = (mc)c = Pc$$

$$\text{as } E_A = 2E_B$$

$$\text{Momentum of photon } A = P_A = \frac{E_A}{c} = \frac{2E_B}{c} \text{......(1}$$

$$\text{Momentum of photon } B = P_B = \frac{E_B}{c} \text{.......... (2}$$

dividing both equations to get the result

$$\frac{P_A}{P_B} = \frac{\frac{2E_B}{c}}{\frac{E_B}{c}} = \frac{2}{1}$$

18. **Why don't we observe a Compton Effect with visible light?

We don't observe a Compton Effect with visible light because photons of visible light has low energy photon and momentum then the photon of X-rays.

19. **Can pair production take place in vacuum? Explain.

No, pair production can't take place in vacuum. Because, in vacuum, there is no heavy nucleus present. Pair production always takes place in the presence of a heavy nucleus.

20. Is it possible to create a single electron from energy? Explain.**

No it is not possible to create a single electron from energy. The creation of single electron from energy is violation of law of conservation of charge and momentum. Whenever pair production takes place, the electrons and positrons are created at the same time.

21. **If electrons behaved only like particles, what pattern would you expect on the screen after the electrons passes through the double slit?

If electron behave only like particles then then no interference pattern is observed. After passing through the double slit, only those parts of the screen are affected which are in front of the slit.

22. **If an electron and a proton have the same de Broglie wavelength, which particle has greater speed?

Electron will have the greater speed. According to de Broglie hypothesis velocity is inversely proportional to mass so electron have least mass and greater speed. $\lambda = \frac{h}{p} = \frac{h}{mv}, \lambda \propto \frac{1}{v}$

23. **We do not notice the de Broglie wavelength for a pitched cricket ball. Explain why?

According to de-Broglie hypothesis $\lambda = \frac{h}{p} = \frac{h}{mv}$ cricket ball has large mass, therefore wavelength associated with it is so small that it is not detected.

24. If the following particles have the same energy, which has the shortest wavelength? Electron, alpha particle, neutron, proton.**

Alpha particles have shortest wavelength

From the de-Broglie hypothesis, wavelength associated with moving particle is inversely proportional to mass, and alpha particles have greater mass then other so they have shortest wavelength. $\lambda \propto \frac{1}{\sqrt{m}}$.

25. **When does light behave as a wave as a particle?

Light behave as a wave when it travel from a source, like in interference, diffraction and polarization, light behave as particle when it interact with matter like in photo electric effect, Compton effect, pair production.

26. What advantages an electron microscope has over an optical microscope?**

There are following advantage of electron microscope

i. The resolving power of electron microscope is thousand times greater than an Optical microscope.

ii. The internal structure of an object can also be obtained by electron microscope which is not possible with optical microscope

27. If measurements show a precise position for an electron, can those measurements show precise momentum also? Explain.** No, those measurements cannot show precise momentum also. Because according to uncertainty principle position and momentum of a particle cannot be measured at the same time, if one measurement is precise then other will be uncertain. $\Delta x \Delta p = h,\ \Delta p = \frac{h}{\Delta x}$

Chapter 19

19.1: A particle called the pion lives on the average only about $2.6\times10^{-8}s$ when at rest in the laboratory. It then changes to another form. How long would such a particle live when shooting through the space at 0.95c?

$$\text{Given Data}: t_o = 2.6*10^{-8}\Omega, v = 0.95c, t = ?$$

$$t = \frac{t_o}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{2.6*10^{-8}}{\sqrt{1-\frac{(0.95c)^2}{c^2}}} = \frac{2.6*10^{-8}}{\sqrt{1-\frac{(0.95)^2c^2}{c^2}}} = 8.3*10^{-8}\text{ sec}$$

19.2: What is the mass of a 70 kg man in a space rocket traveling at 0.8 c from us as measured from Earth?

$$\text{Given Data}: m_o = 70\text{Kg}, v = 0.8c, m = ?$$

$$m = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{70}{\sqrt{1-\frac{(0.8c)^2}{c^2}}} = \frac{2.6*10^{-8}}{\sqrt{1-\frac{(0.8)^2c^2}{c^2}}} = 116.7\text{ Kg}$$

19.3: Find the energy of photo in

(a) Radiowave of wavelength 100m

(b) Green light of wavelength 550 nm

(c) X-ray with wavelength 0.2 nm

$$\text{Given Data}: \lambda_1 = 100\text{m},\quad \lambda_2 = 550\text{nm} = 550*10^{-9}\text{m},\quad \lambda_3 = 0.2*10^{-9}\text{m}\quad E_1, E_2, E_3 = ?$$

$$E_1 = \frac{hc}{\lambda_1} = \frac{6.63*10^{-34}*3*10^8}{100} = 19.89*10^{-28}J \Rightarrow \frac{19.89*10^{-28}}{1.6*10^{-19}} = 1.24*10^{-8}eV$$

$$E_2 = \frac{hc}{\lambda_2} = \frac{6.63*10^{-34}*3*10^8}{550*10^{-9}} = 0.036*10^{-17}J \Rightarrow \frac{0.036*10^{-17}}{1.6*10^{-19}} = 2.25eV$$

$$E_3 = \frac{hc}{\lambda_3} = \frac{6.63*10^{-34}*3*10^8}{0.2*10^{-9}} = 99.45*10^{-17}J \Rightarrow \frac{99.45*10^{-17}}{1.6*10^{-19}} = 6215.6eV$$

19.4: Yellow light of 577 nm wavelength is incident on a cesium surface. The stopping voltage is found to be 0.25V. Find

(a) The Maximum K.E. of the photoelectrons

(b) The work function of cesium

$$\text{Given Data}: \lambda = 577\text{nm} = 577*10^{-9}\text{m}, Vo = 0.25\text{V}, (\text{K.E})_{max} = ?\ \text{work function} = \varphi = ?$$

$$(\text{K.E})_{max} = eVo = 1.6*10^{-19}*0.25 = 4*10^{-20}J$$

$$hf = (\text{K.E})_{max} + \varphi \Rightarrow \varphi = hc/\lambda - (\text{K.E})_{max} = 6.63*10^{-34}*3*10^8/577*10^{-9} - 4*10^{-20} = 30.4*10^{-20}J \Rightarrow \frac{30.4*10^{-20}}{1.6*10^{-19}} = 1.9eV$$

19.5: X-rays of wavelength 22 pm are scattered from a carbon target. The scattered radiation being viewed at 85° to the incident beam. What is Compton shift?

$$\text{Given Data}: \lambda = 22\text{pm} = 22*10^{-12}\text{m}, \theta = 85^\circ, m_o = 9.1*10^{-31}Kg, c = 3*10^8 m/s, \Delta\lambda = ?$$

$$\Delta\lambda = \frac{h}{m_oc}(1-\cos\theta) = \frac{6.63*10^{-34}}{9.1*10^{-31}*3*10^8}(1-\cos85^\circ) = 2.2*10^{-12}m$$

19.6: A 90 keV X-ray photon is fired at a carbon target and Compton scattering occurs. Find the wavelength of the incident and the wavelength of the scattered photon for scattering angle of (a) 30^o (b) 60^o

$$\text{Given Data}: E = 90KeV = 90*10^3*1.6*10^{-19} = 144*10^{-16}\,J,\ \lambda = ?,\ \lambda' = ?,\ \lambda'' = ?$$

$$\lambda = \frac{hc}{E} = \frac{6.63*10^{-34}*3*10^8}{144*10^{-16}} = 13.8*10^{-12}\,m = 13.8\,pm$$

$$\text{For } \lambda' \text{ using } \Delta\lambda = \frac{h}{m_o c}(1-\cos\theta) \Rightarrow \lambda'-\lambda = \frac{h}{m_o c}(1-\cos\theta) \Rightarrow \lambda' = \frac{h}{m_o c}(1-\cos\theta)+\lambda$$

$$\lambda' = \frac{6.63*10^{-34}}{9.1*10^{-31}*3*10^8}(1-\cos 30^o)+13.8*10^{-12} = 14.12*10^{-12}\,m = 14.12\,pm$$

$$\lambda'' = \frac{6.63*10^{-34}}{9.1*10^{-31}*3*10^8}(1-\cos 60^o)+13.8*10^{-12} = 15.01*10^{-12}\,m = 15.01\,pm$$

19.7: What is the maximum wavelength of the two photons produced when a positron annihilates an electron? The rest mass energy of each is 0.51 MeV.

$$\text{Given Data}: E = 0.51MeV = 0.51*10^6*1.6*10^{-19} = 8.16*10^{-14}\,J,\quad \lambda = ?$$

$$\lambda = \frac{hc}{E} \Rightarrow \frac{6.63*10^{-34}*3*10^8}{8.16*10^{-14}} = 2.43*10^{-12}\,m = 2.43\,Pm$$

19.8: Calculate the wavelength of

(a): A 140 g ball moving at 40ms^{-1}

$$\text{Given Data}: m = 140g = 140*10^{-3}\,Kg,\ v = 40\,m/s,\ \lambda = ?\ \lambda = \frac{h}{mv} = \frac{6.63*10^{-34}}{140*10^{-3}*40} = 1.18*10^{-34}\,m$$

(b): A proton moving at the same speed

$$\text{Given Data}: m = 1.67*10^{-27}\,Kg,\ v = 40\,m/s,\ \lambda = ?\ \lambda = \frac{h}{mv} = \frac{6.63*10^{-34}}{1.67*10^{-27}*40} = 9.92*10^{-9}\,m$$

(c): An electron moving at the same speed

$$\text{Given Data}: m = 9.1*10^{-31}\,Kg,\ v = 40\,m/s,\ \lambda = ?\ \lambda = \frac{h}{mv} = \frac{6.63*10^{-34}}{9.1*10^{-31}*40} = 1.82*10^{-5}\,m$$

19.9: What is the de Broglie wavelength of an electron whose kinetic energy is 120 eV?

$$\text{Given Data}: K.E = 120eV = 120*1.6*10^{-19}\,J = 192*10^{-19}\,J,\ m = 9.1*10^{-31}\,Kg,\ \lambda = ?$$

$$\text{Using eq. } \lambda = \frac{h}{\sqrt{2m(KE)}} = \frac{6.63*10-34}{\sqrt{2*9.1*10^{-31}(192*10^{-19})}} = 1.12*10^{-10}\,m$$

19.10: An electron is placed in a box about the size of an atom that is about $1.0\times10^{-10}\,m$. What is the velocity of the electron?

$$\text{Given Data}: \text{size} = \Delta x = \lambda = 1*10^{-10}\,m,\ m = 9.1*10^{-31}\,kg,\ h = 6.63*10^{-34}\,Js$$

$$\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda} = \frac{6.63*10^{-34}}{9.1*10^{-31}*1*10^{-10}} = 7.29*10^6\,m/s$$

CHAPTER 20 ATOMIC SPECTRA

What is Spectroscopy? "The branch of Physics which deals with investigation of wavelength and intensities of electromagnetic radiations emitted or absorbed by atoms is called spectroscopy".

Define the Types of spectra? There are following three types of spectra

i. Continuous spectra
ii. Band spectra
iii. Discrete or line spectra

Continuous spectrum: A spectrum which consists of continuously frequency region without broken up in lines or band is called continuous spectrum. For example **Black body radiation spectrum.**

What is Band spectrum: A spectrum that appears as a number of bands of emitted or absorption radiations is called band spectrum. For example Molecular spectrum

Line or discrete spectrum: A spectrum which consists of discrete lines corresponding to single wavelength of emitted radiations is called line spectrum. For example **atomic spectra of hydrogen atom.**

Atomic spectrum

A spectrum of radiations due to transition b/w energy levels in an atom is called atomic spectrum.

Spectral series: The spectrum of an element contains certain wavelengths that show definite regularities into certain groups called spectral series General formula for spectral series $\frac{1}{\lambda}=R_H\left(\frac{1}{p^2}-\frac{1}{n^2}\right)$.

R_H= Rydberg constant=1.0974*10^7 m^{-1}

Name of series	Formula	n=	Region in which lies	Range of wavelength
Lyman series	$\frac{1}{\lambda}=R_H\left(\frac{1}{1^2}-\frac{1}{n^2}\right)$	2, 3,4,..	Ultraviolet Region	91 nm to 122 nm
Balmer Series **In 1896**	$\frac{1}{\lambda}=R_H\left(\frac{1}{2^2}-\frac{1}{n^2}\right)$	3, 4,5,..	Visible region	365 nm to 656 nm
Paschen series	$\frac{1}{\lambda}=R_H\left(\frac{1}{3^2}-\frac{1}{n^2}\right)$	4, 5,6,..	Infrared region	820 nm to ownward…
Bracket series	$\frac{1}{\lambda}=R_H\left(\frac{1}{4^2}-\frac{1}{n^2}\right)$	5, 6,7,…	Infrared region	…….
Pfund series	$\frac{1}{\lambda}=R_H\left(\frac{1}{5^2}-\frac{1}{n^2}\right)$	6, 7,8,…	Infrared region	…….

Explain postulates of Bohr Model Of Hydrogen Atom and de-Broglie interpretation of Bohr postulate.

Bohr devised a model of hydrogen atom in 1913

First postulate: Electrons are moving around the nucleus in circular orbit.

Stationary state of atom: When an electron remains in any of allowed orbit, no energy is radiated, these orbit are quantized stationary state of atom.

2nd postulate: Only those orbits are allowed in which angular momentum of electron is integral multiple of h/2π.

$$mvr = n\frac{h}{2\pi}.$$

3rd postulate: When an electron jump from a high energy state En to Ep, a photon of energy hf s emitted such that

$$En - Ep = hf \ .$$

De-Broglie interpretation of Bohr Postulate

Consider a string of length l, in stationary wave set on

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$$l = n\lambda \quad l = 2\pi r \quad \text{circumference of circle}$$

$$2\pi r = n\lambda = --$$

$$\lambda = \frac{2\pi r}{n} - (1$$

$$\lambda = \frac{h}{mv} ---------(2$$

$$\text{comparing both eq} \quad mvr = n\frac{h}{2\pi}$$

Write General formula for radius, velocity and energy of hydrogen atom

Quantized Radii: $r_n = n^2 \times 0.053nm$

Quantized energy: $En = -\frac{Eo}{n^2}, \quad Eo = 13.6eV$

Velocity of electron $V_n = \frac{2\pi Ke^2}{nh}$ **in first Bohr orbit v is 2.18*10^6 m/s.**

Define Ground state?When the electron is in its lowest energy state, it is said to be in its ground state.
DefineExcited state?When the electron is in the higher orbit, it is said to be in excited state
DefineExcitation potential?The potential which require to raise an atom from normal state to higher state is called excitation potential. As excitation potential b/w 2nd and 3rd state is 10.2 V.
DefineIonization?The removal of an electron from the atom is called ionization.
DefineIonization energy?The amount of energy required to remove an electron from the ground state of an atom completely is called ionization energy. Ionization energy for H-atom is 13.6 eV.
DefineIonization potential? The potential which is required to remove an electron from ground state is called excitation potential which 13.6V.

Write formula for Rydberg constant and value. $R_H = \frac{E_o}{hc} = \frac{13.6*1.6*10^{-19}}{6.63*10^{-34}*3*10^8} = 1.09*10^7 m^{-1}$

Find the speed of the electron in the first Bohr orbit.

Given Data : Bohr orbit = n = 1 speed = v = ?

$$v = \frac{2\pi Ke^2}{nh} = \frac{2*3.14*9*10^9*(1.6*10-19)^2}{1*6.63*10^{-34}} = 2.18*10^6 m/s$$

Practice MCQs

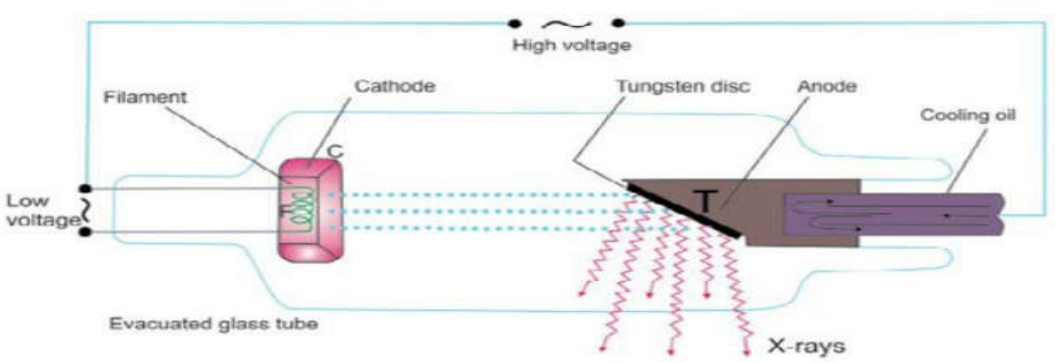
1	If an electron jump from nth orbit of energy En to pth(lower) orbit of Energy Ep and a photon of frequency f and wavelength λ is thus emitted than	fλ=En-Ep	**hc/λ=En-Ep**	hf=Ep-En	hλ=Ep-En
2	SI unit of Rydberg constant is	m^{-2}	ms	**m^{-1}**	ms^{-1}
3	If one or more electrons are completely removed from an atom then atom is to be	Excited	**Ionized**	Polarized	Stabilized
4	The numerical value of ground state energy for hydrogen atom in eV is	-10	13.6	10	**-13.6**
5	The value of Rydberg constant is – m^{-1}	**1.09x10^7**	1.07x10^8	1.07x10^9	6.63x10^{-34}
6	In electronic transition atom cannot emit	**Gamma rays**	Infra red rays	Visible light	UV rays
7	The energy in the 4th orbit of hydrogen atom is	-2.51eV	-3.50eV	-3.4eV	**-0.85eV**

8	The relation between Rydberg constant RH and ground state energy Eo is	**R_H=Eo/hc**	RH=hc/Eo	Eo=RH/hc	RH=E_ohC
9	Balmer series lies in the	UV region	Far UV region	Infrared region	**Visible region**
10	The radius of 2nd orbit by a factor of	2	**4**	3	9
11	The radius of 10th Bohr orbit in hydrogen atom is	0.053nm	0.053nm	**5.3nm**	53nm
12	Which is an example of continuous spectra	**Black body radiation spectrum**	Molecular spectra	Atomic spectra	None of these
13	Atomic spectra are the example of spectra	Continuous spectra	**Line**	Band	Mix
14	The radius of 3rdbohr orbit in hydrogen atom is greater then the radius of 1st orbit by a factor	2	3	4	**9**
15	Which of the following series H-spectrum lies in UV region	**Lyman series**	Balmer series	Pachen series	Bracket series
16	Joule second is the unit of	Energy	Heat	**Plank constant**	Work
17	Which of the following is an example of continuous spectra	**BB radiation spectrum**	Molecular spectrum	Atomic spectra	None
18	In the spectrum of which of the following will you find Balmer series	Oxygen	Nitrogen	**Hydrogen**	All of these
19	The radius of 3rdbohr orbit is	0.159nm	**0.477 nm**	0.53nm	1.59nm
20	The total energy of electron in the state n=infinity of hydrogen atom is	**Zero**	3.2 eV	10.2eV	13.6eV
21	Bohr second postulate was justified by	Bohr himself	**De-Broglie**	Plank	Davisson and Germer
22	The total number of spectral lines for an electron transition from n=5 to n=1 is	1	**5**	7	10
23	Orbital angular momentum in the allowed stationary orbit of H atom is given by	2π/nh	**nh/ 2π**	2h/n π	None
24	When an electron absorb energy it jumps to	Lower energy state	**Higher energy state**	Ground state	Remains in same state
25	Paschen series is obtained when all the transition of electron starts on	2nd orbit	**3rd orbit**	4th orbit	5th orbit
26	Quantized radius of first Bohr orbit in hydrogen atom is	**0.053nm**	0.0053nm	0.0053nm	0.53nm

27	In one or more electrons are completely removed from an atom then atom is said to be	Excited	Polarized	Stabilized	**Ionized**
28	In Balmer series the shortest wavelength radiations have wavelength equal to	$\left(\frac{R_H}{4}\right)m$	$\left(\frac{4}{R_H}\right)m$	$\left(\frac{R_H}{9}\right)m$	$(9R_H)m$
29	The longest wavelength radiations in Braket series have wavelength equal to	$-\frac{25}{16}R_H$	$\frac{16}{25}R_H$	$\frac{135}{27R_H}$	**None of these**
30	Which was identified in sun by using spectroscopy	Hydrogen	**Helium**	Oxygen	Uranium
31	Which series lies in visible region of spectrum	**Balmer**	Paschen	Pfund	Bracket

WHAT ARE X-RAYS? EXPLAIN PRODUCTION OF X-RAYS?

X-rays discoveredGerman Physicist by Dr. RontgenIn 1895.
X-rays: Such type of electromagnetic radiations of short wavelength 10A° to 0.5A° are called X-rays.They lie in visible, infrared and ultraviolet region due to small energy differences.
Characteristics X-rays: Such type of X-rays consist of series of specific wavelengths or frequencies are called characteristic X-rays.
Study of characteristic X-ray spectra is important: Because it has important role in the study of atomic structure and periodic table of elements.
Production of X-rays: For production of X-rays take experimental setup which consists of a high vacuum tube, when cathode is heated by a filament, it emits the electrons which accelerated towards the anode. If Vo is the potential applied then K.E of electrons with which they collide the target is K.E=eVo
Production of X-rays is reverse process of photoelectric effect.
Kα X-rays: When electron from K shell of atom is removed, it produces a vacancy of electron or hole in K shell. The electron from L shell jumps to occupy the hole and emitting a photon of energy $hf_{K\alpha}$ called Kα Xrays. $hf_{K\alpha}=E_L-E_K$.
K_β X-rays: When electron from K shell of atom is removed, it produces a vacancy of electron or hole in K shell. The electron from M shell jumps to occupy the hole and emitting a photon of energy $hf_{K\beta}$ called K_βXrays. $hf_{K\beta}=E_L-E_K$.



Continuous X-rays: Such type of X-rays with a continuous range of frequencies is called continuous X-rays. This is obtained due to deceleration of impacting electrons. This effect is also known as brehmstrahlung or breaking radiations.
Applications of X-rays: There are following applications of X-rays

1. X-rays have many applications in medicines and industry because they penetrate several cm into a solid matter so they can be visualizes the interior of material.
2. They are used in CAT scanner

CAT scanner: CAT stands for computerized axial tomography. It is special technique developed on X-rays and corresponding instrument is called CAT scanner. Density difference of the order of one percent can be detected by CAT scanner such tumors etc.
Biological effects of X-rays: X-rays are ionization radiations. They may cause damage to living tissues. As X-rays useful for selective destruction of cancer cells. X-rays can cause cancer by excessive use. X-rays photons are absorbed in tissues and break the molecular bonds create highly reactive free radicals.

Why electron cannot exist inside the nucleus?

Electron cannot exist inside the nucleus because according to uncertainty principle if electron is to be confined in nucleus its speed would be greater than speed of light which is not possible.

Lets consider if electron can exist inside the nucleus then size of nucleus $\Delta x = 10^{-14}$ m, using uncertainty principle

$$\Delta V = \frac{h}{m\Delta\Delta} = \frac{6.63*10^{-34}}{9.1*10^{-31}*10^{-14}} = 7.3*10^{10} \text{ m/s} \text{ This is not possible as speed can not be greater than speed of ligth.}$$

Now consider electron outside the nucleus then radius of H - atom is $\Delta x = 5*10^{-11}$ m

$$\Delta V = \frac{h}{m\Delta\Delta} = \frac{6.63*10^{-34}}{9.1*10^{-31}*5*10^{-11}} = 1.46*10^{7} \text{ m/s, this is possible as speed of electron is less than speed of light}$$

WHAT IS LASER? EXPLAIN ITS PRINCIPLE AND WORKING.

LASER stands for light amplification by stimulated emission of radiation
Laser: It is a device which produce very narrow beam of radiations having following properties
i) intense ii) unidirectional iii) coherent iv) monochromatic is called laser.
Kinds of transitions occurs during the process of laser: There are following types of transition occur in laser.

i. **Stimulate absorption**: if the atom is initially in lower state E_1, it can raised to E_2 by absorbing a photon of energy E_2-E_1=hf is called induced absorption of stimulated absorption.
ii. **Spontaneous emission**: if the atom is initially in excited state E2, it can drop to E1 by emitting photon of energy hf, this is called spontaneous emission. 10-8 sec time is required for it.
iii. **Stimulated emission**: the process in which de-excitation of an atom is caused by an incident photon with emission of second photon of same energy is called stimulated emission.

Life time for excited and metastable state: Excited state= 10^{-8} sec metastable state= 10^{-3} sec
Meta stable state: Long lived state than excited state is metastable state, its life time is 10^{-3} sec.
Normal population: A normal population of atomic energy state with more atoms in the lower energy state E_1 than in the excited state E_2.
Population inversion: A population inversion in which high energy state has greater population then lower energy state

WHAT IS He-Ne laser? WRITE ITS USES.

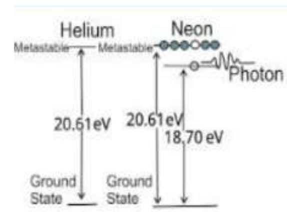
It is most common type of laser which consist of discharge tube filled with 15% neon gas and 85% helium gas.

i. Neon is the lasing or active medium in tube
ii. Helium and neon have nearly identical metastable state
iii. Helium is located at 20.61 eV
iv. Neon is located at 20.66eV

Uses of He-Ne laser: There are following uses of laser

i. It is used to diagnose disease of eye
ii. The use of laser technology in the field of ophthalmology is widespread

Population inversion occur in neon: It is achieved by direct collision with same energy electrons of helium atoms.
Uses of laser: There are following uses of Laser



i. Laser beam is used as surgical tool for welding detached retinas
ii. It is used to diagnose the disease of eye
iii. It is used to destroy cancerous, pre-cancerous cells
iv. It is potential energy source for inducing fusion reaction
v. It can be used for telecommunication in optical fiber
vi. It can be used to generate three dimensional image of object

<u>WHAT IS Holography</u>?Such a process in which three dimensional image of objects is generated by using the laser beam is called holography

<u>Difference b/w orbital and free electrons</u>: The orbital electrons have specific amount of energies whereas free electrons may have any amount of energy.

<u>Practice MCQs</u>

1	X-rays are	High energy electrons	**<u>High energy photons</u>**	High energy protons	High energy neutrons
2	Which one of the following is not characteristic of laser	High intensity	High directivity	**<u>Incoherence</u>**	Monochromatic
3	Laser can only be produced if an atom is in its	Normal state	**<u>Excited state</u>**	Ionized state	De-excited state
4	X-ray photon moves with a velocity of	Less than light	**<u>Light</u>**	Greater than light	Sound
5	Helium Neon laser discharge tube contain neon	82%	**<u>15%</u>**	25%	85%
6	X-rays are EM radiations having wavelength in the range of	10^{-12} m	**<u>10^{-10} m</u>**	10^{-8} m	10^{-6} m
7	X-rays production is reverse phenomenon of	Compton effect	**<u>Photo electric effect</u>**	Pair production	Annihilation of matter
8	X-rays can be	Reflected	Diffracted	Polarized	**<u>All of these</u>**
9	After the emission of X-rays the atom of the target is	Doubly ionized	Single ionized	In the excited state	**<u>In the ground state</u>**
10	What is color of light emitted from He-Ne laser	Blue	Green	**<u>Red</u>**	Yellow
11	Electron can reside in excited state for about	10^{-3} sec	10^{-5} sec	**<u>10^{-8} sec</u>**	10^{-11} sec
12	For holography we use a beam of	Gamma rays	X-rays	Beta rays	**<u>Laser</u>**
13	Which of the following requires a material medium for their propagation	Heat waves	X-rays	**<u>Sound waves</u>**	UV rays
14	Joule second is the unit of	Energy	Heat	**<u>Plank constant</u>**	Work
15	Which is not true for X-rays	Not deflected by E	**<u>Are polarized</u>**	Consist of EM waves	Can be diffracted by grating
16	The diameter of an atom is of the order	10^{-12} m	**<u>10^{-10}m</u>**	10^{-4} m	10^{-5} m
17	Helium neon laser contain helium	25%	**<u>85%</u>**	15%	80%
18	Laser light has the property of	**<u>Coherent waves</u>**	Non coherent waves	Sound waves	Water waves

19	Production of X-rays is reverse process of	Pair production	Compton effect	**Photoelectric effect**	Annihilation of matter
20	X rays diffraction reveals that these are	Particle type	**Wave type**	Dual type	None
21	In CAT scanning a---- array of X-rays beam is directed through patient	Skin out	**Fanned out**	Normal out	Fitted
22	He-Ne laser is being used to diagnose diseases of	**Eye**	Brain	Skull	Skin

EXERCISE SHORT QUESTIONS

1. **Bohr's theory of hydrogen atom is based upon several assumptions. Do any of these postulate contradict classical physics?

Yes, Bohr's first postulate contradicts classical physics. According to this postulate: An electron in an orbit revolving around the nucleus doesn't radiate energy by radiation. But according to the classical physics, an accelerated electron radiates energy due to its circular motion around nucleus

2. **What is meant by a line spectrum? Explain, how line spectrum can be used for the identification of elements?

A spectrum which consists of isolated sharp parallel lines, in which each line corresponds to a definite frequency and wavelength, is called line spectra. Each element gives its own characteristic lines of definite wavelengths. So, elements can be easily identified by observing its spectrum.

3. **Can the electron in the ground state of hydrogen absorb a photon of energy 13.6 eV and greater than 13.6 eV?

Yes it can absorb a photon of energy 13.6 eV and greater than 13.6 eV. Since the ionization energy of the electron in the ground state of hydrogen atom is 13.6 eV. So by absorbing a photon having energy greater than 13.6 eV, ionization of H-atom will take place and the surplus energy of photon is taken away by electron as kinetic energy.

4. **How can the spectrum of hydrogen contain so many lines when hydrogen contains one electron?

When H-atom de-excites, the electron will come from higher energy level to ground level by several jumps. As the result, photons of different wavelengths are emitted. That's why the spectrum of hydrogen contains so many lines.

5. **Is energy conserved when an atom emits a photon of light?

Yes, energy is conserved when an atom emits a photon of light. Because the energy emitted during de-excitation is exactly equal to the energy absorbed by the atom during excitations. So the energy is conserved in this process.

6. Explain why a glowing gas gives only certain wavelengths of light and why that gas is capable of absorbing the same wavelengths? Give a reason why it is transparent to other wavelengths?

When white light is passed through gas, it absorbs only those photons which have the energy equal to the difference of energy levels in atoms of the gas. All other photons pass through the gas un-absorbed. In other words, gas is transparent for those photons

7. **What do we mean when we say that the atom is excited?

When certain amount of energy is supplied to the electrons of an atom by an external source, it will be raised up to one of the higher allowed states by absorption of energy. Then the atom is said to be in excited state.

8. **Can X-rays be reflected, refracted, diffracted and polarized just like any other waves? Explain.

Yes, X-rays can be reflected, refracted, diffracted and polarized as they are also electromagnetic waves of higher frequency and smaller wavelength.

9. **What are the advantages of lasers over ordinary light?

Advantages of laser over ordinary light

i. It is intense beam of light
ii. It is monochromatic

iii. It is unidirectional
iv. It is coherent

10. **Explain why laser action could not occur without population inversion between atomic levels?
In population inversion, more than 50% vacancies in the meta-stable states become filled. Then all the electrons in the meta-stable state simultaneously jump to the ground level, thereby producing a pulse of coherent beam without population inversion, laser action could not occur.

CHAPTER 21 NUCLEAR PHYSICS
ATOMIC NUCLEUS

What is Rutherford nuclear model? Rutherford model of atom consisted of a small dense, positively charged nucleus with negative electrons orbiting about it.
Neutron was discovered byJames Chadwick In 1932. It is neutral particle which has no charge
Electron was discovered by JJ Thomson in 1897. It has negative charge
Proton was discovered by Gold stein in 1927. It has positive charge
Almost 99.9% of mass of atom is concentrated in nucleus.
Radius of atom is 10^5 times the radius of the nucleus.

Particle	**Charge**	**Charge value(C)**	**Mass in kg**	**Mass in amu**
Proton	+ive	$1.6*10^{-19}$	$1.673*10^{-27}$	1.007276
Electron	-ive	$-1.6*10^{-19}$	$9.1*10^{-31}$	0.00055
Neutron	no	Zero	$1.675*10^{-27}$	1.008665

<u>What is Atomic number/Charge number</u>?The number of protons inside the nucleus is called charge number or atomic number. It is denoted by Z.
<u>Neutron number:</u>The number of neutrons inside a given nucleus is called neutron number denoted by N.
<u>What is Mass number</u>?Total number of protons and neutrons in a nucleus is called mass number A=N+Z
For example $_2^4He$, atomic number is 2, mass number is 4 and number of neutrons is 2. More examples

1. Hydrogen $_1^1H$, Z=1, N=0, A=1
2. Helium $_2^4He$, Z=2, N=2, A=4
3. Uranium $_{92}^{235}U$ Z=92, N=143, A=235 As N=A-Z, 235-92=143

What are ISOTOPES? Give examples.

<u>Isotopes</u>: Those nuclei having same atomic number but different mass number are called isotopes. For example isotopes
Of hydrogen are $_1^1H$, $_1^2H$, $_1^3H$, for helium $_2^3He, _2^4He$.
Isotopes have same number of electrons and protons but different number of neutrons.
Chemical properties of an element depend on the number of electrons around the nucleus. So isotopes haves same chemical properties.

WHAT IS MASS SPECTROGRAPH? WRITE ITS PRINCIPLE AND EQUATION.

Mass spectrograph: A device which separates the isotopes of elements and determines its masses is called mass spectrograph.
Principle of mass spectrograph: It uses electric and magnetic field to separate the isotopes according to their masses.

Equation of mass spectrograph. $m = (\frac{er^2}{2V})B^2$

Isotopes of neon: Neon has mass number of 20, 21, 22 and most abundant isotope is Ne-20.

Practice MCQs

1	The amount of energy equailent to 1amu	9.315 MeV	93.45 MeV	**<u>931.5MeV</u>**	1.025MeV

	is				
2	The name electron suggested by	Thomson	Rutherford	Millikan	**Stoney**
3	The number of neutrons in nucleus is	**N=A-Z**	N=A+Z	N=A+Z/2	None
4	The number of protons in any atom are always equal to number of	**Electrons**	Neutrons	Positron	Mesons
5	The chemical properties of an element depend only upon the number of	Protons	Neutrons	**Electrons**	Mesons
6	Neutron was discovered in 1932 by	Bohr	**Chadwick**	dirac	Fermi
7	In mass spectrograph mass of each ion reaching the detector is proportional to	$\sqrt{r}$	**B^2**	V2	$\sqrt{B}$
8	The radius of atom is of the order of	10^{10}m	**10^{-10} m**	10^{-14}m	10^{14}m
9	Hydrogen H-1 is also called	Deuterium	Tritium	**Protium**	All of these
10	The particle which has its mass number and charge number is equal to zero	Proton	Electron	Neutron	**Photon**
11	The chemical properties of any element depends on its	Number of isotopes	Number of isobars	**Atomic number**	Mass number
12	Number of isotopes of helium is	**2**	3	4	5
13	The number of isotopes of cesium are	4	32	**36**	22
14	Xenon and cesium have isotopes	35	**36**	37	38
15	Which is most abundant isotopes of neon	**Neon-20**	Neon-21	Neon-22	All
16					

WHAT IS MASS DEFECT AND BINDING ENERGY? WRITE EQUATIONS.

Mass defect: The mass of nucleus is always less then total mass of its protons and neutrons, this difference in mass is called mass defect. $\Delta m = Zm_p + (A-Z)m_n - m_{nucleus}$

Packing fraction: Mass defect per nucleon is called packing fraction.

$$f = \frac{\Delta m}{A} = \frac{Zm_p + (A-Z)m_n - m_{nucleus}}{A}.$$

Binding energy: The mass defect is converted into energy during formation of nucleus, this energy is called binding energy. OR the energy required to break the nucleus into its nucleons is called binding energy.

$B.E = (Zm_p + (A-Z)m_n - m_{nucleus})c^2$ Binding energy of helium is 28.2 MeV

Properties of binding energy per nucleon: There are following properties of B.E/nucleon

i. Binding energy per nucleon increase with mass number
ii. It increase till value of 8.8MeV at mass number 58
iii. After mass number 58 it decrease to a value of 7.6MeV at mass number 238
iv. Binding energy per nucleon is maximum for iron
Iron is most stable elements

Iron is most stable element as it has maximum value of binding energy per nucleon 8.8 MeV.

WHAT IS RADIOACTIVITY? EXPLAIN THE DIFFERENT TYPES OF DECAY.

Radioactive elements& radioactivity: The elements having atomic number greater than 82 emit invisible radiations which affect photo graphic plate, such elements are called radioactive elements and the process is called radioactivity.
Radioactivity is purely nuclear phenomenon which is not affected by physical or chemical reaction. It does not depends on physical state such as temperature, pressure and density. Etc.
Radioactivity discovered by Henry Becquerel in 1896.
Transuranic elements: The elements having atomic number greater than 92 are called transuranic elements.
There are three types of namely, alpha, beta and gamma rays.
Alpha particles: They are helium nuclei, has 2 protons, 2 neutrons and positive charge
Beta particles: They are fast moving electron having negative charge and charge number -1
Gamma particles: they are EM rays like X-rays the wavelength is larger than x-rays and high frequency having no charge.
Radioactive decay: Change in the nucleus of radioactive elements by emission of radiations and elements into a new element is called radioactive decay.
Parent and daughter element: The original element in radioactive decay is called parent element
Daughter element: The element formed due to radioactive decay is called daughter element.
Alpha decay: Such a decay in which charge number Z decrease by 2 and the mass number A decrease by 4 is called alpha decay. ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$ e.g ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Y + {}^{4}_{2}He$.
Beta decay: Such a decay in which mass number does not change but charge number increase by one is called beta decay. ${}^{A}_{z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e$, e.g. ${}^{232}_{90}X \rightarrow {}^{232}_{91}PA + {}^{0}_{-1}e$
Gamma decay: Such a decay in which there is no change in charge number as well as mass number is called gamma decay. ${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X^{*} + \gamma$ Radiations. E.g ${}^{60}_{28}Ni \rightarrow {}^{60}_{28}Ni + \gamma$.

WHAT IS HALF LIFE AND DECAY CONSTANT?

Half-life: The time during which half of the atoms of radioactive elements decay is called half-life.
Decay constant: The ratio of fraction of decaying atom per unit time is called decay constant, its unit is s^{-1}.

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

Relation b/w half-life and decay constant:

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

Formula for finding the remaining number of atoms in half life: $\left(\frac{1}{2}\right)^{2} N_o$

Element	Half life
Uranium-238	4.5*10^{9} years
Radium-226	1620 years
Radon gas	3.8 days
U-239	23.5 min

Define artificial radioactive elements? When very high energy particles are bombarded on stable elements, this excites the nuclei and nuclei after bombarding unstable the radioactive elements, such radioactive elements are called artificial radioactive elements.

What is range of alpha particle? On which factors it depend?

Range of alpha particle: An alpha particle travel a well-defined distance in a medium before coming to rest. This distance is called range of alpha particle.
Range of alpha particle depend on charge, mass, and energy of particle as well as density of medium and ionization potential.

Write the properties of alpha particles

Alpha particle has following properties

i. Alpha particle is 7000 times more massive than electron
ii. They produce fluorescence on striking some substance like ZnSetc
iii. Ionization may be due to direct elastic collision through electrostatic attraction

Write the Properties of beta particles?

There are following properties of beta particles

i. Its ionization ability is 100 times less than alpha particles

ii. Its range is 100 time more than alpha particles
iii. They produce fluorescence on striking ZnSetc

Write the Properties of gamma rays?

There are following properties of gamma particles

i. They produce little ionization as it has no charge
ii. Intensity obey inverse square law
iii. They produce fluorescence

Write Interaction of gamma rays with matter

There are three ways

i. At low energies(less than 0.5MeV), photoelectric effect is occurred at this.
ii. At intermediate energies(b/w 0.5-1.02 MeV) Compton effect
iii. At high energies (more than 1.02 MeV) pair production take place

Neutron being neutral particle has range very large as well as extremely penetrating particle.
To stop or slow a neutron must undergo a direct collision with a nucleus or some other particle that has mass comparable to that of neutron.

Practice MCQs

1	After two halve lives the number of decayed nuclei of an element are	N	N/2	N/4	**3N/4**
	Binding energy can be found by relation	$E=\Delta m/C^2$	**$E=\Delta mC^2$**	$E=1/2\ \Delta mc^2$	E=mgh
	Which of the following is similar to electrons	Alpha particles	**Beta particles**	Neutrino	Photon
	The rate of decay of radioactive substance	Remains constant with time	Increase with time	**Decrease with time**	May increase or decrease with time
	The element formed due to radioactive decay is called	Parent element	**Daughter element**	Mother element	Son element
	The energy required to break a nucleus of an atom is called	Atomic energy	Nuclear energy	**Binding energy**	Breaking energy
	Which one the following is not the nuclear radiations	Alpha particle	Beta particle	Gamma rays	**X – rays**
	Gamma rays consists of	Helium nuclei	Hydrogen nuclei	Neutrons	**Radiations similar to X-rays**
	Materials can be identified by measuring their	Hardness	Density	Mass	**Half life**
	A sample contains N radioactive nuclei. After 4 half-lives number of nuclei decayed is	N/16	**15N/16**	N/8	7N/8
	When alpha particle is emitted from any nucleus, its mass number ---- and its charge number ----	Increase by 2, increase by 2	Decrease by 4, increase by 2	Decrease by 4, increase by 2	**Decrease by 4, decrease by 2**
	Extremely penetrating particles are	Neutrons	Alpha particle	Beta particle	**Gamma particle**
	By emitting beta particle and gamma particle simultaneously the	Losses by 1	**Increase by 1**	Increase by 2	No charge will be

	nucleus change its charge by				observed
	Which is true for both alpha particles and gamma rays	They cause ionization in air	They can be deflected by electric field	They can be deflected by magnetic field	**They can penetrate a few millimeter of Al**
	Half-life of I-131 is 8 days and its weighs 20mg. after 4 half-lives, the amount left undecayed will be	2.5 mg	**1.25 mg**	0.625 mg	0.312 mg
	Which one of the following radiation is extremely penetrating	Alpha rays	Beta rays	**Gamma rays**	None of these
	The particle which has its mass number and charge number is equal to zero	Proton	Electron	Neutron	**Photon**
	Alpha particles consists of	**Positively charged**	Negatively charged	Neutral particles	Photons
	An alpha particle contains	1 proton and 1 neutron	**2 proton and 2 neutrons**	3 protons and 3 neutrons	4 protons and 4 protons
	Gamma emission from the nucleus of an atom causes a	Change in Z	Change in A	Change in both A&Z	**No change in A and Z**
	Binding energy for deuteron nucleus is given by	2.8MeV	**2.23MeV**	2.28MeV	2.25MeV
	Which particle has larger range in air	Alpha	Beta	Gamma	**Neutron**
	Alpha particle carries a charge	-e	**+2e**	-2e	No charge
	The speed of beta particle	10^6 m/s	**10^8 m/s**	10^5 m/s	10^7 m/s
	Speed of alpha particles are	10^6 m/s	10^8 m/s	10^5 m/s	**10^7 m/s**
	Pu has life time is	2400 years	**24000 years**	240 years	24 years
	The rate of decay of radioactive substance	Remains constant with time	Increase with time	**Decrease with time**	May increase or decrease with time
	Alpha rays of energy more than 0.5MeV can produce	Pair production	**Compton effect**	Photo electric effect	Fission process
	The emission of beta particle from Polonium-218 result in formation of	**Asatitine-218**	U-222	U-234	H-1

RADIATION DETECTORS

Radiation detectors: The devices which are used for the detection of nuclear radiations are called radiation detectors, for example WC chamber, GM counter, Solid state detector etc.

What is WC chamber? Write its principle.

A device which show the visible path of ionizing particles is called WC chamber.

Principle of working of WC chamber: Supersaturated vapors condense preferentially on ions and these ionizing particle passes through a region in which cloud droplet form, the droplets formed show that path as trail of droplets.
Gas is used in WC chamber: Alcohol vapors
Potential required b/w top and bottom of WC chamber: 1KV=1000 V.
What is the Track of particles in WC chamber? There are following tracks of particles in WC chamber

i. **Alpha particle:** they have thick, straight and continuous track due to intense ionization
ii. **Beta particles:** they are thin and discontinuous track in erratic manner
iii. **Gamma ray:** no definite track along the path, length of track is proportional to energy of incident particles

What is Geiger Muller Counter.

Principle of GM counter: The discharge in tube is produced due to the ionization produced by incident radiation.
Pressure gas is filled in GM counter 1/10=0.1 of atmospheric pressure.
Potential difference required in GM counter: 400 Volt
Scalar in GM counter: The counter which provides power to GM counter is called scalar.
Time required for entire electron pulse: Less than 1μs.
Dead time in GM counter: The time during which incoming particles across GM counter cannot be counted as positive ions take more time to reach the cathode due to massiveness, is called dead time. Dead time of counter is 10^{-4} sec.
Spurious count in GM counter: When positive ions strike the cathode, secondary electrons are emitted from the surface, these electrons would give counting is called spurious counting.
What is Self-quenching? Spurious counting is prevented by mixing a small amount of quenching gas with principal (Neon), this process is called self-quenching. The quenching gas must have an ionization potential lower than that of principal gas
What is Electronic quenching?Such type quenching in which large negative voltage is applied to anode after the recording of output pulse which reduced field below the critical value for ionization is called electronic quenching.
Write the Uses of GM counter? There are following uses of GM counter

i. It is used to find the range and penetration power of ionizing particles
ii. It is not suitable for fast counting due to long dead time

WHAT IS SOLID STATE DETECTOR? WRITE PRINCIPLE AND PROPERTIES.

Solid state detector: A specially designed pn junction which is used for fast enough, more efficient and accurate detection of radiations is called solid state detector.
Principle of working of solid state detector: It is based upon following principle
When radiations are allowed to enter the depletion region, electrons hole pairs are produced.
Potential is required for solid state detector: 50 V
Energy is required for producing a current pulse: 3 eV to 4 eV.
Properties of solid state detector: There are following uses of solid state detector.

i. It is used for detecting low energy particles
ii. It can count very fast counting than other detectors
iii. It is small in size than other detector and operate at low voltage
iv. It is useful to detecting alpha and beta particles

Practice MCQs

1	A detector can count fast and operate at low voltage is	GM counter	**<u>Solid state detector</u>**	WC chamber	Bubble chamber
2	GM tube can be used to detect	Charge	Mass	Charge/mass ratio	**<u>Nuclear radiations</u>**
3	A device which show the visible path of ionizing particle is called	GM counter	Solid state detector	Scalar	**<u>WC chamber</u>**
4	Specially designed solid state detector can be used to detect	Beta rays	Alpha rays	**<u>Gamma rays</u>**	x-rays

5	Beta particle in Wilson cloud chamber have path	**Zig zag**	Curved	Circular	Elliptical
6	In Wilson cloud chamber we use	**Alcohol vapors**	Neon gas	Bromine gas	Water vapors
7	A high potential difference of --- is used in GM counter	**400V**	1000V	50000V	4000V
8	Potential difference applied across the Wilson cloud chamber	400V	**1000V**	50000V	4000V
9	Potential difference applied across the Wilson cloud chamber	400V	1000V	**50V**	4000V
10	Energy is required for producing a current pulse	10 eV to 20 eV	30 eV to 40 eV	**3eV to 4eV**	1 to 2 eV
11	Dead time of counter is	10^{-3} sec	10^{-5} sec	**10^{-4} sec**	10^{-2} sec
11	In nuclear radiations, track of alpha particles is	Thin	Discontinuous	Erratic	**Continuous**

NUCLEAR REACTIONS

Nuclear reactions: The process which changes the structure of nucleus by the bombardment of target nucleus with some fast moving particles such as neutron or alpha particles are called nuclear reactions.
Conditions must be satisfied for nuclear reaction: There are following conditions must be satisfied for nuclear reaction taking place

i. Conservation of mass
ii. Conservation of energy

Neutron discovery: 1932 James Chadwick discovered neutron with following reaction $_4^9Be + _2^4He \rightarrow _6^{12}C + _0^1n$.

NUCLEAR FISSION

Define nuclear fission? Such a reaction in which a heavy nucleus like U-235 is broken into two nuclei of nearly equal size along with the emission of energy is called nuclear fission.
Nuclear reaction for fission reaction: $_{92}^{235}U + _0^1n \rightarrow _{56}^{141}Ba + _{36}^{92}Kr + 3_0^1n + Q$.
235*0.9=**211.5 MeV** is given out in the fission of one uranium nucleus.
What is Fission chain reaction? Such a reaction which can be produced in more uranium atoms such that a fission reaction can continuously maintain itself, this process is called fission chain reaction.
What is Critical mass and critical volume? Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction produces further fission is called critical mass and volume of this mass of uranium is called critical volume.
What is Principle of working of atomic bomb?"If the mass of uranium is much greater then critical mass, then reaction proceeds at high speed and huge explosion is produced".
Why Cadmium is used to absorb large number of neutrons? Cadmium is an element that is capable of absorbing a large number of neutron without becoming unstable and fission reaction is controlled.

What is NUCLEAR REACTOR? Explain its principle, parts and types.

Nuclear reactor: A device in which nuclear fission chain reaction take place at constant rate in controlled manner is called nuclear reactor. It is used to produce nuclear energy.
Principle of nuclear reactor: Fission chain reaction.
Principle of working of nuclear reactor: It is like a furnace in thermal power station. Heat energy is produced in fission reaction, this energy is used to rotate turbine, and this turbine rotates the generator which produce electricity.

Core of nuclear reactor: It is the main part of nuclear reactor. Here fuel is kept in the form of cylindrical tubes.
Fuel in nuclear reactor: Uranium is used as fuel. The quantity of U-235 is increased from 2 to 4 percent.
Naturally occurring uranium U-235: Only 0.7%
Moderator in nuclear reactor: The part of nuclear reactor which slow down the speed of neutrons produced during fission process by means of fuel rods in substance of small atomic weight such as water, heavy water etc. is called moderator**.** In KANUP heavy water is used as moderator.
Types of reactors: There are two types of reactor

i. Thermal reactors
ii. Fast reactors

Thermal reactors: The thermal reactor are one in which moderator are used to slow down the fast neutrons to thermal energies so that they can produce further fission either natural or enriched uranium is used as fuel in it.
Fast reactors: The reactors in which natural uranium is used as fuel which is nearly 99% of uranium, fast neutron can produce fission, so moderators are not required in fast reactors.
Enriched uranium: Such a uranium in which percentage of U-235 is greater than its percentage in natural uranium is called enriched uranium.

FUSION REACTION

Define Fusion reaction?Such a nuclear reaction in which two light nuclei merge to form a heavy nucleus is called fusion reaction.
What are the Methods for producing fusion reaction?There are following methods

i. By using accelerator
ii. By increasing temperature

What is the Temperature of core and surface of sun?Core temperature= 20 million CelsiusSurface temperature= 6000 degree Celsius.
From which parts Sun is primarily composed of?Sun is composed of hydrogen. It has a little amount of helium and slight amount of other heavy elements.

Practice MCQs

1	In a fast nuclear reactor U-238 absorb a fast neutron and is ultimately transformed into --- by emitting beta particles	U-238	**Pu-239**	Pb-208	Th-232
2	Which of the following isotopes of natural uranium undergoes a fission reaction with slow neutrons	U-234	**U-235**	U-238	None of these
3	The PU-239 breeder reactor is called	ACR	**PWR**	LMFBR	HWR
4	Hydrogen bomb is an example of	Nuclear fission	Nuclear fusion	Chemical reaction	**Fission Chain reaction**
5	The process by which a heavy nucleus splits up into lighter nuclei is called	**Fission**	Fusion	Alpha decay	A chain reaction
6	Energy liberated when one atom of uranium undergoes fission reaction is	28MeV	60MeV	140MeV	**200MeV**
7	The energy emitted from sun is due to	Fission reaction	**Fusion reaction**	Chemical reaction	Pair production
8	Which nuclear reaction takes place	Fission	Chemical	**Fusion**	Mechanical

	in the sun and stars				
9	Nuclear fission chain reaction is controlled by using	Steel rods	Graphite rods	**Cadmium rods**	Platinum rods
10	The energy released by fusion of two deuterons into helium nucleus is about	**24MeV**	200MeV	1.02 MeV	7.7MeV

RADIATION EXPOSURE

What are Cosmic rays? Cosmic radiation consists of large energy charge particles and electromagnetic radiations.

How Ozone layer is most important? The ozone layer and atmosphere acts as a shield against radiations and absorb ultraviolet rays which can cause eye and skin diseases.

How Depletion of ozone layer suspected? The depletion of ozone layer is suspected due to use of some chemicals in atmosphere such CFC used in refrigeration, aerosol spray and plastic foam industry.

What are the Sources of radiation exposure

There are following sources of radiation exposure

i. Nuclear waste of reactor
ii. Hospital, research and industrial units
iii. Television
iv. Luminous watches
v. Tobacco leaves

BIOLOGICAL EFFECTS OF RADIATIONS(Definitions)

Activity of radioactive elements: Number of disintegrations per unit time is called activity of radioactive element.

Becquerel (Bq): One Bq is equal to one disintegration per second.

Curie: Curie is larger unit. One curie is equal to $3.7*10^{10}$Bq.

Radioactive absorbed dose: The amount of energy absorbed from an ionizing radiation per unit mass of absorbing body is called absorbed dose. D= energy absorbed/ mass $D= E/m$, its SI unit is Gray.

Gray and rad: The amount of energy equal to one joule absorbed by a body of mass 1kg is called gray. 1Gy= 1J/kg

And one rad=0.01 Gy.

Equivalent dose: The product of RBE and absorbed dose is called equivalent dose. De=RBE*D/

Sv and rem: SI unit of equivalent dose is Sievert, 1Sv=1Gy*RBEAnd old unit is 1rem=0.01 Sv

Amount of radiations is normally considered safe: 1mSv

Diseases are caused by low level radiations: Low level radiations can cause diarrhea, vomiting and fever known as radiations sickness, loss of hair, ulceration, stiffening of lungs and drop in white blood cells.

BIOLOGICAL AND MEDICAL USES OF RADIATIONS

Write the Uses of radioisotopes?

There are following uses of radioisotopes

i. To study complex reactions and chemical reactions taking place in plants and animals
ii. To measure amount of fertilizer absorbed by plant
iii. To improve varieties of crops such as rice
iv. To improve the structure of plants

Write Uses of radioactive tracer?

There are following uses of radioactive tracer

i. **In medicine**: It is used to detect malignant tumors
ii. **In agriculture**: It is used to uptake the fertilizer by a plant

iii. In understanding the complex process of photosynthesis
iv. In identification of faults in underground pipes of fountain system

Which isotope is used for blood circulation checking: Sodium-24
Which isotope is used to cure cancer in radiotherapy: Cobalt-60
Which isotopes is used to cure thyroid cancer: Iodine-131 is used
Which isotope is used for skin cancer: Phosphorous-32, strontium-90
What is Radiography? "Such a technique which is used for producing a photographic image of an opaque specimen by transmitting a beam of X-ray or gamma rays, it is also used for internal imaging of brain is called radiography".

BASIC FORCES OF NATURE

Write the names of any four Basic forces of nature: There are following basic forces of nature

i. Gravitational force
ii. Magnetic force
iii. Electric force
iv. Weak nuclear force
v. Strong nuclear force

Faraday and Maxwell unified the electric and magnetic force.
Strong nuclear force It is short range force which kept the nucleus stable and range of 10^{-15} m.
Electromagnetic force: It is long range force cause all chemical reactions, binds all atoms, molecules, crystals, tree, building and man. It cause friction, cohesion, adhesion.
Weak nuclear force: It is short range force responsible for transition of radioactive elements. It is repulsive force of range 10^{-17}m.
Gravitational force: It is long range force which kept the atmosphere and sea fixed to surface of earth, it give rise to ocean tides and forces earth to orbit around sun.
Unification of electromagnetic and weak forces: In 1979, Glashow, Weinberg and Abdul Salam unified electromagnetic force and weak nuclear force and won the Nobel Prize.

BUILDING BLOCK OF MATTER(definitions)

There are three types of subatomic particles

i. Photons
ii. Leptons
iii. Hadrons

All photons and leptons are elementary particles and hadrons are composed of quarks
Hadrons: These are the particles that experience strong nuclear force.e.g protons, neutrons, mesons are hadrons.
Baryons: The particles equal in mass or greater than protons are called baryons.
Mesons: The particles lighter than protons are called mesons
Leptons: The particles which do not experience strong nuclear force like electrons, muons and neutrino are leptons.
Quark theory was given by M Gell Mann and G zweig
Quark theory: According to quark theory the quarks are proposed as building blocks of mesons and baryons. As pair of quark and anti-quark makes a meson and 3 quarks makes a baryon. It is proposed there are six quarks Up, down, strange, charge, bottom, top Up=2e/3, down= -e/3
Proton= two up and one down quarks=2*(2/3)e-1/3e=1e
Neutron= one up and two down quarks 2/3e-1/3e-1/3e=0e
Practice MCQs

1	Two up and one down quarks make	**Proton**	Neutron	Electron	Meson
2	3 quarks make a	Proton	Neutron	Electron	**Baryon**
3	One up and two down quark makes a	Proton	**Neutron**	Electron	Baryon
4	Which is used for monitor radiations received by worker in nuclear facilities	**Film badge dosimeter**	Radiation detector	x-ray source	Potentiometer

5	Radioactive waste are of ----types	**3**	4	5	6
6	On what surface ozone becomes vital to life as it absorb all UV radiations	10-20 km	20-25 km	**20-50 km**	20-30 km
7	UV radiations cause	Sunburn	Blindness	Skin cancer	**All of these**
8	RBE for heavy recoil nuclei	10	2	**20**	15
9	Two down and one up quarks make	Proton	**Neutron**	Photon	Positron
10	A pair of quark and anti quark makes a	Proton	Neutron	Electron	**Meson**
11	Which of the following belongs to "hadrons" group	**Protons**	Electrons	Muons	Neutrinos
12	One curie is equal to	3.70×10^{-10}Bq	**3.70×10^{10} Bq**	1 Bq	103 Bq
13	For a person absorb average radiations doses by watching television during one year	50mSv	40mSv	30mSv	**10mSv**
14	The number of Quarks are	2	3	4	**6**
15	Dr. Abdul Salam unified electromagnetic force and	**Weak nuclear force**	Strong nuclear force	Magnetic force	Gravitational force
16	One joule of energy absorbed in a body per kilogram is equal to	One rad	One rem	**One gray**	One Sievert
17	Thyroid gland plays a major role in the distribution of	**Iodine**	Glycerin	Germanium	All of these
18	Three up quarks combine to form a new particle, the charge no on this particle is	**2**	3	4	5
19	Which group belong to hadrons	Protons and neutrons	**Mesons and neutrons**	Photons and electrons	Positron and electrons
20	The old and new units of absorbed dose are related by	1Gy=10 rad	**1Gy=100 rad**	1Gy= 1000 rad	1Gy=10000 rad
21	The maximum safe limit dose for person working in nuclear reactor is	**1 rem**	2 rem	3 rem	5 rem
22	Mass of meson is	Greater than proton	**Less than proton**	Equal to proton	Equal to neutron
23	Which one belongs to leptons group	Electron	Muons	Neutrinos	**All of these**
24	A pair of quark and anti-quark makes	**Meson**	Baryon	Photon	Proton
25	A particle is made up of two up quarks and one down quark is	**Proton**	Neutron	Boson	Lepton

26	Which of the following are elementary particles	Protons	Neutrons	**Photons**	Mesons
27	Three up quarks combine to form a new particle the charge on this particle	1	**2**	3	4
28	SI unit of absorbed dose is	**Gray**	Roentgen	Curie	Rem
29	An electric eye operates because of	Compton effect	Photo refraction	**Photo electric effect**	Gamma ray counter
30	Thyroid cancer is caused by	C-14	Na-24	**I-131**	Co-60
31	Color TV (while operating) emits	Alpha rays	Beta rays	Gamma rays	**X-rays**

Tid bits

What were the results of alpha scattering experiment: From alpha particles scattering experiment Rutherford discovered that most of part of atom is empty and max mass is concentrated in a very small region called nucleus.
Isotopes of Xenon and cesium have: Both have 36, 36 isotopes.
Beta decay occur: It occur when a neutron in an unstable parent nucleus decay into a proton and electron, the electron being emitted as beta particle.
Range and benefit of ozone: It is on the surface is Earth and corrosive and poisonous gas but at height of 20-50km from earth surface, it become vital to life as it absorb almost all UV radiations which are harmful to living things/
Diseases caused by ultraviolet radiations: UV radiations cause

i. Sunburn, blindness and skin cancer
ii. Severe crop damage
iii. Decay of micro organism
iv. Disrupt the ocean ecosystem

Device is used to monitor radiations received by worker in nuclear facilities: Film badge dosimeter
Types of radioactive waste: There are three types of radioactive waste. High level, medium level, and low level. All these wastes are dangerous for ground water and land environment

Half-life of Pu: 24,000 years

Table regarding mcqs

Isotope	Half life	Example of use
Sodium-24	15 hours	Plasma volume
Iron-59	45 days	Iron in plasma
Te-99	6 hours	Thyroid scans
I-131	8 days	Kidney tests
I-125	60 days	Plasma volume vein flow

properties	Alpha particles	Beta particles	Gamma rays
Nature	Helium nuclei charge 2e	Electron or positron charge ±e	EM waves with no charge
Typical source	Radon-222	Strontium-94	Cobalt-60
Ionization	About 10^4	About 10^2	About 1
Range in air	Several centimeters	Several meters	Obey inverse square law
Absorbed by	A paper	1-5 mm of Al sheet	1-10 cm of lead sheet
Energy spectrum	Emitted with same energy	Variable energy	Variable energy
Speed	10^7 m/s	$1*10^8$ m/s	$3*10^8$ m/s

The half-life of $^{91}_{38}Sr$ is 9.70 hours. Find its decay constant.

$$\text{Given data : Half life} = T_{1/2} = 9.70\text{h} = 9.70*60*60 = 34920\,\text{sec, Decay constant} = \lambda = ?$$

$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{34920} = 1.98*10^{-5}\,s^{-1}$$

The element $^{234}_{91}Pa$ is unstable and decays by β-emission with a half-life 6.66 hours. State the nuclear reaction and the daughter nuclei.

Given Data : Nuclear reaction = ? Daughter nuclei = ?

Using eq of β decay $^{A}_{Z}X \rightarrow ^{A}_{Z+1}Y + ^{0}_{-1}\beta$

$^{234}_{91}P \rightarrow ^{234}_{92}U + ^{0}_{-1}\beta$ Parent element=$^{234}_{91}P$, Daughter element=$^{234}_{92}U$

21.6: If $^{233}_{92}U$ decays twice by α-emission, what is the resulting isotope?

Using eq of α decay $^{A}_{Z}X \rightarrow ^{A-4}_{Z-2}Y + ^{4}_{2}He$ in $^{233}_{92}U$

after first decay $^{233}_{92}U \rightarrow ^{229}_{90}Y + ^{4}_{2}He$, after 2nd decay $^{229}_{90}X \rightarrow ^{225}_{88}Y + ^{4}_{2}He$

Resulting isotope $^{225}_{88}Y$ radium - 88 is formed.

EXERCISE SHORT QUESTIONS

1.What are isotopes? What do they have in common and what are their differences?**

Isotopes are those nuclei, which have same atomic number but have different mass number.

i. The isotopes have the same number of protons and have different number of neutrons.
ii. They have same chemical properties but different physical properties

2.Why are heavy nuclei unstable?**

The heavy nuclei have very small value of their binding energy per nucleon. So they are unstable, and less energy is required to break it. For example U-238.

3. If a nucleus has a half-life of 1 year, does this mean that it will be completely decayed after 2 years? Explain.**

No, it does not mean that it will completely decay after 2 years. Because infinite time is required to decay completely. And after two half-life only 75% atoms will be decayed.

4.What fraction of a radioactive sample decays after two half-lives have elapsed?**

¾ of radioactive sample decay after two half lives

If n is number of half-lives, N_o is original no of atoms

Number of undecayed atom after n half-lives = $(1/2)^n N_o$

Put n=2, = $(1/2)^2 N_o = N_o/4$= No/4*100=25%So number of decayed atoms=75%

5.The radioactive element $^{226}_{88}Ra$ has a half-life of 1.6×10^{3} years. Since the Earth is about 5 billion years old, how can you explain why we still can find this element in nature?

We still can find Ra-226 in nature because there is an infinite time required to for an element to decay completely.

6.Describe a brief account of interaction of various types of radiations with matter.**

There are three ways

i. At low energies(less than 0.5MeV), photoelectric effect is occurred at this.
ii. At intermediate energies(b/w 0.5-1.02 MeV) Compton effect
iii. At high energies (more than 1.02 MeV) pair production take place.

7. Explain how α and β-particles may ionize an atom without directly hitting the electrons? What is the difference in the action of the two particles for producing ionization?

There are following methods for ionization by alpha and beta particles without hitting

i. It may ionize an atom by pulling the electron through electrostatic attraction
ii. Beta particles may ionize by electrostatic repulsion

Because alpha particle attract electrons and beta particle repel electron due to same charge.

8. A particle, which produces more ionization, is less penetrating? Why?**
A particle which produces more ionization is less penetrating because it loses most of its energy in ionizing the atoms. So, it travel very small distance in medium before coming to rest.

9.What information is revealed by the length and shape of the tracks of an incident particle in Wilson cloud chamber?**

i. **Alpha particle:** they have thick, straight and continuous track due to intense ionization
ii. **Beta particles:** they are thin and discontinuous track in erratic manner
iii. **Gamma ray:** no definite track along the path, length of track is proportional to energy of incident particles

10.Why must a Geiger Muller tube for detecting α-particles have a very thin end window? Why does a Geiger Muller tube for detecting γ -rays not need a window at all?
It detect alpha particle because this window provides easy way for these low penetrating particles, to enter into the tube.
For detecting rays, there is no need of such a window because rays are highly penetrating

11. Describe the principle of operation of a solid-state detector of ionizing radiation in terms of generation and detection of charge carriers.**
It is based upon following principle
"When radiations are allowed to enter the depletion region, electrons hole pairs are produced that generate current pulse used for detection process".

12. What do we mean by the term critical mass?**
Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction produces further fission is called critical mass.

13. Discuss the advantages and disadvantages of nuclear power compared to the use of fossil fuel generated power

Nuclear power	Fossil fuel power
It is cheaper for electricity	It is not cheaper
It is permanent for a given period of time	It is not permanent and not for long period of time
It does not produce smoke	It produces smoke
It is of large amount	It is not of large amount

Disadvantages it is dangerous and injurious and harmful to living things

14. What factors make a fusion reaction difficult to achieve?**
The fusion reaction requires temperature up to 10 million degree centigrade and high energy. These requirements are very difficult to achieve.

15. Discuss the advantage and disadvantages of fusion power from the point of safety, and resources.
Advantage: As the fusion reaction is free from radioactive fossil products, so it is not dangerous. It also gives more energy per nucleon as compared with nuclear fission reaction.
Disadvantage: The fusion reaction requires temperature up to million degree centigrade and high energy. These requirements are very difficult to achieve

16. What do you understand by "background radiation"? State two sources of this radiation.**
The radiation present due to cosmic rays and due to presence of radioactive materials under crest of earth, are called background radiations. Two sources of radiations
Radioactive potassium and carbon in body.

17.If someone accidently swallow an α-source and a β-source, which would be the more dangerous to him? Explain why?
Alpha source will be more dangerous than beta source. It is because that ionizing power of alpha particle is greater than beta particle.

18. Which radiation dose would deposit more energy to the body (a) 10 mGy to the hand, or (b) 1 mGy dose to the entire body?
As we know that absorbed dose=energy/mass
Energy=m*D, as energy is proportional to mass so mass of whole body is much greater than hand, so 1mGy deposit more energy.

19. What is a radioactive tracer? Describe one application each in medicine, agriculture and industry.

Use of radioisotopes behave as normal isotopes in living organism to find what happens in chemical and biological process is called radioactive tracer

The use of phosphorous or nitrogen as a tracer has helped to adopt a better mode of fertilizer supply to plants.

Radioactive iodine can be used to check that a person's thyroid gland is working properly or not. A similar method can be used to study the circulation of blood using sodium-24.

20. How can radioactivity help in the treatment of cancer?**

Radiotherapy with gamma rays from cobalt -60 is used in treatment of cancer of various types. These radiations are carefully focused on malignant tissues. Cancerous cells absorb more radiations and more easily destroyed than normal cells, also thyroid cancer is treated withI-131, and for skin cancer P-32 and Strontium-90 are used

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Physics 2nd year (Pairing Scheme 2022-23) All Punjab Boards

Total Marks: 85 **Time (20 min for objective and 2.40 h for subjective)**

Q.1 Mcqs: **total Marks: 17**

chapter	12	13	14	15	16	17	18	19	20	21
No of Q	02	01	02	02	02	01	02	02	01	02

Short Questions **Total Marks: 44**

chapter	12	13	14	15	16	17	18	19	20	21
No of Q	04	03	04	04	03	03	03	03	02	04

Q.2	Chapter 12=04 Q	Chapter 14=04 Q	Chapter 21=04 Q	-------------------	08/12=16 Marks
Q.3	Chapter 13=03 Q	Chapter 16=03 Q	Chapter 17= 03 Q	Chapter 18=03 Q	08/12=16 Marks
Q.4	Chapter 15=04 Q	Chapter 19=03 Q	Chapter 20= 02 Q	---------------------	06/09=12 Marks

Extensive Questions (To Solve Any Three out of Five) Marks: (05+03)*3=24

Q.5	Chapter 12+13(a or b part from any of one chapter)
Q.6	Chapter 14+15 (a or b part from any of one chapter)
Q.7	Chapter 16+18 (a or b part from any of one chapter)
Q.8	Chapter 17+19 (a or b part from any of one chapter)
Q.9	Chapter 20+21 (a or b part from any of one chapter)

Physics paper 2nd year Annual 2022(BISE Sargodha)
Objective

Q.1 MCQs **17**

Q#	Statement	Option A	Option B	Option C	Option D
01	A rubber ball of radius 2cm has charge of 5μC on its surface, which is uniformly distributed, value of E at its center is	10 N/C	Zero	2.5 N/C	$5*10^{-6}$ N/C
02	The minimum value of charge on free particle is	⅔e	⅓ e	-⅔ e	e
03	During danger the "eel" turn itself into a living battery, then the potential difference between head and tail can be upto	600 V	440 V	220 V	160 V
04	The sum of electric and magnetic force is	Maxwell force	Newton force	Lorentz force	Centripetal force
05	Output waveform of sweep or time base generator is	Saw tooth wave	Digital wave	Sinusoidal wave	Square wave
06	Emf is induced due to change in	Electric flux	Magnetic flux	Electric potential	Electric field
07	When the motor is just started, back emf is	Maximum	Minimum	Almost zero	Equal to current
08	An AC voltmeter reads 220 V, its peak value	255 V	311.12 V	300 V	220 V
09	When we accelerate the charge, which type of waves are produced?	Mechanical waves	Travelling waves	Stationary waves	Electro-magnetic waves
10	A device used to detect very weak magnetic field produced by brain is named as	MRI	CAT scanner	SQUIDS	CRO
11	The magnitude of voltage gain of amplifier having r_{ie}=1 ohm, β=100, Rc=200 ohm	20000	200	150	20
12	Which one is used as temperature sensor in electrical circuit	Capacitor	Diode	LDR	Thermistor
13	The rest mass of photon is	Infinite	Zero	$1.6*10^{-27}$ kg	$3*10^{8}$ kg
14	The materialization of energy take place in the process of	Photo electric effect	Compton effect	Pair production	Annihilation of matter
15	The unit of Rydberg's constant is	m/s	m	m^2	m^{-1}
16	The unit of Decay constant is	m	s	mK	s^{-1}
17	Half life of radioactive isotope of iodine-131	6 days	8 days	10 days	12 days

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