SCHOOL EDUCATION DEPARTMENT

CHIEF EDUCATIONAL OFFICER

CHENNAI DISTRICT

HIGHER SECONDARY SECOND YEAR

PHYSICS

LEARNING MATERIAL

2022 -23

Conceived and scripted by

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PERSPICUOUS PHYSICS

Under the stewardship of CEO Chennai , we physics teachers of Chennai have made an earnest attempt to present 12th Standard physics in a student friendly manner for them to come out successfully with flying colours in their public exam

The two strategies of this venture are, selecting the topics and exhausting the concepts in it in a very simple way, so that the students can assimilate it easily in a short duration.

Setting goals is the first step in turning the invisible into the visible

All the best in all your endeavours

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1 . ELECTROSTATICS

2 MARK - QUESTIONS AND ANSWERS :

1. **What is called electrostatics?**
   - Branch of physics dealing with charges at rest or stationary charges
2. **What is Called triboelectric charging?**
   - Charging the object through rubbing is called triboelectric charging.
3. **What is meant by quantisation of charges?**
   - The charge in an object $q = ne$.
   - Here n = 0, ±1, ±2, ±3, ±4….. and e is electron charge.
4. **State conservation of electric charges.**
   - The total electric charge in the universe is constant and charge can neither be created nor be destroyed
   - In any physical process, the net change in charge will be zero.
5. **Write down Coulomb's law in vector form and mention what each term represents.**
   - Coulomb's law in vector form $\vec{F} = k\frac{q_1q_2}{r^2}\hat{r}$
   - Here, $\vec{F}$ - the force between point charges
   - q_1,q_2 - magnitude of point charges
   - r - distance between the two charges
   - $\hat{r}$ - the unit vector pointing along the line joining q_1, and q_2
6. **State coulomb's law in electrostatics.**
   - The electrostatic force is directly proportional to the product of the magnitude of the two point charges
   - And is inversely proportional to the square of the distance between them.
   - i.e $\vec{F} \alpha \frac{q_1q_2}{r^2}\hat{r}$
7. **Write short notes on superposition principle**
   - The total force acting on a given charge is equal to the vector sum of forces exerted on it by all the other charges.
   - $\overrightarrow{F_1^{tot}} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \cdots \ldots . . + \vec{F}_{1n}$
8. **Define electric field. Give its unit.**
   - The electric field at a point is defined as the force experienced by a unit charge placed at that point.
   - Its unit is NC^{-1} (or) Vm^{-1}.
9. **What is meant by electric field lines.**
   - A set of continuous lines which are the visual representation of the electric field in some region of space is called electric field lines.
10. **The electric field lines never intersect. Justify.**
    - If two lines cross at a point, then there will be two different electric field vectors at that point.
    - If a charge is placed in the intersection point, then it has to move in two different directions at the same time, which is physically impossible. Hence, electric field lines do not intersect
11. **What is an electric dipole? Give the magnitude and direction of dipole moment.**
    - Two equal and opposite charges separated by a small distance constitute an electric dipole.
    - The magnitude of dipole moment is equal to the product of the magnitude of one of the charges and the distance between them. (i.e) p = 2qa.
    - Direction is from –q to +q

12. **Define Electrostatic potential. Give its unit.**
   - The electrostatic potential at a point is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to that point in the region of the external electric field.
   - Its unit is ***volt* (V).**
13. **Define potential difference. Give its unit.**
   - The electric potential difference is defined as the work done by an external force to bring unit positive charge from one point to another point against the electric field.
   - Its unit is ***volt* (V)**
14. **What is an Equipotential Surface?**
   - An equipotential surface is a surface on which all the points are at the same electric potential.
15. **What are the properties of an equipotential surface?**
   - The work done to move a charge between any two points on the equipotential surface is zero.
   - The electric field must always be normal to an equipotential surface.
16. **Give the relation between electric field and electric potential.**
   - Electric field is the negative gradient of the electric potential. (i. e) $E = -\frac{dV}{dx}$
17. **Define Electrostatic potential energy. Give its unit.**
   - Electrostatic potential energy for system of charges is equal to the work done to arrange the charges in the given configuration.
   - Its unit is ***joule* (J).**
18. **Define Electric flux. Give its unit.**
   - The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux.
   - Its unit is $\boldsymbol{Nm^2C^{-1}}$
19. **State Gauss law in electrostatics.**
   - The total electric flux through a closed surface $\phi_E = \frac{Q_{enclosed}}{\varepsilon_o}$
   - Here $Q_{enclosed}$ is the net charge enclosed by the surface.
20. **Define electrostatic energy density.**
   - The electrostatic potential energy stored per unit volume of space is defined as energy density.
21. **What is dielectric (or) insulator?**
   - A dielectric is a non-conducting material and has no free electrons.
   - **Examples:** Ebonite, glass and mica.
22. **What are non polar molecules? Give examples.**
   - A non polar molecule is one in which the centers of the positive and negative charges coincide.
   - It has no permanent dipole moment. **Examples :** O_2, H_2, CO_2.
23. **What are polar molecules ? Give examples.**
   - A polar molecule is one in which the centers of the positive and the negative charges are separated.
   - They have a permanent dipole moment. **Examples :** N_2O, H_2O, HCl, NH_3.
24. **Define (electric) polarisation?**
   - (Electric) Polarisation is defined as the total dipole moment per unit volume of the dielectric.
25. **Define electric susceptibility. Give its unit.**
   - Electric susceptibility is defined as polarization per unit external electric field. $\vec{P} = \chi_e \vec{E}_{ex}$.
   - Its unit is $\boldsymbol{C^2 N^{-1} m^{-2}}$.

26. What is dielectric breakdown.?

- When the external electric field applied to a dielectric is very large, it tears the atoms apart so that the bound charges become free charges.
- Then the dielectric starts to conduct electricity. This is called dielectric breakdown.

27. What is dielectric strength?

- The maximum electric field, the dielectric can withstand before it breakdown is called dielectric strength.
- E.g. dielectric field strength of air is 3×10^6 Vm^{-1}.

28. What is an electrostatic induction?

- The phenomenon of charging without actual contact of charged body is called electrostatic induction.

29. Define capacitance of a capacitor. Give its unit.

- The capacitance C of a capacitor is defined as the ratio of the magnitude of charge on either of the conductor plates to the potential difference existing between them. (i.e) $C = Q/V$
- Its unit is ***farad*** **(F)** or $\mathbf{CV^{-1}}$.

30. Write a note on electrostatic shielding.

- It is the process of isolating a certain region of space from external field. $\vec{E}$ inside is zero.
- A sensitive electrical instrument which is to be protected from external electrical disturbance is kept inside the cavity of a charged conductor. This is called electrostatic shielding. (e.g) Faraday cage.

31. What is corona discharge (or) action at points ?

- Leakage of electric charges from the sharp edge of the charged conductor is called corona discharge or action at points.

32. Why is it safer to be inside a car than standing under a tree during lightning?

- The metal body of the car provides electrostatic shielding, since the electric field inside is zero.
- During lightning the electric discharge passes through the body of the car.

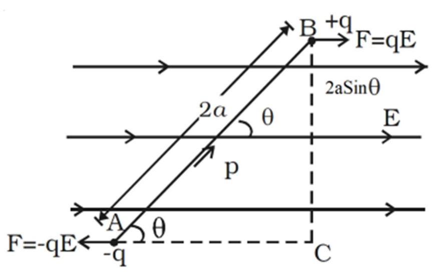
<u>3 MARK - QUESTIONS AND ANSWERS :</u>

1. Distinguish between Coulomb force and Gravitational force.

S.No.	Coulomb forces	Gravitational force
1	Force between two charges	Force between two masses
2	Force can be attractive or repulsive	Force is only attractive
3	Force always greater in magnitude	Force always lesser in magnitude
4	Force depends on nature of the medium	Force independent of the medium

2. Derive an expression for torque experienced by an electric dipole placed in the uniform electric field.

- Consider an electric dipole AB placed in an uniform electric field $\vec{E}$ at an angle θ.
- The force on +q = q$\vec{E}$; The force on -q = − q$\vec{E}$.
- Due to these two forces the dipole experiences a torque.
- Torque (τ) = qE x 2a sinθ.
- Since (p = 2qa): τ = pE sinθ.
- In vector notation, $\vec{\tau} = \vec{p}\times\vec{E}$

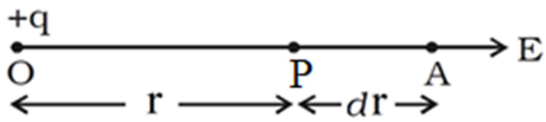


3. List the properties of electric field lines.

i) They start from positive charge and end at negative charge.
ii) The electric field is tangential to the electric field line at that point.
iii)If E is greater field lines are closer. If E is lesser field lines are far apart.

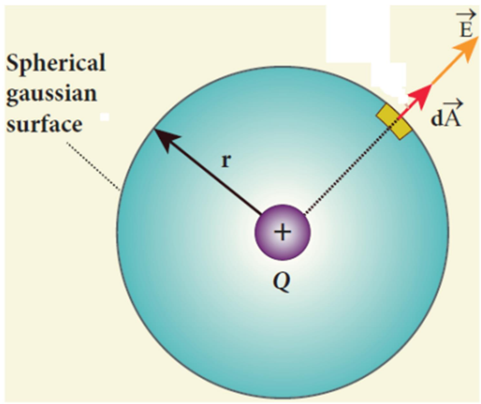
iv) Electric field lines do not intersect each other.
v) From a charge the number of electric field line is $N = \frac{q}{\varepsilon_o}$

4. Obtain an expression for electric potential at a point due to a point charge.



- The electric potential at the point is defined as the work done in moving a unit positive charge from infinity to that point against the electric force.
- Consider a point charge $+\boldsymbol{q}$ at origin. Let P be a point at a distance r from the origin.
- Electric potential at P, $V = -\int_{\infty}^{r} \vec{E}.\overrightarrow{dr}$.
- By definition, at P the electric field, $E = \frac{q}{4\pi\varepsilon_o r^2}\hat{r}$
- $V = -\int_{\infty}^{r} \frac{q}{4\pi\varepsilon_o r^2}\hat{r}.\overrightarrow{dr}$
- $V = \frac{q}{4\pi\varepsilon_o r}$

5. Obtain Gauss's law from Coulomb's law.



- Consider a point charge +q. C-is a point at a distance of r from the charge. q_o is test charge.
- Coulomb force between the charges, $\vec{F} = \frac{qq_o}{4\pi\varepsilon_o r^2}\hat{r}$
- From Gauss's law, the electric flux $\varphi_E = \oint \vec{E}.\overrightarrow{dA} = \oint \frac{q}{4\pi\varepsilon_o r^2}\hat{r}.\overrightarrow{dA} = \frac{q}{4\pi\varepsilon_o r^2}\oint \hat{r}.\overrightarrow{dA}$
- $\oint \hat{r}.\overrightarrow{dA} = 4\pi r^2$
- $\therefore \varphi_E = \frac{q}{\varepsilon_o}$
- This is Gauss's law.
- Thus we can obtain Gauss's law from Coulomb's law.

6. Give the applications and disadvantage of capacitors

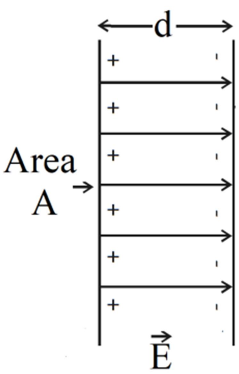
Applications of capacitor:

i) Flash capacitors are used in digital camera.
ii) It is used in heart defibrillator.
iii) Capacitors are used in automobile engines to eliminate sparking.
iv) Capacitors are used to reduce power fluctuations and to increase the efficiency of power transmission.

Disadvantage:

Even after the battery or power supply is removed, it causes unwanted electric shock.

7. Derive an expression for capacitance of parallel plate capacitor.



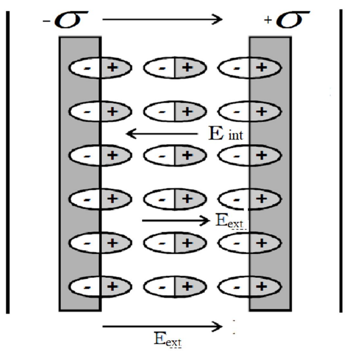
- Consider a capacitor consisting two parallel plates of area A and separated by a distance d.
- Capacitance of capacitor $C = \frac{Q}{V}$. Q =charge, V= potential difference.
- Charge Q= σA. (∵ surface charge density $\sigma = \frac{Q}{A}$)
- Potential difference between the plates $V = Ed = \frac{\sigma}{\varepsilon_o}d$. (∵ $E = \frac{\sigma}{\varepsilon_o}$)
- Substitute for Q and V
  $C = \frac{\sigma A}{\frac{\sigma}{\varepsilon_o}d} = \frac{\varepsilon_o A}{d}$

8. **Derive an expression for energy stored in capacitor**.
   - The work done to transfer dQ charge; $dW = VdQ = \frac{Q}{C}dQ$. ($\because V = \frac{Q}{C}$)
   - The total work done to charge a capacitor ; $W = \int_0^Q \frac{Q}{C}\, dQ = \frac{Q^2}{2C}$
   - This work done is stored as electrostatic energy of the capacitor
     $U = \frac{Q^2}{2C}$ (or) $\frac{1}{2}CV^2$

9. **Discuss the various properties of conductors in electrostatic equilibrium.**
   - The electric field is zero everywhere inside the conductor, whether the conductor is solid or hollow.
   - The charges must reside only on the surface of the conductors. Q_{net} inside is zero
   - The electric field outside the conductor is perpendicular to the surface of the conductor. $E = \frac{\sigma}{\varepsilon_0}$, σ = surface charge density.
   - The electrostatic potential has the same value on the surface and inside of the conductor.

10. **Explain the process of electrostatic induction.**
    - Charging without actual contact is called electrostatic induction.
    - An uncharged conducting sphere at rest on an insulating stand.
    - Suppose a negatively charged rod is brought near the sphere without touching.
    - As a result, nearer surface of the sphere becomes positively charged and other side becomes negative.
    - The other side of the sphere is connected to the ground through a conducting wire and then removed.
    - Now the charged negative rod is taken away from the conductor. The positive charges remains and gets distributed uniformly on the surface.

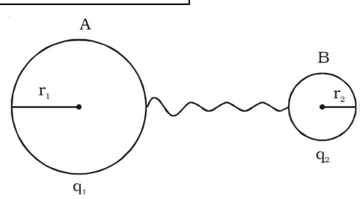
11. **Explain dielectrics in detail and how an electric field is induced inside a dielectric.**
    - A dielectric is a non-conducting material and has no free electrons.
    - When an external electric field is applied, the electrons are not free to move anywhere but they are realigned in such a way that an internal electric field is created
    - The created electric field is tend to cancel the external electric field.
    - The magnitude of the internal electric field is smaller than that of external electric field.
    - The net electric field is not zero. $\vec{E}_{net} = \vec{E}_{ext} - \vec{E}_{int}$



12. **Explain in detail how charges are distributed in a conductor and the principle behind the lightning conductor.**

Qty	Sphere A	Sphere B
Charge	q_1	q_2
Radius	r_1	r_2
Potential	$V_A = \frac{q_1}{4\pi\varepsilon_o r_1}$	$V_B = \frac{q_2}{4\pi\varepsilon_o r_2}$

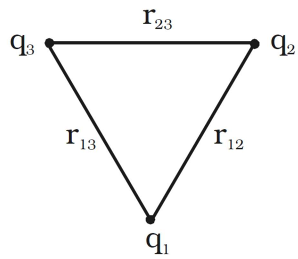
   - When spheres are connected by conducting wire, then $V_A = V_B$
   - $\frac{q_1}{r_1} = \frac{q_2}{r_2}$; $\frac{4\pi r_1^2 \sigma_1}{r_1} = \frac{4\pi r_2^2 \sigma_2}{r_2}$
   - $\sigma_1 r_1 = \sigma_2 r_2$; in general σr=constant.
   - Principle of lighting conductor is electrostatic induction and action of point.



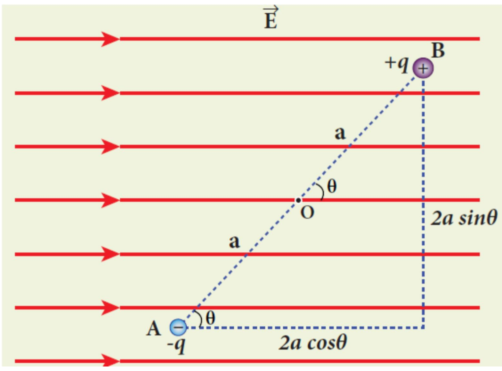
13. **Discuss the basic properties of electric charges.**
    - Write Answers of 2 mark questions 5 and 6
    - Write Answers of 3 mark question 1
    - $F = \varepsilon_r F_O$, $F > F_O$, $\varepsilon_r > 1$

14. **Explain in detail Coulomb's law and its various aspects.**
   - Write Answers of 2 mark questions 3 and 4
   - Charges are an inherent property of particles. Unit is coulomb.

15. **Obtain an expression for potential energy due to a collection of three point charges which are separated by finite distances.**
   - Potential energy general equation U = $\frac{q_1 q_2}{4\pi\varepsilon_o r}$.
   - Potential energy due to q_1 and q_2, $U_{12} = \frac{q_1 q_2}{4\pi\varepsilon_o r_{12}}$.
   - Potential energy due to q_2 and q_3, $U_{23} = \frac{q_2 q_3}{4\pi\varepsilon_o r_{23}}$.
   - Potential energy due to q_1 and q_3, $U_{13} = \frac{q_1 q_3}{4\pi\varepsilon_o r_{13}}$.
   - Total potential energy $U = U_{12} + U_{23} + U_{13}$
   - $U = \frac{1}{4\pi\varepsilon_o}\left(\frac{q_1 q_2}{r_{12}} + \frac{q_2 q_3}{r_{23}} + \frac{q_1 q_3}{r_{13}}\right)$

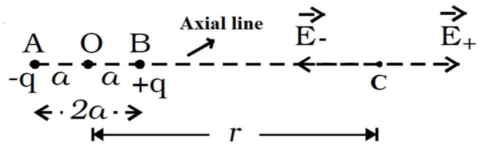


16. **Obtain electrostatic potential energy of dipole in a uniform electric field.**
   - Electrostatic potential energy for system of charges is equal to the work done to arrange the charges in the given configuration.
   - The work done by the external torque to rotate the dipole from angle θ' to θ is
     $W = \int_{\theta'}^{\theta} \tau_{ext} d\theta$
   - $\tau_{ext} = pEsin\theta$
   - $W = \int_{\theta'}^{\theta} pESin\theta \, d\theta$
   - W = - pECosθ + pECosθ'
   - If the initial angle is $\theta' = 90^O$, then the potential energy stored in the system is U = - pECosθ

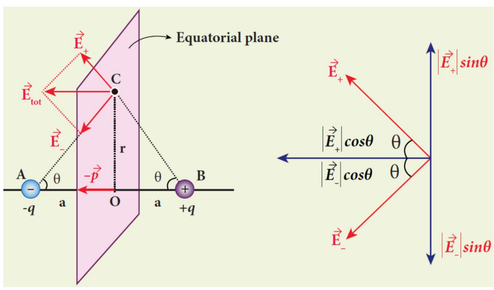


<u>5 MARK - QUESTIONS AND ANSWERS :</u>

1. **Calculate the electric field due to a dipole on its axial line.**
   - AB – dipole, O – it's midpoint, C – a point on axial line
   - AB= 2a, OC = r
   - Electric field at C due to +q, $\vec{E}_+ = \frac{q}{4\pi\varepsilon_o (r-a)^2}\hat{p}$
   - Electric field at C due to −q, $\vec{E}_- = -\frac{q}{4\pi\varepsilon_o (r+a)^2}\hat{p}$
   - The total electric field at 'c' due to dipole is $\vec{E}_{tot} = \vec{E}_+ + \vec{E}_-$
     $\vec{E}_{tot} = \left(\frac{q}{4\pi\varepsilon_o (r-a)^2} - \frac{q}{4\pi\varepsilon_o (r+a)^2}\right)\hat{p}$
     $\vec{E}_{tot} = \frac{q}{4\pi\varepsilon_o}\left[\frac{4ra}{(r^2-a^2)^2}\right]\hat{p}$
   - If r>>a then $\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_o}\frac{2\vec{p}}{r^3}$ [$\because \vec{p} = 2aq\hat{p}$]
   - $\vec{E}_{tot}$ is along $\vec{p}$

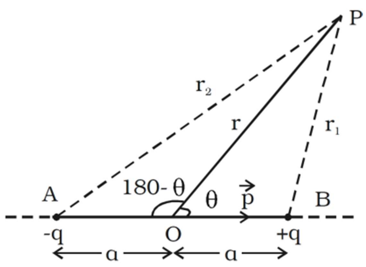


2. **Calculate the electric field due to a dipole on its equatorial line.**
   - AB – dipole, O – it's midpoint, C – a point on equatorial plane. AB= 2a, OC = r
   - Electric field at C due to +q, $|\vec{E}_+| = \frac{q}{4\pi\varepsilon_o (r^2+a^2)}$.
   - Electric field at C due to −q, $|\vec{E}_-| = \frac{q}{4\pi\varepsilon_o (r^2+a^2)}$.



- Here , $|\vec{E}_+| = |\vec{E}_-|$
  $|\vec{E}_+|$ Sinθ & $|\vec{E}_-|$ Sinθ are equal and opposite, so they cancel each other.
  $|\vec{E}_+|$ Cosθ & $|\vec{E}_-|$ Cosθ are equal and same direction, so they add up together.
  $\vec{E}_{tot} = -2|\vec{E}_+|$ Cos$\theta\ \hat{p}$
- Here, Cos$\theta = \frac{a}{(r^2+a^2)^{1/2}}$; Therefor $\vec{E}_{tot} = -2\ \frac{q}{4\pi\varepsilon_o(r^2+d^2)}\frac{a}{(r^2+a^2)^{1/2}}\hat{p}$
  $\vec{E}_{tot} = -\frac{2aq}{4\pi\varepsilon_o(r^2+a^2)^{3/2}}\hat{p}$
- If r>>a then , $\vec{E}_{tot} = -\frac{\vec{p}}{4\pi\varepsilon_o r^3}$, $[\because \vec{p} = 2aq\hat{p}]$
- $\vec{E}_{tot}$ is opposite to $\vec{p}$

3. Derive an expression for electrostatic potential due to electric dipole.



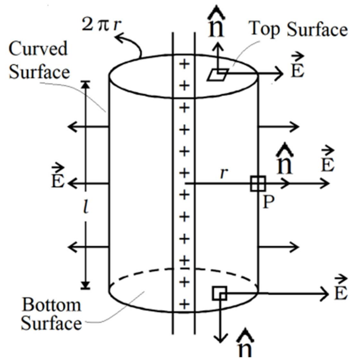
- AB – dipole, O – It's midpoint, P – point at any point.
- AB= 2a, OP = r, AP = r_2, BP=r_1.
- Electric potential at P due to +q , $V_1 = \frac{1}{4\pi\varepsilon_o}\frac{q}{r_1}$
- Electric potential at P due to −q , $V_2 = -\frac{1}{4\pi\varepsilon_o}\frac{q}{r_2}$
- Electric potential at 'P' due to dipole is
  $V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r_1} - \frac{1}{4\pi\varepsilon_o}\frac{q}{r_2}$
  $V = \frac{q}{4\pi\varepsilon_o}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$
- $\therefore \frac{1}{r_1} = \frac{1}{r}\left(1 + \frac{acos\theta}{r}\right)$ and $\therefore \frac{1}{r_2} = \frac{1}{r}\left(1 - \frac{acos\theta}{r}\right)$

By substuting, $V = \frac{q}{4\pi\varepsilon_o}\left[\frac{1}{r}\left(1 + \frac{acos\theta}{r}\right) - \frac{1}{r}\left(1 - \frac{acos\theta}{r}\right)\right]$

$V = \frac{q}{4\pi\varepsilon_o}\frac{2acos\theta}{r^2} = \frac{1}{4\pi\varepsilon_o}\frac{pcos\theta}{r^2}$ (Since p=2qa) (or) $V = \frac{1}{4\pi\varepsilon_o}\frac{\vec{p}.\hat{r}}{r^2}$

Θ = 0°	$V = \frac{1}{4\pi\varepsilon_o}\frac{p}{r^2}$
Θ = 180°	$V = -\frac{1}{4\pi\varepsilon_o}\frac{p}{r^2}$
Θ = 90°	V = 0

4. Obtain an expression for electric field due to an infinitely long charged wire.

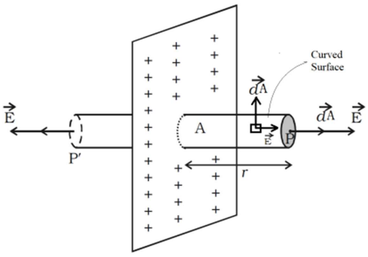


- Consider an infinitely long straight wire of uniform linear charge density λ. *i. e* $\lambda = \frac{Q_{enclosed}}{L}$.
- Gaussian surface : A cylinder of length L and radius r.
- The total electric flux is
  $\varphi_E = \oint \vec{E}.\overrightarrow{dA} = \int \vec{E}.\overrightarrow{dA} + \int \vec{E}.\overrightarrow{dA} + \int \vec{E}.\overrightarrow{dA}$.
  (Curved Surface, Top Surface, Bottom Surface)

Surface	θ	Cosθ	$\int \vec{E}.\overrightarrow{dA}$
Top	90°	0	0
Bottom	90°	0	0
Curved	0°	1	$\int E.dA$

- Therefore $\varphi_E = \int E.dA$ = E (2πrL)
- According to Gauss's law $\varphi_E = \frac{Q_{enclosed}}{\varepsilon_o}$
- By applying Gauss's law; E (2πrL) = $\frac{\lambda L}{\varepsilon_o}$
  $E = \frac{\lambda}{2\pi\varepsilon_o r}$: $\vec{E} = \frac{\lambda}{2\pi\varepsilon_o r}\hat{r}$
- The direction of is perpendicular to wire. If $\lambda > 0$, then pointing outward, if $\lambda < 0$ inward.

5. **Obtain an expression for electric field due to an charged infinite plane sheet.**

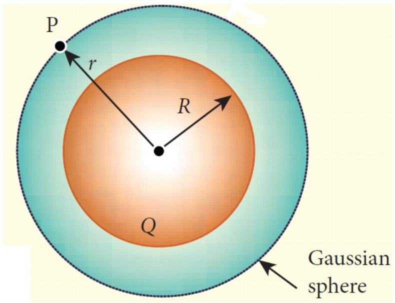
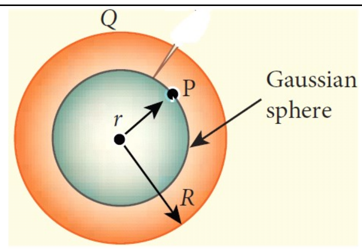


- Consider an infinitely charged plane sheet of uniform linear of surface charge density σ. $i.e$ $\sigma = \frac{Q_{enclosed}}{A}$.
- Electric field : Let E be the electric field at P which is at a distance r from the sheet.
- Gaussian surface : a cylinder of length 2r and area of cross section A
- The total electric flux is
- $\varphi_E = \oint \vec{E}.\overrightarrow{dA} = \int_{\text{Curved Surface}} \vec{E}.\overrightarrow{dA} + \int_{p} \vec{E}.\overrightarrow{dA} + \int_{p'} \vec{E}.\overrightarrow{dA}$.

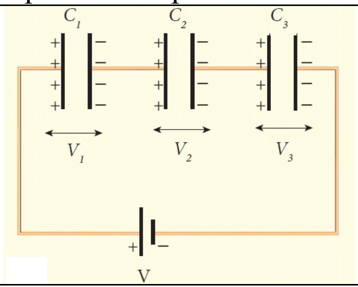
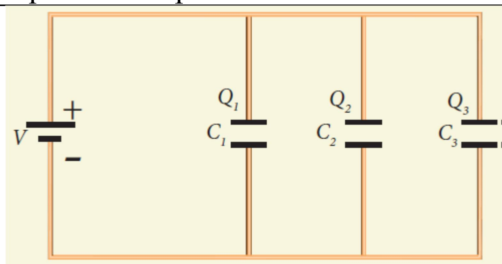
Surface	$\boldsymbol{\theta}$	**Cos**$\boldsymbol{\theta}$	$\int \vec{E}.\overrightarrow{dA}$
Curved	90°	0	0
P	0	1	$\int E.dA$
P'	0°	1	$\int E.dA$

- Therefore $\varphi_E = \int_{p} \vec{E}.\overrightarrow{dA} + \int_{p'} \vec{E}.\overrightarrow{dA}$ = = EA+EA = 2 EA
- According to Gauss's law $\varphi_E = \frac{Q_{enclosed}}{\varepsilon_o}$
- By apply Gauss's law: 2EA = $\frac{\sigma A}{\varepsilon_o}$. Therefore $\mathbf{E} = \frac{\sigma}{2\varepsilon_o}$;In vector form $\vec{E} = \frac{\sigma}{2\varepsilon_o}\hat{r}$.

6. **Obtain an expression for electric field due to an uniformly charged spherical shell.**

At a point outside the shell	**At a point on the surface of the shell**	**At a point inside the shell**
Gaussian Surface : Sphere with r	Gaussian Surface : Sphere with r	Gaussian Surface : Sphere with r
R- Radius of spherical shell, r > R	R- Radius of spherical shell, r = R	R- Radius of spherical shell, r < R
	Substitute r = R	
According to Gauss's law $\oint \vec{E}.\overrightarrow{dA} = \frac{Q_{enclosed}}{\varepsilon_o}$		According to Gauss's law $\oint \vec{E}.\overrightarrow{dA} = \frac{Q_{enclosed}}{\varepsilon_o}$
Since θ = 0, E = constant, A=4πr^2, $Q_{enclosed}$ = Q		Since θ = 0, E = constant, A=4πr^2, $Q_{enclosed}$ = 0
E(4πr^2) = $\frac{Q}{\varepsilon_o}$ E = $\frac{Q}{4\pi r^2 \varepsilon_o}$	E = $\frac{Q}{4\pi R^2 \varepsilon_o}$	E(4πr^2) = $\frac{0}{\varepsilon_o}$ E = 0

7. **Derive the expression for resultant capacitance, when capacitors are connected in series and in parallel.**

Capacitors in series	**Capacitors in parallel**
C_1,C_2 and C_3 are connected in series. C_S is equivalent capacitance	C_1,C_2 and C_3 are connected in parallel. C_P is equivalent capacitance
	
Each capacitor has same amount of charge (Q). But V across each will be different. $V = V_1 + V_2 + V_3$	Each capacitor has same potential difference (V). But Q will be different. $Q = Q_1 + Q_2 + Q_3$
$V = \frac{q}{C_S}$: $V_1 = \frac{q}{C_1}$; $V_2 = \frac{q}{C_2}$; $V_3 = \frac{q}{C_3}$	$Q = C_pV$; $Q_1 = C_1V$; $Q_2 = C_2V$; $Q_3 = C_3V$.
$\frac{Q}{C_S} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$ $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_pV = C_1V + C_2V + C_3V$ $C_P = C_1 + C_2 + C_3$
The reciprocal of the equivalent capacitance is equal to the sum of the reciprocal of each capacitance.	The equivalent capacitance is equal to the sum of the individual capacitance.

8. **Explain in detail the effect of introducing a dielectric medium between the plates of a parallel plate capacitor, when the capacitor is disconnected from the battery.**

Quantity	**Connected Battery and before introducing dielectric**	**After disconnecting Battery and after introducing dielectric**
Charge	Q_o	Q_o
Voltage	V_o	**V**
Electric Field	E_o	**E**
Capacitance	$C_o = \frac{Q_o}{V_o}$	$C = \varepsilon_r \frac{Q_o}{V_o} = \varepsilon_r C_o$

➢ Effect of di electric medium between the plates

Quantity	**Value**	**Effect of dielectric when ε_r >1**
Electric Field	$E = \frac{E_o}{\varepsilon_r}$	$E < E_o$, Decreased.
Potential Difference	$V = \frac{V}{\varepsilon_r}$	$V < V_o$, Decreased.
Capacitance	$C = \varepsilon_r C_o$	$C > C_o$, Increased.
Energy	$U = \frac{U_o}{\varepsilon_r}$	$U < U_o$, Decreased.

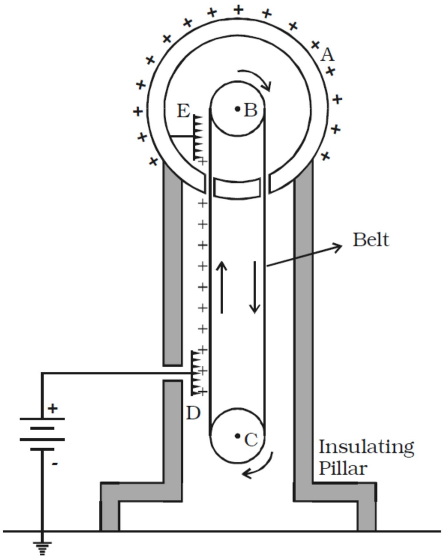
9. **Explain in detail the construction and working of Van de Graff generator.**

➢ **Principle** : Electrostatic induction and Action at points.

➢ **Construction** :

- A is a hollow spherical conductor.
- B and C are pulleys and they are connected by a silk belt
- D and E are metallic combs
- The comb D is at a positive potential of $10^4\,V$.
- The upper comb 'E' is connected to the inner side of the hollow metal sphere.

- **Working of comb D:**
  - **Due to action of point air near comb D gets ionized.**
  - The positive charges are repelled to the belt.
  - And negative charges are attracted towards the comb D.
  - The positive charges are carried by the belt and reach comb E.
- **Working of comb E:**
  - Due to electrostatic induction ,the comb 'E' get negative charges and the sphere gets positive charges.
  - Due to action at points at 'E' ,descending belt has no charge.
- **Charge leakage:**
  - Beyond $10^7 V$ of the sphere, the charges start leaking.
  - It is prevented by enclosing the sphere with a gas filled chamber.



- **Application**:
  - Used to accelerate positive ions (protons and deuterons) in nuclear disintegrations.

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2. Current electricity

2 MARK - QUESTIONS AND ANSWERS :

1. **Define electric current and give its unit**
   - The rate of flow of charges through a given cross Sectional area in a conductor.
   - Unit is A
2. **Why is nichrome used as heating element in electric heater?**
   Nichrome has
   - high specitic resistance (ρ)
   - high melting point
   - heated to very high temperature without oxidation.
3. **Electric Current is a Scalar. Why?**
   - It does not obey to vector laws even through it has magnitude and direction.
4. **Define current density and give its unit**
   - Current flowing per unit area of cross section of the conductor J= I/A; Unit Am^{-2}
5. **Give microscopic form of ohm's law**
   - Current density is directly Proportional to applied electric filed
   - $J \alpha E$; $J=\sigma E$; $\sigma \rightarrow$ Conductivity.
6. **Give macroscopic form of Ohm's law**
   - V= IR; V-Potential difference; I-Current; R-Resistance
7. **Define Electrical resistivity & give its unit.**
   - Resistance offered to the current flow by a conductor of unit length having unit area of cross section.
8. **Define temperature Co-efficient of resistivity and give its unit**
   - The ratio of increase in resistivity per degree rise in tempenture to its resistivity at 0^o C
   - Its unit is $/^oC$
9. **State Kirchuff's first rule (Current law or junction)**
   - The algebraic sum of the currents meeting at any junction in a circuit is zero.
   - At junction $\sum I = 0$

10. State Kirchoff's second rule (voltage law or loop law)

- The algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the Circuit
- $\sum IR = \sum E$

11. State the Principle of potentiometer.

- The emf of a cell is directly proportional to balancing length. ie.. $E \propto l$

12. Define internal resistance of a cell?

- The resistance given by the ions of the electrolyte to the flow of electric charges inside the cell.

13. What is known as superconductivity? (or) state critical temp

- It is the property of the materials whose resistance become **zero** below certain temperature called critical Temp (or) Transition temp.
- The materials at this temperature are called super conductor.

14. State Joule's law of heating

- Heat produced due to the flow of current in a conductor is directly proportional to
  - square of the current ($H \propto I^2$)
  - Resistance of the conductor ($H \propto R$)
  - time of flow ($H \propto t$)

15. What is seebeck effect?

- When the junctions of the two dissimilar metals are kept at two different temperatures, an emf (potential Difference) is developed. This phenomenon is called Seebeck effect.

16. What is Peltier effect?

- When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction.

17. What is Thomson effect?

- When electric current is passed through a conductor in which two points are at different temperature, heat is either evolved or absorbed throughout the conductor.

18. State the applications of seebeck effect.

- Seebeck effect is used in
  - electric generators (to convert heat energy into electric energy)
  - automotive thermo electric generators to increase fuel efficiency
  - thermo couple & thermopiles to measure the temperature difference between two objects.

19. Distinguish between drift velocity and mobility.

Drift velocity	Mobility
The average velocity gained by the electrons inside the conductor when it is subjected to an electric field (E)	Drift velocity per unit electric field (E)
It is unit is m/s (or) ms^{-1}	Its unit is $m^2V^{-1}s^{-1}$

20. What are ohmic and non-ohmic material

Ohmic materials	Non-ohmic material
V-I graph in a straight line	V-I graph is non – linear (not straight)
Obey to ohm's law	Does not obey to ohm's law.
They have constant resistance (R=V/I)	They don't have constant resistance

21. Differentiate Joule's heating effect and peltier effect

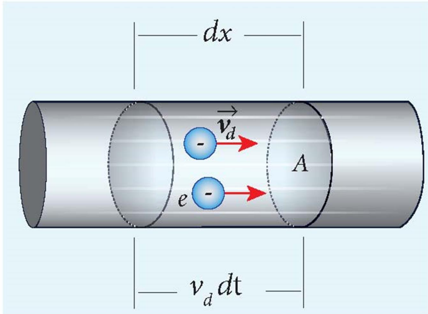
Joule's heating effect	Peltier effect
It is irreversible	It is reversible
$H \alpha I^2$ (Heat produced is directly proportional to square of the current)	$H \alpha I$ (Heat Produced per time is directly proportional to current)
Independent of the direction of current	Depends on the direction of current

22. **Differentiate electric energy and electric power.**

Electric energy (U)	Electric Power (P)
Work done (W) by the cell to move the charge from one and to another of the conductor	Electric energy delivered per unit time $\left(P = \frac{U}{t}\right)$
SI unit is Joule.	Its unit is Joule/second (or) watt
Its practical unit is kilowatt-hour (Kwh) 1 kwh = 3.6×10^6 J	Its practical unit is horse power (HP) 1 H.P = 746 w.

<u>3 MARK - QUESTIONS AND ANSWERS :</u>

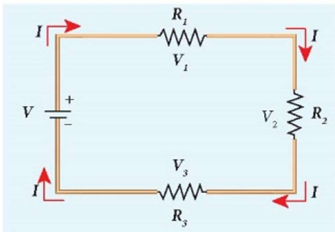
1. **Obtain the macroscopic form of ohm's law from its microscopic form Microscopic form**



- Microscopic form
  - By ohm's law $J = \sigma E$ ---------1
  - Current density $J = \frac{I}{A}$ ---------2
  - Sub 2 in 1; $\frac{I}{A} = \sigma E$
  - Electric field $E = \frac{V}{l}$
  - Therefore $\frac{I}{A} = \sigma \frac{V}{l}$
  - $V = \frac{Il}{A\sigma} = I\left(\frac{l}{A\sigma}\right)$
  - V = IR. This is the macroscopic form of ohm's law

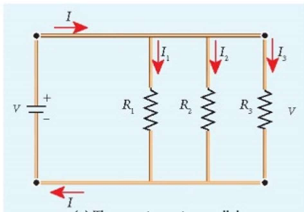
2. **Explain the equivalent resistance of a series and parallel resistor network**

<u>Resistances connected in series</u>



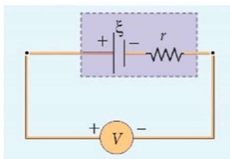
- R_1, R_2 and R_3 are resistances connected in series
- V - Potential difference applied; I-Current in series
- I – Same; but V – different
- $V=V_1+V_2+V_3$
- $IR_S=IR_1+IR_2+IR_3$
- Effective Resistance $R_S = R_1+R_2+R_3$

<u>Resistances connected in Parallel</u>

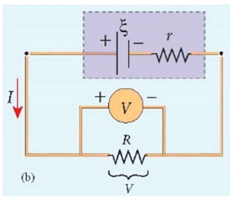


- R_1, R_2 and R_3 are resistances connected in Parallel
- V - Potential difference applied; I-Current in series
- V – Same; but I – different
- $I = I_1+I_2+I_3$
- $\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
- $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

3. **Explain the determination of internal resistance of a cell using voltmeter.**



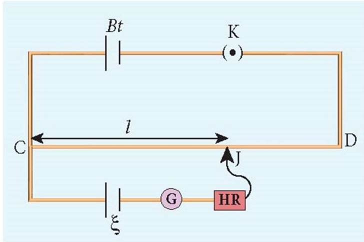
- When the electric circuit is open, reading in the voltmeters (v) is equal to emf (ε) of the cell.
- V = ε ——————— 1
- When the electrical circuit is closed (current I is drawn), By including external Resistance R



- Potential drop across R ; V=IR ------ 2
- Due to internal resistance r the reading in Voltmeter is V which is less than ε
- ε = V + Ir

- Ir = ε-V ----------- 3
- $\frac{Equation\ 3}{Equation\ 2}$ gives; $\frac{\varepsilon - V}{V} = \frac{r}{R}$
- r =$\left(\frac{\varepsilon - V}{V}\right)$R

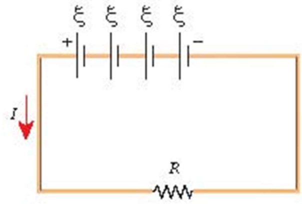
4. Explain the Principle of a Potentiometer.



- Primary circuit: The battery (Bt), key (k) and Potentiometer wire (CD) are Connected in Series to form Primary Circuit.
- Secondary circuit: The Positive terminal of a cell of emf ε is connected to the point C and negative is connected to the Jockey J through a galvanometer G and a high resistance HR. This forms a secondary circuit.
- Contact is made at any point J on the wire. If potential difference across CJ = emf (ε) of the cell, no current will flow through the galvanometer and it will show **zero deflection.**
- CJ = balancing length.
- Potential difference across CJ = Irl
- I – Current, r- resistance/length and l – balancing length
- emf of the cell = potential difference across CJ
- ε=Irl
- $\varepsilon \propto \ell$. (Since I, r are constants)
- emf of the cell is directly proportional to its balancing length

5. Explain series and Parallel Connections in cells.

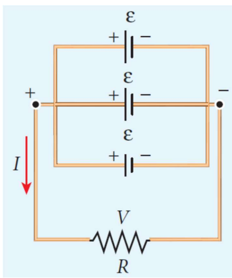
Cells in Series



- n cells having internal resistance r and emf ε are connected in series.
- Total emf = ε+ε+ε+......+ε
- E = nε ——— 1
- Total internal resistances = r+r+r+..........+r = nr (Since all 'r' in series)
- Total resistance in the circuit = nr + R ------ 2
- Current in the circuit = $\frac{\text{Total emf}}{\text{Total resistance}}$
- Substitute 1 and 2

  I = $\frac{n\varepsilon}{nr+R}$ -------------- 3
- Case : 1; If r<<<R, nr is neglected. So I = $\frac{n\varepsilon}{R}$
- Case : 2 If r>>>R, R is neglected. So, I = $\frac{\varepsilon}{r}$

Cells in Parallel

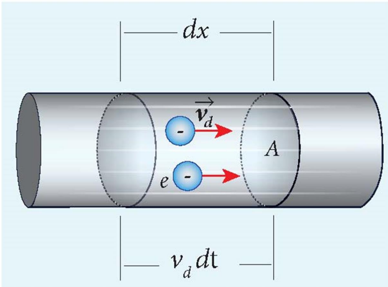


- n cells having internal resistance r and emf ε are connected in parallel
- Since all the cells are connected in Parallel, total emf = ε
- Reciprocal of the total internal resistance
- $\frac{1}{r_{eq}} = \frac{1}{r} + \frac{1}{r} + \ldots\ldots\ldots\ldots + \frac{1}{r}$ (n terms) = $\frac{n}{r}$
- Total resistance in the circuit = $\frac{r+R}{n}$
- Total Current in the circuit I = $\frac{\text{Total emf}}{\text{Total resistance}}$
- I = $\frac{n\varepsilon}{R+nr}$
- Case 1: If r >>R, I = $\frac{n\varepsilon}{r}$
- Case 2: If r <<R, I = $\frac{\varepsilon}{R}$

5 MARK - QUESTIONS AND ANSWERS :

1. Describe the microscopic model of correct and obtain general form of ohm's law

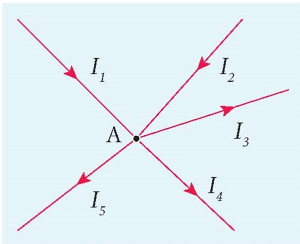
- n-number of electrons /volume in a conductor
- A-Area of cross section of the conductor
- V_d- Drift velocity of electron
- dt-time taken to travel the distance 'dx'
- Number of electrons available in the volume element
- Total Electrons in the volume element (Adx)
  $N = nAdx = nA(V_d\, dt) = nAV_d\, dt$ ---- 1
- Total charge in the Volume element
  $dQ=Ne=nAV_d\, dt\, e$ →→②
- Current $I = \frac{dQ}{dt}$
- $I = nAeV_d$
- Current Density $J = \frac{I}{A} = neV_d = = neE\left(\frac{-e\tau}{m}\right)$
- $\vec{J} = \sigma \vec{E}$
- But Conventionally we take the direction of current density as direction of the electric field.



2. State and explain Kirchoff's rules.

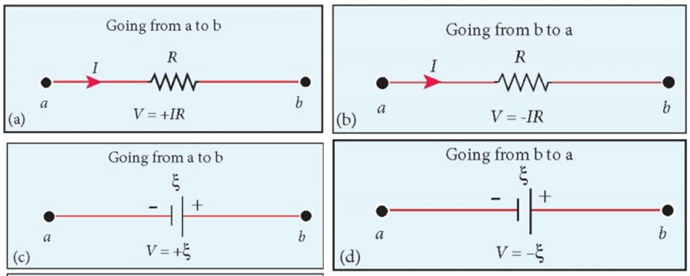
Kirchoff's First rule:

- The algebraic sum of the currents at any junction of the circuit is zero.
- Current entering into the junction is taken as +ve (Positive) and leaving the junction is taken as – ve (negative)
- It is obeying the statement of the law of conservation of electric charges
- $I_1+I_2-I_3-I_4-I_5=0$.



Kirchoff's second rule

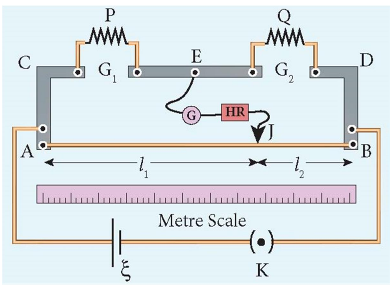
- In a closed circuit, the algebraic sum of the products of current and resistance of each part of the circuit is equal to the total emf included in the circuit.
- This rule obeys the law of conservation of energy.
- The product of current and resistance is taken as +ve when we follow the direction of current.
- The Product of the current and resistance is taken as –ve when we follow the direction opposite to the direction of current.
- The emf of the cell ε is considered as positive (+ve) when we proceed from –ve to +ve terminal.
- The emf of the cell ε is considered as Negative (–ve) when we proceed from +ve terminal to –ve terminal.



3. Explain the determination of unknown resistance using meter bridge

Construction :

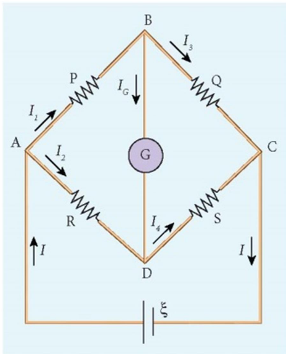
- A uniform wire of manganin AB of one meter length is stretched along a meter scale on a wooden board between two copper strips.
- In the gap G_1 unknown resistance P and in the gap G_2 standard resistance Q is connected.
- A Jockey is connected to the terminal E on the central



strip through the galvanometer (G) and a high resistance (HR)
- A Lechlanche cell and a key are connected between the ends of the bridge wire.

<u>Working</u>
- The Position of the jockey on the wire is adjusted so that the galvanometer shows Zero deflection.
- The resistance corresponding to AJ (l_1), and JB (l_2) of the bridge wire form the resistances R and S of the Wheatstone's S bridge. $\frac{P}{Q} = \frac{R}{S} = \frac{r(AJ)}{r(JB)} = \frac{l_1}{l_2}$
- Unknown resistance P=Q $\frac{l_1}{l_2}$
- The end resistance due to the bridge wire soldered at the ends of the strips can be eliminated if another set of reading is taken with 'p' and 'Q' interchanged and average value of 'P' is found.
- Specific resistance of the material of the wire $\rho = \frac{P\pi r^2}{l}$

4. Obtain the Condition for bridge balance in Wheatstone's bridge.
- The bridge consists of four resistances P,Q,R and S connected as shown in figure.



- The galvanometer G is connected between the point B and D
- The battery is connected between the points A and C
- The current through the galvanometer G is Ig and its resistance is G.
- Applying Kirchoff's current rule to junction B and D respectively.

  At B $I_1 - I_G - I_3 = 0$ ------- ①

  At D $I_2 + I_G - I_4 = 0$ ------- ②
- Applying Kirchoff's Voltage rule to the loop ABDA

  $I_1 P + I_G G - I_2 R = 0$ ------- ③
- Applying Kirchoff's Voltage rule to the loop BCDB

  $I_3 Q - I_G G - I_4 S = 0$ ------- ④
- Substitute $I_G = 0$ in ①, ②, ③ & ④

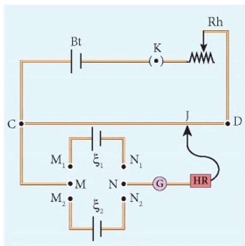
  $I_1 = I_3$ ---------- ⑤

  $I_2 = I_4$ ---------- ⑥

  $I_1 P = I_2 R$ ---------- ⑦

  $I_3 Q = I_4 S$ ---------- ⑧
- $\frac{Equation\ 7}{Equation\ 8}$ gives $\frac{P}{Q} = \frac{R}{S}$

5. How the emf of two cells are compared using potention
- <u>Primary circuit:</u> Potentiometer wire (CD) is connected in series with Battery (Bt), Key (K) and Rheostat (Rh).



- <u>Secondary Circuit:</u> The end C of Potentiometer wire in connected to a terminal M of a DPDT switch and another terminal N is connected to a Jockey (J) through a Galvanometer (G), a high resistance HR
- The cells whose emf ε_1, and ε_2 to be compared are connected to the terminal M_1, N_1 and M_2 N_2 of the DPDT switch.
- I – Steady current Passing through the Potentiometer wire, r- resistance per unit length of Potentiometer wire.
- <u>Procedure : 1</u>

  Initially the cell of emf ε_1 is included in the secondary circuit and the balancing length l_1 is found by adjusting jockey for zero deflection.

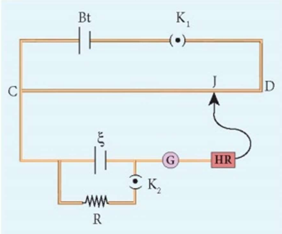
  According to the principle of the Potentiometer $\varepsilon_1 = Irl_1$ ------------ 1
- <u>Procedure : 2</u>

  The cell of emf ε_2 is included in the secondary circuit and the balancing length l_2 is found.

According to the principle of the Potentiometer $\varepsilon_2 = Irl_2$ ----------- 2

- $\frac{Equation\ 1}{Equation\ 2}$ gives $\frac{\varepsilon_1}{\varepsilon_2} = \frac{Irl_1}{Irl_2}$
- $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$

6. Explain the determination of the internal resistance of a cell using Potentiometer



- Primary circuit: Potentiometer is connected in series with battery (Bt) and Key (K_1).
- Secondary circuit: The cell whose internal resistance is to be calculated is connected in parallel with resistance box R and key K_2 is open.
- According to the Principle of Potentiometer, Balancing length l_1, in determined when key K_2 is open.
- According to the principle of Potentiometer, $\varepsilon \propto l_1$ --------- 1
- When the key K_2 is closed, the balancing length l_2 is determined
- $\frac{\varepsilon R}{R+r} \propto l_2$ ------------- 2
- $r = \left(\frac{l_1 - l_2}{l_2}\right) R$ ---------- 3
- Substituting R_1, l_1, l_2 in equation 3, the internal resistance 'r' can be calculated.

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5 – ELECTROMAGNETIC WAVES

2 MARK - QUESTIONS AND ANSWERS :

1. **What are electromagnetic waves?**
   - Non – Mechanical transverse wave travelling with speed of light in vacuum.
2. **What are Fraunhoffer lines? Give its application.**
   - Dark lines found in solar spectrum.
   - It helps to identify elements in Sun's atmosphere.
3. **Give Ampere – Maxwell law.**

$\oint_l \vec{E}.\vec{dl} = \mu_0(i_c + i_d)$ $\quad i_c$ - conduction current

$\oint_l \vec{E}.\vec{dl} = \mu_o\left(i_c + \varepsilon_o \frac{d}{dt}\oint_s \vec{E}.\vec{dA}\right)$ $\quad i_d$ – displacement current

4. **Give the equations of Electromagnetic waves.**
   - $E_x = E_o \sin(kz - \omega t)$, $B_y = B_o \sin(kz - \omega t)$
5. **What is the Velocity of Electromagnetic wave in a medium?**

$v = \frac{E_o}{B_0} < C$ Ratio of amplitudes of Electric and magnetic field in it.

6. **Give the source and use of the following:**
(i) Radiowaves, (ii) Microwaves (iii) Infrared (iv) Visible light (v) Ultra violet (vi) x-rays (vii) Gammarays

S.No.	WAVE	SOURCE	USE
1.	Radio Wave	Accelerated charge in wires	Radio, Television, communication in UHF
2.	Micro Wave	Vacuum tubes	Radar, Microwave oven, wireless communication
3.	Infrared	Hot bodies, molecular transition	Energy to satellites, TV remote, Heat therapy, photography, Dehydrated fruits
4.	Visible light	Incandescent object, excited atoms in gases	Study of molecular structure, vision, photo.
5.	Ultra violet	Sun, ionized gases	Sterilize surgical instruments, Burglar alarm, Detect finger prints, invisible writing.
6.	X- rays	Electron transition Electron deceleration	Detect fractures, diseased organ, formation of bones and stones, flaws and holes in metal.
7.	Gamma Rays	Nuclear transition	Radio therapy for cancer, tumor, kill microorganism in food industry.

3 MARK - QUESTIONS AND ANSWERS :

1. **What is Maxwell's modification in Ampere's circuital law?**
   - Ampere's circuital law → $\oint_l \vec{B}.\vec{dl} = \mu_o i_c$, i_c – conduction current
   - Maxwell introduced displacement current
   - Ampere Maxwell law → $\oint_l \vec{B}.\vec{dl} = \mu_o (i_c + i_d)$, i_d – displacement current
   - i_d is due to time varying electric flux.
   - $i_d = \varepsilon_0 \frac{d\phi_\varepsilon}{dt}$, $\quad \therefore \oint_l \vec{B}.\vec{dl} = \mu_0 \left(i_c + \varepsilon_0 \frac{d\phi_\varepsilon}{dt} \right)$
   - $\therefore$ Magnetic field can be either due to i_c or i_d.
2. **What is displacement current? Obtain an expression for it.**
   Displacement current is due to time varying electric flux in a region.
   $$\frac{d\phi_\varepsilon}{dt} = \frac{d}{dt}\left(\frac{q}{\varepsilon_0}\right) = \frac{1}{\varepsilon_0}\frac{dq}{dt} = \frac{1}{\varepsilon_0} i_d$$
   $$\therefore \quad id = \varepsilon_0 \frac{d\phi_E}{dt}$$
3. **What is Maxwell's law of induction?**
   - Faradays EMI, $\oint_l \vec{E}.\vec{dl} = -\frac{d\phi_B}{dt} \rightarrow$ time varying magnetic flux producing $\vec{E}$
   - Similarly Maxwells' modification $\oint_l \vec{B}.\vec{dl} = \mu_0 \varepsilon_0 \frac{d\phi_E}{dt} \rightarrow$ time varying electric flux producing $\vec{B}$
4. **Give importance of Maxwell's correction.**
   - Radiations from sun travel through empty space and reach us.
   - There are no charges, no current in empty space.

- Ampere's law → $\vec{B}$ is due to conduction current
- Then Radiation won't be there in space
- Maxwell's modification → $\vec{B}$ can also be due to time varying electric flux.
- Thus time varying ϕ_B produces time varying ϕ_E → Faraday's EMI
- Similarly by time varying ϕ_E produces time varying ϕ_B → Maxwell's modification explains propagation of EM wave.

5 MARK - QUESTIONS AND ANSWERS :

1. Write down Maxwell's equations in integral form

Eqn. No.	Law	Equation	Significance
I	Gauss's law in electrostatics	$\oint_s \vec{E}.\vec{dA} = \frac{Q_{enc}}{\varepsilon_0}$	Isolated positive charge or negative charge exist
II	Gauss's law in magnetism	$\oint_s \vec{B}.\vec{dA} = 0$	No isolated magnetic pole exist.
III	Faraday's law of EMI	$\oint_l \vec{E}.\vec{dl} = -\frac{d}{dt}(\phi_B)$	Line integral of electric field around any closed path = - (Rate of change of magnetic flux)
IV	Ampere - Maxwell law	$\oint_l \vec{B}.\vec{dl} = \mu_0(i_c + i_d)$ $i_d = \varepsilon_0 \frac{d\phi_E}{dt}$	Line integral of magnetic field around any closed path = μ_0 (conduction current + displacement current)

2. List down the properties of electromagnetic waves.

- Source → accelerated charge
- No medium required for propagation
- Transverse wave.
- Speed of EM wave = speed of light = c = $\frac{1}{\sqrt{\varepsilon_o \mu_o}}$ = 3X 10^8 ms^{-1}
- For a medium, relative permittivity is ε_r, relative permeability is μ_r ; $n = \frac{c}{v} = \sqrt{\varepsilon_r \mu_r}$
- Not deflected by $\vec{E}$ and $\vec{B}$
- Show interference, diffraction, polarization
- Carry energy, linear momentum and angular momentum.
- EM wave falls on surface and it is absorbed

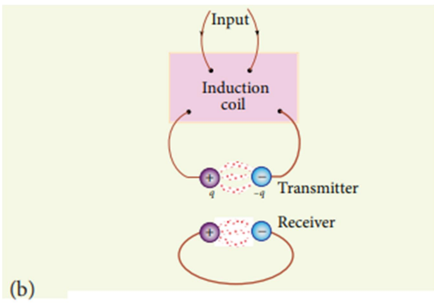
  Energy delivered is U, momentum imparted is p $= \frac{U}{C}$
- EM wave is reflected from surface, momentum delivered

  $\Delta P = \frac{U}{C} - \left(\frac{-U}{C}\right) = \frac{2U}{C}$

3. Describe production of electromagnetic waves by Hertz experiment.

Construction:

- 2 small spherical metals as electrodes
- These are connected to larger spheres
- Ends are connected to induction coil to produce EMF.
- Air between electrodes gets ionized to produce spark
- This discharge of electricity affects another set of ring shaped electrodes at far distance
- If receiver is rotated 90^0, no spark is seen.
- This confirms EM waves are transverse



(b) Schematic diagram of Hertz apparatus

- Speed of EM Wave = $3 \times 10^8 ms^{-1}$ in vacuum.

4. **What is emission spectrum? Classify with example**
- Spectrum of self-luminous source.

  Classification – continuous, line, band.

Continuous	Line	Band
➢ Light from incandescent lamp is passed through prism ➢ Splits into 7 colours ➢ Contains all visible colours from violet to red ➢ Ex: spectrum from carbon arc.	➢ Light from hot gas is passed through prism. ➢ Sharp lines of definite wavelength ➢ Due to excited atoms of element ➢ Characteristic of element ➢ Ex: spectra of Atomic H_2	➢ Several number of closely spaced spectral lines overlap to form bands with dark spaces. ➢ It has sharp edge at one end and fades out at another ➢ Due to excited molecules. ➢ Characteristic of molecules ➢ Ex: spectra of Ammonia gas ➢ Use: Study structure of molecules.

5. **What is absorption spectrum? Classify with examples.**
   - Light is allowed to pass through a medium or absorbing substance, then the spectrum obtained is absorption spectrum.
   - Classification – continuous, line, band.

Continuous absorption	Line absorption	Band absorption
➢ White light is passed through blue glass, it absorbs all colours except blue.	➢ Light is passed through cold gas, it is obtained ➢ Eg: light is passed through sodium vapour, continuous spectrum with 2 dark lines in yellow region is obtained.	➢ Light is passed through iodine vapour, dark bands on continuous bright background is obtained. ➢ Eg: white light passed through dilute blood or chlorophyll.

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8. DUAL NATURE OF RADIATION AND MATTER

2 MARK - QUESTIONS AND ANSWERS :

1. **Why do metals have a large number of free electrons?**
   - In metals, the electrons in the outer most shells are loosely bound to the nucleus.
   - Even at room temperature, there are a large number of free electrons which are moving in a random manner.
2. **Define work function. Give its unit**.
   - The minimum amount of energy required by an electron to just escape from the metal surface is called **work function** of the metal.
   - Unit : eV (or) electron volt

3. **What is surface barrier?**
   - The potential barrier which prevents free electrons from leaving the metallic surface is called **surface barrier**.
4. **What do you mean by Electron Emission? Explain briefly various methods of Electron emission?**
   - The liberation of free electrons from any surface of a substance is called Electron Emission.

S.No.	Types	Process	Example
I	Thermionic Emission	A metal is heated to a high temperature	Electron microscope
Ii	Field Emission	A very strong electric field is applied across the metal.	Field emission Display
Iii	Photo electric emission	A suitable frequency of Electromagnetic radiation incident on the metal.	Photo diodes
iv	Secondary Emission	A beam of fast moving electrons strikes the surface of the metal	Photo multiplier tubes

5. **Define electron volt (eV).**
   - It is the kinetic energy gained by an electron when it is accelerated through a potential difference of 1 Volt.
   - $1eV = 1.6\times10^{-19}\times1V = 1.6\times10^{-19}$ J
6. **What is photo electric effect?**
   - The phenomenon of emission of electrons from a metal surface, when electromagnetic radiations of sufficiently high frequency are incident on it, is called **photoelectric effect**.
7. **Define stopping potential.**
   - It is the minimum value of negative potential that must be applied to the anode to make the photo electric current zero.
8. **Define threshold frequency.**
   - For a given metallic surface, the emission of photo electrons takes place only if the frequency of incident light is greater than a certain minimum frequency called **Threshold frequency**.
9. **What is meant by dual nature of radiation?**
   - Light behaves as a wave during its propagation and behaves as aparticle during its interaction with matter.
10. **What are matter waves? (or) What are Debroglie waves?**
    - The wave particle duality of radiation was extended to matter by De Broglie. Accoring to De Broglie hypothesis all material particles like electrons, protons, neutrons in motion are associated with waves. These waves are called **De Broglie waves** (or) **matter waves**.
11. **What is photo cell? What are its types?**
    - It is a device which converts light energy into electrical energy. It works on the principle of photo electric effect.
    - Three types : Photo emissive cell, photo voltaic cell, photo conductive cell.
12. **Give the definition of intensity of light according to quantum concept and its unit.**
    - According to quantum theory, number of photons incident per unit area per unit time, with each photon having same energy.
    - Unit: Wm^{-2}

13. **Why do we do not see the wave properties of base ball ?**
   - According to debroglie wavelength of matter waves
     $\lambda = h/m\,v$ (ie) $\lambda \propto 1/m$
   - Since mass of ball is higher, the wavelength is shorter.
14. **Write the expression for the de Broglie wavelength associated with a charged particle of charge q and mass m, when it is accelerated through a potential V.**
   - $\lambda = \frac{h}{\sqrt{2mqv}}$
15. **Write the relationship of de Broglie wavelength λ associated with a particle of mass m in in terms of its kinetic energy K.**
   $\lambda = \frac{h}{\sqrt{2mK}}$
16. **An electron and an alpha particle have same kinetic energy. How are the de Broglie wavelengths associated with them related?**
   - $\lambda = \frac{h}{\sqrt{2mK}}$
   - Kinetic Energy K equal; $\lambda \propto \frac{1}{\sqrt{m}}$
   - Mass of alpha particle is high when compared to mass of an electron,
   - $\therefore \lambda_{electron} > \lambda_{alpha}$
   - A low massive electron has a longer wavelength than an alpha particle.
17. **A proton and an electron have same kinetic energy. Which one has greater de Broglie wavelength. Justify.**
   - $\lambda = \frac{h}{\sqrt{2mK}}$
   - Kinetic Energy K equal; $\lambda \propto \frac{1}{\sqrt{m}}$
   - $m_p > m_e$; $\lambda_e > \lambda_p$
   - A low massive electron has a longer wavelength than a proton.
18. **What is Bremsstrahlung or Braking Radiation?**
   - The radiation produced from decelerating electron in continuous X-ray spectrum is called **Bremsstrahlung or braking radiation**.

3 MARK - QUESTIONS AND ANSWERS :

1. **List out the laws of photoelectric effect.**
   - For a given metallic surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than certain minimum frequency called the **threshold frequency**.
   - For a given frequency of incident light (above threshold frequency) , the number of photo electrons emitted is directly proportional to the intensity of the incident light.
   - Maximum kinetic energy of the photoelectrons is independent of intensity of the incident light.
   - Maximum kinetic energy of the photoelectrons is directly proportional to the frequency of incident light.
   - There is no time lag between incidence of light and ejection of photoelectrons.
2. **Derive an expression for de Broglie wavelength of electron.**
   - m = mass of an electron
   - electron accelerated through a potential V – volt
   - The kinetic energy of the electron is given by $\frac{1}{2} mv^2 = eV$
   - The speed of the electron is $v = \frac{\sqrt{2eV}}{m}$.
   - De Broglie wavelength of the electron is $\lambda = \frac{h}{mv}$

- Substituting for v we get, $\lambda = \frac{h}{m\sqrt{\frac{2e}{m}}}$
- $\lambda = \frac{h}{\sqrt{2meV}}$
- Substituting the known values, $\lambda = \frac{12.27A^0}{\sqrt{V}}$

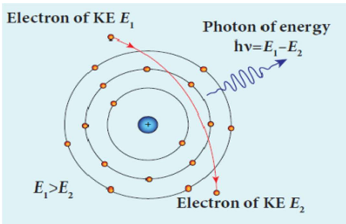
3. List out the characteristics of photons.

- Each photon will have energy E = hν, h – Planck's constant, ν – frequency of radiation.
  E = hc / λ (λ – wavelength)
- The energy of a photon is determined by the frequency of the radiation not by intensity.
- The photons travel with the speed of light.
- They are unaffected by electric and magnetic fields.
- During photon interaction with matter, the total energy, total linear momentum and total angular momentum are conserved.

4. Give the applications of photo cells.

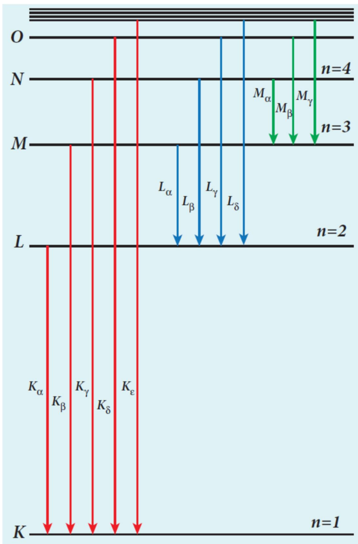
- As switches and sensors.
- Automatic lights that turn on in dark.
- Street lights that switch on and off in night or day.
- For reproduction of sound in motion pictures.
- As timers to measure the speeds of athletes during a race.
- To find exposure time in photography.

5. Write a note on Continuous X-ray spectra.



- When a fast moving electron penetrates and approaches a target nucleus, the electron either accelerates (or) decelerates.
- The radiation produced from such decelerating electron is called Bremsstrahlung (or) braking radiation.
- The energy of the photon emitted = The loss of kinetic energy of the electron.
- $h\nu_o = hc/\lambda_o = eV$
  ν_o - Maximum frequency; λ_o - Minimum wavelength
- Substituting the known values, $\lambda_o = \frac{12400}{V}$ A°
- This is called **Duane – Hunt formula**.

6. Write a note on Characteristic X-ray spectra.

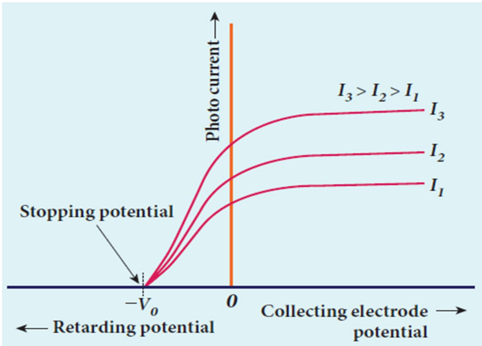


- When the target is hit by fast electrons, the obtained X-ray spectra shows some narrow peaks at some well-defined wavelength.
- The line spectrum showing these peaks is called Characteristic X-ray spectrum.
- For example, when an energetic electron penetrates in to the target atom and removes the electrons in K-shell and creates a vacancy in it.
- So the electrons from outer orbits (L,M,N,O,…) jump to fill up the vacancy in K-shell.
- The energy difference between the levels is given out in the form of X-ray photon.
- K-series (K_α , K_β , K_γ , …) originates due to electronic transition from L,M,N,O,… shells to K shell.
- L series (L_α , L_β , L_γ , …) originates due to electronic transition from M,N,O shells to L shell.

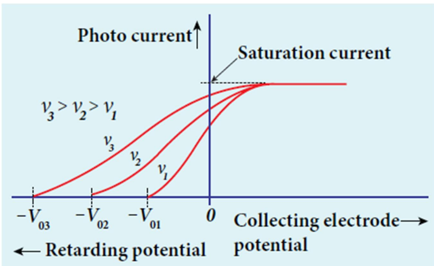
7. **List out X-ray properties.**
   - X-rays are electromagnetic waves of short wavelength ranging from 0.1A° to 100A°.
   - They travel along straight lines with the velocity of light.
   - X-rays are not affected by electric and magnetic fields.
   - They pass through materials which are opaque to visible light.
   - The quality of X-rays is measured in terms of their penetrating power.
   - The intensity of X-rays is dependent on the number of electrons striking the target.
8. **List out the applications of X-rays.**
   - **a) <u>In medical field</u> :**
     - It is used to detect fractures, foreign bodies in medical diagnosis.
     - It is used to cure malignant tumours.
   - **<u>In Industry</u> :**
     - It is used to check the flaws in welded joints, tennis balls.
     - It is used for detection of contra band goods in customs.
   - **<u>In Scientific research</u> :**
     - It is used to study the structure of the crystalline materials.

<u>5 MARK - QUESTIONS AND ANSWERS :</u>

1. **Explain the effect of Potential difference on photoelectric current.**
   - Frequency, Intensity – Constant.
   - Positive Anode potential increases, Photo current increases.
   - Finally Photo current reaches saturation.
   - When a negative potential is applied to A photocurrent becomes zero V_0 called **stopping potential (or) cut off potential**.
   - The negative potential when given to the collecting electrode, photo electrons emitted make the photo current zero, is called stopping potential.
   - The initial kinetic energy of the fastest electron (K_{max}) is equal to the work done by the stopping potential to stop it. (eV_o)
   - $K_{max} = \frac{1}{2} mv^2_{max} = eV_o$
   - $V_{max} = \sqrt{\frac{2eV_0}{m}}$
   - Stopping potential and the maximum kinetic energy of the photoelectrons is independent of intensity of the incident light.

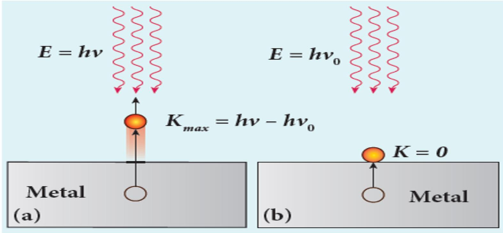


2. **Explain how frequency of incident light varies with stopping potential.**
   - The intensity of the incident light is kept constant.
   - If frequency of the incident radiation is increased the kinetic energy of Photoelectrons and hence stopping potential also increases.
   - Stopping potential varies linearly with frequency. Below certain frequency called threshold frequency no electrons are emitted. Stopping potential is zero.



3. **Obtain Einstein's photoelectric equation with necessary explanation.**
   - When a photon of energy $h\nu$ is incident on a metal surface, it is completely absorbed by a single electron and is utilized in two ways.

- Part of the photon energy is used for the ejection of the electrons from the metal surface and it is called **work function**. (φ_o).



- Remaining energy as the kinetic energy ($\frac{1}{2}mv^2$) of the ejected electron.
- From the law of conservation of energy,

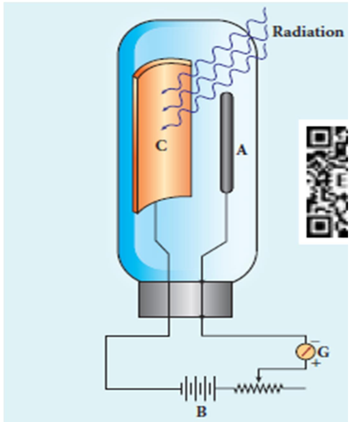
  $h\nu = \varphi_o + \frac{1}{2} mv^2$ ... (1)
- Here m – mass of the electron and v – velocity.
- At threshold frequency, the kinetic energy of ejected electrons will be zero.

  $h\nu_0 = \varphi_o$ ... (2)
- Substitute (2) in (1)

  $h\nu = h\nu_o + \frac{1}{2}mv^2$ ... (3)
- The equation (3) is known as **Einstein's photoelectric equation.**
- If the electron does not lose energy by internal collisions, then it is emitted with maximum kinetic energy. Therefore, $h\nu = h\nu_o + \frac{1}{2} mv^2_{max}$ ... (4)
- Maximum kinetic energy of photoelectron $K_{max} = \frac{1}{2} mv^2_{max}$
- Then, $h\nu = h\nu_o + K_{max}$ ... (5)

  $K_{max} = h\nu - h\nu_o$

4. Give the construction and working of photo emissive cell.



<u>Principle</u> :

- Photoelectric effect.

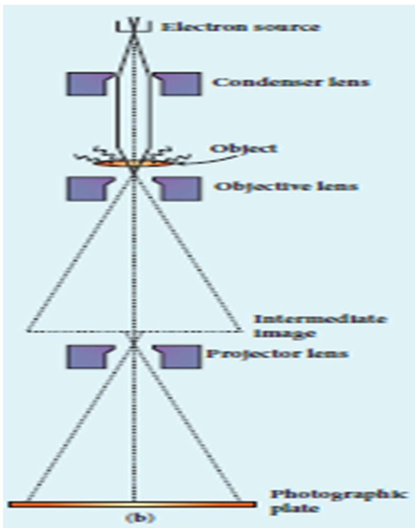
<u>Construction</u> :

- It consists of an evacuated glass or quartz bulb.
- Two metallic electrodes - Anode and Cathode are fixed.
- The cathode C is semi-cylindrical in shape and is coated with a photo sensitive material.
- The anode A is a thin rod or wire.
- A potential difference is applied between the anode and the cathode through a galvanometer G.

<u>Working</u> :

- When cathode is irradiated with suitable radiation, electrons are emitted and attracted by anode and hence a current is produced.
- Current is measured by the galvanometer.
- The magnitude of the current depends on:
  - The intensity of incident radiation and
  - The potential difference between anode and cathode.

5. Explain the principle and working of electron microscope.



<u>Principle</u>:

- The wave nature of the moving electron.

<u>Construction &Working</u> :

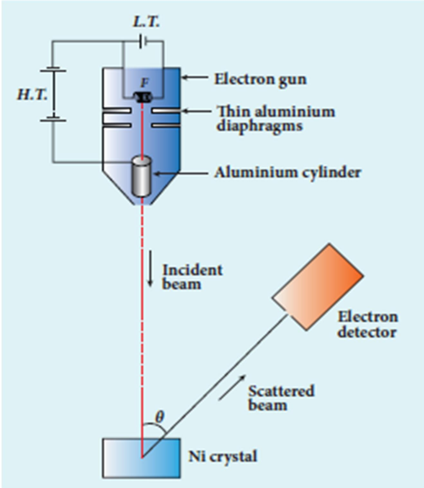
- In electron microscope focusing of electron beam is done by the electrostatic or magnetic lenses.
- The electrons emitted from the source are accelerated by high potentials.
- The beam is made parallel by magnetic condenser lens.
- When the beam passes through the sample whose magnified image is needed, the beam carries the image of the sample.
- With the help of magnetic objective lens and magnetic projector lens system, the magnified image is obtained on the screen.

Uses:

- Its magnification is more than 2,00,000.

6. Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.

- Experiment demonstrates that electron beams are diffracted when they fall on crystal.



Construction :

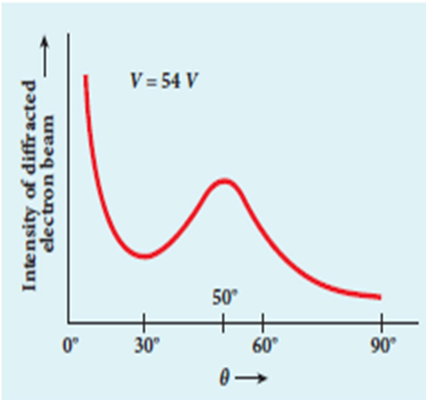
- The filament F is heated by a low tension (L.T.) battery.
- Electrons are emitted from the hot filament by **thermionic emission**.
- They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery.
- Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.

Working :

- The intensity of electron scattered by Ni atoms in different directions are measured by the electron detector which is capable of rotation.
- For a given accelerating voltage (54V), the scattered wave shows a maximum intensity at an angle of 50^o .
- The intensity of the scattered electron beam is measured as a function of angle θ between the incident beam and the scattered beam.

Conclusion :

- The wavelength of electron
- By experiment (angle = 50 °) λ = 1.65 A °
- De Broglie equation (V = 54 V) $\lambda = \frac{12.27}{\sqrt{V}} A^o$
- $\lambda = \frac{12.27}{\sqrt{54}} A^o = 1.67\ A^o$
- **This value agrees with experimentally observed wavelength.**



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9. ATOMIC AND NUCLEAR PHYSICS

2 MARK - QUESTIONS AND ANSWERS :

1. Give the properties of (i) cathode rays (ii) neutrons (iii) neutrino

Cathode rays	Neutron	Neutrino
• Travel in straight line • Deflected by $\vec{E}$ and $\vec{B}$ • Ionize gas • It speed = $\frac{1}{10}$ c • Affect photographic plates	• Zero charge • Not deflected by $\vec{E}$ and $\vec{B}$ • Inside nucleus stable $m_n > m_H$ • Based on kinetic energy 3 types : slow, fast & thermal neutrons	• Zero charge • Antiparticle is antineutrino • Tiny mass • Difficult to detect

2. List down the properties of nuclear force
- ➢ Strong force
- ➢ short range
- ➢ attractive
- ➢ Nuclear force is same for *p-n, n-n,* and *p-p*
- ➢ Force which holds nucleons inside nucleus.

3. Define Half-life.
- ➢ Time required for number of atoms initially present to reduce one half of initial amount
- ➢ $T_{1/2} = \frac{0.693}{\lambda}$

4. Define a) Isotope b) Isobar c) Isotone with an example for each

	Elements	Atomic No	Mass No	Example
Isotope	Same	Same	Different	${}_1H^1$, ${}_1H^2$
Isobar	Different	Different	Same	${}_{16}Si^{40}$, ${}_{17}cl^{40}$
Isotone	Different	Different	Different	Same no of neutron ${}_5B^{12}$, ${}_6C^{13}$

5. Define Impact parameter
- ➢ Perpendicular distance between Centre of gold nucleus and velocity vector of alpha particle at large distance.

6. What is mean life
- ➢ Ratio of sum of life time of all nuclei to total number of nuclei present initialty.
- ➢ $\tau = \frac{1}{\lambda}$

7. What is nuclear fission
- ➢ Breaking up nucleus of heavier atom into 2 smaller nuclei, releasing large amount of energy.
- ➢ (eg.) .Atom bomb

8. What is nuclear fusion
- ➢ 2 lighter nuclei combine to form heavier nuclei releasing large amount of energy.
- ➢ (eg.) Hydrogen bomb

9. Define 1 atomic mass unit
- ➢ 1 amu = $\frac{1}{12}$ (mass of ${}^{12}_{6}C$)

10. Define curie
- ➢ 1 curie = 3.7 x 10^{10} decays / second = activity of 1gm of radium

11. Define binding energy
- ➢ Energy required to separate single nucleon from nucleus

12. **What is mass defect**
    - Mass defect = Total mass of nucleons – mass of nucleus.
13. **Define excitation energy and excitational potential**
    - Energy required to excite an electron from lower energy state to higher energy state.
    - Excitation potential = excitation energy per unit charge.
14. **Define Ionisation energy and ionization potential.**
    - Energy required to remove an electron from ground state of an atom (13.6 eV).
    - Ionization energy per unit charge is Ionization potential (13.6 V).
15. **Explain proton – proton cycle**

    $_1H^1 + _1H^1 \rightarrow _1H^2 + _1e^0 + \upsilon$

    $_1H^1 + _1H^2 \rightarrow _2He^3 + \gamma$

    $_2He^3 + _2He^3 \rightarrow _2He^4 + 2_1H^1$ + 27 MeV Energy
16. **What are the 2 types of β decay?**

    β_- decay

    $_ZX^A \rightarrow _{Z+1}Y^A + e^- + \bar{\upsilon}$

    $n \rightarrow p + e^- + \bar{\upsilon}$ (Atomic number increases by 1 Mass no is same)

    β_+ decay

    $_ZX^A \rightarrow _{Z-1}Y^A + e^+ + \upsilon$

    $p \rightarrow n + e^+ + \upsilon$ ((Atomic number decreases by 1 Mass no is same)
17. **What is meant by radioactivity?**

    Spontaneous emission of highly penetrating radiations such as α, β and ϒ rays by an element (Z>82) is called radioactivity.
18. **Show that nuclear density is almost constant for nucleus.**
    - $S = \frac{\text{mass of the nuclei}}{\text{volume of the nuclei}} = \frac{A.m}{\frac{4}{3}\pi R_0^3 A} = 2.3 \times 10^{17}\, kgm^{-3}$
    - Nuclear density is independent of the mass number A.
19. **What is meant by activity or decay rate? Give its unit.**
    - Number of nuclei decayed per second R = $-\frac{dN}{dt}$
    - Unit is Becquerel.
20. **What are the constituent particles of neutron and proton?**
    - Proton – two up quarks and one down quark
    - Neutron – one up quark and two down quarks.

3 MARK - QUESTIONS AND ANSWERS :

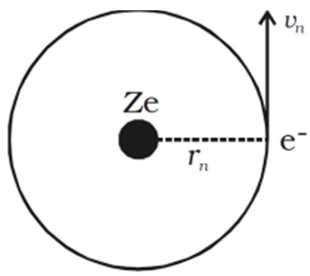
1. **Explain Rutherford model.**
    - Atom has lot of empty space
    - Positively charged nucleus of size 10^{-14}m at the centre.
    - Electrons revolve around nucleus
2. **Derive distance of closest approach**
    - Kinetic energy of alpha particle = potential energy of system of alpha and gold nucleus

    $$E_k = \frac{1}{2}mV^2 = \frac{1}{4\pi\varepsilon_0}\frac{(2e)(Ze)}{r_0}$$

    $$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{E_k}$$

3. **List down Bohr's postulates of atom model.**
   - Coulomb force between nucleus and electron = centripetal force of revolving electron
   - Electron revolves in orbits in which its angular momentum = $\frac{nh}{2\pi}$.
   - Electron jumps from one orbit to another emitting a photon of energy $\Delta E = h\nu$
4. **Give the limitations of Bohr atom model.**
   - Valid only for H_2
   - Cannot explain fine structure
   - Cannot explain intensity variation of spectral lines
   - Cannot explain distribution of electrons.
5. **Give features of Binding energy curve.**
   - Mass no A increases, average binding energy per nucleon $\overline{BE}$ increases.
   - $\overline{BE}$ becomes maximum for Fe, which is 8.8 MeV
   - $\overline{BE}$ is 8.5 MeV for A = 40 to A=120, which are stable and non-radioactive
   - $\overrightarrow{BE}$ decreases to 7.6 MeV for Uranium.
   - A < 28, elements combine to form A < 56 →Nuclear fusion
   - Heavy element split to form medium A nuclei → Nuclear fission
6. **Explain i) α decay with an example**
   - Unstable nuclei emit α particle.
   - Atomic number decreases by 2, Mass no decreases by 4.
   - ${}_{z}X^{A} \rightarrow {}^{A-4}_{z-2}Y + {}^{4}_{2}He$
   - ${}^{238}_{92}U \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}He$
7. **What is carbon dating?**
   - Cosmic rays bombard with atoms to form ${}_6C^{14}$
   - ${}_6C^{14}$ decays to ${}_6C^{12}$
   - ${}_6C^{14}$, ${}_6C^{12}$ ratio is constant
   - Organism dies, intake of carbon stops
   - ${}_6C^{14}$, ${}_6C^{12}$ ratio decreases
   - Using this age of organism can be calculated.
8. **Derive the energy expression for hydrogen atom using Bohr model.**
   - Potential energy $U_n = \frac{(Ze)(-e)}{4\pi\varepsilon_0 r_n} = \frac{-Ze^2}{4\pi\varepsilon_0 r_n}$ .....(1)

   $r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m Z e^2}$

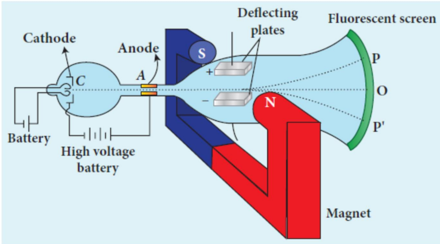
   

   Energy of the electron

   - Substituting in eqn (1) $U_n = \frac{-Z^2 m e^4}{4n^2 h^2 \varepsilon_0^2}$ ....(2)
   - Kinetic energy = $\frac{1}{2} m v_n^2$
   - $KE_n = \frac{Z^2 m e^4}{8n^2 h^2 \varepsilon_0^2}$ ......(3)
   - $U_n = -2KE_n$ ……… (4)
   - $E_n = KE_n + U_n = KE_n - 2KE_n = -KE_n$
   - $E_n = -\frac{me^4 Z^2}{8\varepsilon_0^2 h^2 n^2}$ ....(5)
   - Substituting for H_2 known values $E_n = -\frac{13.6}{n^2}$ eV ....(6)
   - Negative sign indicate that electron is bound to the nucleus.

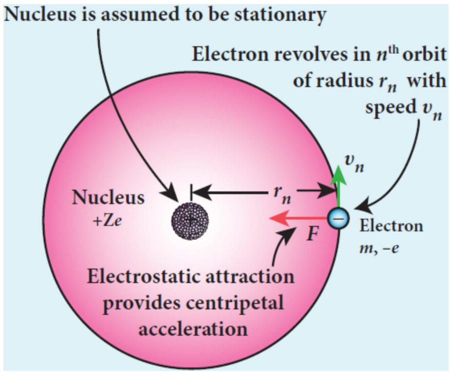
5 MARK - QUESTIONS AND ANSWERS :

1. Describe J.J. Thomson's experiment for determination of $\frac{e}{m}$



- Principle : Deflection of electron with $\vec{E}$ *and* $\vec{B}$
- Construction: Cathode rays are produced in discharge tube
  - It is made into narrow beam by anode disc
  - $\vec{E}$ is provided by parallel plates
  - $\vec{B}$ is provided by magnets
  - Cathode rays fall on screen at O to produce fluorescence.
- Velocity selector: Force due to $\vec{E}$ = Force due to $\vec{B}$
  eE = eυB
  $\upsilon = \frac{E}{B}$
- Determination of $\frac{e}{m}$:
  - potential energy = kinetic energy, $eV= \frac{1}{2}mv^2$
  - $\therefore \frac{e}{m} = \frac{v^2}{2V} = \frac{E^2}{2VB^2}$
  - $\therefore \frac{e}{m} = 1.7 \text{ X } 10^{11} \text{ C kg}^{-1}$

2. Expression for radius of electron in n^{th} orbit

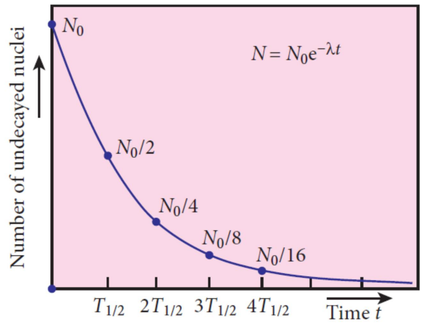


- Coulomb's law $\vec{F}_{coulomb} = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n^2}\hat{r}_n$
- Centripetal force $\vec{F}_{centripetal} = \frac{m{v_n}^2}{r_n}\hat{r}_n$
- Coulomb force provides centripetal force.
- $\frac{Ze^2}{4\pi\varepsilon_0 r_n^2} = \frac{mv_n^2}{r_n}$
- $r_n = \frac{4\pi\varepsilon_0 r_2^n m\upsilon_n^2}{Ze^2} \times \frac{m}{m}$
- $r_n = \frac{4\pi\varepsilon_0}{mZe^2}\left(m^2\upsilon_n^2 r_n^2\right)$
- According to Bohr,
  $m\upsilon_n r_n = \frac{nh}{2\pi}$
  $m^2\upsilon_n^2 r_n^2 = \frac{n^2h^2}{4\pi^2}$
- $\therefore r_n = \frac{4\pi\varepsilon_0}{mZe^2}\frac{n^2h^2}{4\pi^2} = \frac{\varepsilon_0 n^2h^2}{\pi mZe^2}$
- $r_n = \frac{a_o n^2}{Z}, \quad r_n \alpha \frac{n^2}{Z}$
- ∴ for hydrogen $n = 1$
- $r_1 = 0.529 \text{ A}^0$

3. Give the spectral series of H_2 atom.

Series	When electron jumps from *m*	To *n*	Formula Wave number	Region
Lyman	2, 3, 4	1	$\bar{\nu} = R\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$	UV
Balmer	3, 4, 5	2	$\bar{\nu} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$	Visible
Paschen	4, 5, 6	3	$\bar{\nu} = R\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$	IR
Bracket	5, 6	4	$\bar{\nu} = R\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$	IR
Pfund	6, 7	5	$\bar{\nu} = R\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$	Far IR

4. Obtain the expression for number of atoms present at any instant and also derive the equation for half-life period.



- Law: Rate of decay at any instant is directly proportional to number of nuclei at same instant.

$-\frac{dN}{dt} \propto N$

$\frac{dN}{dt} = -\lambda N$, λ - decay constant

- Integrating $\int_{N_o}^{N} \frac{dN}{N} = \int_0^t -\lambda . dt$ $\quad \ln\frac{N}{N_o} = -\lambda t$
- Taking exponential $\frac{N}{N_o} = e^{-\lambda t}$, $\quad N = N_o e^{-\lambda t}$
- N decreases exponentially with time
- Half-life period: Time required for number of atoms to reduce one half the initial amount.

$t = T_{1/2}, N = \frac{N_o}{2}$

$N = N_o e^{-\lambda t}, \quad \frac{N_o}{2} = N_0 e^{-\lambda T_{1/2}},$

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

- Taking log, $\quad \lambda T_{1/2} = ln2, \quad T_{1/2} = \frac{0.693}{\lambda}$

5. What is nuclear reactor? Explain its essential parts.

Part	Function	Material
Fuel	Fissionable	$_{92}U^{235}$, Plutonium Polonium
Moderator	Slow down neutron	Water, heavy water
Control rod	Controls reaction rate by absorbing neutron	Cadmium, Boron
Coolant	Removes heat generated in core	Water, heavy water, liquid sodium
Shielding	Protects from harmful radiation	Concrete wall

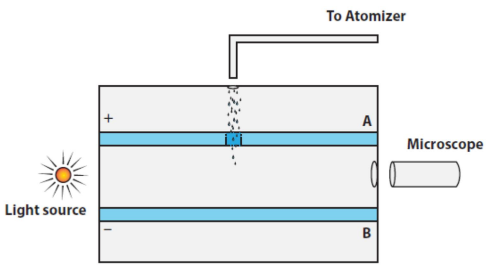
6. How will you determine charge of electron by Millikan's oil drop experiment

Principle:

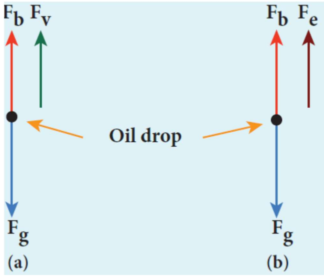
- Oil drop can be made to move up or down by adjusting. Electric field.

Experimental arrangement:

- 2 circular metal plates are maintained at 10 KV potential differences.
- Fine droplet sprayed falls through hole in upper plate under effect of gravity.



- Oil drops acquire negative charge when x-rays is passed through plates.
- When Chamber is illuminated, drops can be observed using microscope.



<u>Forces on drop :</u>

- gravitational force $F_g = mg = \frac{4}{3}\pi r^3 \rho g \downarrow$
- electric force $Fe = qE$
- buoyant force $f_b = \frac{4}{3}\pi r^3 \sigma g \uparrow$
- Viscous force $F_v = 6\pi\eta r v$
- Case (i) under gravity : $Fg = Fb + Fv$, $\frac{4}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 \sigma g + 6\pi\eta r v$

  $\frac{4}{3}\pi r^3 (\rho - \sigma) g = 6\pi\eta r v$

  $r = \left[\frac{9\eta}{2(\rho-\sigma)g}\right]^{1/2}$
- Case (ii) under electric field : $F_e + F_b = F_g$

  $qE + \frac{4}{3}\pi r^3 \sigma g = \frac{4}{3}\pi r^3 \rho g$

  $qE = \frac{4}{3}\pi r^3 (\rho - \sigma) g$

  $q = \frac{4}{3E} . \pi r^3 (\rho - \sigma) g.$
- q can be calculated which is integral multiples of e.
- The charge of electron is calculated e = -1.6×10^{-19} C

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