CHAPTER - 13
CURRENT ELECTRICITY & CAPACITANCE

SYNOPSIS

Electric current through a conductor is defined as the time rate of flow of charge through any cross section of a conductor. If q is the charge flowing in time t, then current $I = \frac{q}{t}$. (for steady current) Unit of current is Ampere. Current is a scalar quantity.

- If the rate of flow of charge varies with time, then the current at any time is given by $I = \frac{dq}{dt}$

Electromotive force

To maintain a steady current, we need a closed circuit with a source. The work done per unit charge by the source in taking a positive charge from lower to higher potential energy is called *electromotive force or emf* of the source.

OR

It is the p.d between the two terminals of a source in open circuit. SI unit of e.m.f is volt. (V)

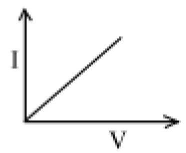
Ohm's law

At constant temperature, the electric current flowing through a conductor is directly proportional to the potential difference across the two ends of the conductor.

ie $V \alpha I$

V = IR. Where the constant of proportionality R is called the resistance of the conductor.

* Resistance is the opposition to the current flow in a conductor. $R = \frac{V}{I}$ Its unit is V/A or ohm.(Ω) (Define one ohm). Conductors which obey Ohm's law are known as ohmic conductors. Eg: Silver, Copper, Aluminium



V - I characterstic of ohmic conductor.

Factors affecting the resistance

The resistance of a conductor depends on its

i) length ii) area of cross section,

iii) nature of the material and, iv) temperature.

Law of resistance - The resistance of a conductor is directly proportional to its length (*l*) and inversely proportional to its area of cross section (A)

$R \propto \ell,\ R \propto \frac{1}{A} \quad \therefore R \propto \frac{\ell}{A}$

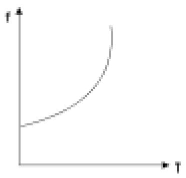
$R = \frac{\rho.\ell}{A}$ Where ρ is a constant known as resistivity or specific resistance.

$\therefore \rho = \frac{RA}{\ell}$ Its unit is ohm metre (Ω - m). [Find its dimension] Also $\left(\rho = \frac{E}{J}\right)$

If $l = 1$ and $A = 1$, then $\rho = R$

Resistivity of the material of a conductor is defined as the resistance of the conductor of unit length and of unit area of cross section.

- Resistivity depends on the nature of the material ($\rho \propto \frac{1}{n}$; $n \rightarrow$ no. of free electrons per unit volume)
- Resistivity increases with the increase in temperature of the conductor.



- Resistivity is independent of geometrical dimensions (ie length, area, shape etc.)
- Substances having low resistivity are conducters of electricity.
- Substances having high resistivity are insulators.

Conductance

The reciprocal of resistance is called conductance. It is denoted by G. $G = \frac{1}{R} = \frac{A}{\rho\ell}$. SI unit is Ω^{-1} or mho

Conductivity

Conductivity a material is its ability to conduct electric current. Conductivity is the reciprocal of resistivity.

$\sigma = \frac{1}{\rho}$. Its unit is $\Omega^{-1}m^{-1}$ or mho m^{-1}.

Temperature dependance of Resistance

For a conductor, $R \propto \frac{1}{\tau}$ where $R \rightarrow$ Resistance, $\tau \rightarrow$ Relaxation time

When a metallic conductor is heated, vibration of atoms increases and collision increases. This reduces the relaxation time t and increases the value of resistance R.

If R_0 be the resistance of a conductor at 0°C and R_t at t°C then $R_t = R_0(1+\alpha t)$

Where a is called temperature coefficient of resistance of the material

$$\alpha = \frac{R_t - R_0}{R_0 t} = \frac{\text{charge in resistance/degree rise in temperature}}{\text{resistance at } 0^\circ C}$$

Thus the *temperature coefficient of resistance* can be defined as the ratio of the change in resistance per unit rise of temperature to the resistance at 0°C. (It's unit is K^{-1})

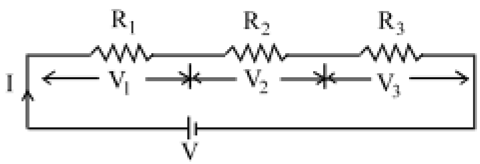
If R_1 and R_2 are resistances at t_1 and t_2°C, $\alpha = \frac{R_2 - R_1}{R_1 t_2 - R_2 t_1}$

- For metals α is +ve. Thus metals (conductors) has positive temperature coefficient of resistance.
- For semiconductors α is -ve. (negative temperature coefficient of resistance)
- *Due to high resistance and low temperature coefficient of resistance, the alloys like constantan, manganin and nichrome are used as standard resistance coil.*

Combination of resistances

i) Resistance in series

The resistors are said to be in series if the current through each one must be same and equal to main current.



Let three resistances R_1, R_2 and R_3 are connected in series to a source of potential V. Since they are in series combination the current through them is same. Let I be the current through the circuit. Let V_1, V_2 and V_3 be the potential difference across the resistances R_1, R_2 and R_3 respectively.

$V = V_1 + V_2 + V_3$

But $V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$

$\therefore V = IR_1 + IR_2 + IR_3 = I(R_1 + R_2 + R_3)$

If R_s is the equivalent resistance of their series combination, then $V = IR_s$ $\therefore IR_s = 1(R_1 + R_2 + R_3)$

$\mathbf{R_s = R_1 + R_2 + R_3}$

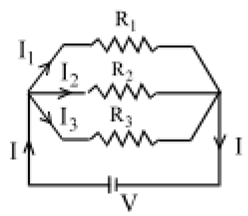
ii) Resistances in parallel

The resistances are said to be in parallel if the p.d across each resistor is the same.

Let three resistance R_1, R_2 & R_3 are connected in parallel to a source of potential difference V. Since they are in parallel, potential difference across each resistor is same. Let I_1 be the current through R_1, I_2 through R_2 and I_3 through R_3 respectively. Let I be the total current then, $I = I_1 + I_2 + I_3$

from Ohm's law, $I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$ & $I_3 = \frac{V}{R_3}$

If R_p is the equivalent resistance of the parallel combination,



$I = \frac{V}{R_p}$ $\quad\quad$ $\therefore \frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ $\quad\quad$ $\therefore \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Potentiometer

It is used for measuring potential difference accurately, comparing e.m.f's of two cells, measuring internal resistance of a cell etc. A potentiometer consists of a uniform resistance wire of 10m length, stretched on a wooden board.

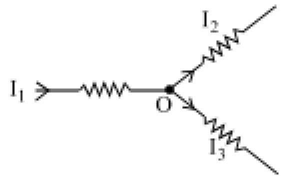
KIRCHOFF'S LAWS & ITS APPLICATION

Kirchoff's laws

First law (Point rule, Junction rule)

The algebraic sum of the current meeting at any junction in a closed circuit is zero.

Consider a circuit as shown below



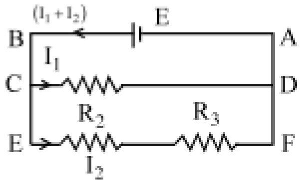
Three currents are meeting at O. Incomming current I_1 is taken as +ve and outgoing currents I_2 & I_3 are taken as -ve.

Then according to this rule, $I_1 - I_2 - I_3 = 0$ ie, $\Sigma I = 0$

Second law

The algebraic sum of the product of current and resistance in any closed loop is equal to the total e.m.f in that loop.

Consider a circuit,



Here anticlock wise currents are taken as positive and clockwise current are taken as negative.

Now consider loop ABCDA, $I_1R_1 = E$

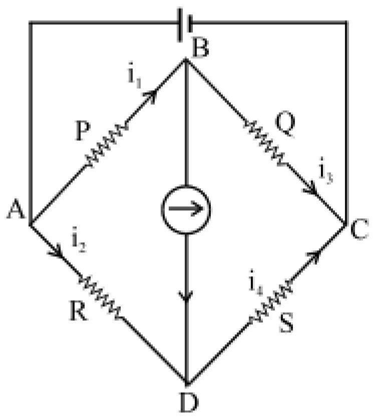
then ABEFA, $I_2R_3 + I_2R_2 = E$ or in general $\Sigma IR = \Sigma E$

Wheatstone's Bridge Network

Wheastone's Bridge is an arrangement of four resistance used for measuring one unknown resistance in terms of the other three known resistances.

<u>Wheatstone's Network</u>

P,Q,R and S are four resistors connected to form a loop ABCD. A cell is connected between A and C. A sensitive galvanometer of resistance G is connected between B and D. The current flowing through each branch of the circuit is shown in the diagram.



Applying Kirchhoff's rule to the mesh ABDA. $-i_1P - i_gG + i_2R=0$
For the loop BCDB, $-i_3Q + i_4S + i_gG = 0$
Now the four resistances are so adjusted so that the galvanometer current i_g is zero. Now the network is said to balanced.
Then, $i_1 = i_3$ and $i_2 = i_4$
so $i_1P = i_2 R$ ....(1) and $i_3Q = i_4S$ ....(2)

$(1)\div(2)$, we get $\frac{i_1P}{i_3Q}=\frac{i_2R}{i_4S}$ $\quad \frac{P}{Q}=\frac{R}{S}$ This is Wheatstone's Principle

Flow of electric charges in a Metalic Conductor

In conductors, valence electrons can move about in whole conductor and are known as free electrons. When an external field is applied, these free electrons moves in a definite direction constituting an electric current. Thus electrons are current carries in conductors.

- Since conduction is due to free electrons, these electrons are also called conduction electrons.

Drift Velocity

Drift velocity is defined as the average velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied electric field. [It is in the order of 10^{-5}m/s]

- Consider a conductor connected to a cell which provides an electric field in the conductor.

The electrons experiences a force $\vec{F}=-e\vec{E}$ $\qquad [\because F = qE \;\; \text{here, } q = e]$

but F = m.a $\quad \therefore \vec{a}=\frac{-e\vec{E}}{m}$

ie, In the presence of an external field, each electron experiences an acceleration $\frac{eE}{m}$ opposite to the field direction. This acceleration remains for a very short time (τ), called relaxation time. The small interval of time between two successive collissions between electrons and ions in the lattice is called relaxation time.

Now drift velocity $\vec{V}_d = u+\vec{a}t = O+\frac{-e\vec{E}}{m}.\tau$ $\qquad V_d=\frac{-e\vec{E}}{m}\tau$

- In the absence of electric field, the motion of electrons in the conductor is randomely distributed and there is no overall drift.

Mobility

Mobility of a charge carrier is defined as the drift veocity of the charge carrier per unit electric field. $\mu=\frac{V_d}{E}$. [It's unit is $m^2V^{-1}S^{-1}$]. Mobility is positive for both free electrons and holes*.

If m_e and m_h are electron and hole mobilities then $\mu_e=\frac{e\tau_e}{m_e}$ and $\mu_h=\frac{e\tau_h}{m_h}$

* Holes - Vacancy of an electron which acts like positive charge.

The electrical conductivity (σ)for a semiconductor containing electrons and holes can be represented as $\sigma = ne\mu_e + pe\mu_n$.

Relation between drift velocity and electric current

Let V be the potential difference applied across the ends of a conductor with length ℓ and area of cross section 'A'.

Electric field produced across the conductor $E=\frac{V}{\ell}$

Let n be the number of free electrons per unit volume.
The total no. of electrons in the conductor = n $\times$ volume of the conductor = n $\times$ **A** ℓ
Now total charge in the conductor, Q=(n.Aℓ)e

let 't' be the time taken by the charge to cross the conductor, $t=\frac{\ell}{V_d}$ where $V_d \rightarrow$ drift velocity

$\ell \rightarrow$ length of the conductor (distance)

From the definition of electric current $I = \frac{Q}{t}$

$I = \frac{nA\ell(e)}{\ell / V_d} = nAV_d e$ $\quad I \, \alpha \, V_d$ (e, A & n are constants) $\quad \therefore V_d = \frac{I}{nAe}$

Relation between mobility and electric current

Electric current $I = nAeV_d$ but $V_d = \mu_e E$

$\therefore I = nAe.\mu_e E$ or $\mu_e = \frac{I}{nAeE}$

Cell

Cell is a device which provides the necessary potential difference to maintain a continuous flow of current in an electric circuit. [Its symbol is $-|\vdash$]

emf

EMF of a cell in the potential difference between the terminals of a cell when no current is drawn from it.

Potential difference

Potential difference is the differenc of potentials between any two points in a closed circuit.

Comparison of emf & p.d

	emf	p.d
1	emf of a cell is the potential difference between the terminals of a cell when no current is drawn from it	Potential difference is the difference of potentials between any two points in a closed circuit.
2	is independent of resistance of the circuit	but pd is directly proportional to resistance
3	term emf is related with a cell	p.d is measured between any two points
4	emf is always greater than p.d.	

Internal resistance of a cell

The electrical resistance offered by the electrolyte and the electrodes of a cell to the flow of current is called internal resistance.

Internal resistance of a cell depends on the

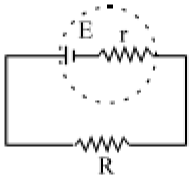
i) Separation between the electrodes

ii) Conductivity

iii) Area of the plates

iv) nature of the electrodes

Consider a cell with emf E and internal resistance 'r' is connected with a resistance R as shown



Then $E = I(R + r)$ or $I = \frac{E}{R+r}$ (circuit equation)

$E = IR + Ir \quad = V + Ir \quad V = E - Ir$

This is the relation between pd, internal resistance and emf of a cell.

Grouping of cells

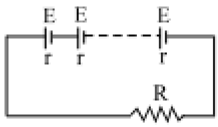
i) Cells in series

When cells are connected in series,

1) the emf of the battery is equal to the sum of the individual emfs of the various cells.

2) The current in each cell is the same and is equal to the main current through the arrangement.

3) Total internal resistance of the battery is equal to the sum of the individual internal resistances.



Let n cells of emf E and internal resistance (r) are connected in series with R. Then total emf = nE

Then total resistance = R + nr Current $I = \frac{nE}{nr+R}$

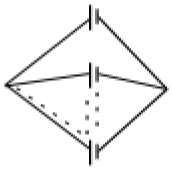
ii) Cells in parallel

When (n) identical cells are connected in parallel,

1) The emf of the battery is the same as that of a single cell.

2) The reciprocal of total internal resistance of a cell is equal to the sum of the reciprocal of the resistances of the individual cells.

3) The main current is divided equally among the cells.



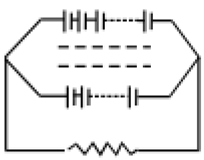
Total internal resistance R^1 $\frac{I}{R^1} = \frac{1}{r} + \frac{1}{r} + \ldots\ldots\ldots n \text{ times } \frac{n}{r}$ $\therefore R^1 = \frac{r}{n}$

$\therefore$ Total resistance = $\left(R + \frac{r}{n}\right)$ $\therefore$ Current $I = \frac{E}{R + \frac{r}{n}}$

iii) Mixed grouping

Let n cells of emf E and internal resistance r are connected in series and m' such combination is connected in parallel.

Total emf = nE



Internal resistance each row = nr

Total resistance = $\frac{nr}{m}$ $\therefore$ Total resistance = $R+\frac{nr}{m}$ $\therefore$ Current $I=\frac{nE}{R=\frac{nr}{m}}$

THERMAL & CHEMICAL EFFECTS OF ELECTRIC CURRENT

I. JOULES HEATING EFFECT

* Heat produced across resistance according to H = I^2Rt = $\frac{V^2}{R}t = VIt$ in Joules

  I = current, R = resistance, t = time, V = applied voltage

* In calories heat equation is $H=\frac{I^2Rt}{4.2}\ \text{Cal}=\frac{I^2Rt}{J}$

  J = The mechanical equivalent of heat = 4.2 J/Cal

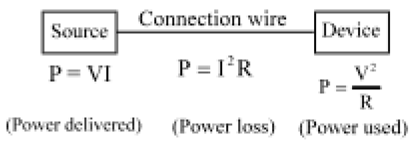
* In this effect heat energy is produced due to the collisions of free electrons with the ions or atoms of the conductor.
* Joules heating effect is irreversible.
* Heating effect produced by ac and dc are the same.

II. ELECTRIC POWER

* Electric power is the rate at which work is done by the source of emf. Its equations are

  P = VI = I^2R = $\frac{V^2}{R}$

* Electricity is always transferred as power from source to device.



  So power is transferred with minimum current and maximum voltage.

* Unit of power - Watt or Ampere volt

  Horse power 1HP = 746 W

* In series combination of resistors, the power consumed P α R
* In series combination of appliances, the effective power consumed P is $\frac{1}{P}=\frac{1}{P_1}+\frac{1}{P_2}+\frac{1}{P_3}+.......$
* In parallel combination of resistors, the power consumed $P\alpha\frac{1}{R}$

* In domestic supply, the appliances are connected in parallel and the effective power consumed is

  $P = P_1 + P_2 + P_3 + \ldots\ldots$

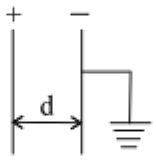
Capacitor or condenser

It is a device for storing large amount of electric charges. Charge stored in a capacitor, q = CV

C – capacitance or capacity

$C = \frac{q}{V}$ $\therefore$ unit is CV^{-1} (Farad)

Parallel plate capacitor



(i) Air capacitor, Capacitance $C = \frac{\epsilon_0 A}{d}$

$$E = \frac{\sigma}{\epsilon_0}$$

$V = E \times d$

(ii) Capacitor with a dielectric,

$$C' = \frac{\epsilon_0 KA}{d}$$

ie $C' = C \times K$ K is the dielectric constant

$E' = \frac{\sigma}{\epsilon_0 K}$ For metals $K = \infty$

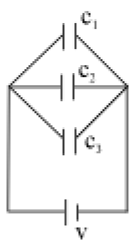
For vacuum K =1

$V' = E' \times d$ For Air K = 1.00059

$\simeq 1$

Combination of capacitors

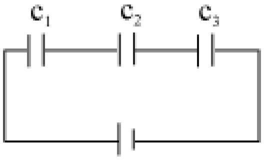
(i) Parallel



Potential difference across all the condensers will be the same, but charge will be different

$q_1 = C_1V$, $q_2 = C_2V$, $q_3 = C_3V$

Effective capacitance, $C_{eff} = C_1 + C_2 + C_3$

(ii) Series 

Potential difference on different capacitors will be different, but the charge will be the same

$$V_1 = \frac{q}{C_1},\quad V_2 = \frac{q}{C_2},\quad V_3 = \frac{q}{C_3}$$

The effective capacitance C_{eff} is

$$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Energy of a charged capacitor is the amount of work done in charging the capacitor

$$U = \frac{1}{2}CV^2 \qquad U = \frac{1}{2}QV \qquad U = \frac{Q^2}{2C}$$

Van de Graff Generator

It is used for accelerating charged particles

Principle

(i) Corona discharge (action of sharp points)

(ii) Charge given to the a hollow conducting sphere will be transferred to the outer surface of the sphere

The minimum radius of spherical shell $R = \frac{V}{E}$ where E is the dielectric strength of the surrounding gas.

Dielectric strength is defined as the maximum electric field that can be applied to a dielectric without its breakdown

Molecule as a dipole

If the +ve charge centre doesn't coincide with the –ve charge centre, the molecule will have a dipole moment. Such molecules are called polar molecules.

In non-polar molecules, the +ve and –ve charge centers coincide

Motion of a charged particle in an electric field

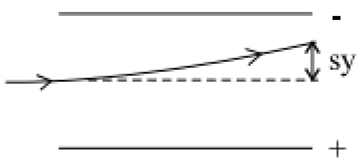
(i) A charged particle moving along the direction of the electric field

A +ve charged particle will move along the direction of the field with an acceleration of $\frac{qE}{m}$

A –ve charged particle will move more along the direction of the field with a deceleration of qE/m

Velocity after t seconds v = u + at

(ii) A charged particle entering perpendicular to a uniform electric field



The path of the charged particle inside the electricfield is a parabola. Let t be the time spent by the particle inside the field. Initial velocity v_x is in the X – direction. Velocity acquired in the Y-direction is v_y. S_y is the displacement in the Y-direction. S_x is displacement in the X-direction within the field. Then

$v_y = u_y + at$ But $u_y = 0$ $\therefore v_y = at$

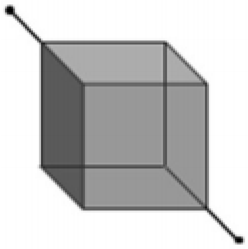
$S_y = u_r + \frac{1}{2} at^2$ But $u_y = 0$ $\therefore S_y = \frac{1}{2} at^2$

$S_x = v_x t$

PART I - (JEEMAIN)

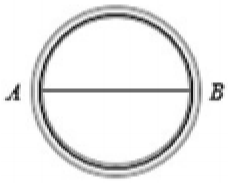
SECTION - I - Straight objective type questions

1. Twelve wires of equal length and same cross-section are connected in the form of a cube. If the resistance of each of the wires is R, then the effective resistance between the two diagonal ends would be



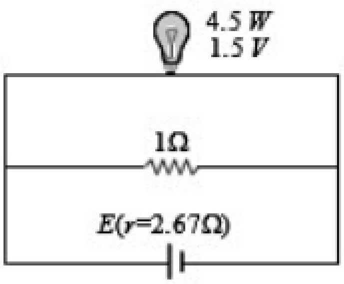
1) 2R 2) 12 R 3) $\frac{5}{6}$R 4) 8 R

2. The resistance of a wire is $10^{-6}\Omega$ per metre. It is bend in the form of a circle of diameter $2m$. A wire of the same material is connected across its diameter. The total resistance across its diameter AB will be



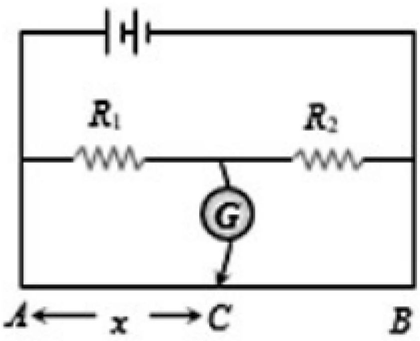
1) $\frac{4}{3}\pi\times10^{-16}\Omega$ 2) $\frac{2}{3}\pi\times10^{-6}\Omega$ 3) $0.88\times10^{-6}\Omega$ 4) $1.22\times10^{-6}\Omega$

3. A torch bulb rated as 4.5 W, 1.5 V is connected as shown in the figure. The e.m.f. of the cell needed to make the bulb glow at full intensity is



1) 4.5 V 2) 1.5 V 3) 2.67 V 4) 13.5 V

4. In the shown arrangement of the experiment of the meter bridge if AC corresponding to null deflection of galvanometer is x, what would be its value if the radius of the wire AB is doubled



1) x 2) x/4 3) 4x 4) 2x

5. Two bulbs of 500 watt and 200 watt are manufactured to operate on 220 volt line. The ratio of heat produced in 500 W and 200 W, in two cases, when firstly they are joined in parallel and secondly in series, will be

1) $\frac{5}{2},\frac{2}{5}$ 2) $\frac{5}{2},\frac{5}{2}$ 3) $\frac{2}{5},\frac{5}{2}$ 4) $\frac{2}{5},\frac{2}{5}$

6. Length of a hollow tube is 5m, it's outer diameter is 10 cm and thickness of it's wall is 5 mm. If resistivity of the material of the tube is $1.7\times10^{-8}\Omega\times m$ then resistance of tube will be

1) $5.6\times10^{-5}\Omega$ 2) $2\times10^{-5}\Omega$ 3) $4\times10^{-5}\Omega$ 4) None of these

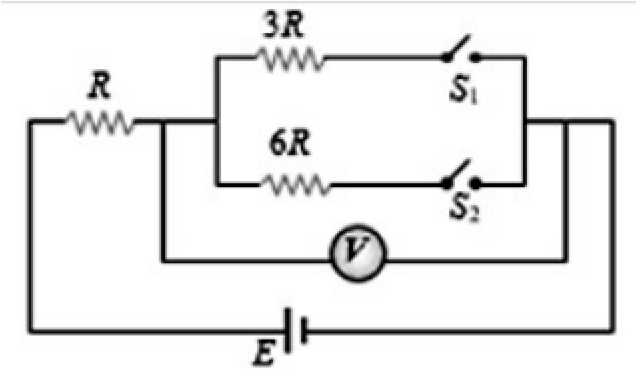
7. Two wires of resistance R_1 and R_2 have temperature coefficient of resistance α_1 and α_2, respectively. These are joined in series. The effective temperature coefficient of resistance is

1) $\frac{\alpha_1+\alpha_2}{2}$ 2) $\sqrt{\alpha_1\alpha_2}$ 3) $\frac{\alpha_1R_1+\alpha_2R_2}{R_1+R_2}$ 4) $\frac{\sqrt{R_1R_2\alpha_1\alpha_2}}{\sqrt{R_1^2+R_2^2}}$

8. Two cells of equal *e.m.f.* and of internal resistances r_1 and r_2 ($r_1 > r_2$) are connected in series. On connecting this combination to an external resistance R, it is observed that the potential difference across the first cell becomes zero. The value of *R* will be

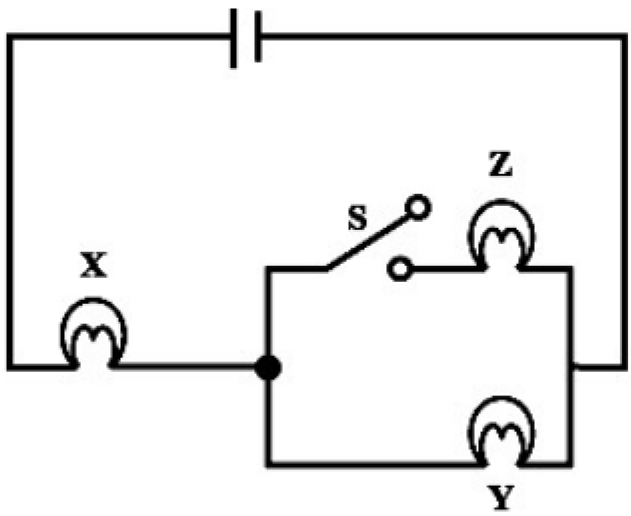
1) $r_1 + r_2$ 2) $r_1 - r_2$ 3) $\frac{r_1+r_2}{2}$ 4) $\frac{r_1-r_2}{2}$

9. In the circuit shown in figure reading of voltmeter is V_1 when only S_1 is closed, reading of voltmeter is V_2 when only S_2 is closed and reading of voltmeter is V_3 when both S_1 and S_2 are closed. Then



1) $V_3 > V_2 > V_1$ 2) $V_2 > V_1 > V_3$ 3) $V_3 > V_1 > V_2$ 4) $V_1 > V_2 > V_3$

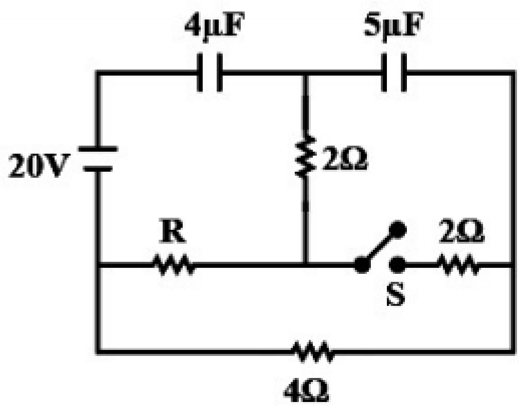
10. If X, Y and Z in figure are identical lamps, which of the following changes to the brightness of the lamps occur when switch S is closed?



1) X stays the same, Y decreases 2) X-increases, Y-decreases

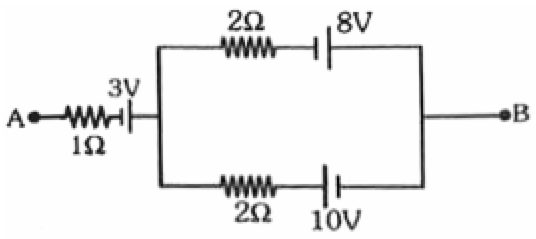
3) X increases, Y-stays the same 4) X decreases, Y increases

11. The heat produced in the capacitor on closing the switch S is



1) 0.0002 J 2) 0.0005 J 3) 0.00075 4) Zero

12. The net emf and internal resistance across AB of three batteries as shown in figure is :



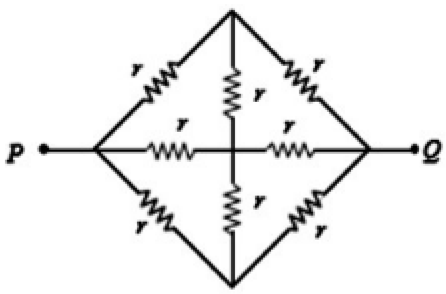
1) $2V, 1\Omega$ 2) $2V, 2\Omega$ 3) $2V, 1.5\Omega$ 40) $4V, 2\Omega$

SECTION - II - Numerical Type Questions

13. Water boils in an electric kettle in 15 *minutes* after switching on. If the length of the heating wire is decreased to 2/3 of its initial value, then the same amount of water will boil with the same supply voltage in _______ minutes_

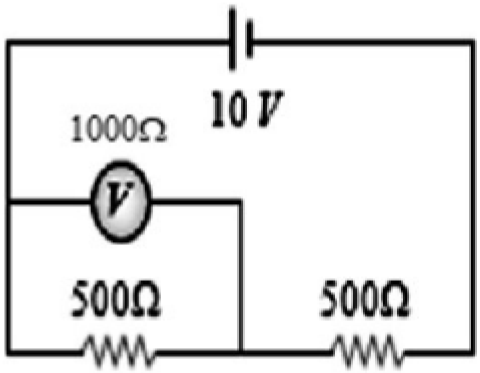
14. Water boils in an electric kettle in 15 *minutes* after switching on. If the length of the heating wire is decreased to 2/3 of its initial value, then the same amount of water will boil with the same supply voltage in _______ minutes

15. The equivalent resistance between the points P and Q in the network given here is _____ ohm (given $r = \frac{3}{2}\Omega$)

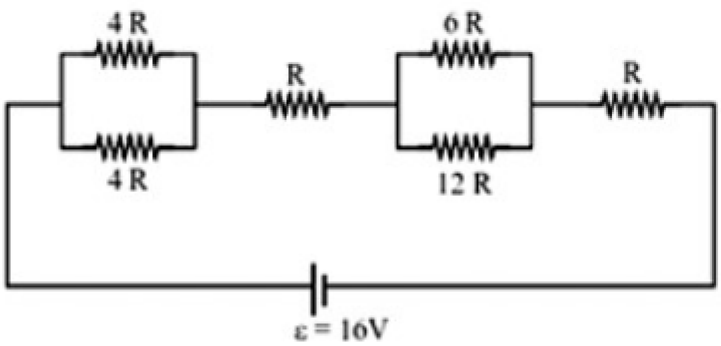


16. The resistance of the series combination of two resistance is S. When they are joined in parallel the total resistance is P. If $S = nP$, then the minimum possible value of n is

17. A voltmeter of resistance 1000Ω is connected across a resistance of 500Ω in the given circuit. Then the reading of voltmeter is _____ volts



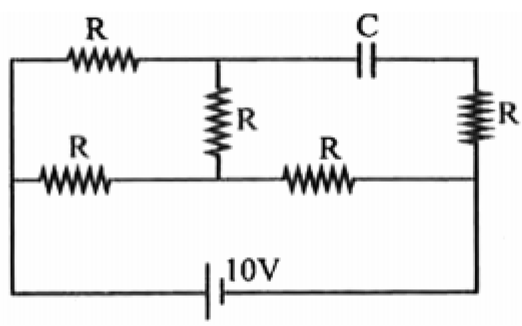
18. The resistive network shown below is connected to a D.C. source of 16 V. The power consumed by the network is 4 watt. The value of R is _____ ohm



PART - II (JEE ADVANCED)

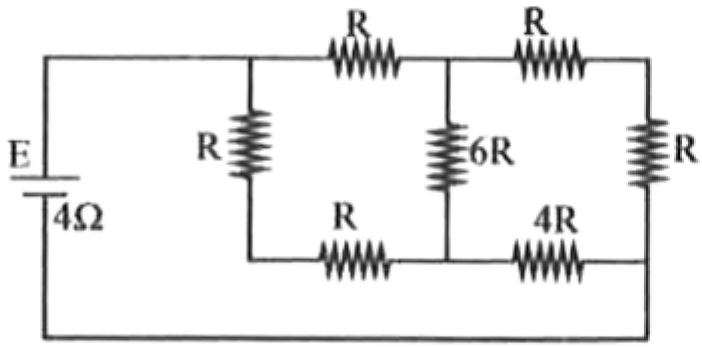
SECTION - III (Only one option correct type)

19. Find the potential difference across the capacitor in volts



A) 7 B) 8 C) 9 D) 10

20. A battery of internal resistance 4Ω is connected to the network of resistances as shown in figure. In order that the maximum power can be delivered to the network, the value of R in Ω should be



A) 2 B) 3 C) 4 D) 1

21. A battery of internal resistance 2Ω is connected to a variable resistor whose value can vary from 4Ω to 10Ω. The resistance is initially set at 4Ω. If the resistance is now increased then:

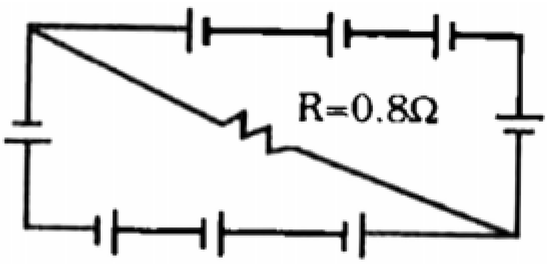
A) power consumed by it will decrease

B) power consumed by it will increase

C) power consumed by it may increase or may decrease

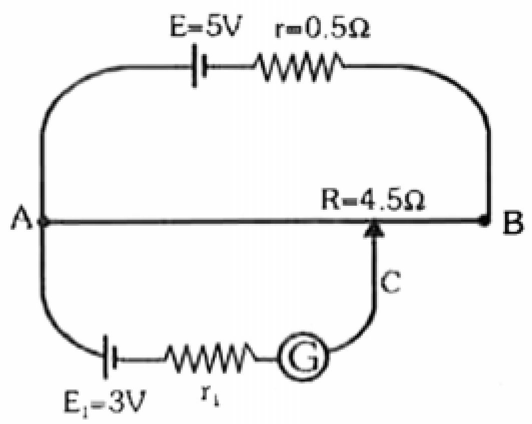
D) power consumed will first increase then decrease

22. A circuit is comprised of eight identical batteries and a resistor $R = 0.8\Omega$. Each battery has an emf of 1.0V and internal resistance of 0.2Ω. The voltage difference across any of the battery is



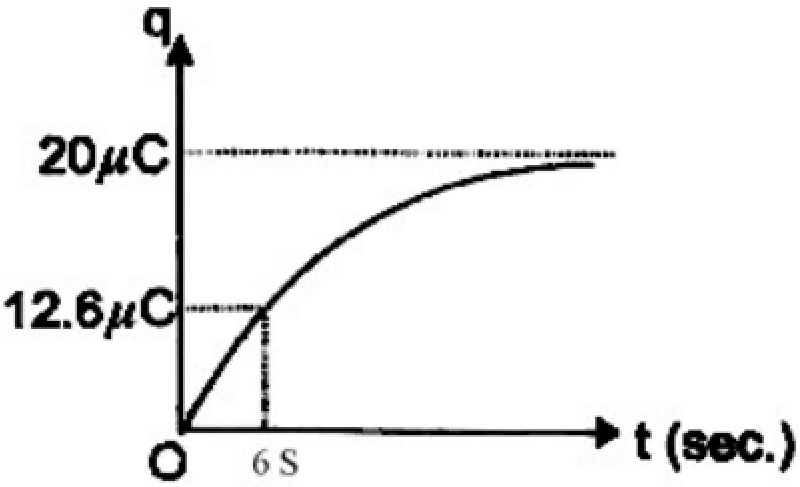
A) 0.5 V B) 1.0 V C) 0 V D) 2 V

23. In the given potentiometer circuit length of the wire AB is 3m and resistance is $R = 4.5\Omega$. The length AC for no deflection in galvanometer is



A) 2m B) 1.8m C) dependent on r_1 D) none of these

24. Charge q versus t graph for a capacitor, initially unchanged is charged with a battery of emf 5V as shown in figure. The resistance R of the circuit is (use approximation)



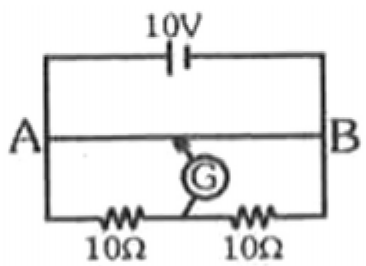
A) $2M\Omega$ B) $6M\Omega$ C) $3M\Omega$ D) $1.5M\Omega$

SECTION - IV (More than one correct answer)

25. A current posses through a wire of non uniform cross section. Which of the following quantities are independent of the cross-section?

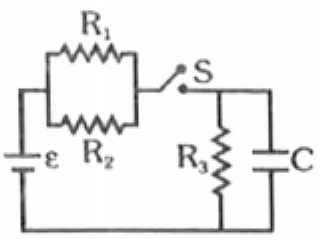
A) The charge crossing in a given time interval
B) Drift speed
C) Current density
D) Free-electron density

26. The wire AB of a meter bridge changes linearly from radius r to 2r from left end to right end. Length of wire is 1m. Where should the free end of the galvanometer be connected on AB so that the deflection in the galvanometer is zero?



A) $\frac{2}{3}$m from end B B) $\frac{1}{3}$m from end **A** C) $\frac{1}{4}$m from end **A** D) $\frac{3}{4}$m from end B

27. The circuit shown in the figure consists of a battery of emf $\varepsilon = 10\text{V}$; a capacitor of capacitance C = 1.0 μF and three resistor of values $R_1 = 2\Omega$; $R_2 = 2\Omega$ and $R_3 = 1\Omega$, Initially the capacitor is completely uncharged and the switch S is open. The switch S is closed at t=0.

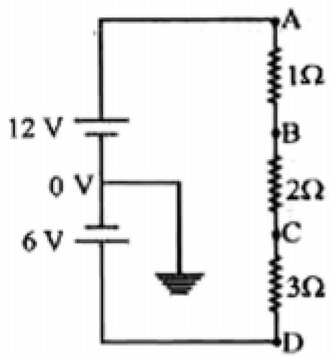


A) The current through resistor R_3 at the moment the switch closed is zero
B) The current through resistor R_3 a long time after the switch closed to 5A
C) The ratio of current through R_1 and R_2 is always constant
D) The maximum charge on the capacitor during the operation is $5\mu\text{C}$

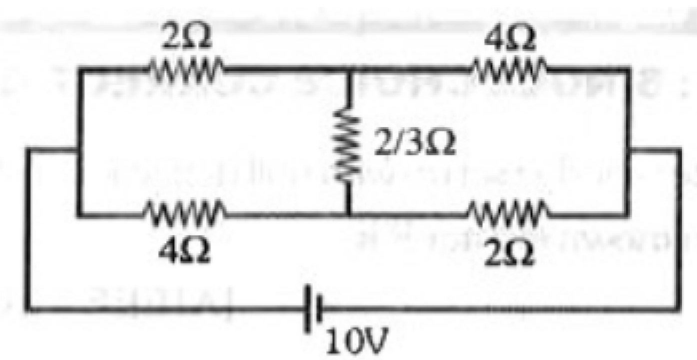
<u>SECTION - V (Numerical Type - Upto two decimal place)</u>

28. An electric bulb rated for 500W at 100V is used in a circuit having a 200V supply. The resistance R that must be put in series with the bulb, so that the bulb delivers 500W is ....Ω

29. In the circuit shown what is the potential at B ? (in volt)

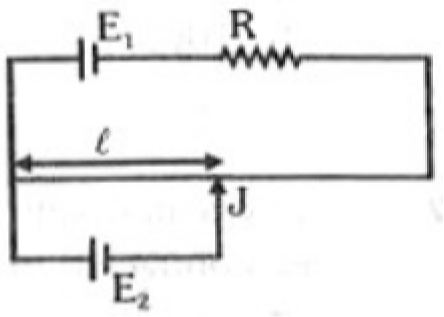


30. Find the current through $\frac{2}{3}\Omega$ resistance in the figure shown



SECTION - VI (Matrix Matching)

31. In the potentiometer arrangement shown in figure, null point is obtained at length ℓ.



Column I	Column II
A) If E_1 is increased	p) l should increase
B) If R is increased	q) l should decrease
C) If E_2 is increased	r) l should remain the same to again get the null point

CAPACITANCE

PART I - (JEEMAIN LEVEL)

SECTION - I - Straight objective type questions

1. N identical capacitor are joined in parallel and the combination is charged to a potential V. Now if they are separated and then joined in series then energy of combination will :

   1) remain same and potential difference will also remain same

   2) remain same and potential difference will become NV

   3) increases N times and potential difference will become NV

   4) increase N time and potential difference will remains same

2. Two identical capacitor are joined in parallel, charged to a potential V and then separated and then connected in series i.e., the positive plate of one is connected to negative of the other

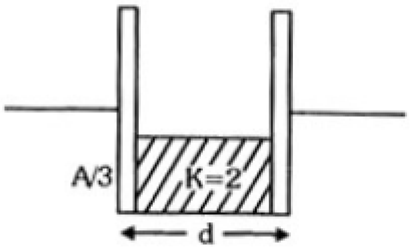
   1) The charges on the free plates connected together are destroyed

   2) The charges on the free plates are enhanced

   3) The energy stored in the system increases

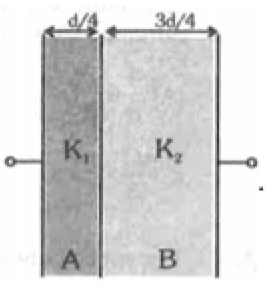
   4) The potential difference in the free plates becomes 2V

3. Capacitor of given system is C. Find the capacitance if dielectric is removed (A is the area of plate, K dielectric constant)



A1) $\frac{4}{3}C$ 2) $\frac{2}{3}C$ 3) $\frac{C}{3}$ 4) $\frac{3}{4}C$

4. Two medium of dielectric constant K_1 and K_2 are introduced according to given figure. If $\frac{K_1}{K_2}=3$ then calculate ratio of capacity of part A and part B and net capacity of system. (Area of each plate is A)



1) 9 : 1 2) 1 : 9 3) 4 : 1 4) 1 : 4

5. The plates of a parallel plate capacitor are charged up to 100 volt. A 2mm, thick dielectric plate is inserted between the plates, then to maintain the same potential difference, the distance between the capacitor plate is increased by 1.6mm. The dielectric constant of the plate is:-

1) 5 2) 1.25 3) 4 4) 2.5

SECTION - II

Numerical Type Questions

6. A capacitor of capacitance C is charged to a potential V. The flux of the electric field through a closed surface enclosing the capacitor is ....0................

7. Three capacitors of capacitance $6\mu F$ each are available. The minimum and maximum capacitance, which may be obtained are...................

PART II - (JEE ADVANCED)

SECTION - III (Only one option correct answer type)

8. Two conducting spheres of radii R_1 and R_2 are charged with charges Q_1 and Q_2 respectively. On bringing them in contact there is:

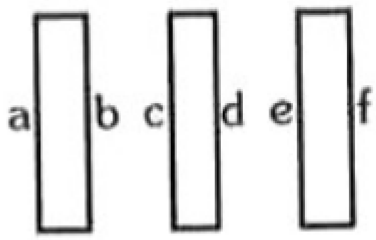
A) no change in the energy of the system

B) an increase in the energy of the system if $Q_1R_2 \neq Q_2R_1$

C) always a decrease in energy of the system

D) a decrease in energy of the system if $Q_1R_2 \neq Q_2R_1$

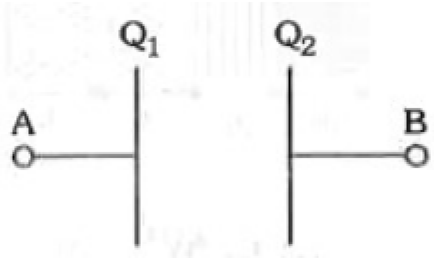
9. Three parallel metallic plates, each of area A are kept as shown in the figure and charge Q_1, Q_2 and Q_3 are given to them. Edge effects are negligible. Calculate the charges on the two outermost surfaces 'a' and 'f'.



A) $\frac{Q_1+Q_2+Q_3}{2}$ B) $\frac{Q_1+Q_2+Q_3}{3}$ C) $\frac{Q_1-Q_2+Q_3}{3}$ D) $\frac{Q_1-Q_2+Q_3}{2}$

SECTION - IV (More than one correct answer)

10. There are two parallel plate of surface area A & separation d. Then



A) Potential difference between the plates is $\frac{(Q_1-Q_2)d}{2\varepsilon_0 A}$

B) Potential difference between the plates is $\frac{(Q_1-Q_2)}{\varepsilon_0 A}d$

C) If A is earthed, the charge (Q_1+Q_2) will flow to earth

D) If B is earthed, the charge (Q_2-Q_1) will flow to earth

11. A parallel plate capacitor is connected to a cell. Its positive plate A and its negative plate B have charges +Q and -Q respectively. A third plate C, identical to A and B, with charge +Q, is now introduced midway between A and B, parallel to them. Which of the following are correct:

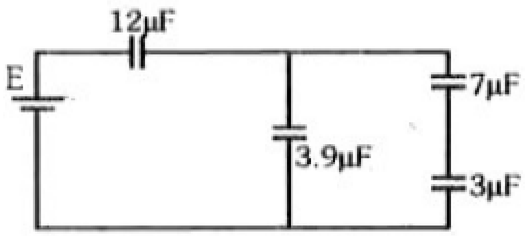
A) Charge on the inner face of B is now $-\frac{3Q}{2}$

B) There is no change in the potential difference between A and B

C) Potential difference between A and C is one-third of the potential difference between B and C

D) Charge on the inner face of A ais now $\frac{Q}{2}$

12. Four capacitors and a battery are connected as shown. The potential drop across the $7\mu F$ capacitor is 6V. Then the



A) potential difference across the $3\mu F$ capacitor is 10V

B) charge on the $3\mu F$ capacitor is $42\mu C$

C) e.m.f of the battery is 30V

D) potential difference across the $12\mu F$ capacitor is 10V

13. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at x = 0 and positive plate is at x = 3d. The slab is equidistant from the plates. The capacitor is given some charge. As one goes from 0 to 3d

A) The magnitude of the electric field remians the same

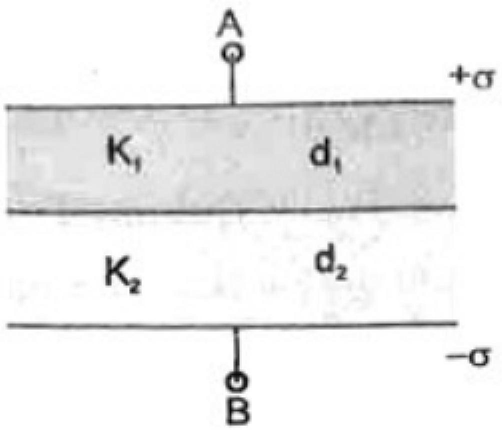
B) The direction of the electric field remains the same

C) The electric potential increases continuously

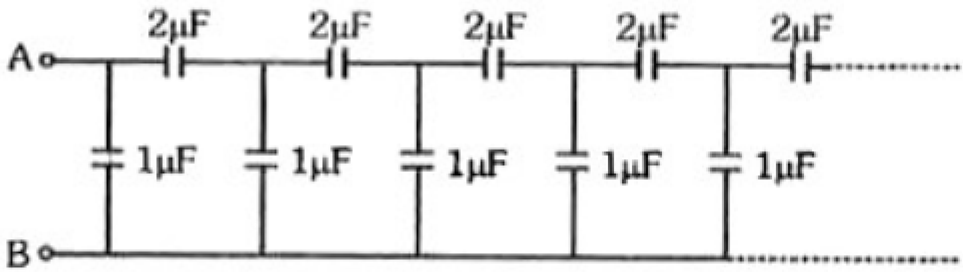
D) The electric potential increases of first, then decreases and again increases

SECTION - V (Numerical Type - Upto two decimal place)

14. The capacitance between A and B is $\frac{A\varepsilon_0 K_1}{nd_1}$. If two dielectric slabs of dielectric constant K_1 and K_2 of thickness d_1 and d_2 and each of area A are inserted between the plates of parallel plate capacitor of plate area A as shown in figure : $(K_2 = 2K_1 : d_2 = 4d_1)$. Find value of n.



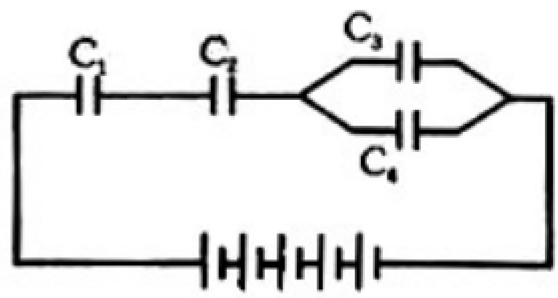
15. Find the equivalent capacitance of the infinite ladder shown in figure between the points A and B. (in μF)



16. A parallel plate condenser is charged to a certain potential and then disconnected. The separation of the plates is now increased by 2.4 mm and a plate of thickness 3mm is inserted into it keeping its potential constant. Field the dielectric constant of the medium.

SECTION - VI (Matrix Matching)

17. In the circuit shown in figure $C_1 = C$, $C_2 = 2C$, $C_3 = 3C$, $C_4 = 4C$



Column I	Column II
A) Maximum potential difference	p) across C_1
B) Minimum potential difference	q) across C_2
C) Maximum potential energy	r) across C_3
D) Minimum potential energy	s) across C_4