THE VILLAGE
INTERNATIONAL SCHOOL
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GRADE XII – PHYSICS

CHAPTER 2 – ELECTROSTATIC POTENTIAL AND CAPACITANCE

Question Bank 1

1) Is there any conductor which can be given almost unlimited charge?
   Ans- Earth is one such conductor
2) A metal plate foil is placed in the middle of a [parallel plate capacitor .What is the effect on the capacitance?
   Ans – There will not be any effect on the capacitor
3) Name the physical quantity whose SI unit is Coulomb volt^{-1}
   Ans- Electrical capacitance
4) In which form is the energy stored in a capacitor/
   Ans – In the form of electric field
5) What is dielectric?
   Ans – It is material which transmits electric effects without conducting
6) What is the net charge on a charged capacitor?
   Ans – Zero
7) Where does the energy of the capacitor resides?
   Ans – The energy resides in the dielectric medium between the plates
8) If the plates of a charged capacitor be suddenly connected to each other by a wire What will happen?
   Ans – The capacitor will discharge
9)Name the physical quantity whose SI unit is joule coulomb^{-1}
   Ans – Electric potential
10) What is the work done to moving a charge of 40c between two points on an Equipotential surface?
   Ans- No work is done
11) Is potential difference is scalar or vector?
   Ans – It is a scalar
12) What is the shape of equipotential surfaces for a uniform electric field?

Ans – The equipotential surface is perpendicular to the direction of electric field

13) Why is electrostatic potential constant throughout the volume of the conductor and has the same value (as inside) on its surface?

Ans - Electric field inside the conductor = 0

Electric field inside the conductor = 0

$$E = -\frac{dV}{dr} \quad \Rightarrow \quad \frac{dV}{dr} = 0 \quad \therefore \ \mathbf{V = constant}$$

14) Distinguish between dielectric and a conductor

Ans –

Dielectric	Conductor
Dielectrics are the insulating materials which transmit electric effects without conducting.	Conductors are the substances which can be used to carry or conduct electric charge from one place to the other.

15) Conductors are the substances which can be used to carry or conduct electric charge from one place to the other.

Ans- Inside the hollow charged conductor, electric field is zero therefore no work is done in moving a small test charge within the conductor. Hence electrostatic potential inside a hollow charged conductor is same at every point.

16) What is the geometrical shape of equipotential surfaces due to a single isolated charge?

Ans - Concentric spheres with a gap between them not being uniform as $V \propto 1r$

17) What is the amount of work done in moving a point charge around a circular arc of radius r at the centre of which another point charge is located?

Ans- Being an equipotential surface, work done will be zero.

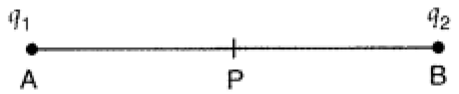
18) For any charge configuration, equipotential surface through a point is normal to the electric field.” Justify

Ans - Work done in moving a charge over an equipotential surface is zero, hence a point on it will be normal to the electric field.
W = FS cos θ ∴ cos θ = 0 or θ = 90 degree

19) Two point charges, $q_1 = 10 \times 10^{-8}$C, $q_2 = -2 \times 10^{-8}$C are separated by a distance of 60 cm in air.
(i) Find at what distance from the 1st charge, q_1 would the electric potential be zero.
(ii) Also calculate the electrostatic potential energy of the system.

Ans - (i) Given $q_1 = 10 \times 10^{-8}$C, $q_2 = -2 \times 10^{-8}$C
AB = 60 cm = 0.60 = 0.6m
Let AP = x

Let $AP = x$ then $PB = 0.6 - x$



$$\text{Potential P due to charge } q_1 = \frac{Kq_1}{AP}$$

$$\text{Potential P due to charge } q_2 = \frac{Kq_2}{BP}$$

∵ Potential at P = 0

$$\Rightarrow \frac{Kq_1}{AP} + \frac{Kq_2}{BP} = 0 \quad \Rightarrow \quad \frac{q_1}{AP} = \frac{-q_2}{PB}$$

$$\therefore \frac{10 \times 10^{-8}}{x} = \frac{-(-2 \times 10^{-8})}{0.6 - x}$$

$$\Rightarrow 2x + 10x = 6 \quad \Rightarrow \quad 12x = 6$$

$$\therefore x = \frac{1}{2} = 0.5\text{m}$$

Distance from first charge = 0.5 m = 50 cm.
(ii) Electrostatic energy of the system is

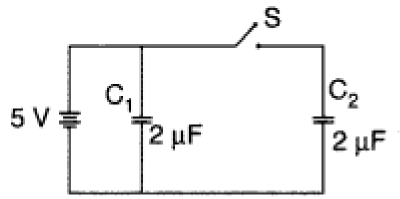
$$E_n = \frac{Kq_1q_2}{r} = \frac{-9 \times 10^9 \times 10^{-7} \times 2 \times 10^{-8}}{60 \times 10^{-2}}$$

$$= \frac{-18 \times 10^{-6}}{60 \times 10^{-2}}$$

$$= \frac{-3}{10} \times 10^{-4} = -3 \times 10^{-5} \text{ Joule}$$

$$\therefore \text{U or } E_n = \mathbf{-3 \times 10^{-5} \text{ Joule}}$$

20) Figure shows two identical capacitors C_1 and C_2, each of 2 μF capacitance, connected to a battery of 5 V. Initially switch 'S' is left open and dielectric slabs of dielectric constant K = 5 are inserted to fill completely the space between the plates of the two capacitors. How will the charge and



(ii) potential difference between the plates of the capacitors be affected after the slabs are inserted?

Ans - (i) When switch S is open and dielectric is introduced, charge on each capacitor will be $q_1 = C_1 V$, $q_2 = C_2V$

$q_1 = 5CV$

$= 5 \times 2 \times 5 = 50$ μC, $q_2 = 50$ μC

Charge on each capacitor will become 5 times

(ii) P.d. across C_1 is still 5V and across C_2,

$q = (5C) V$

$$V' = \frac{V}{5} = \frac{5}{5} = \mathbf{1V}$$

21) Net capacitance of three identical capacitors in series is 1 pF. What will be their net capacitance if connected in parallel?
Find the ratio of energy stored in the two configurations if they are both connected to the same source

Ans - Let C be the capacitance of a capacitor

Given : $C_1 = C_2 = C_3 = C$ When connected in series:

When connected in series:

$$C_S = \frac{C}{3} = 1 \text{ μF} \qquad \therefore C = 3 \text{ μF}$$

When connected in parallel:

$$C_p = C + C + C = 3 + 3 + 3 = 9 \text{ μF}$$

Energy stored in capacitor

$$E = \frac{1}{2} CV^2$$

$$\therefore \frac{E_s}{E_p} = \frac{\frac{1}{2}C_sV^2}{\frac{1}{2}C_pV^2} = \frac{C_s}{C_p} = \frac{1}{9} = \mathbf{1 : 9}$$

22) If uniform electric field exists along Z-axis, equipotential is along-

Ans-XY-Plane .

23) Prove that the energy stored in a parallel plate capacitor is given by $\frac{1}{2}CV^2$?

Ans- Suppose a capacitor is connected to a battery and it supplies small amount of change dq at constant potential V, then small amount of work done by the battery is given by

dw = Vdq

dw = qc/dq (Since q = CV)

Total work done where capacitor is fully changed to q.

$$\int dw = W = \int_0^q q/c\, dq \Rightarrow W = \frac{1}{C}\int_0^q qdq \Rightarrow W = \frac{q^2}{2C} = \frac{C^2V^2}{2C}$$

$$W = \frac{1}{2}CV^2$$

This work done is stored in the capacitor in the form of electrostatic potential energy.

$$\Rightarrow W = U = \frac{1}{2}CV^2$$

24) Derive an expression for the total work done in rotating an electric dipole through an angle θ in a uniform electric field?

Ans - We know τ = PE sin θ

If an electric dipole is rotated through an angled θ against the torque acting on it, then small amount of work done is

dw = τ dθ = PE sin θdθ

For rotating through on angle θ, from 90^o

$$w = \int_{90^0}^{\theta} PE\sin\theta$$

$$w = PE\left|-\cos\theta\right|_{90}^{\theta}$$

w = – PE cos θ

25) Keeping the voltage of the charging source constant. What would be the percentage change in the energy stored in a parallel plate capacitor if the separation between its plates were to be decreased by 10%?

Ans -. $U = \frac{1}{2} C V^2$

For parallel plate $U = \frac{1}{2} \frac{A \in o}{d} V^2$

When d' = d – 10% of d= 0.9 d

Then $U' = \frac{1}{2} \frac{A \in o}{0.9d} V^2$

Change in energy = U'-U = $\frac{1}{2} \frac{AEo}{d} V^2 (\frac{1}{0.9} - 1)$

$U' - U = U(\frac{0.1}{0.9}) = U/9$

% change = $\frac{U' - U}{U} \times 100\ \% = \frac{U}{9} \times \frac{1}{U} \times 100\% = \frac{100\%}{9}$

% change = 11.1%

26) Three capacitors each of capacitance 9 pF are connected in series.

1. What is the total capacitance of the combination?

2. What is the potential difference across each capacitor if the combination is connected to a 120 V supply?

Ans - Capacitance of each of the three capacitors, C = 9 pF

Equivalent capacitance (C') of the combination of the capacitors is given by the relation,

$$\frac{1}{C^1} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$$

$$= \frac{1}{9} + \frac{1}{9} + \frac{1}{9} + \frac{1}{9} = \frac{1}{9}$$

$$\therefore C' = 3\mu F$$

Therefore, total capacitance of the combination is $3\mu F$.

1. Supply voltage, V = 100 V

Potential difference (V) across each capacitor is equal to one-third of the supply voltage.

$$\therefore V' = \frac{V}{3} = \frac{120}{3} = 40V$$

Therefore, the potential difference across each capacitor is 40 V.

27) Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel.

1. What is the total capacitance of the combination?
2. Determine the charge on each capacitor if the combination is connected to a 100 V supply.

Ans. Capacitances of the given capacitors are

$C_1 = 2pF$

$C_2 = 3pF$

$C_3 = 4pF$

For the parallel combination of the capacitors, equivalent capacitor C' is given by the algebraic sum,

$C' = 2+3+9pF$

Therefore, total capacitance of the combination is 9 pF.

1. Supply voltage, V = 100 V

The voltage through all the three capacitors is same = V = 100 V

Charge on a capacitor of capacitance C and potential difference V is given by the relation,

$q = vc.....(i)$

For C = 2 pF,

$Charge = VC = 100 \times 2 = 200\ pc = 2 \times 10^{-10} C$

For C = 3 pF,

$Charge = VC = 100 \times 3 = 300\ pc = 3 \times 10^{-10} C$

For C = 4 pF,

$Charge = VC = 100 \times 4 = 200\ pc = 4 \times 10^{-10} C$

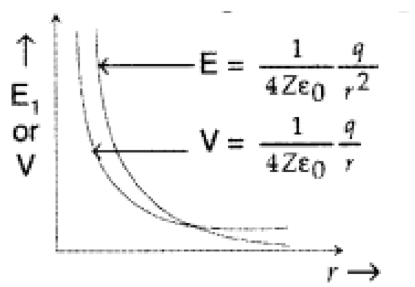
28) Draw a plot showing the variation of

(i) electric field (E) and

(ii) electric potential

(iii) with distance r due to a point charge Q.

Ans -



29) An electric dipole is held in a uniform electric field.

(i) Show that the net force acting on it is zero.

(ii) The dipole is alligned parallel to the field.

Find the work done in rotating it through the angle of 180°.

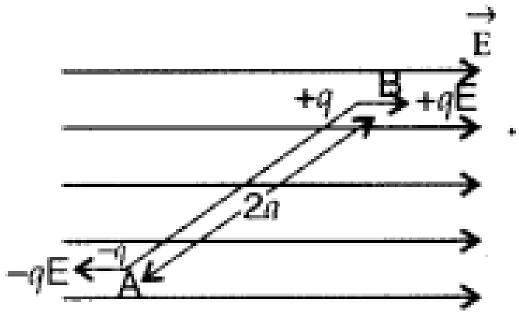
Ans –

(i) Force acting on point A due to charge -q is -qE

Force acting on point B due to charge +q. is + qE

Net force acting on

= -qE + qE = 0 (zero)



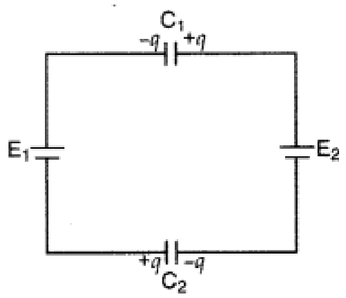
Hence, the net force acting on electric dipole held in a uniform electric field is zero.

(ii) $W = -pE(\cos 0_2 — \cos \theta_2)$

$W = -pE(\cos 180° – \cos 0°)$

=> $W = -pE(-1 – (1)) = +2pE$

30) Determine the potential difference across the plates of the capacitor 'C_1' of the network shown in the figure.



Ans - Net E = $E_2 - E_1$

Both capacitors are in series

$$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \qquad \Rightarrow C = \frac{C_1 \times C_2}{C_1 + C_2}$$

$\therefore V_1$, (Potential difference across the plates of the capacitor C_1) = qC1

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