PHYSICS

CLASS NOTES FOR CBSE

Chapter 18. Electrostatic Potential and Capacitance

01. Introduction

(i) When a conductor is given a charge, it's potential rises in proportional to the charge given **i. e.**

$Q \propto V$ or $Q = CV$ or $C = Q/V$

This C is a constant and is called the *CAPACITANCE* of conductor

(ii) A given conductor can be charged to a limit. Charging after the limit results into ionization of medium, and charge gets leaked into medium

(iii) C depends on

(1) Size and shape of conductor

(2) Surrounding medium

(3) Presence of other conductor near by

(iv) Unit (1) Coulomb/volt

(2) Farad

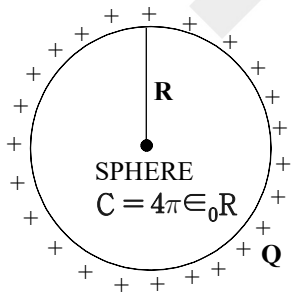
1 Farad = 1 Coulomb/volt.

Capacitance of an isolated spherical conductor

Q : Charge on the sphere

V : Potential at the surface of sphere

R : Radius of sphere



(i) $V = \dfrac{Q}{4\pi\varepsilon_0 R}$ also $V = \dfrac{Q}{C}$

hence $C = 4\pi\varepsilon_0 R$

02. Energy of a Charged Conductor

(i) The work done in charging the conductor gets stored as potential energy in the electric field in the vicinity of the conductor.

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(ii) Suppose, a conductor is given a charge q, then potential of conductor $V = \frac{q}{C}$

Work done to bring a further charge dq is given by $dw = V\,dq = \frac{q}{C}\,dq$

So, work done to charge it from 0 to Q is

$$W = \frac{1}{C}\int_0^Q q\,dq \quad = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV.$$

This is energy U which is stored.

(iii) This energy does not depend upon size of the conductor

03. Distribution of Charges

(i) Two insulated conductors A and B of capacitances C_1 and C_2 are given charges q_1 and q_2 and raised to potential V_1 and V_2 respectively. Then $q_1 = C_1V_1$ and $q_2 = C_2V_2$

(ii) When, these conductors are joined by a thin wire, then positive charge will flow from the conductor at higher charge will flow from the conductor at higher potential to conductor at lower potential till their potentials become equal.

(iii) Charge remains conserved in this process i.e. If q'_1 and q'_2 are charges after distribution and V the potential on each conductor then

$q'_1 = C_1V$

and $q'_2 = C_2V$

and $C_1V_1 + C_2V_2 = C_1V + C_2V$

(iv) $V = \frac{\text{Total charge}}{\text{Total capacitance}} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

(v) On connecting two charged conductors their distributed charged on them are in the ratio of their capacitances

i.e. $\frac{q_1}{q_2} = \frac{C_1}{C_2}$

(vi) Loss of energy :

$\Delta U = U_{initial} - U_{final}$

$\Delta U = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$

04. Capacitor/Condenser

As we know, that capacitance of a conductor depends on the presence of other conductors nearby. This fact is used to make a capacitor.


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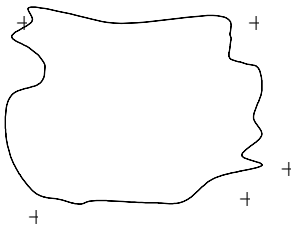
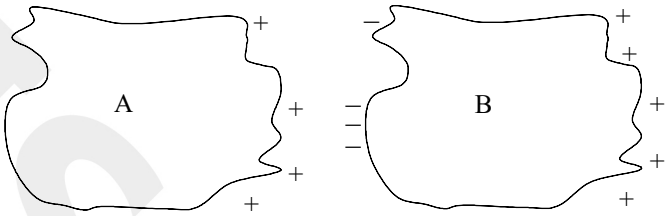
(i) Concept of condenser



$$C = \frac{Q}{V_A}$$

Now, a second conductor is brought near A,



$V'_A = V_A + V_{B-} + V_{B+}$

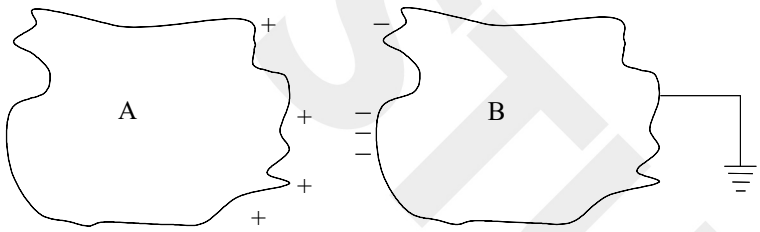
V_{B-} is negative

V_{B+} is positive and $|V_{B-}| > |V_{B+}|$, because of lesser distance of negative charge

$\Rightarrow V'_A < V_A$

$\Rightarrow$ Capacitance increases

If B is earthed $V_{B+} = 0$ hence



$V'_A = V_A + V_{B-}$ and capacitance of A increases.

(ii) Capacitance of a condenser depend on the following points

(a) Distance between plates

C is inversely proportional to 'd' i.e. $C \propto 1/d$ as d increases, C decreases and viceversa

(b) Overlapping area of plates

C is directly proportional to 'A', i.e.

$C \propto A$

(c) Medium between the plates :

Capacitance is directly proportional to the dielectric constant of the medium, i.e.

$C \propto K$

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