03. Electrostatics

3.0 Basic concepts :

Charge:

1. The study of electricity or electric charges at rest is known as electrostatics.
2. The property of a particle which produces electrical influence around it, is called as charge
3. The property acquired by the material body when it is rubbed with another body which produces electrical influence is called as charge, The rubbed body which acquires a charge is called electrified body.
4. The electricity developed on bodies, when they are rubbed against each other is called frictional or static electricity. The bodies gets charged due to transfer of electrons from one body to the other.
5. The smallest amount of charge that can be obtained by any practical means is electronic charge. It is always present on proton and electron.
   ($e = 1.6 \times 10^{-19}$ C)
6. The total charge of a system is equal to the algebraic sum of all individual charges of the system.
7. Charge (q) on a body is always equal to integral multiple of electronic charge (e)
   i.e. $q = \pm ne$, where n = 1, 2, 3...
   This fact is also known as discrete nature of charge. Net charge on an isolated system always remains constant. In other words, charge can neither be created nor destroyed.
8. There are two types of charge,
   i) **Positive charge:** The charge acquired by the glass rod when it is rubbed with silk is positive charge i.e. The absence of electron is positive charge.
   ii) **Negative charge:** The charge acquired by the ebonite rod when it is rubbed with fur is negative charge i.e. the presence of electron is negative charge.
9. The concept of positive and negative charges was introduced by Benjamin Franklin.
   There is force of attraction or repulsion between two electric charges was shown by William Gilbert. The force between two electric charges was given by Coulomb in 1784, called as Coulomb's law.
10. Charge is the fundamental property associated with matter due to which it produces and experiences magnetic and the electric effects.
11. The excess or deficiency of electrons in a body gives the concept of charge.
12. When a positive charge is given to a body its mass some what decreases and when a negative charge is given, it increases.
13. Just as masses are responsible for the gravitational force, charges are responsible for electric force.
14. The net charge of a neutral body–is zero and it is equal to sum of positive and negative charges on it.

Properties of charges :

1. Like charges repel each other and unlike charges attract each other.
2. A charged body attracts an other uncharged particles.
3. Charge always resides on the outer surface of the charged body. It accumulates more at sharp points.
4. Charge is a scalar. SI unit of charge is coulomb. Charge is a derived physical quantity with dimensions [AT].
5. Electric charge is additive in nature i.e. the total charge on a body is the algebraic sum of the charges located at different points on the body.
6. The charge is always quantised i.e. electric charge can exist only as an integral multiple of charge of an electron. i.e. if q is the charge then $q = \pm ne$, where n is an integer.
7. The total net charge of an isolated physical system always remains constant. Charge can neither be created nor destroyed but it can be transferred from one body to another. (Law of conservation of charge).
8. Charge can not exist without mass though mass

can exist without charge e.g. particles like photon, neutron have no rest mass so they can never have a charge.

9. Charge is independent of frame of reference i.e. charge on a body does not change what ever be its speed. (Charge is invariant.)
10. Accelerated charge radiates energy. If the motion of a charged particle is accelerated it not only produces electric and magnetic fields but also radiates energy in the form of electromagnetic waves.
11. i) Repulsion is the sure test of electrification.
    ii) Charge conservation is observed in nuclear reactions, radioactive decay, pair production.
    iii) 1 coulomb of charge is equal to the charge of 6.25×10^{18} electrons.
12. Conductors contain free electrons and insulators have no free electrons.
13. Metals and electrolytes are conductors. Mica, glass, plastic etc., are insulators.

Unit of charge:

1. S.I. unit of charge is coulomb (C). One coulomb charge is that charge, which when placed from an identical charge at a distance of 1m from it, and repels it with a force of 9×10^9 N.
2. The electrostatic unit of charge is stat–coulomb or franklin and 1 coulomb = 3×10^9 stat coulomb.
3. The electromagnetic unit of charge is ab coulomb, 1 ab coulomb = 3×10^{10} stat coulomb = 10 coulomb.

Electrification:

1. A body can be charged by friction, conduction or induction.
2. **Friction:** When two bodies are rubbed together, electrons are transferred from one body to the other. The substance which loses the electrons is said to has acquired positive charge and the substance which gains electrons is said to has acquired negative charge. Here both positive and negative charges are in equal amounts e.g. when a glass rod is rubbed with silk cloth, glass rod acquires positive charge and silk cloth acquires negative charge.
   When an ebonite rod is rubbed with fur, ebonite rod acquires negative charge and fur cloth acquires positive charge.
3. **Conduction:** If a neutral body is kept in contact with a charged body, the latter it shares its charge with the former. Conduction precedes repulsion.
4. **Induction:** If a charge body is brought near a neutral body, the charged body will attract opposite charge and repel similar charge present in the neutral body. Opposite charge is induced at the near end and similar charge at the farther end. Inducing body neither gains nor loses charge. Induction always precedes attraction. The nature of induced charge is always opposite to that of inducing charge (by connecting the uncharged body to the earth).
   Induced charge can be lesser or equal to inducing charge (never greater).
   Maximum value of induced charge is given by $q' = -q\,(1 - 1/K)$.
   Here q is inducing charge and K is dielectric constant of the material of uncharged body.
   For metals $K = \infty$ and so $q' = -q$.
5. Charge can be measured with the help of gold leaf electroscope, electrometer or ballistic galvanometer.

Charge density :

There are three types of charge densities.

1. The charge per unit length is linear charge density (λ).

   $$\text{Linear charge density } (\lambda) = \frac{\text{Charge}}{\text{Length}} = \frac{q}{l}$$

2. The charge per unit surface area is surface charge density (σ).

   $$\text{Surface charge density } (\sigma) = \frac{\text{Charge}}{\text{Surface area}} = \frac{q}{A}$$

   SI unit of cr is Cm^{-2}. Its dimensional formula is $[ATL^{-2}]$.

   For a charged sphere, $\sigma = \dfrac{q}{4\pi r^2}$

3. The charge per unit volume is called volume charge density (ρ).

Coulomb's law:

1. **Coulomb's law:** Two electric charges always attract or repel each other with a force which is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

i.e. $F = C\,\dfrac{q_1 q_2}{r^2}$ where C is the constant of proportionality. It's value depends on nature of the medium separating the two charges and system of units in which various quantities are measured. C for air medium and in S.I. system,

$$C = \frac{1}{4\pi \in_0}$$

C for dielectric medium and in S.I. system,

$$C = \frac{1}{4\pi \in_0 k}$$

C for air medium and in C.G.S. system,

$C = 1$

C for dielectric medium and in C.G.S. system,

$$C = \frac{1}{k}$$

In dielectric medium, $F = \dfrac{1}{4\pi \in_0} \times \dfrac{q_1 q_2}{r^2}$

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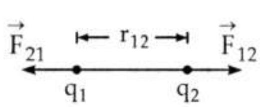
Where $\in_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$ is permittivity constant of vacuum.

2. The ratio of permittivity constant of dielectric medium to permittivity constant of air medium is called relative permittivity or dielectric constant (k) or specific inductive capacity. For air k = 1 and for dielectric medium k > 1, for conductor $k = \infty$.
3. The ratio of force between two electric charges in air medium to the force between two electric charges in dielectric medium is also called as dielectric constant of dielectric medium.
4. Force of attraction between the two charges is directed inwards along. the line joining the two charges. Force of repulsion between two charges is directed outwards along the line joining the two charges.
5. **Coulomb's law in vector from:**

$$\vec{F}_{12} = \frac{1}{4\pi \in_0} \frac{q_1 q_2}{r_{12}^2}\,\hat{r}$$



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

Here F_{12} is force exerted by q_1 on q_2 and F_{21} is force exerted by q_2 on q_1.

6. Coulomb's law holds for stationary charges only which are point sized.
7. This law obeys Newton's third law (i.e. $\vec{F}_{12} = -\vec{F}_{21}$).
8. This law is not universal.
9. Coulomb force is a conservative force and obeys inverse square law. .
10. Electrostatic force between two charges can be attractive or repulsive where as gravitational force between two bodies is always attractive.
11. Electrostatic force between charged particles is much stronger than gravitational force.
12. Electric force depends on the nature of medium between the charges while gravitational force does not.
13. Force on a charged particle due to a number of point charges is the resultant of forces due to individual point charges i.e. $\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \ldots..$
14. In a medium of dielectric constant k, electric force between two point charges decreases and becomes 1/k times of its value in free space.
15. The equilibrium of a charged particle under the action of coulombian forces alone can never be stable.
16. Force between two pointcharges is independent of presence or absence of other charges.
17. Coulomb is that charge which when placed 1m from an equal and similar charge in vacuum or free space which repels it with a force of 9×10^9 N.
18. When the same charges are separated by the same distance in two different media,

$$F_1 = \frac{1}{k_1}\frac{1}{4\pi \in_0}\frac{q_1 q_2}{r^2} \text{ and } F_2 = \frac{1}{k_2}\frac{1}{4\pi \in_0}\frac{q_1 q_2}{r^2}$$

$\Rightarrow F_1 k_1 = F_2 k_2$

19. When the same charges are separated by different distances in the same medium,

$Fd^2 = \text{constant (or) } F_1 d_1^2 = F_2 d_2^2$

20. If the force between two charges in two different media is the same for different separations,

$$F = \frac{1}{k}\frac{1}{4\pi \in_0}\frac{q_1 q_2}{r^2} = \text{Constant}$$

kr^2 = Constant $k_1r_1^2 = k_2r_2^2$

If the force between two charges separated by a distance 'r_0' in vacuum is same as the force between the same charges separated distance 'r' in a medium.

$$kr^2 = r_0^2 \Rightarrow r = \frac{r_0}{\sqrt{k}}$$

Here k is dielectric constant of the medium.

21. If different charges are at the same separation in a given medium,

$$\frac{F^1}{F} = \frac{q_1^1 q_2^1}{q_1 q_2}$$

22. Two points sized identical spheres carrying charges q_1 and q_2 on them are separated by certain distance. The mutual force between them is F. Those two are brought in contact and kept at the same separation. Now the force between them is F^1.

Then, $$\frac{F^1}{F} = \frac{(q_1 + q_2)^2}{4q_1q_2}$$

23. A system of charge is said to be in equilibrium, if the net force experienced by each charge of the system is zero.
24. A metal or conductor cannot be charged by friction, but it can be charged by the phenomenon of electric induction.

Electric field :

1. The space or region surrounding the static charge in which a unit positive charge experiences a force is called electric field.
2. The concept of electric field was introduced by Michael Faraday in 1820 and it was developed by James Clerk Maxwell. The imaginary lines of force are used for the representation of electric field.

Electric intensity:

1. The strength of electric field at a point in electric field is represented by a vector, called as electric intensity.
2. The electric intensity at a point in electric field is the force per unit positive charge at that point

i.e. $$E = \frac{F}{q_0}$$

3. The negative gradient of potential is electric intensity.
4. The total number of electric lines of force passing normally through unit area is electric intensity or electric flux density.
5. Electric intensity is a vector, it is directed along the direction of force. In S.I. system, unit of electric intensity is N/C or V/m. Dimensional formula of $\vec{E}$ is $[MLT^{-3}I^{-1}]$.
6. Electric intensity at a point due to a point charge in air medium and in S.I. system is given by,

$$E = \frac{1}{4\pi \epsilon_0} \times \frac{q}{r^2}$$

and in a dielectric medium it is given by,

$$E_m = \frac{1}{k}\frac{1}{4\pi \epsilon_0}\frac{q}{r^2} \Rightarrow E_m = \frac{E_a}{k}$$

7. Electric intensity at a point due to a point charge in air medium and in C.C.S. system is $E = \frac{q}{r^2}$.
8. If instead of a single charge, field is produced by a charge distribution, by principle of superposition,

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ...$$

9. A charged particle in an electric field always experiences a force either it is at rest or in motion and the direction of force is that of field if it is positive and opposite to the field if it is negative.
10. Force experienced by a charge q in an electric field of intensity E is F = Eq.

If m is mass of the charged particle then its acceleration is $a = \frac{Eq}{m}$

If q is positive, $\vec{a} \parallel \vec{E}$

If q is negative, $\vec{a} \parallel -\vec{E}$

i) The electric force is independent of the mass and velocity of the charged particle, but depends on the charge only.

ii) A proton and an electron in the same electric field experience forces of same magnitude but in opposite directions.

Here force on proton is accelerating where as force on electron is retarding.

Here acceleration of proton (a_p) and acceleration of electron (a_e) are not the same in magnitude.

$$\frac{a_p}{a_e} = \frac{\text{Mass of electron}}{\text{Mass a proton}} \text{ (in the same field)}$$

Here directions of ap and ae are opposite to each other.

11. If the intensity at all points in an electric field is same both in magnitude and direction, such field is said to be uniform electric field.

    If the intensity at all points in an electric field differ in magnitude or direction or both, such field is said to be nonuniform electric field.

Electric potential:

1. The strength of electric field at a point in electric field is represented by a scalar called as electric potential.

   The amount of work done in bringing a unit positive charge from infinity to the given point against the direction of electric intensity is called electric potential.

   Electric potential is a scalar quantity. It is given by,

$$V = \frac{W}{q_0}$$

2. Potential at a point is numerically equal to the potential energy per unit charge at that point.
3. S.I. unit of electric potential is joule/coulomb which is called as volt. Electrostatic unit of electric potential is stat volt.

$$1 \text{ volt} = \frac{1}{300} \text{ stat volt.}$$

4. Electric potential at a point is said to be 1 volt, if 1joule of work is done in displacing a charge of 1 coulomb from infinity to that point against the direction of electric intensity.
5. Dimensional formula of potential is $[M L^2 T^{-3} A^{-1}]$.
6. Electric potential at a point due to a point charge is given by,

$$V = \frac{1}{4\pi \epsilon_0} \times \frac{q}{r}$$

7. Potential due to a positive charge is positive and due to a negative charge is negative.
8. Potential at a point due to a number of charges is,

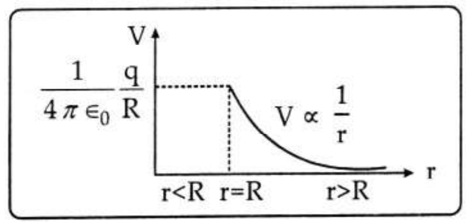
$$V = V_1 + V_2 + V_3 + ...$$

9. In case of a spherical charged conductor hollow or solid, for an internal point (r < R), potential every where inside is same, constant, maximum and equal to value at the surface.

$$V = \frac{1}{4\pi \epsilon_0} \frac{q}{r} \text{ q (for } r \leq R)$$

For any external point r > R

$$V = \frac{1}{4\pi \epsilon_0} \frac{q}{r}$$



Variation of V due to a charged spherical conductor will be as shown in figure.

10. In case of spherical volume distribution of charge, for an internal point (r < R) potential varies non linearly as

$$V = \frac{1}{4\pi \epsilon_0} \frac{q}{2r} \left(3 - \frac{r^2}{R^2}\right) \text{ for } (r < R)$$

At the centre, r = 0 and $V = \frac{3}{2} \frac{1}{4\pi \epsilon_0} \frac{q}{R}$

At the surface, r = R and $V = \frac{1}{4\pi \epsilon_0} \frac{q}{R}$

At any external point r > R and $V = \frac{1}{4\pi \epsilon_0} \frac{q}{r}$

11. A positive charge in field moves from high potential to low potential. An electron moves from low potential to high potential.
12. The work done in moving a charge between two points in an electric field is independent of the path followed between these two points.
13. If a proton and an electron are accelerated from rest through the same potential difference then they gain equal amount of kinetic energy.
14. The difference of potential between two points in electric field is called as potential difference. It is given by,

$$V_A - V_B = \frac{W_A - W_B}{q_0} = \frac{W_{BA}}{q_0}$$

15. The work done in displacing a positive charge (q_0) from infinity to a distance r from the source charge q is called the potential energy of the test charge in the electric field of the source charge. It is given by,

$$U = \frac{1}{4\pi\epsilon_0}\frac{q_0 q}{r}$$

16. When the charge moves against the direction of the field, work is done on the charge and its potential energy increases.
    When the charge moves along the direction of force (field), work is done by the charge and its potential energy decreases.
17. The negative potential gradient at any point in electric field is called as electric intensity

i.e. $E = \frac{-dV}{dr}$

Electric intensity is directed along the direction at which electric potential decreases.

18. The velocity of a moving particle in an electric field is,

$$v = \sqrt{\frac{2qV}{m}}$$

19. The kinetic energy acquired by the particle in an electric field is given by,

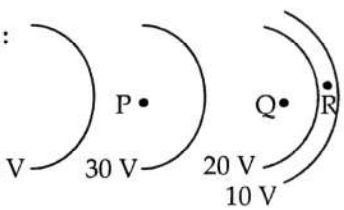
$$K.E. = \frac{1}{2}mv^2 = q.V.$$

Equipotential surface :

1. The surface which is the locus of all points which are at the same potential is known as equipotential surface.
2. No work is required to move a charge from one point to another on the equipotential surface.
3. No two equipotential surfaces intersect.
4. The direction of electric lines of force or direction of electric field is always norrna l to the equipotential surface.
5. Inside a hollow charged spherical conductor the potential is constant. This can be treated as equipotential volume. No work is required to move a charge from the centre to the surface.
6. For an isolated point charge, the equipotential surface is a sphere i.e. concentric spheres about the point charge are different equipotential surfaces.
7. In a uniform electric field any plane normal to the field direction is an equipotential surface.
8. The spacing between equipotential surfaces enables us to identify regions of strong and weak field.

$$E = -\frac{dV}{dr} \Rightarrow E \propto \frac{1}{dr}$$

e.g.:



$E_P < E_Q < E_R$

Electric potential energy:

1. Potential energy of a system of charges is equal to the amount of work done in bringing those charges from infinite separation to their respective position.
2. A charged particle placed in an electric field has potential energy because of its interaction with the electric field.
3. If two charges q_1 and q_2 are separated by a distance 'r' then potential energy of the system is,

$$U = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

4. Potential energy of a system of three charges q_1, q_2 and q_3 is given by,

$$U = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1q_2}{r_{12}} + \frac{q_2q_3}{r_{23}} + \frac{q_3q_1}{r_{31}}\right]$$

Here r_{12} is distance between q_1 and q_2.
r_{23} is distance between q_2 and q_3 and
r_{31} is distance between q_3 and q_1.

5. If two like charges are brought nearer, potential energy of the system increases.
6. If two unlike charges are brought nearer, potential energy of the system decreases.
7. Potential energy of the system of charges can be positive or negative.
8. Electron volt is smaller unit of energy used in

atomic physics and nuclear physics.

The energy gained by an electron when it is displaced from one point to another point whose potential is higher by one volt is called as electron volt.

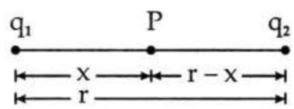
$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

[1 keV = 103 eV, 1 MeV = 10^6 eV, 1 BeV = 10^9 eV, 1 GeV = 10^{12} eV]

Combined field due to point charges:

1. If charges q_1 and q_2 are separated by a distance 'r', null point (where resulting field intensity is zero) is formed on the line joining those two charges. If x is distance of null point from ql' then

$$\frac{q_1}{x^2} = \frac{q_2}{(r-x)^2}$$



$$\Rightarrow x = \frac{r}{\sqrt{q_2/q_1}+1}$$

Here q_1 and q_2 are like charges.

If q_1 and q_2 are unlike charges then null point is formed outside q_1 at a distance x such that

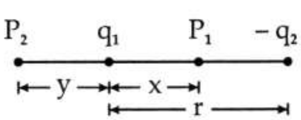
$$\frac{q_1}{x^2} = \frac{q_2}{(r+x)^2}$$

$$\Rightarrow x = \frac{r}{\sqrt{q_2/q_1}-1}$$

In the above formulae q_2/q_1 is numerical ratio of charges.

2. If two unlike charges q_1 and q_2 are separated by a distance r, the net potential is zero at two points on the line joining them, one in between them and the other outside the charges.

$$\frac{q_1}{x} = \frac{q_2}{(r-x)} \text{ (for } P_1\text{)}$$



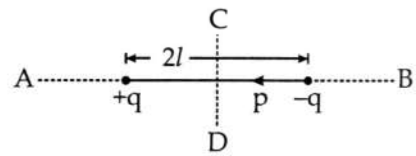
$$\frac{q_1}{y} = \frac{q_2}{(r+y)} \text{ (for } P_2\text{)}$$

Here q_2 is numerical value of charge

$$x = \frac{r}{(q_2/q_1)+1} \qquad y = \frac{r}{(q_2/q_1)-1}$$

Electric dipole:

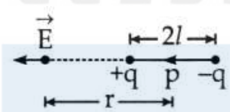
1. Two equal and opposite charges separated by a finite distance is electric dipole.



2. The line passing through the two charges is axis (AB) of electric dipole and perpendicular bisector of electric dipole is equator (CD) of electric dipole. The distance between two charges is length of electric dipole (2*l*).
3. The product of positive charge and the distance between the two charges is called as electric dipole moment. It is given by,

   $$p = q \cdot 2l$$
4. Electric dipole moment is a vector. It is directed from the negative charge to the positive charge. In S.I. system, unit of electric dipole moment is coulomb–metre (C–m).
5. i) Electric intensity at a point which is at a distance 'r' from the centre of the dipole on its axial line (end on position or longitudinal position or tan A position) is given by,

$$E = \frac{1}{4\pi\epsilon_0}\frac{2pr}{(r^2-l^2)^2}$$



For $r >> l$, $E = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$

(Direction of $\vec{E}$ is parallel to $\vec{p}$)

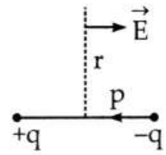
ii) Electric potential at a point which is at a distance 'r' from the centre of the short dipole on its axial line (end on position or longitudinal position or tan A position) is given by,

$$V = \frac{1}{4\pi\epsilon_0}\frac{p}{r^2}$$

6. i) Electric intensity at a point which is at a distance 'r' from the centre of the dipole on its equatorial line (broad side on position or transverse position or tan B position) is given by,

$$E = \frac{1}{4\pi\epsilon_0}\frac{p}{(r^2+l^2)^{3/2}}$$

For $r >> l, E = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$

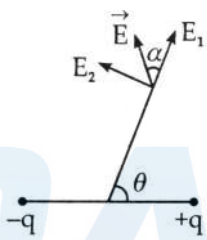


(Direction of $\vec{E}$ is parallel to $-\vec{p}$)

ii) Electric potential at a point which is at a distance 'r' from the centre of the short dipole on its equatorial line (broad side on position or transverse position or tan B position) is given by V = 0.

7. i) Electric intensity at a point which is at a distance 'r' from the centre of the short dipole at any point is given by,

$$E = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}\sqrt{3\cos^2\theta + 1}$$



and $\tan\alpha = \frac{1}{2}\tan\theta$

ii) Electric potential at a point which is at a distance 'r' from the centre of the short dipole at any point is given by,

$$v = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2}$$

8. When an electric dipole is suspended in a uniform electric field, each charge experiences a force F = Eq. The two forces on these charges constitute a couple, which rotate the dipole tending to align the dipole along the field direction.

Torque on the dipole is $\vec{\tau} = \vec{P} \times \vec{E}$

$$\tau = pE\sin\theta$$

When $\theta = 0°$, T = 0 (minimum)

When $\theta = 90°$, T = pE (maximum)

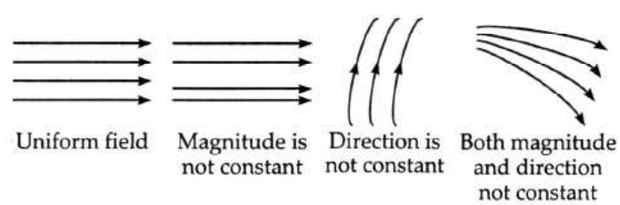
Remark: If E = 1 N/C then p = τ i.e. the electric dipole moment of an electric dipole is equal to the moment of couple acting on the dipole, held with its axis perpendicular to a uniform electric field of unit intensity.

Electric lines of force :

The path traced by unit positive charge in electric field is called as line of force. Lines of force are used for the representation of electric field. The tangent drawn to the line of force gives direction of electric intensity and the magnitude of electric intensity at a point is measured by the number of lines of force passing normally through unit area around that point.

Properties:

1. Electric lines of force diverge from a positive charge and converge at a negative charge.
2. Electric lines of force will never intersect with each other because electric intensity has one direction at a point.
3. Electric lines of forces contract lengthwise but expand laterally.
4. Closer are the electric lines of force, stronger is the electric field and farther apart are the electric lines of forces, weaker is the electric field.
5. The tangent drawn at any point on the line of force gives the direction of electric field at that point.
6. If in a region of space, there is no electric field, there will be no lines of force. Inside a conductor there can not be any line of force.
7. Number of lines of force passing normally through unit area around a point is numerically equal to E.
8. The lines of force are perpendicular to the surface from where they start and where they end therefore parallel component of electric intensity is always zero.
9. The electric lines of forces are parallel and equidistant for an uniform electric field and curved for non uniform electric field.



Non uniform field

The concept of electric lines of force, tubes of force and tubes of induction was introduced by

Faraday and developed by Maxwell.

Electric flux, tubes of force and tubes of induction:

1. The total number of electric lines of force passing normally through the given surface area is electric flux.
2. The dot product of electric intensity and surface area vector is electric flux.

   i.e. ϕ = ds E cos θ or $\phi = \vec{E}.\vec{ds}$
3. Electric flux is a scalar and S.I. unit of electric flux is N m^2/C.
4. Electric flux per unit area is called flux density or intensity of electric field i.e. the total number of electric lines of force passing normally through unit area is flux density.

i) Flux will be maximum when electric field is normal to the area (ϕ = Eds).

ii) Flux will be minimum when field is parallel to area (ϕ = 0).

iii) For a closed surface, outward flux is positive and inward flux is negative.

5. The group of limited number of electric lines of force forming a tube like structure is tube of force. The number of tubes of force emitted from charge q is given by,

$$N = \frac{q}{\epsilon_0 k}$$

6. The group of limited number of electric lines of force forming a tube like structure which is independent on medium is tube of induction.
7. The properties of tubes of force and tubes of induction are same as that of electric lines of force.
8. The number of tubes of force depends upon the magnitudes of the charge and the permittivity of the surrounding medium. The number of tubes of induction depends upon the magnitudes of the charge.

N.E.I. and T.N.E.I. :

1. The total number of tubes of induction passing normally through unit area is,

   N.E.I. (Normal electric induction) OR

   N.E.I. is the product of electric intensity and permittivity constant of a dielectric medium

   i.e. N.E.I. = E × ϵ_0k
2. The total number of tubes of induction passing normally through the given surface area is T.N.E.I. (total normal electric induction) OR

   The product of N. E. I. and given area is, T.N.E.I. It is given by,

   T.N.E.I. = ϵ_0k E cos θ ds

   T.N.E.I. over entire area of a closed surface of any size is given by,

   T.N.E.I. = $\int \epsilon_0$ k E cos θ ds

3.1 Gauss's theorem and its applications

1. Gauss's theorem states that, T. N. E. I. over entire area of a closed surface of any size is equal to the total charge enclosed by the surface i.e. T. N. E. I. over entire area = + q. OR

   Gauss's theorem states that, the total flux through a closed surface is 1/ϵ_0 times the total charge enclosed by the surface.

   Mathematically, $\oint \vec{E}.\vec{ds} = \phi = \frac{q}{\epsilon_0}$
2. Any closed surface around the charge distribution, so that Gauss's theorem can be applied to find intensity of electric field is called the Gaussian surface.
3. The position of point charge inside a closed surface is not important in calculation of the T.N.E.I. over the closed surface.
4. The charges outside the closed surface do not contribute to T.N.E.I. over the closed surface.
5. For positively charged conductor, T.N.E.I. is directed outwards and for nega ti vel y charged conductor T.N.E.I. is directed inwards.
6. If the algebraic sum of the charges within the closed surface is zero then the T.N.E.I. over the surface is also zero.
7. The T.N.E.I. over a closed surface due to a charge outside the surface is zero.
8. The electric intensity at any point inside a closed surface of any shape is zero because Gaussian surface does not enclose any charge.

   Gauss's theorem is used for the determination of electric intensity due to symmetric charge distribution.
9. Electric flux through a small portion of the closed surface is affected by the charges present outside the surface. However the total electric flux through a closed surface is not affected by the charge present outside the closed surface.

10. Electric flux through a small portion of the closed surface may change, if the charges inside the closed surface are moved to the new position. However the total electric flux through a closed surface.is not affected, if the charges inside the closed surface are moved to the new positions.
11. Intensity of electric field due to a solid sphere of charge (e.g. nucleus) density ρ and radius R

i) $E = \frac{1}{4\pi \in_0 k}\frac{q}{r^2}$, for r > R (Out side the sphere)

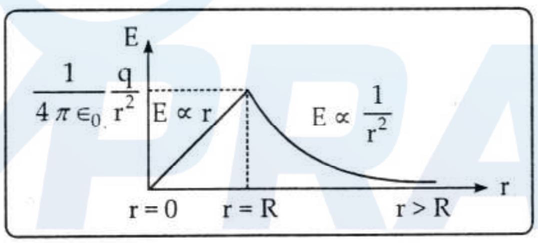
ii) $E = \frac{1}{4\pi \in_0 k}\frac{qr}{R^3}$ for r < R (inside the sphere)

iii) $E = \frac{1}{4\pi \in_0 k}\frac{q}{R^2}$, for r = R (at the surface)

here $q = \frac{4}{3}\pi R^3 \rho$

iv) E = 0, at the centre of the sphere.

v) The variation of E with r for spherical volume distribution of charge is as shown in figure.



12. Electric field due to a spherical shell of charge density σ and radius R:

i) $E = \frac{1}{4\pi \in_0 k}\frac{q}{r^2} = \frac{\sigma R^2}{\in_0 kr^2}$

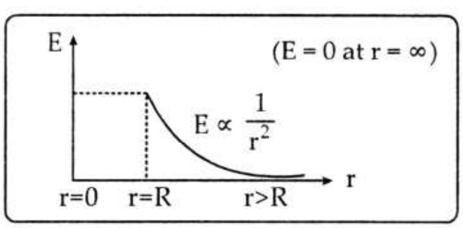
for r > R (Out side the sphere)

ii) E = 0, for, r < R (inside the shell)

iii) $E = \frac{1}{4\pi \in_0 k}\frac{q}{R^2} = \frac{\sigma}{\in_0 k}$ for r = R (at the surface)

here $q = 4\pi R^2 . \sigma$

iv) The variation of E with 'r' for a charged conducting sphere is as shown in figure.



Note: For both the spherical shell and the sphere, electric field at a point outside is same as if the charge is concentrated at their centre.

13. Intensity of electric field due to a charged cylinder of radius R and linear charge density (σ),

i) $E = \frac{1}{2\pi \in_0 k}\cdot\frac{q}{r}$

$= \frac{\sigma R}{\in_0 kr}$ for r > R (Outside the cylinder)

ii) E = 0, for, r < R (inside the cylinder)

iii) $E = \frac{1}{2\pi \in_0 k}\cdot\frac{q}{R} = \frac{\sigma}{\in_0 k}$ for r = R (at the surface)

here $q = 2\pi R . \sigma$

14. Intensity of electric field due to a charged conductor of any shape

$$E = \frac{\sigma}{\in_0 k}$$

15. Intensity of electric field due to infinite thin plane sheet of charge density c i.e. for plane conductor of infinite length

$$E = \frac{\sigma}{2\in_0 k}$$

16. In the case of a charged ring of radius R on its axis at a distance x from the centre of the ring

$$E = \frac{1}{4\pi\in_0}\frac{qx}{(R^2+x^2)^{3/2}}$$

At the centre x = 0 and E = 0

17. Electric intensity at a point near a charged sphere is inversely proportional to square of its distance from the centre of the sphere.
18. Electric intensity at a point near a charged cylinder is inversely proportional to its distance from the axis of the cylinder.

3.2 Mechanical force on unit area of a charged conductor

1. The force acting an area ds in electric field is given by,

$$F = \frac{\sigma^2}{2\in_0 k} ds$$

2. The mechanical stress i.e. mechanical force per unit area of a charged conductor is given by,

$$f = \frac{\sigma^2}{2\epsilon_0 k} = \frac{1}{2} k \epsilon_0 E^2$$

3. The mechanical force per unit area of a charged conductor is directly proportional to the
   i) square of charge density and
   ii) square of electric intensity
4. Mechanical force per unit area of a charged conductor is always directed outwards for positively or negatively charged conductor.

3.3 Energy per unlt volume of the medium

1. The energy per unit volume i.e. energy density of a dielectric medium is given by,

$$u = \frac{\sigma^2}{2\epsilon_0 k} = \frac{1}{2} \epsilon_0 k E^2$$

2. The energy per unit volume of a dielectric medium is directly proportional to the
   i) square of charge density and
   ii) square of electric intensity
3. The surface area of a circular ring or circular metal plate = ds = 2 π R^2
4. The surface area of a very thin metal plate is, ds = 2 l b.
5. For circular metal plate and thin metal plate charge is distributed on both sides of surfaces. Hence double area is considered to find surface charge density.

3.4 Dielectrics and Polarization :

1. A dielectric substance is a material which does not conduct electricity i.e. dielectrics are insulators.
2. Dielectrics or insulators do not contain any free electrons.
3. The molecules of a dielectric can be classified into two types. They are nonpolar molecules and polar molecules.

a) Non–Polar molecules:

i) The molecules in which the positive and negative charge centres coincide and whose net dipole moment is zero are defined as nonpolar molecules.

ii) In nonpolar molecules the positive and negative charges have a symmetrical charge distribution about their centres.

iii) Nonpolar molecules do not have any permanent dipole moment because the dipole length is zero.

iv) Examples for nonpolar molecules are H_2, O_2, N_2, CO_2, CH_4 etc.

v) If a dielectric containing nonpolar molecules is placed in an electric field, the centre of negative charge in an opposite direction as a result the dipole moment is induced in that dielectric. This phenomenon is called electric polarisation.

vi) The net dipole moment per unit volume is known as dielectric polarisation.

$$\therefore \quad \text{Polarisation} \; \frac{\text{Dipole moment}}{\text{Volume}}$$

vii) A nonpolar dielectric can be polarised by applying an external electric field on the dielectric. The effective electric field ($\vec{E}$) in a polarised dielectric is given by, $\vec{E} = \vec{E}_0 - \vec{E}_P$. Where $\vec{E}_0$ is strength of external field applied and $\vec{E}_P$ is the intensity of induced electric field set up due to polarisation. It is equal to surface density of induced charge.

viii) The ratio $\frac{E_0}{E}$ = K, is known as dielectric constant.

b) Polar molecules:

i) The molecules whose positive and negative charge centres do not coincide and which possess a net dipole moment are defined as polar molecules.

ii) In polar molecules the positive and negative charges have a asymmetrical charge distribution about their centres.

iii) Examples for polar molecules are H_2O, NH_3, HCl etc.

iv) The dielectric constant of polar dielectrics depends on its temperature.

v) The polar molecules behave as dipoles and posses permanent dipole moment which is given by,
P = 2 l q, where 2 l is the distance of separation between the charge centres and 'q' is the total positive or negative charge.

vi) The net dipole moment of a given volume containing large number of molecules, is zero since the dipole moments of the molecules orient in different directions due to thermal agitation (Fig. a).

vii) If a polar dielectric material is placed in an electric field, the individual dipoles experience a torque and align along the direction of field. Consequently the material posses a net dipole moment (Fig. b).

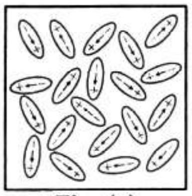


Fig. (a)

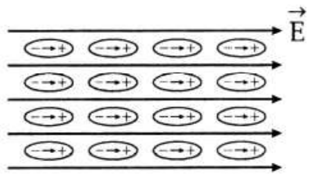


Fig. (b)

viii) The degree of alignment of molecules depends upon the intensity of the applied field and temperature of the dipole.

ix) Greater the intensity of the electric field greater will be the separation between positive and negative charges. Thus the dipole moment per unit volume will increase.

x) Lower the temperature less will be the thermal vibration of the molecules and hence it will be easier for the molecular dipoles to align in the direction of field.

3.5 Capacity of conductor and concept of condenser

1. For a charged conductor,
   i) charge resides only at the surface of the conductor,
   ii) electric potential is constant at the surface and inside the conductor,
   iii) the electric field is zero inside the conductor.
2. For a charged conductor, charge on the conductor is directly proportional to its potential
   i.e. $Q \propto V \quad \therefore \quad Q = CV$
3. The ability of a conductor to stored charge is called capacity of a conductor. OR
   The ratio of charge deposited on a conductor to its potential is capacity of a conductor. OR
   The quantity of charge required to raise its potential by one unit, is called capacity of conductor.
4. In S.I. system, unit of capacity is farad
   i.e. 1 F = 1 coulomb / 1 volt
   The capacity of a conductor is said to be 1 farad if a charge of one coulomb deposited on a conductor will increase its potential by one volt.
   Electrostatic unit of capacity is stat farad .
   1 farad = 9×10^{11} stat farad
5. Capacity is a scalar. Its dimensional formula is $[M^{-1} L^{-2} T^4 I^2]$.
6. The capacity of a body is independent of the charge given to the body or its potential raised and depends on its shape, size and nature of the surrounding medium only.
7. The capacity of a spherical conductor is,
   $C = 4\pi \in_0 k R$, where R–radius of conductor.
8. A device which increases charge storing capacity of a conductor at a relatively low potential is called condenser or capacitor.
   An arrangement which consist of two conductors separated by a dielectric is called condenser. Out of two conductors one conductor is charged and other conductor is earthed.
9. Parallel plate condenser, spherical condenser and cylindrical condenser are the three types of condensers.

3.6 Capacity of parallel plate condenser

1. Capacity of a parallel plate condenser is,
   $$C = \frac{Ak \in_0}{d}$$
   Also $C_m = C_{air}\, k$, $\quad V_m = \frac{V_{air}}{k}$, $\quad E_m = \frac{E_{air}}{k}$
2. Force of attraction between the parallel plates of a condenser is,
   $$F = \frac{q^2}{2 \in_0 Ak}$$
3. Capacity of a condenser with 'n' plates,
   $$C = \frac{(n-1) \in_0 kA}{d}$$
4. The capacitance of a spherical condenser is given by,
   $C = 4\pi \in_0 k \left(\frac{ab}{b-a}\right)$ (when outer shell is earthed)
   and $C = 4\pi \in_0 k \left(\frac{b^2}{b-a}\right)$ (when inner shell is earthed)
   Here 'a' and 'b' are the radii of inner and outer spherical conductors of capacitor.
5. The capacitance of a cylindrical condenser is given by,
   $$C = \frac{2\pi \in_0 kl}{2.303 \log(r_2/r_1)}$$

r_2 – radius of outer cylinder

r_1 – radius of inner cylinder

6. When dielectric slab of dielectric constant k and thickness t (t < d) is placed between the plates of a parallel plate condenser, then

$$C = \frac{A \epsilon_0}{d - t\left(1 - \frac{1}{k}\right)}$$

Thus, in order to maintain the original p.d. after introducing a dielectric slab between the plates of a condenser, the distance between the plates must be increased by,

$$t\left(1 - \frac{1}{k}\right)$$

7. When conducting slab of thickness t ($k = \infty$, t < d) is introduced between the plates of a parallel plate condenser, then

$$C = \frac{\epsilon_0 A}{d - t}$$

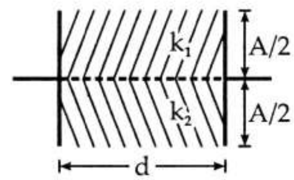
8. When the number of plates of thickness t_1, t_2, t_3 ... having the respective dielectric constants k_1, k_2, k_3 ... are introduced between the plates of a parallel plate condenser, then its' capacity is given by,

$$C = \frac{\epsilon_0 A}{\left[d - (t_1 + t_2 + ...) + \left(\frac{t_1}{k_1} + \frac{t_2}{k_2} + ...\right)\right]}$$

If there is no air gap, then

$$C = \frac{\epsilon_0 A}{\left(\frac{t_1}{k_1} + \frac{t_2}{k_2} + ...\right)}$$

9. The capacity of a conductor can be increased by decreasing its potential without increasing its size and by bringing another insulated metal plate nearer to it.
10. The capacity of a condenser does not depend on the material of plates, potential difference between the plates and the charge given to the plates.
11. Resistance of an ideal capacitor can be taken as infinity.
12. Capacity of a given conductor is constant. As charge on it increases, its potential increases. At a certain stage, the dielectric strength of the surrounding medium breaks and the conductor discharges.
13. If dielectric medium of dielectric constant k_1 and k_2 are filled in between the plates of the condenser as shown in figure, then the arrangement is equivalent to two condensers in parallel. Hence the effective capacity of the system becomes.

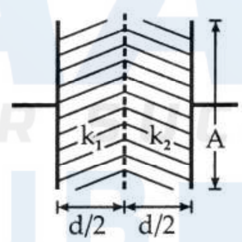


$$C = \frac{\epsilon_0 A}{2d}(k_1 + k_2)$$

and equivalent dielectric constant of the medium is,

$$k = \frac{k_1 + k_2}{2}$$

14. If dielectric medium of constants k_1 and k_2 are filled between the plates of condenser as shown in the figure, then the arrangement is equivalent to two condensers in series. Hence, the effective capacity of the system is;



$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{d}{2k_1 \epsilon_0 A} + \frac{d}{2k_2 \epsilon_0 A}$$

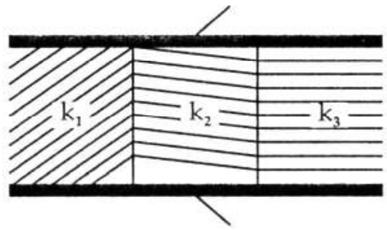
$$\therefore \quad C = \frac{2\epsilon_0 A k_1 k_2}{d(k_1 + k_2)}$$

and equivalent dielectric constant of the system is,

$$k = \frac{2k_1 + k_2}{(k_1 + k_2)}$$

15. If three different dielectric slabs are inserted between the plates, the capacity will be as given

below.



The arrangement is parallel combination of three capacities C_1, C_2 and C_3.

where $C_1 = \dfrac{\epsilon_0 k_1 A}{3d}$, $C_2 = \dfrac{\epsilon_0 k_2 A}{3d}$, $C_3 = \dfrac{\epsilon_0 k_3 A}{3d}$

Equivalent capacity $C = C_1 + C_2 + C_3$

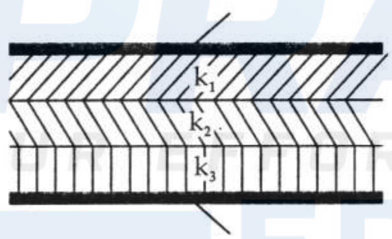
$$\Rightarrow C = \frac{\epsilon_0 A}{3d}(k_1 + k_2 + k_3)$$

Here equivalent dielectric constant

$$k = \frac{k_1 + k_2 + k_3}{3}$$

16. The arrangement is series combination of three capacities C_1, C_2 and C_3

where $C_1 = \dfrac{\epsilon_0 k_1 A}{d/3}$, $C_2 = \dfrac{\epsilon_0 k_2 A}{d/3}$, $C_3 = \dfrac{\epsilon_0 k_3 A}{d/3}$

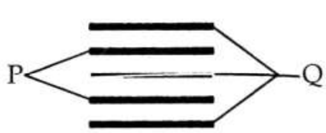


Equivalent capacity C is given by the formula

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

17. Capacity of condenser with n plates such that plates are connected alternately between two point P and Q as shown in figure, is

$$C^1 = \frac{(n-1)\epsilon_0 A}{d}$$



or $C^1 = \dfrac{(n-1)k \epsilon_0 A}{d} \Rightarrow C^1 = (n-1)\,C$

C is capacity between any two adjacent plates.

3.7 Effect of Dielectrics on Capacity

1. A dielectric substance is a material which does not conduct electricity i.e. dielectrics are insulators.
2. Dielectrics or insulators do not contain any free electrons.
3. The capacity of a condenser having the space between its plates filled by a dielectric is greater than its capacity when there is air or vacuum between the plates. In other words, the presence of dielectric material helps to increase the capacity of a parallel plate condenser. This is true for all types of condensers.
4. $K = C_m / C_{air}$ i.e. the ratio of capacity of parallel plate condenser with medium to the capacity of parallel plate condenser with air medium is called as dielectric constant.

Physical Quantity	When capacitor is fully charged with air between the plates	When a dielectric slab K is introduced in between the parallel plates after disconnecting battery (Q constant)	When dielectric slab K is placed in between the plates with battery connected (V constant)
Charge	Q_0	Q_0	KQ_0
Capacity	C_0	KC_0	KC_0
Potential difference between the plate	V_0	V_0/K	V_0
Electric field between the plates	E_0	E_0/K	E_0
Energy stored in a condensor	U_0	U_0/K	KU_0

3.8 Energy of a charged condense :

1. If a capacitor of capacity C is charged to potential V, then energy stored in the capacitor is,

$$U \frac{q^2}{2C} \text{ or } U = \frac{1}{2}CV^2 \text{ or } U = \frac{1}{2}qV.$$

i) Here the energy is stored in the field between the two plates.

ii) If the condenser is discharged, then amount of heat produced is,

$$U = \frac{1}{2}CV^2 = \frac{1}{2}qV = \frac{q^2}{2C}$$

2. If a number of capacitors are connected in series across a battery, the ratio of energies stored on those capacitors is,

$$U_1 : U_2 : U_3 : .... = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3} : ....$$

If those capacitors are connected in parallel, then ratio of energies stored on those capacitors is, $U_1 : U_2 : U_3 : = C_1 : C_2 : C_3 : ....$

3. Energy stored between the plates of a capacitor can be expressed as,

$$U = \frac{1}{2}\frac{\epsilon_0 A}{d}(Ed)^2 = \frac{1}{2}\epsilon_0 Ad\, E^2$$

or $\Rightarrow U = \frac{1}{2}(Ad)\frac{\sigma^2}{\epsilon_0^2}$ (as $E = \frac{\sigma}{\epsilon_0}$)

So energy density $\frac{U}{V} = \frac{\sigma^2}{2\epsilon_0} = \frac{1}{2}\epsilon_0 E^2$

(Here V is volume i.e. Ad)

If the medium is other than air or vacuum, then

energy density $= \frac{\sigma^2}{2\epsilon_0 k} = \frac{1}{2}\epsilon_0 kE^2$

4. If n identical capacitors each of capacity C are connected in series across p.d. 'V', then the energy stored is given by,

$$U_S = \frac{1}{2}\left(\frac{C}{n}\right)V^2 = \frac{U}{n}.$$

If those capacitors are connected in parallel, then the energy stored is given by,

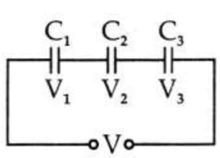
$$U_P = \frac{1}{2}(nC)\,V^2 = nU$$

Here $U = \frac{1}{2}CV^2$ which is energy stored if a single capacitor is connected across V.

3.9 Condensers in series and in parallel

Condensers in series :

1. The equivalent capacity of number of condensers connected in series is,



$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$$

i.e. the reciprocal of equivalent capacity of series combination of condensers is equal to sum of reciprocals of their individual capacities.

2. In series combination of condensers, the equivalent capacity is always lower than lowest individual capacity. Thus series combination is used to decrease capacitance.
3. In series combination of condensers, charge on each condenser is same but potential difference across each condenser is different. Thus, the potential is distributed in inverse proportion to their capacitances.
4. Series combination of condenser is used when a high voltage is to be divided on several capacitors.
5. If 'n' identical condensers are connected in series then their equivalent capacitance is,

$$C = \frac{C}{n}$$

6. In series combination of condensers, the total energy stored is,

$E = E_1 + E_2 + ... + E_n$

7. In series combination of condensers,

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

8. Ratio of charges on the capacitors is,

$q_1 : q_2 : q_3 = 1 : 1 : 1$

9. Ratio of potential of the capacitors is,

$$V_1 : V_2 : V_3 = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$$

10. i) If two capacities C_1 and C_2 are in series equivalent capacity is,

$$C_s = \frac{C_1C_2}{C_1 + C_2}$$

ii) P.d. across capacitor C_1 is,

$$V_1 = \left(\frac{C_2}{C_1 + C_2}\right)V$$

iii) P.d. across capacitor C_2 is,

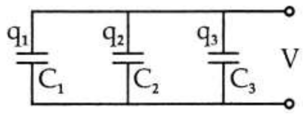
$$V_2 = \left(\frac{C_1}{C_1 + C_2}\right)V$$

11. When three capacitors C_1, C_2 and C_3 are in series, then equivalent capacity is,

$$C = \frac{C_1C_2C_3}{C_1C_2 + C_2C_3 + C_3C_1}$$

Condensers in parallel :

1. The equivalent capacity of number of condensers connected in parallel is,



$C_P = C_1 + C_2 + ... + C_n$
i.e. the equivalent capacity of the parallel combination of condensers is equal to sum of their individual capacities.

2. In parallel combination of condensers, the equivalent capacity is always higher than the highest individual capacity. Thus, parallel combination is used to increase capacitance.
3. In parallel combination of condensers, potential difference across each condenser is same but charge on each condenser is different. Thus, the charge is distributed in proportion to their capacitances.
4. Parallel combination of condensers is used when we require a large capacitance at a small potential.
5. If n identical condensers are connected in parallel, then their equivalent capacity is $C_P = nC$.
6. In parallel combination of condensers total energy stored is, $E = E_1 + E_2 + ... + E_n$
7. In parallel combination of condensers,
$Q_1 = C_1V,\ Q_2 = C_2V,\ Q_3 = C_3V$ ......
8. Ratio of potentials $V_1 : V_2 : V_3 = 1 : 1 : 1$
9. Ratio charges $q_1 : q_2 : q_3 = C_1 : C_2 : C_3$
10. If C_1, C_2, C_3 are connected in parallel and q is the total charge then charge on C_1 is,

$$q_1 = \frac{C_1 q}{C_1 + C_2 + C_3}$$

$$q_2 = \frac{C_2 q}{C_1 + C_2 + C_3} \text{ and } q_3 = \frac{C_3 q}{C_1 + C_2 + C_3}$$

Remark:

1. If C_p and C_s are the effective capacities when n identical capacitors are first connected in parallel and then in series the $\frac{C_P}{C_s} = n^2$.
2. C_P and C_s are the effective capacities when two capacitors are connected in parallel and then in series, then their individual capacities' are given by

$$\frac{C_P \pm \sqrt{C_P^2 - 4C_PC_s}}{2}$$

3. If three different capacitors are given, they can be connected in eight different ways by taking all the three at a time.
4. If two are identical and the third is different, they can be connected in six different ways by taking all the three at a time.
5. If those three are identical they can be connected in four different ways by taking all the three at a time.
6. Mixed grouping: If there are N capacitors each rated at capacity C and voltage V, by combining those we can obtain effective capacity rated at C_1 and voltage V_1. For this n capacitors are connected in a row and m such rows are connected in parallel.

Then $n = \frac{V^1}{V}$ and $m = \frac{nC^1}{C}$, where mn = N.

Uses of condensers:

Condenser is used i) to store energy, ii) to store a large quantity of charge at a relatively low potential, iii) to obtain the electric field of desired symmetry, iv) to block D.C. and allow A. C. to pass through it, v) to select or reject a particular frequency in resonant circuits.

Additional Information

Kirchhoff's laws for capacitors

First law: The algebraic sum of the charges at a junction point in the circuit is zero.
i.e. $\Sigma\ q = 0$

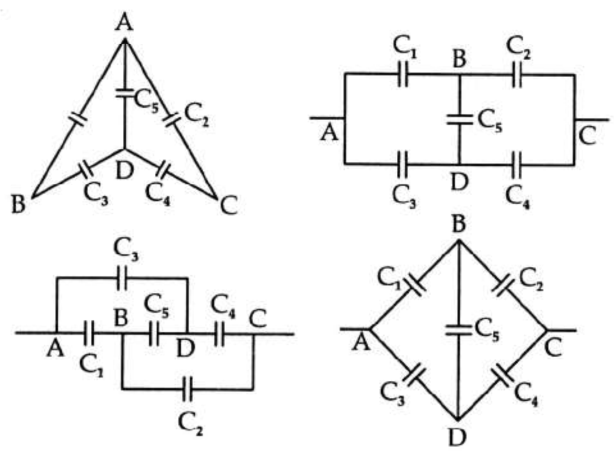
Second law: The algebraic sum of quantity q/C in different branches of a closed mesh is equal to the net e.m.f. in the mesh.

i.e. $\Sigma \frac{q}{C} = \Sigma E$

Wheatstone's bridge for capacitors

1. Wheatstone's network is used to determine capacity.
2. Different circuit diagrams of network are as

shown in figure.



3. For balanced bridge, $\frac{C_1}{C_2} = \frac{C_3}{C_4}$

4. In the balanced bridge,

i) The potential difference of the points B and D of bridge is same. Therefore the potential difference between the point B and D is zero:

ii) No charge on C_5, therefore C_1 and C_2 are in series and C_3 and C_4 are in series. The combined capacities of these two branches are in parallel.

5. Sensitivity of network depends on capacitance. It is maximum if arm ratio is one i.e.
   i) $C_1 = C_2$ and $C_3 = C_4$,
   ii) $C_1 = C_2 = C_3 = C_4$.

6. In Wheatstone's network, if $C_1 = C_2 = C_3 = C_4 = C$ (suppose) whatever may be C_5 then equivalent capacitance between point A and C is given by $C_{AC} = C$.

Distribution of charges and loss of energy

1. Suppose two conductors / condensers of capacitances C_1 and C_2 are given charges q_1 and q_2 respectively and raised to potentials V_1 and V_2 respectively. Then, $q_1 = C_1 V_1$ and $q_2 = C_2V_2$.

2. If the two conductors / condensers are connected by a thin wire then the charges are distributed although the total charge $(q_1 + q_2)$ remains constant. The combined capacity is $(C_1 + C_2)$. After the redistribution of charges the common potential of the conductors is given by,

$$V = \frac{\text{Total charge}}{\text{Total capacity}} = \frac{q_1 + q_2}{C_1 + C_2} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

3. After the distribution of charges, the charge on the conductors / condensers are

$$q_1' = C_1 V \text{ and } q'_2 = C_2 V$$

$$\therefore \quad \frac{q_1'}{q'_2} = \frac{C_1V}{C_2V} = \frac{C_1}{C_2}$$

4. If $V_1 > V_2$, then the charge transferred by the first conductor is,

$$q_1 - q_1' = C_1 V_1 - C_1 V = C_1 (V_1 - V)$$
$$q_2 - q_2 = C_2 V - C_2 V_2 = C_2 (V - V_2)$$

5. The total energy of the conductors before connecting by the wire is,

$$E = E_1 + E_2$$
$$= \frac{1}{2} C_1 V_1^2 + \frac{1}{2} C_2 V_2^2$$
$$= \frac{1}{2}(C_1V_1^2 + C_2V_2^2)$$

Now, the total energy of the conductors after connecting by the wire is,

$$E' = \frac{1}{2} (C_1 + C_2)V^2$$
$$= \frac{1}{2} (C_1 + C_2) \left(\frac{C_1V_1 + C_2V_2}{C_1 + C_2}\right)^2$$

The capacity of the combination of conductors after connecting by the wire is, $C = C_1 + C_2$ and common potential is V.

6. When there is sharing of charges i.e. distribution of charges then there is loss of energy due to heat which is given by,

$$\Delta E = E - E' = \frac{1}{2}\left(\frac{C_1C_2}{C_1 + C_2}\right)(V_1 - V_2)^2$$

OR $$\Delta E = \frac{(C_2q_1 - q_2C_1)^2}{2C_1C_2(C_1 + C_2)}$$

Coalescence of charged drop

There are n drops each of radius r and charge q. These drops merge to form a bigger drop, then

i) Charge of the bigger drop = nq
ii) Capacity of the bigger drop = $n^{1/3}$ C
iii) Potential of the bigger drop = $n^{2/3}$ V
iv) Energy stored in bigger drop – $n^{5/3}$ V
v) Surface charge density of bigger drop = $n^{1/3}$ σ
vi) Radius of bigger drop = $n^{1/3}$ r

Here C, V, U, σ are the capacity, potential, energy stored and surface charge density of smaller drop.

3.10 Van de Graff generator

1. AVan de graff generator is a device used to generate high potential difference of the order of a few million volts.
2. It was designed by Van de graff in 1931.
3. **Principle:** This generator is based on the principle of (1) the action of sharp points i.e. the phenomenon of corona discharge. (2) The charge given to a hollow conductor is transferred to outer surface and it distributed uniformly over it.
4. **Uses :** The main use of the Van de Graaff generator is to produce very high energy charged particles having energies of the order of 10 MeV. Such high energy particles are used
   i) to carry out the disintegration of the nuclei of different elements,
   ii) to produce radioactive isotopes
   iii) to study the nuclear structure,
   iv) to study different types of nuclear reactions etc.
5. **Disadvantages:**
   i) Size of Van De Graaff generator is large therefore it is inconvenient to use.
   ii) As it produce high potential difference, it is dangerous to handle.

❍❍❍

MULTIPLE CHOICE QUESTIONS

3.0 Basic concepts

Charge, Coulomb's law, electric intensity and electric potential

1. The branch of physics which deals with the study of static charges is
a) electrostatics b) current electricity
c) electronics d) modern physics
2. The static electricity is produced due to
a) conduction b) friction
c) induction d) all of these
3. The property acquired by the material body when it is rubbed with another body is
a) charge b) mass
c) resistance d) inductance
4. The bodies gets charged when rubbed with each other due to transfer of
a) photons b) atoms
c) molecules d) electrons
5. The smallest quantity of electricity called as electrostatic unit of charge is present on
a) photon b) α – particle
c) electron and proton d) none of these
6. Which of the following is a scalar quantity?
a) charge b) velocity
c) force d) electric intensity
7. Like charges repel each other and unlike charges attract each other was proved by
a) Coulomb b) Gilbert
c) Faraday d) Franklin
8. The positive and negative names of the charges were given by
a) Coulomb b) Gilbert
c) Aristotle d) Franklin
9. Electric charge on a body at rest produces
a) electric field
b) magnetic field
c) deficiency of electrons
d) both 'a' and 'b'
10. An electrical charge is a
a) scalar quantity
b) vector quantity
c) vector quantity (radial)
d) none of these
11. Charge can take only those values, which are integral multiples of charge on
a) α – particle b) proton
c) electron d) a hydrogen ion
12. The charge in uniform motion, produces
a) electric field b) magnetic field
c) both 'a' and 'b' d) neither 'a' nor 'b'
13. The magnitude of electrostatic unit of charge in S.I. system is
a) 1.602×10^{-19} C b) 9.1×10^{-31} C
c) 3×10^{8} C d) 3×10^{-19} C
14. Which of the following phenomena follows law of conservation of charge?
a) Electrification by friction
b) Electrification by induction
c) Nuclear reactions
d) All of these
15. The charge acquired by the glass rod when it is rubbed with silk is
a) positive charge b) negative charge
c) can not be charged d) none of these
16. The charge acquired by the ebonite rod when it is rubbed with fur is
a) positive charge b) negative charge
c) can not be charged d) none of these
17. If an isolated metallic conductor is positively charged, then its mass will
a) increase
b) decrease
c) remain same
d) reduce to half of its original mass.
18. If a glass rod is rubbed with silk, silk acquires negative charge because
a) protons are added to it
b) protons are removed from it
c) electrons are added to it
d) electrons are removed from it
19. A soap bubble is given a negative charge. Then its radius
a) decreases
b) increases
c) remains unchanged
d) nothing can be predicted
20. A positively charged glass rod is brought near an uncharged pith ball pendulum. The pith ball is

a) attracted towards the rod
b) repelled away from the rod
c) not affected by the rod
d) attracted towards the rod, touches it and is then thrown away from it

21. A polythene piece rubbed with wool is found to have a negative charge of 4×10^{-7} C. Then, the number of electrons transferred is
a) 2.5×10^{12} from wool to polythene
b) 1.5×10^{12} from polythene to wool
c) 2.56×10^{-15} from wool to polythene
d) 10^{-13} from wool to polythene.

22. When a body is charged by induction the body
a) becomes neutral
b) does not lose any charge
c) loses whole of the charge on it
d) lose part of the charge on it

23. When a piece of polythene is rubbed with wool, a charge of -2×10^{-7} C is developed on polythene. What is the amount of mass, which is transferred to polythene ?
a) 569×10^{-19} kg b) 6.25×10^{-19} kg
c) 9.63×10^{-19} kg d) 11.38×10^{-19} kg

24. A charged conductor has 1500 electrons in excess. The quantity of the charge on the conductor is
a) 2.4×10^{-16} C b) 4.4×10^{-16} C
c) 5.5×10^{-16} C d) 6.6×10^{-16} C

25. Which of the following is the unit of electric charge?
a) Faraday b) Ampere
c) Coulomb d) Coulomb / Volt

26. The law, which gives the force between two electric charges, is
a) Ohm's law b) Ampere's law
c) Faraday's law d) Coulomb's law

27. The force between two electrons separated by a distance r is proportional to
a) r^3 b) $r^{1/2}$
c) $r^{-1/3}$ d) r^{-2}

28. Coulomb's law is restricted to charged rods and balls only. This statement is
a) true b) false
c) often true d) unpredictable

29. A charge q_1 exerts a force on the second charge q_2. If a third charge q_3 is brought near, the force of q_1 exerted on q_2
a) decreases b) increases
c) becomes zero d) remains constant

30. When the distance between two charged particles is halved, the force between them will become
a) one–third b) one–half
c) four times d) five times

31. In a hydrogen atom the distance between proton and electron is 5.3×10^{-11} m. The electrical force of attraction between them will be
a) 6.3×10^{-8} N b) 8.2×10^{-8} N
c) 9.6×10^{-8} N d) 12.2×10^{-8} N

32. Force between two charges, when placed in free space is 10 N. If they are in a medium of relative permittivity 5, the force between them will be
a) 2 N b) 50 N
c) 0.5 N d) 10 N

33. The force between two electric charges 5 μC and – 2 μC, separated by a distance of 10 cm is
a) 4 N b) 5 N
c) 9 N d) 13 N

34. In S.I. system, unit of permittivity is
a) $Nm^2\ C^{-2}$ b) $Nm^{-2}\ C^{-1}$
c) $C^2\ N^{-1}\ m^{-2}$ d) $A\ m^{-1}$

35. If the distance between two charged conductors is doubled and their quantities are also doubled, then the force between them will be
a) halved b) remain same
c) doubled d) becomes zero

36. In 1820, concept of electric field was introduced by
a) Faraday b) Maxwell
c) Coulomb d) Gilbert

37. The space or region surrounding the static charge in which unit positive charge experiences electric force is
a) gravitational field b) electric field
c) magnetic field d) none of these

38. The quantitative (i. e. both in magnitude and direction) study of an electric field by grouping the electric lines of force was first done by
a) Faraday b) Maxwell
c) Gilbert d) Franklin

39. The force on a unit charge, due to a charged conductor, is called
a) magnetic force b) electric intensity
c) electromotive force d) electric permittivity

40. Electric intensity at a place due to a charge is
a) vector quantity

b) scalar quantity
c) unitless quantity
d) dimensionless quantity

41. The intensity at a point due to a charge is inversely proportional to
a) charge
b) size of the charge
c) distance of the point charge
d) square of the distance from the charge

42. In S.I. system, unit of electric intensity is
a) NC^{-1} b) Vm^{-1}
c) Nm d) both 'a' and 'b'

43. A force of 2.25 N acts on a charge of 15×10^{-4} C. The intensity of the electric field at the point is
a) 375 N/C b) 1500 N/C
c) 1666 N/C d) 2000 N/C

44. The value of the electric field in which an electron experiences an electric force equal to its weight will be
a) 4.36×10^{-11} N/C b) 5.573×10^{-11} N/C
c) 6.67×10^{-11} N/C d) 9.86×10^{-11} N/C

45. The intensity of electric field at a distance of 0.2 m form a charge of 5 mC is
a) 1.125×10^{9} V/m b) 2.125×10^{9} V/m
c) 1.525×10^{9} V/m d) 2.525×10^{9} V/m

46. Two fixed point charges + 4 q and + q units are separated by a distance of a. The point, where the resultant electric field intensity is zero, is
a) (2/3) a b) a/2
c) 3a/2 d) none of these

47. The strength of the electric field is such that an electron of charge e placed inside if experiences an electric force equal to its own weight mg. The strength of the field is given by
a) e/mg b) mg/e
c) mge d) can not be found

48. In going from the surface of a charged conducting sphere towards the centre of the sphere the electric field
a) increases
b) decreases
c) remains the same as on the surface
d) remains zero at every place

49. An electron and a proton are situated in a uniform electric field. The ratio of their accelerations will be
a) zero
b) unity
c) ratio of the mass of proton and electron
d) ratio of the mass of electron and proton

50. Electric field strength at a point varies as 1/r for
a) a point charge
b) an electric dipole
c) a plane infinite sheet of charge
d) a line charge for infinite length

51. Who observed that a material named Amber is rubbed with wool, acquires the property of attracting light bodies?
a) Edison b) Franklin
c) Coulomb d) Thales

52. The net charge of electrified glass rod silk system, ebonite rod–wool system is
a) zero b) positive
c) negative d) none of these

53. Electricity on the moist day
a) increases b) decreases
c) leaks d) spreads

54. The work done in bringing a unit positive charge from infinity to the given point against the direction of electric intensity is
a) electric potential
b) magnetic potential
c) gravitational potential
d) none of these

55. The strength of electric field at a point is represented by a scalar, called as
a) electric intensity
b) electric potential
c) gravitational intensity
d) none of these

56. The work require to displace charge q from infinity to given point is W, then electric potential at that point is
a) W/q b) Wq
c) q/W d) q^2W

57. Electric potential is a
a) scalar quantity
b) vector quantity
c) unitless quantity
d) dimensionless quantity

58. Which of the following expression represent a volt?
a) joule / coulomb b) erg / coulomb
c) coulomb / joule d) coulomb / erg

59. An equipotential surface is that surface on which each and every point has
a) same potential b) zero potential
c) negative potential d) different potential

60. Two plates are 1 cm apart and the potential difference between them is 10 V.The electric field between the plates is
a) 400 N/C b) 600 N/C
c) 1000 N/C d) 800 N/C

61. The negative gradient of potential at any point in electric field is
a) electric intensity
b) electric flux
c) electric dipole moment
d) none of these

62. Electric intensity is directed along the direction at which electric potential
a) increases b) decreases
c) remains same d) cannot be found

63. When a charge is moved against the Coulomb's force of an electric field, then
a) work is done by the electric field
b) energy of the system is decreased
c) strength of the field is decreased
d) energy is used from some outside source

64. In bringing an electron towards another electron, electrostatic potential energy of the system
a) decreases b) increases
c) becomes zero d) remains same

65. If ΔV be the change in potential between two neighbouring point Δr apart, then the electric intensity E is given by
a) $V \times \Delta r$ b) $-\frac{\Delta r}{\Delta V}$
c) $-\frac{\Delta V}{\Delta r}$ d) $\left(\frac{\Delta V}{\Delta r}\right)^2$

66. If the electric field in a given region is zero, the potential at that region
a) can only be zero throughout the region
b) can only be uniform throughout the region
c) can be zero or uniform throughout the region
d) can not be uniform throughout the region

67. To move a unit positive charge from one point to another point on an equipotential surface
a) work is done on the charge
b) no work is done
c) work done is constant
d) work is done by the charge

68. In bringing a proton towards another proton, the electrostatic potential energy of the system
a) increases b) decreases
c) remain unchanged d) becomes zero

69. Can a body have charge and still be at zero potential
a) yes, always
b) yes, but not always
c) never
d) depends upon the nature of charge

70. Can a body have electric potential and still be uncharged
a) yes, always
b) yes, but not always
c) never
d) depends upon the type of potential

71. The energy gained by an electron when it is displaced from one point to another point whose potential is higher by one volt is
a) joule b) erg
c) electron–volt d) newton

72. Two equal and opposite charges separated by a finite distance is
a) electric dipole
b) electric torque
c) electric dipole moment
d) none of these

73. The product of positive charge and distance between the two charges is
a) electric dipole
b) electric dipole moment
c) electric flux
d) electric intensity

74. In S.I. system, coulomb–meter is unit of
a) electric intensity b) electric potential
c) electric flux d) electric dipole moment

75. The torque acting on electric dipole of moment p in uniform electric field E is given by
a) pE sin θ b) pE cos θ
c) pE tan θ d) pE sec θ

76. When an electric dipole is placed in a uniform electric field, it experiences
a) force only

b) torque only
c) both force and torque
d) neither a force nor a torque

77. An electric dipole consist of two opposite charges each of magnitude 1 μC separated by a distance of 2 cm. The dipole is placed in an electric field of 1×10^5 N/C. The maximum torque on the dipole is
a) 0.2×10^{-3} Nm b) 1×10^{-3} Nm
c) 2×10^{-3} Nm d) 4×10^{-3} Nm

78. The angle between the electric dipole moment and the electric field strength due to it on the axial line is
a) 0° b) 90°
c) 180° d) none of these

79. When a negative charge is taken at a height from earths surface, then its potential energy
a) decreases b) increases
c) remains unchanged d) will become infinity

80. The electric potential at a distance of 10 m from a point charge of 25 μC is
a) 2500 V b) 22500 V
c) 2000 V d) 20500 V

81. If E = 0 at all points on a closed surface
a) electric flux through the surface is zero
b) the total charge enclosed by the surface is zero
c) no charge resides on the surface
d) all of these

82. A particle having positive charge is released from rest in the electric field and moves under the influence of both electric field and gravity. The quantity connected with the charged particle that increases continuously with time is
a) electric charge
b) kinetic energy
c) electric potential energy
d) gravitational potential energy

Electric lines of force, electric flux and electric tubes of force

83. The path traced by a unit positive charge inian electric field is
a) electric line of force
b) magnetic line of force
c) both 'a' and 'b'
d) neither 'a' nor 'b'

84. Electric line of force about a negative point charge are
a) circular, anticlockwise
b) circular, clockwise
c) radial inward
d) radial outward

85. Which of the following statement is correct in case of lines of force?
a) they originate from positive charge and end at negative charge
b) they do not pass through conductor
c) they exhibit longitudinal tension and lateral pressure
d) all of these

86. Electric lines of force originate from positive charge and terminate on
a) positive charge b) neutral charge
c) negative charge d) none of these

87. The electric lines of force do not passes through
a) metals b) conductors
c) semiconductors d) all of these

88. The component of electric intensity parallel to the surface of a charged conductor is
a) zero b) maximum
c) infinity d) $\in$ E

89. There is force of repulsion between two like charges, because electric lines of force
a) exert lateral pressure on one another
b) exert normal pressure on one another
c) exert no pressure on one another
d) none of these

90. There is force of attraction between two unlike charges because lines of force have tendency
a) to shrink along their length and they are under tension
b) to intersect each other
c) to elongate along their length
d) none of these

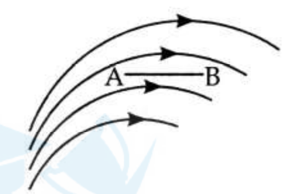
91. The properties of electric lines of force, tubes of force and tubes of induction are
a) never similar
b) approximately similar
c) exactly similar
d) none of these

92. The lines of force are always
a) perpendicular to the surface of charged body
b) parallel to the surface of charged body
c) inclined to the surface of charged body
d) none of these

93. The electric lines of force never
a) intersect with each other
b) diverging
c) converging
d) parallel to each other

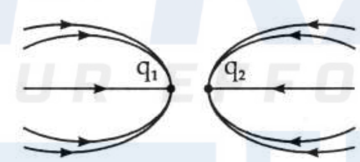
94. In uniform electric field lines of force are
a) parallel and equally spaced
b) perpendicular and equally spaced
c) diverging
d) converging

95. The figure shows electric lines of force emerging from charged body, If the electric fields at points A and B are E_A and E_B respectively and the distance between points A and B is f, then



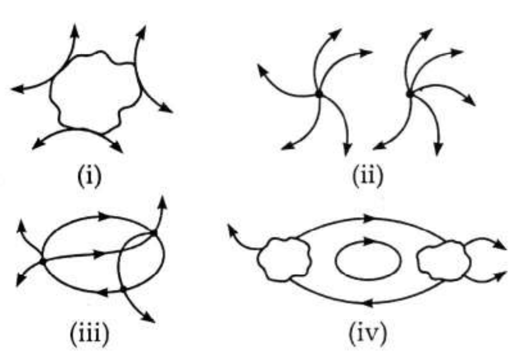
a) $E_A > E_B$ b) $E_A < E_B$
c) $E_A = E_B$ d) cannot be predicted

96. Figure gives electric lines of force due to two charges q_1 and q_2. What are the signs of the charges?



a) Both are positive
b) Both are negative
c) q_1 is positive but q_2 is negative
d) q_1 is negative but q_2 is positive

97. Which of the following figures cannot possibly represent electrostatic field lines



a) i, ii, iii, iv b) i, ii, iii only
c) i, iii, iv only d) ii, iii, iv only

98. The total number of electric lines of force passing normally through a given area is,
a) electric flux b) magnetic flux
c) flux density d) none of these

99. The dot product of E and normal area ds, calculated over the closed surface, is
a) electric field b) electric flux
c) electric potential d) all of these

100. Electric flux in an electric field $\vec{E}$ through area vector $\overrightarrow{ds}$ is given by
a) $\vec{E} \times \overrightarrow{ds}$ b) $\vec{E} \cdot \overrightarrow{ds}$
c) $\vec{E} / \overrightarrow{ds}$ d) $\overrightarrow{ds} / \vec{E}$

101. A cylinder of radius R and length L placed in a uniform electric field E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by
a $2\pi R^2E$ b) πR^2E
c) $\pi RE^2/2$ d) zero

102. The number of electric lines of force passing normally through a unit area is
a) flux density b) electric intensity
c) both 'a' and 'b' d) neither 'a' nor 'b'

103. If the dielectric constant of a medium increases then the number of electric lines of force passing through that medium
a) decreases b) increases
c) remains same d) none of these

104. Lines of force cut equipotential surface
a) obliquely b) normally
c) tangentially d) at 45°

105. A charged particle is projected perpendicular to the direction of uniform electric field. It's path in the region of the field will be
a) elliptic b) linear
c) circular d) parabolic

106. One electron volt is equal to
a) 1.6×10^{-12} erg b) 4.8×10^{-10} erg
c) 300 erg d) 1/300 erg

107. One giga electron volt (1 Gev) is equal to
a) 10^8 eV b) 10^9 eV
c) 10^{10} eV d) 10^{12} eV

108. Mathematically, the electric flux (ϕ) through small area ds placed in electric field E is given by

a) ds E cos θ b) $\overrightarrow{ds} \cdot \vec{E}$

c) $\vec{E} / \overrightarrow{ds}$ d) both 'a' and 'b'

109. A surface is enclosed in an electric dipole. The flux through the surface is
a) zero b) positive
c) negative d) infinite

110. A plane area of 100 cm^2 is placed in uniform electric field of 100 N/C such that the angle between area vector and electric field is 60°. The electric flux over the surface is
a) 1 Nm^2/C b) 2 Nm^2/C^2
c) 3 Nm^2/C^2 d) 0.5 Nm^2/C

111. A point charge of 10^{-7} C is situated at the centre of cube of 1 m side. The electric flux through its surface is
a) 113 × 10^4 Nm^2/C b) 11.3 × 10^4 Nm^2/C
c) 1.13 × 10^4 Nm^2/C d) 22 × 10^4 Nm^2/C

112. The product of small area element and normal component of electric intensity is
a) electric flux b) flux density
c) electric potential d) charge density

113. The total electric flux ϕ through the entire area of a closed surface is given by
a) $\phi = \oint \vec{E} \times \overrightarrow{ds}$ b) $\phi = \oint \vec{E} . \overrightarrow{ds}$
c) both 'a' and 'b' d) none of these

114. The concept of electric tubes of force was developed by
a) Faraday b) Maxwell
c) Gilbert d) Coulomb

115. The group of limited number of lines of force forming a tube like structure which depends on medium is
a) tube of force b) tube of induction
c) tube of charge d) none of these

116. The group of limited number of lines of force forming a tube like structure which is independent on medium is
a) tube of force b) tube of induction
c) tube of air d) none of these

117. The total number of tubes of force passing normally through the given area is called as
a) electric flux b) flux density
c) electric intensity d) both 'b' and 'c'

118. The total number of tubes of induction passing normally through unit area is called as
a) electric flux b) flux density
c) electric intensity d) both 'b' and 'c'

119. The number of tubes of induction originating from a unit positive charge is
a) 1 b) $q/\in_0$
c) $q \in_0$ d) $\in_0$

120. The number of tubes of force originating from a charge of magnitude q are
a) $\frac{q}{\in_0 k}$ b) $\frac{q}{\in_0}$
c) $q E \in_0 k$ d) $\frac{\in_0 k}{q}$

121. The tubes of induction that originate from a charge q are
a) $\in$ b) q
c) $q/\in_0$ d) $q/\in_0 k$

122. The number of tubes of force emerging normally through unit area of sphere's surface drawn around a charge q in a medium of permittivity $\in$ is $\frac{q}{4\pi \in r^2}$. It is also called as
a) electric intensity b) coulomb's force
c) electric potential d) none of these

123. The number of tubes of force originating from a point charge of 8.85 × 10^{-9} C in a medium of dielectric constant 5 are
a) 100 b) 200
c) 300 d) 400

124. A cubical Gaussian surface enclose 30 C of charge. The electric flux through each surface of the cube is
a) 30 C b) 5 C
c) 1 C d) 0.5 C

N. E. I. and T. N. E. I.

125. The total number of tubes of induction passing normally through the unit area is called as
a) normal electric induction
b) total normal electric induction
c) electric potential
d) electric power

126. The product of electric intensity and permittivity constant of a dielectric medium is called
a) total normal electric induction
b) normal electric induction

c) electric potential
d) electric energy

127. The product of N.E.I. and given surface area of the closed surface is called as
a) total normal electric induction
b) normal electric induction
c) electric potential
d) electric energy

128. The total number of tubes of induction passing normally through the given area is called as
a) normal electric induction
b) total normal electric induction
c) electric potential
d) electric power

129. If a charge q is placed at the centre of imaginary sphere of radius r then the N.E.I. at a point on such a sphere is
a) $\frac{4\pi r^2}{q}$ b) $\frac{q}{4\pi r^2}$
c) $\in_0 kE$ d) both 'b' and 'c'

130. The product of permittivity ($\in_0 k$) of a medium the normal com pon ent of electric intensity ($E\cos\theta$) and the given small area (ds) is called as
a) T. N. E. I. over small area ds
b) T. N. E. I. over entire area of a closed surface
c) electrostatic potential energy
d) all of these

131. A point charge of 3 mC is situated in air at the centre of a sphere of radius 10 cm, Find the T.N.E.I. through a portion of the surface of the sphere which subtends an angle of $\pi/2$ steradian at its centre.
a) 0.375 mC b) 0.573 mC
c) 0.735 mC d) 0.473 mC

132. Two ball bearings, one having a radius of 2 mm and a surface charge density equal to 5 $\mu C/m^2$ and another having a radius of 1mm and a surface density of charge equal to $-2\ \mu C/m^2$ are situated inside a closed surface. The T.N.E.I. over the closed surface is
a) 1.262×10^{-10} C b) 1.262×10^{-8} C
c) 2.262×10^{-8} C d) 2.262×10^{-10} C

3.1 Gauss's theorem and its applications

133. Which of the following law gives a relation between the electric flux through any closed surface and the charge enclosed by the surface?
a) Coulomb's law b) Charle's law
c) Newton's law d) Gauss's law

134. Gauss's law helps in
a) determination of electric field due to symmetric charge distribution
b) determination of electric potential due to symmetric charge distribution
c) determination of electric flux
d) situations where Coulomb's law fails

135. Gauss's theorem in electrostatics can be mathematically expressed as
a) $\phi = \frac{\pi \in_0}{q}$ b) $\phi = \frac{q}{\in_0}$
c) $\phi = 4\pi E_0 \rho$ d) $\phi = 4\pi \in_0$

136. A Gaussian surface encloses no charge. Which of the following is true for a point inside it ?
a) electric field must be zero
b) electric potential must be zero
c) both electric potential and intensity must be zero
d) none of these

137. Gauss's theorem
a) does not hold, if the closed surface encloses a discrete distribution of charges
b) does not hold, if the closed surface encloses, a line, a surface or a volume charge distribution
c) holds, if the surface encloses a point charge only
d) holds irrespective of the form in which charges are enclosed by the closed surface.

138. 'The total normal electric induction over a closed surface is equal to the algebraic sum of the charges enclosed by the surface' is the statement of
a) Gauss's theorem b) Coulomb's theorem
c) Loop theorem d) Junction theorem

139. If the charge lies outside the closed 'surface then by Gauss's theorem, T.N.E.I. over that surface will be
a) zero b) positive
c) $\sum_{i=1}^{n} q_i$ d) 2 q

140. Gauss's theorem is true for any point charge situated any where

a) outside the surface b) inside the surface
c) on the surface d) none of these

141. If negative charge is enclosed by the surface, then the T. N. E. I. over the surface will be
a) directed outwards and considered positive
b) directed inwards and considered positive
c) directed outwards and considered negative
d) directed inwards and considered negative

142. The solid angle substended at any point inside the surface due to small area ds is given by

a) $\frac{ds\cos\theta}{r^2}$ b) $\frac{dsr^2}{\cos\theta}$

c) ds cos θ r^2 d) $\frac{r^2}{ds\cos\theta}$

143. The electric charges of +9 C, –10 C and –8 C are enclosed anywhere by a closed surface. T.N.E.I. through that surface is
a) –9 C b) +9 C
c) 5 C d) 4 C

144. An infinite parallel plane sheet of a metal is charged to σ C/m^2 in a medium of dielectric constant k. Intensity of electric field near the metallic surface will be

a) $E = \frac{\sigma}{\epsilon_0 k}$ b) $E = \frac{\sigma}{2\epsilon_0 k}$

c) $E = \sigma^2 2\epsilon_0 k$ d) $E = \sigma$

145. Electric intensity at a point near a charged sphere of charge q is given by

a) $E = \frac{1}{4\pi\epsilon_0 k}\cdot\frac{q}{r^2}$ b) $E = \frac{1}{2\pi\epsilon_0 k}\cdot\frac{q}{r}$

c) $E = \frac{\sigma}{\epsilon_0 k}$ d) none of these

146. A cylinder of length L has a charge of magnitude q. The electric intensity at a point at a distance r from the axis of the cylinder is

a) $E = \frac{1}{4\pi\epsilon_0 k}\cdot\frac{q}{r^2}$ b) $E = \frac{1}{2\pi\epsilon_0 k}\cdot\frac{q}{r}$

c) $E = \frac{\sigma}{\epsilon_0 k}$ d) none of these

147. The electric intensity at a point near a charged conductor of surface charge density a is
a) $E = \sigma/\epsilon_0 k$ b) $E = \sigma\ \epsilon_0 k$
c) $E = \sigma/2\epsilon_0 k$ d) $E = \sigma^2$

148. A sphere of radius R has a charge density σ. The electric intensity at a point at a distance r from its centre is

a) $E = \frac{\sigma R^2}{\epsilon_0 kr^2}$ b) $E = \frac{\sigma}{\epsilon_0 k}$

c) $E = R^2$ d) $E = \epsilon_0 kr^2\sigma^2$

149. A charge +q is placed at the mid point of a cube of side L. The electric flux emerging from cube is

a) $\frac{q}{\epsilon_0}$ b) $\frac{q}{6L^2\epsilon_0}$

c) $\frac{6qL^2}{\epsilon_0}$ d) zero

150. The electric flux through a hemispherical surface of radius R placed in a uniform electric field E parallel to the axis of the circular plane is
a) $(2\pi R)$ E b) (πR^2) E

c) $\left(\frac{4}{3}\pi R^3\right)E$ d) $\left(\frac{2}{3}\pi R^3\right)E$

151. Electric field intensity at a point is inversely proportional to cube of its distance due to
a) a point charge
b) an infinite line charge
c) an electric dipole
d) an infinite plane sheet of charge

152. Electric intensity at a point due to a charged cylinder of infinite length is inversely proportional to its
a) distance b) square of distance
c) cube of distance d) none of these

153. The electric field inside a spherical shell of uniform surface charge density is
a) zero
b) uniform
c) non uniform
d) proportional to distance from the centre

154. If one penetrates a uniformly charged sphere, the electric field strength E
a) increases
b) decreases
c) remains the same as at the surface
d) is zero at all points

155. Potential at any point inside a charged hollow

sphere
a) increases with distance
b) is a constant
c) decreases with distance from centre
d) is zero

156. A hollow sphere of charge does not produce an electric field at any
a) interior point b) outer point
c) beyond 2 m d) beyond 10 m

157. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is
a) 0 V
b) 10 V
c) same as at a point 5 cm away from the surface
d) same as at a point 25 cm away from the surface

158. A spherical shell of radius R has a charge +q units. The electric field due to the shell at a point
a) inside is zero and varies as r^{-1} outside it
b) inside is constant and varies as r^{-2}
c) inside is zero and varies as r^{-2} outside it
d) inside is constant and varies as r^{-1} outside it

159. The intensity of electric field at a point due to charged conductor of any shape or plane charged sheet is
a) independent of distance of that point
b) depends on distance of that point
c) independent of charge density and surrounding medium
d) none of these

160. The charge deposited per unit area of the surface is called
a) linear charge density
b) surface charge density
c) charge density
d) all of these

161. If σ is surface density of charge on the charged cylinder of radius R, then electric intensity E at outer point at a distance r from its axis is

a) $\frac{\sigma R}{\epsilon_0 kr}$ b) $\frac{\sigma r}{\epsilon_0 kR}$

c) $\frac{\sigma}{\epsilon_0 k}$ d) $\frac{\sigma^2 R}{\epsilon_0 kr}$

162. The charge deposited per unit length of cylinder is called as
a) linear charge density
b) surface charge density
c) charge density
d) all of these

163. The charge density on the surface of a conducting sphere is 64×10^{-7} C/m^2, and the electric intensity at a distance of 2 m from the centre of the sphere is $4\pi \times 10^4$ N/C. The radius of the sphere is
a) 0.83 m b) 0.4 m
c) 0.6 m d) 0.38 m

164. An isolated conducting sphere of radius 0.1 m placed in vacuum carries a positive charge of 0.1 μC. Find the electric intensity at a point at a distance 0.2 m from the centre of the sphere.
a) 2.25×10^2 N/C b) 2.25×10^4 N/C
c) 2.52×10^2 N/C d) 2.52×10^4 N/C

165. A conductor having a charge density at 120 μC/m^2 is surrounded by a medium of dielectric constant 4. The electric intensity at a point very near the charged conductor is
a) 9.33×10^6 N/C b) 3.39×10^8 N/C
c) 9.33×10^8 N/C d) 3.389×10^6 N/C

166. A metal sphere of radius 5 cm is charged to 100 V. Electric intensity at a point on its surface is
a) 20 kV/m b) 0.2 kV/m
c) 2 kV/m d) 100 kV/m

167. The electric intensity at a point distant 1 m from the centre of a sphere of radius 25 cm in air is 10^4 N/C. The surface density of the charge on the surface of sphere is
a) 1.416 μC/m^2 b) 2.416 μC/m^2
c) 1.446 μC/m^2 d) 2 μC/m^2.

168. A charge of 8×10^{-6} C is given to a metallic sphere of radius 5 cm placed in a medium of dielectric constant 5. The surface charge density of sphere is
a) 2.547×10^{-4} C/m^2 b) 5.248×10^{-4} C/m^2
c) 25.48×10^{-4} C/m^2 d) 52.48×10^{-4} C/m^2

169. A charge of 5×10^{-10} C is given to a metal cylinder of length 10 cm, placed in air. The electric intensity due to the cylinder at a distance of 0.2 m from its axis is
a) 150 V/m b) 250 V/m
c) 350 V/m d) 450 V/m

170. The electric intensity due to a charged conducting cylinder of radius 0.1 m at a distance of 1 m

from the axis of the cylinder of charge density 1.77 μC/m in a dielectric medium of dielectric constant 2 is

a) 2×10^5 V/m b) 1.5×10^4 V/m
c) 2.59×10^5 V/m d) 4×10^5 V/m

171. A metal cylinder of length 2 km is charged with 2×10^{-2} C. The linear charge density of the cylinder is

a) 10 μC/m b) 20 μC/m
c) 5 μC/m d) 30 μC/m

172. A charged cylinder of radius 2 cm has surface density of charge 8.85×10^{-9} C/m^2. It is placed in a medium of dielectric constant 5. The electric intensity at a point at a distance of 4 m from its axis is

a) 5 V/m b) 4 V/m
c) 3 V/m d) 1 V/m

173. The surface density of charge on a conductor situated in air, is 2×10^{-4} C/m^2. The electric intensity at a point very near to its surface is

a) 2.259×10^7 N/C b) $2.261. \times 10^9$ N/C
c) 3.321×10^7 N/C d) 3.321×10^9 N/C

174. An electric cable of diameter 10 cm runs under water for a distance of 5 km. If the cable carries a charge of 0.01 C on its surface then its linear charge density is

a) 2 μC/m b) 0.5 μC/m
c) 4 μC/m d) 1.5 μC/m

175. A circular metal plate of radius 10 cm is given a charge of 20 μC on its surface. The charge density of the plate is

a) 3.185×10^{-6} C/m^2 b) 2×10^{-6} C/m^2
c) 3×10^{-9} C/m^2 d) 3.184×10^{-4} C/m^2

176. The surface density of charge on the earth's surface is 2.65×10^{-9} C/m^2. If the radius of the earth is 6400 km then the charge carried by the earth is

a) 1.363×10^6 C b) 1.364×10^9 C
c) 3.364×10^6 C d) 2.396×10^6 C

3.2 Mechanical force per unit area of the charged conductor

177. The mechanical force acting on a unit area of a charged conductor is

a) $f = \dfrac{\sigma^2}{2 \in_0 k}$ b) $f = \dfrac{\sigma}{2 \in_0 k}$
c) $f = \dfrac{\sigma^2}{\in_0 k}$ d) $f = \dfrac{\sigma}{\in_0 k}$

178. The mechanical stress of a charged conductor is directly proportional to

a) square of surface charge density
b) square of electric intensity
c) both 'a' and 'b'
d) neither 'a' nor 'b'

179. A metal surface of area 1 m^2 is charged with $\sqrt{8.85}$ μC in air. The mechanical force acting on it is

a) 1 N b) 0.5 N
c) 10 N d) 50 N

180. In an electron gun, electrons are accelerate through a potential difference V. If the electron has a charge 'e' and mass 'm' their maximum velocity is

a) $\sqrt{\dfrac{eV}{m}}$ b) $\sqrt{\dfrac{e}{Vm}}$
c) $\sqrt{\dfrac{2eV}{m}}$ d) none of these

181. A charged conductor of area ds is placed in electric field of strength E. The force acting on unit area of the conductor is

a) $\dfrac{\in_0 kE^2}{2}$ b) $\dfrac{\in_0 k}{2E}$
c) $\dfrac{E^2}{2 \in_0 k}$ d) $\in_0 kE^2$

182. The mechanical stress of a charged conductor of charge density σ is always directed outwards because

a) σ^2 is always negative
b) σ^2 is always positive
c) σ is zero
d) none of these

183. A metal sphere of radius 10 cm is given a charge of 12 μC. The force acting on unit area of its surface is

a) 5.151×10^2 N/m^2 b) 5.15×10^3 N/m^2
c) 515×10^{-2} N/m^2 d) 5.15×10^{-3} N/m^2

184. Inside a hollow spherical conductor, the potential

a) is constant
b) varies directly as the distance from the centre

c) varies inversely as the distance from the centre
d) varies inversely as the square of the distance from the centre

3.3 Energy per unit volume of tile medium

185. The energy per unit volume of a dielectric medium is directly proportional to square of
a) relative permittivity b) charge
c) electric intensity d) both 'a' and 'b'

186. The energy density of air medium is 44.25×10^{-8} J/m^3. The intensity of the electric field in the medium is
a) 300 N/C b) 3 N/C
c) 305 N/C d) 316.2 N/C

187. The energy density of a medium of dielectric constant k surrounding the charged conductor is
a) $\frac{\sigma^2}{2\epsilon_0 k}$ b) $\frac{1}{2}\epsilon_0 kE^2$
c) $\frac{\sigma}{\epsilon_0 k}$ d) both 'a' and 'b'

188. Calculate the energy per unit volume of a medium of dielectric constant 3, if the intensity of the electric field is 100 V/m.
a) 1.328×10^{-8} J/m^3 b) 4.2×10^{-8} J/m^3
c) 13.28×10^{-8} J/m^3 d) 42×10^{-8} J/m^3

189. The electrostatic energy stored in the 1 litre volume of air when it is placed in uniform electric field of intensity 10^3 V/m is
a) 44.25×10^{-9} J b) 4.425×10^{-9} J
c) 44.25×10^{-6} J d) 44.25×10^{-5} J

190. A potential difference of 50 V is maintained between the two plates of a parallel plate condenser, separated by 5 mm of air. The energy stored in unit volume of air between the plates of the condenser is
a) 4.425×10^{-4} J/m^3 b) 2.425×10^{-4} J/m^3
c) 8.425×10^{-4} J/m^3 d) 6.425×10^{-4} J/m^3

191. A cube of marble of each side 5 m long is placed in electric field of intensity of 3 kV/m. The amount of electrostatic energy stored in marble of dielectric constant 8 is
a) 39.82×10^{-3} J b) 4.982×10^{-2} J
c) 9.832×10^{-3} J d) 8.392×10^{-3} J

192. A small sphere carries a charge of 20 μC. The energy density of electric field at a point 25 cm away from the centre of the sphere in air is
a) 0.367 J/m^3 b) 3.67 J/m^3
c) 36.7 J/m^3 d) 3.76 J/m^3

3.4 Dielectrics and Polarization

193. Due to polarisation the electric field inside a dielectric is
a) decreased
b) increased
c) remains same
d) may increase or may decrease depending the upon material

194. If a dielectric constant and dielectric strength be denoted by K and X respectively, then a material suitable for use as a dielectric in a capacitor must have
a) high K and high X b) high K and low X
c) low K and high X d) low K and low X

195. A molecule in which centre of gravity of positive nuclei and revolving electrons do not coincide is
a) polar molecule b) non polar molecule
c) bipolar molecule d) unipolar molecule

196. Polar molecules have permanent
a) resistance
b) current
c) electric dipole moment
d) magnetic flux

197. Which of the following is example of polar molecule?
a) H_2O b) O_2
c) H_2 d) CO_2

198. A molecule in which centre of gravity of positive nuclei and revolving electrons coincide is
a) polar molecule b) non polar molecule
c) bipolar molecule d) unipolar molecule

199. Non polar molecules have donot permanent
a) force
b) pressure
c) electric dipole moment
d) torque

200. Which of the following is example of non polar molecule?
a) H_2 b) HCl
c) H_2O d) HO_2

201. The electric dipole moment per unit volume of electric dipole is
a) polarisation b) diffraction
c) interference d) reflection

202. The ratio of polarisation to electric intensity is
a) electric permitivity b) electric susceptibility
c) electric flux d) electric torque

203. The amount of induced surface charge per unit area of the surface is
a) polarisation b) torque
c) electric dipole d) electric flux

204. Which of the following is vector?
a) electric potential b) electric charge
c) electric polarisation d) electric flux

3.5 Concept of condenser

205. The quantity of charge required to raise its potential by one unit is
a) capacity of conductor
b) inductance of conductor
c) resistance of conductor
d) none of these

206. An arrangement which increases charge storing capacity without an appreciable increase in its potential is
a) resistor b) conductor
c) inductor d) capacitor

207. The S.I. unit of capacitance of a condenser is
a) henry b) ohm
c) farad d) volt

208. Which of the following expression represents a farad?
a) joule/volt b) volt/coulomb
c) coulomb/volt d) coulomb/joule

209. The relation between electric charge, electric potential and capacity is
a) $C = \frac{Q}{V}$ b) $C = \frac{V}{Q}$
c) $V = Q C$ d) all of these

3.6 Capacity of parallel plate condenser

210. The capacity of a parallel plate condenser is given by
a) $C = \frac{Q}{V}$ b) $C = \frac{Ak \in_0}{d}$
c) $C = \frac{d}{Ak \in_0}$ d) $C = A.d.$

211. The capacity of a parallel plate condenser is inversely proportional to the
a) dielectric constant of the medium
b) area of the plate
c) length of the plate
d) distance between the two plates

212. The capacity of a parallel plate condenser depends upon
a) area of the plate
b) distance between the two plates
c) permittivity constant of a dielectric medium
d) all of these

213. A capacitor works in
a) A. C. circuits b) D. C. circuits
c) both 'a' and 'b' d) neither 'a' nor 'b'

214. To reduce the capacity of a parallel plate condenser, separation between the plates is
a) reduced and area of the plates decreased
b) decreased and area of the plates increased
c) increased and area of the plates decreased
d) increased and area of the plates increased

215. In a charged capacitor, 'the energy is stored in
a) the negative charges
b) the positive charges
c) the field between the plates
d) both 'a' and 'b'

216. A parallel plate capacitor is charged and then isolated. What is the effect of increasing the plate separation on charge, potential, capacitance respectively?
a) constant, decreases, decreases
b) increases, decreases, decreases
c) constant, decreases, increases
d) constant, increases, decreases

217. A parallel plate capacitor is made by stacking 'n' equally spaced plates connected alternately. If the capacitance between any two plates is C then the resulting capacitance is
a) C b) n C
c) (n + 1) C d) (n – 1) C

218. One picofarad is equal to
a) 10^{-9} F b) 10^{-19} F
c) 10^{-109} F d) 10^{-12} F

219. When a parallel plate capacitor is connected to a source of constant potential difference
a) all the charge drawn from the source is stored in the capacitor
b) the potential difference across capacitor grows very rapidly initially and this rate decreases to

zero eventually

c) only half of the energy drawn from the source is dissipated outside the capacitor

d) all of these

220. When two identical capacitors are charged individually to different potentials and then connected in parallel, after disconnecting from the source

a) net charge = sum of initial charges

b) net potential differencet sum of individual initial potential difference

c) net energy stored L sum of individual initial energy

d) all of these

221. If E is the electric field intensity of an electrostatic field between the parallel plates of condenser, then the electrostatic energy density is proportional to

a) E b) E^2

c) $1/E^2$ d) E^3

222. A parallel plate capacitor is charged. If the plates are pulled apart

a) the potential difference increases

b) the capacitance increases

c) the total charge increases

d) the charge and the potential difference remain the same

223. Charges present on the clouds are due to

a) motion of water drops

b) earth's magnetic field

c) lightning

d) motion of the clouds

224. The accumulation of charge on clouds, which produces lightning, is caused by

a) rain drops changing into electrons

b) the electric field of the earth

c) ionisation by the sun

d) electrification due to motion of water molecules.

225. The capacitance of a parallel plate condenser does not depend upon

a) area of the plates

b) metal of the plates

c) medium between the plates

d) distance between the plates

226. The energy stored in a capacitor of capacity C and potential V is given by

a) $0.5\ C^2V$ b) $0.5\ CV^2$

c) $0.5\ CV$ d) $0.5\ C^2V^2$

227. If two charged conductors are brought in contact, then they show

a) gain in energy b) loss of some energy

c) gain in charge d) loss of same charge

228. Two conducting spheres of radii r_1 and r_2 are equally charged. The ratio of their potentials is

a) $\frac{r_2}{r_1}$ b) $\frac{r_1}{r_2}$

c) $(r_1/r_2)^2$ d) $(r_2/r_1)^2$

229. The ratio of charge to potential of a conductor is called as

a) inductance b) resistance

c) conductance d) capacitance

230. An arrangement which consist of two conductors separated by a dielectric medium is called

a) resistor b) inductor

c) rectifier d) capacitor

231. The earthed conductor plate of a condenser helps to

a) decrease the potential of charged conductor

b) increase the potential of charged conductor

c) keep constant the potential of charged conductor

d) none of these

232. The ohmic resistance of a condenser for D.C. current is

a) finite b) infinite

c) zero d) V/l

233. The condenser always block D. C. permits

a) pulsating current through it

b) alternating current through external circuit

c) only half cycle of alternating current through it

d) none of these

234. The condenser always stores the amount of

a) magnetic energy b) electrostatic energy

c) electric field d) both 'b' and 'c'

235. The capacitance of earth of radius R treating as spherical conductor is

a) $4\pi E_0R$ b) $4\pi R$

c) $\frac{\epsilon_0}{R}$ d) $\frac{4\pi\epsilon_0}{R}$

236. Earth's surface is considered to be at

a) zero potential b) negative potential

c) positive potential d) infinite potential

237. By keeping the charge on a capacitor unchanged, the energy of capacitor can be decreased by
a) increasing dielectric constant of the medium between the plates
b) decreasing the dielectric constant of the medium between the plates
c) making the dielectric constant zero
d) none of these

238. The capacitance of a capacitor does not depend upon
a) either charge Q or potential V
b) area of either plates
c) distance between the plates
d) nature of medium between the plates

239. Two copper spheres A and B of same radii, one hollow and the other solid are charged to the same potential. Which of the two will hold more charge?
a) A
b) B
c) solid sphere can not hold any charge
d) both the spheres will hold the same charge

240. The dielectric constant of a metal is
a) zero b) one
c) k d) ∞

241. A sphere is constructed around a positive point charge q. The work done in moving a unit positive charge on this sphere is numerically equal to
a) infinity b) zero
c) capacity of sphere d) potential of sphere

242. The capacity of a parallel plate condenser is C. When the distance between the plates is halved, its capacity is
a) 2 C b) C
c) 0.25 C d) 0.2 C

243. The dielectric constant k for an insulator cannot be
a) 4 b) 5
c) 9 d) infinity

244. A capacitor is connected to a battery of 20 V, so that a charge of 100 μC is obtained at the plates. The capacitance of the capacitor is
a) 6 μF b) 5 μF
c) 9.5 μF d) 10 μF

245. Six identical capacitors are joined in parallel, charged to a potential difference of 10 V, separated and then connected in series. Then the potential difference between the free plates is
a) 10 V b) 30 V
c) 60 V d) $\left(\frac{10}{6}\right)$ V

246. The plates of a parallel plate capacitor are charged up to 100 V. A 2mm thick plate is insetted between the plates, then to maintain the same potential difference, the distance between the capacitor plates is increased by 1.6 mm. The dielectric constant of the plate is
a) 5 b) 1.25
c) 4 d) 2.5

247. The capacitance of the earth viewed as a spherical conductor of radius 6408 Km is
a) 980 μF b) 1424 μF
c) 712.2 μF d) 600 μF

248. A 4 μF capacitor is charged to 400 V. If its plates are joined through a resistance of 2 $k\Omega$, then heat produced in the resistance is
a) 0.16 J b) 0.32 J
c) 0.64 J d) 1.28 J

249. The area of each plate of parallel plate condenser is 20 cm^2 and distance between them is 2 mm. It stores the energy of 5 J. The energy density of electric field between its plates is
a) 250×10^6 J/m^3 b) 1.25×10^6 J/m^3
c) 2×10^6 J/m^3 d) 4×10^6 J/m^3

250. A parallel plate condenser is made up of two plates, each of surface area 40 cm^2, separated by a distance of 0.4 cm. If a material of dielectric constant 10 is introduced between the plates, then the capacity of the condenser is
a) 8.85 pF b) 88.5 pF
c) 885 pF d) 585 pF

251. If two conducting spheres are separately charged and then brought in contact
a) the total energy of two spheres is conserved
b) the total charge on two spheres is conserved
c) both the total energy and charge are conserved
d) the final potential is always the mean of the original potentials of the two spheres

252. The parallel plates of a condenser are separated by an insulating material. It is because of
a) potential between the plate increases
b) potential between the plate decreases
c) capacity of the condenser decreases
d) energy stored by the condenser decreases

253. A condenser is connected across another charged condenser. The energy in two condensers will be
a) equal to the energy in the initial condenser
b) less than that in the initial condenser
c) more than that in the initial condenser
d) more or less depending upon the relative capacities of the two condensers

254. Capacity of a parallel plate condenser can be increased by
a) increasing the distance between the plates
b) increasing the thickness of the plates
c) decreasing the thickness of the plates
d) decreasing the distance between the plates

3.7 Effect of dielectrics on capacity :

255. A dielectric is introduced between the elements of the condenser kept at a constant potential difference, then the charge on condenser
a) decreases
b) increases
c) unchanged
d) may increase or decrease

256. When air is replaced by a dielectric constant k, the maximum capacitance of the capacitor
a) increases k times b) remains unchanged
c) increases k^2 times d) decreases k times

257. A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved further apart by means of insulating handles
a) the charge on the capacitor increases
b) the voltage across the plates increases
c) the electrostatic energy stored in the capacitor increases
d) both 'b' and 'c'

258. A metal foil of negligible thickness is introduced between the two plates of a capacitor at the centre. The capacitance of capacitor will be
a) same b) double
c) half d) k times

259. If the distance between the plates of parallel plate condenser is halved and dielectric constant of dielectric is doubled then its capacity will
a) increases by 16 times.
b) increases by 4 times
c) increases by 2 times
d) remains the same

260. In order to increase the capacity of a parallel plate condenser, one should introduce between the plates a sheet of
a) mica b) tin
c) copper d) stainless steel

261. A parallel plate capacitor has a capacitance of 50 μF in air and 110 μF when immersed in an oil. The dielectric constant k of the oil is
a) 0.2 b) 1.5
c) 2.2 d) 2.5

262. The capacity of parallel plate condenser is 5 μF. When a glass plate is placed between the plates of the condenser, its potential difference reduces to 1/8 of the original value. The magnitude of relative dielectric constant of glass is
a) 4 b) 6
c) 7 d) 8

263. A capacitor has a capacity C, when air is present between the two plates. If a dielectric of value k is placed between the plates, the new capacity C will be equal to
a) kC b) k^2C
c) C^2k d) 2kC

264. A parallel plate capacitor has a capacity C. If the separation between the plates is doubled and a dielectric medium is inserted between plates, the new capacity becomes 3 C. The dielectric constant of medium is
a) 1.5 b) 3
c) 6 d) 12.0

265. The capacity of condenser containing air is 4 μF. The dielectric constant of the slab is What will be its capacity if the air is replaced by a material of dielectric constant 5 ?
a) 20 μF b) 40 μF
c) 4 μF d) 10 μF

266. The capacity of a parallel plate condenser increases four times if the air between the plates is replaced by glass. The permittivity of glass will be
a) $3.54 \times 10^{-11} C^2/Nm^2$
b) $3.54 \times 10^{-12} C^2/Nm^2$
c) $2.54 \times 10^{-11} C^2/Nm^2$
d) $2.22 \times 10^{-12} C^2/Nm^2$

267. A parallel plate capacitor having capacitance C farad is connected with a battery of emf V volts. Keeping the capacitor connected with the battery, a dielectric slab of dielectric constant K is inserted

between the plates. The dimensions of the slab are such that it fills the space between the capacitor plates. Then,

a) charge on the capacitor plates remains the same

b) charge on the plates increases K times

c) potential difference between the plates decreases to V/K

d) all of these

268. A capacitor is charged by using a battery which is then disconnected. A dielectric slab is then slipped between the plates which results in

a) reduction of charge on the plates and increase of potential across the plates.

b) increase in potential difference across the plates, reduction in stored energy, but no change in charge on the plates

c) decrease in potential difference across the plates, reduction in stored energy but no change in charge on the plates

d) none of these

269. A parallel plate capacitor has plates with area A and separation d. A battery charges the plates to a potential difference V_0. The battery is then disconnected and a dielectric slab of thickness d is introduced. The ratio of the energy stored in the capacitor before and after the slab is introduced, is

a) K   b) $\frac{1}{K}$

c) $\frac{A}{d^2K}$ d) $\frac{d^2K}{A}$

270. Capacitance of a parallel plate capacitor becomes $\frac{4}{3}$ times its original value if a dielectric slab of thickness $t = \frac{d}{2}$ is inserted between the plates. The dielectric constant of the slab is

a) 8   b) 4

c) 6   d) 2

3.8 Energy of charged condenser

271. Energy of a charged condenser is given by

a) $E = \frac{CV^2}{2}$ b) $E = \frac{Q^2}{2C}$

c) $E = \frac{QV}{2}$ d) all of these

272. Energy of a charged condenser is directly proportional to square of

a) charge   b) potential

c) both 'a' and 'b'   d) neither 'a' nor 'b'

273. Energy of a charged conductor is given by

a) $\frac{1}{2}CV^2$ b) $\frac{1}{4}CV^2$

c) $\frac{1}{2}CV$ d) $\frac{1}{4}CV$

274. The amount of energy stored in condenser becomes nine times the initial energy. The new potential of condenser is

a) three times the initial potential

b) nine times the initial potential

c) four times the initial potential

d) none of these

275. The capacity of a parallel plate air capacitor is 10 μF and it is given a charge of 40 μC. The electrical energy stored in the capacitor is

a) 400 erg   b) 600 erg

c) 800 erg   d) 900 erg

276. When a capacitor having capacitance 4 μF and potential difference 100 volt is discharged, the energy released in joules is

a) 0.01   b) 0.02

c) 0.03   d) 0.07

277. The capacitance of a capacitor having a charge 6×10^{-7} C and energy 4.5×10^{-4} J is

a) 4×10^{-10} F   b) 5×10^{-10} F

c) 7×10^{-10} F   d) 9×10^{-10} F

278. A variable condenser is permanently connected to a 100 V battery. If capacity is changed from 2 μF to 10 μF then energy change is equal to

a) 2×10^{-2} J   b) 2.5×10^{-2} J

c) 6.5×10^{-2} J   d) 4×10^{-2} J

279. Two capacitors each of 1 μF capacitance are connected in parallel and are then charged by 200 V. The total energy of their charges is

a) 0.01 J   b) 0.02 J

c) 0.04 J   d) 0.06 J

280. A condenser of capacitance 6 μF was originally charged to 10 V. Now the potential difference is made 20 V. What is the increase in its potential energy?

a) 2×10^{-4} J b) 3×10^{-4} J
c) 6×10^{-4} J d) 9×10^{-4} J

281. If a 10 μF capacitor is to have an energy constant of 1 joule, it must be placed across a potential difference of
a) 900 V b) 750 V
c) 447.2 V d) 200 V

282. A condenser is charged through a potential difference of 200 V possesses charge of 0.1 C. When discharged it would release an energy of
a) 1 J b) 2 J
c) 10 J d) 20 J

3.9 Condensers in series and parallel

283. If the number of condensers are connected one after another then this type of combination of condensers is
a) condensers in series
b) condensers in parallel
c) condensers in series and parallel
d) none of these

284. If the number of condensers are connected in series then
a) charge on each condenser is same and potential is different
b) potential is same but charge is different
c) both charge and potential is same
d) both charge and potential is different

285. The resultant capacitance of n condensers of capacitances C_1 C_2 .... C_n connected in series is given by

a) $C_s = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$

b) $\frac{1}{C_s} = \frac{1}{C_1} + ... + \frac{1}{C_n}$

c) $C_s = C_1 + C_2 + ... + C_n$
d) $C_s = C_1 - C_2 - ...... - C_n$

286. The equivalent capacity of number of condenser can be decreased if they are connected in
a) series b) parallel
c) both 'a' and 'b' d) neither 'a' nor 'b'

287. The equivalent capacity of n identical condensers each of capacity C connected in series is given by
a) n^2 C b) nC
c) n/C d) C/n

288. The reciprocal of equivalent capacity of number of condensers connected in series is equal to
a) sum of reciprocals of their individual capacity
b) sum of their individual capacity.
c) difference of the capacities of each condenser
d) none of these

289. In series combination of condensers, potential is distributed in
a) proportion to there capacitances
b) inverse proportion to their capacitance
c) does not depend on capacitance
d) can not be predicted

290. If the number of condensers are connected one across another then this type of combination of condensers is
a) parallel
b) series
c) both series and parallel
d) neither series nor parallel

291. If the number of condensers are connected in parallel then
a) charge on each condenser is same and potential is different
b) potential is same but charge is different
c) both charge and potential is same
d) both charge and potential is different

292. The equivalent capacity of number of condensers can be increased if they are connected in
a) series
b) parallel
c) both series and parallel
d) neither series nor parallel

293. The resultant capacity of n condensers of capacitances C_1, C_2 ...... C_n connected in parallel is
a) $C_p = C_1 + C_2 + ... + C_n$
b) $C_p = C_1 - C_2 - C_3 - ..... - C_n$

c) $\frac{1}{C_p} = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$

d) $C_p = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$

294. The equivalent capacity of n identical capacitors each of capacity C connected in parallel is
a) n C b) (n –1) C
c) n^2 C d) C/n

295. The resultant capacity of number of condensers connected in parallel is equal to
a) sum of reciprocals of their individual capacity.
b) sum of their individual capacity
c) difference of the capacities of each condenser
d) none of these

296. In parallel combination of condensers charge is distributed in
a) proportion to their capacitances
b) inverse proportion to their capacitances
c) does not depend on capacitance
d) cannot be predicted

297. Two capacitors of capacity C_1 and C_2 are connected in series. The combined capacity C is given by
a) $C_1 + C_2$ b) $C_1 - C_2$
c) $\frac{C_1C_2}{(C_1+C_2)}$ d) $\frac{(C_1+C_2)}{C_1C_2}$

298. Two capacitors C_1 and C_2 are connected in parallel. If a charge Q is given to the combination, the charge gets shared. The ratio of charge on C_1 to charge on C_2 is
a) $\frac{C_1}{C_2}$ b) $\frac{C_2}{C_1}$
c) C_1C_2 d) $\frac{1}{C_1C_2}$

299. The capacitance of two identical condensers connected in parallel is four times when they are connected in series. The ratio of the individual capacitances will be
a)1 : 2 b) 1 : 1
c) 2 : 1 d) 4 : 1

300. Two capacitors of equal capacities when connected in series have some resultant capacity. Then they are connected in parallel. The resultant capacity of parallel combination is
a) same as the series capacity
b) two times of the series capacity
c) three times of the series capacity
d) four times of the series capacity

301. If two capacitors 2 μF and 6 μF are put in series. The effective capacitance of the system will be
a) 8 μF b) 4 μF
c) 3 μF d) 3n μF

302. Two condensers each of 4 μF capacitance are joined in parallel. The resultant capacitance of the combination is
a) 2 μF b) 4 μF
c) 6 μF d) 8 μF

303. There are 10 condensers each of capacity 5 μF. The ratio between maximum and minimum capacity obtained from these condensers will be
a) 25 : 5 b) 40 : 1
c) 60 : 3 d) 100 : 1

304. Two capacitors of 3 μF and 6 μF are connected in series across a potential difference of 120 V. Then the potential difference across 3 μF capacitor is
a) 50 V b) 60 V
c) 70 V d) 80 V

305. Three identical capacitors each of capacitance C are connected in series and this connection is connected in parallel with one such more identical capacitor. Then, the capacitance of the whole combination is
a) 3C b) 4 C/3
c) 3 C/4 d) 2C

306. Two identical capacitors are joined in parallel, charged to a potential V, separated and they are connected in series i.e. the positive plate of one is connected to the negative of the other. Then,
a) charges on the free plates connected together are destroyed
b) the charges on the free plates are. enhanced
c) the energy stored in the system increases
d) the potential difference between the free plates becomes 2V.

307. Two capacitors of capacitances C_1 and C_2 are connected in series and potential difference V is applied across it. Then the potential difference across C_1 will be
a) $V\frac{C_2}{C_1}$ b) $\frac{V(C_1+C_2)}{C_1}$
c) $\frac{VC_2}{(C_1+C_2)}$ d) $\frac{VC_1}{(C_1+C_2)}$

308. Two condensers of capacity 3 μF and 6 μF respectively are connected in series. The combination is connected across a potential of 6V. The ratio of the energies stored by the condensers will be

a) $\frac{1}{2}$ b) $\frac{2}{1}$

c) $\frac{1}{4}$ d) $\frac{4}{1}$

309. Two capacitors having capacities C_1 and C_2 are charged to voltages V_1 and V_2 respectively. There will be no exchange of energy in connecting them in parallel, if

a) $C_1 = C_2$ b) $C_1V_1 = C_2V_2$

c) $V_1 = V_2$ d) $\frac{C_1V_1}{C_2V_2}$

310. A 200 V battery is connected across the combination of capacitors of capacities 5 μF and 10 μF in series. The charge on each capacitor is

a) 2.667×10^{-4} C b) 6.667×10^{-4} C

c) 2×10^{-4} C d) 3×10^{-4} C

311. Two capacitors of capacitances 10 μF and 20 μF are connected in series across a potential difference of 100V. The potential difference across each condenser is respectively

a) 66.67 V, 33.33 V b) 60 V, 40 V

c) 50 V, 50 V d) 90 V, 10 V

312. A 100 volt battery is connected across the series combination of the two capacitors of 4 μF and 8 μF. The energy stored in the series combination is

a) $\frac{3}{4} \times 10^{-2}$ J b) $\frac{4}{3} \times 10^{-2}$ J

c) 0.5 J d) 1 J

313. When two capacitances are connected in series, the equivalent capacitance is 2.4 μF and when they connected in parallel, it is 10 μF. The individual capacitances are

a) 6 μF and 4 μF b) 5 μF and 5 μF

c) 7 μF and 3 μF d) 8 μF and 2 μF

314. Two capacitors, one of 4 JlF and the other of 5 μF, are connected in parallel and then charged on a 100 V supply. The charge on each capacitor is respectively

a) 0.4 mC and 0.5 mC

b) 0.4 mC and 0.8 mC

c) 4 mC and 5 mC

d) 4 mC and 8 mC

315. Two condensers of capacities 8 μF, and 4 μF are connected in parallel across a potential difference of 120 V. The charge and potential difference across 4 μF capacitor is respectively

a) 1 mC, 10 V b) 0.2 mC, 20 V

c) 0.4 mC, 60 V d) 0.48 mC, 120 V

316. A capacitor C_1 is charged to a p.d.V. The charging battery is then removed and the capacitor is connected to an uncharged capacitor C_2. The final p.d. across the combination is

a) $V\frac{C_1}{C_1 + C_2}$ b) $V\frac{C_2}{C_1 + C_2}$

c) $V\frac{C_1C_2}{C_1 + C_2}$ d) $\frac{V}{C_1 + C_2}$

317. An infinite number of capacitors, having capacitances 1 μF, 2 μF , 4 μF and 8 μF ..... are connected in series. The equivalent capacitance of the system is

a) infinite b) 0.25 μF

c) 0.5 μF d) 2 μF

318. Two capacitors of 3 pF and 6 pF are connected in series and a p.d. of 5000 V is applied across the combination. They are then disconnected and reconnected in parallel. The p.d. across the combination is

a) 2250 V b) 1111 V

c) 2.25×10^6 V d) 1.1×10^6 V

319. A parallel plate capacitor having a plate separation of 2 mm is charged by connecting it to a 300 V supply. The energy density is

a) 0.01 J/m³ b) 0.1 J/m³

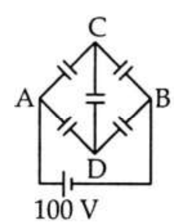
c) 1 J/m³ d) 10 J/m³

320. The capacitors of 8 μF, 8 μF and 4 μF are connected in parallel across a source of p.d. 120 V. The total charge on the effective capacity will be

a) 2.4 mC b) 240 μC

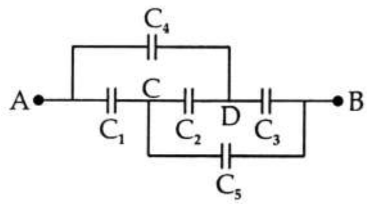
c) 0.24 mC d) 24 μC

321. Five capacitors each of 10 μF capacitance are connected as shown to a source of e.m.f. The equivalent capacitance between point A and B is



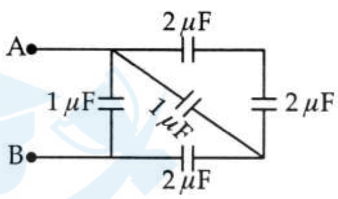
a) 40 μF b) 30 μF
c) 20 μF d) 10 μF

322. Find the effective capacitance between points A and B in the following figure.
If $C_1 = C_3 = C_4 = C_5 = 4$ μF and $C_2 = 10$ μF



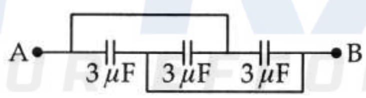
a) 8 μF b) 6 μF
c) 2.5 μF d) 4 μF

323. The net capacitance of system of capacitors in figure between points A and B is



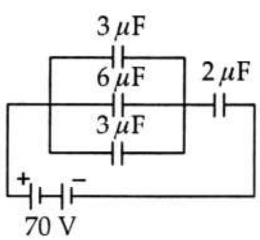
a) 1 μF b) 2 μF
c) 3 μF d) 4 μF

324. The equivalent capacity between the points A and B in the following figure will be



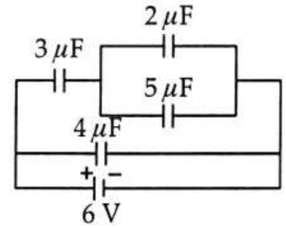
a) 9 μF b) 1 μF
c) 4.5 μF d) 6 μF

325. The p.d. across the capacitance of 2 μF in the figure along with is



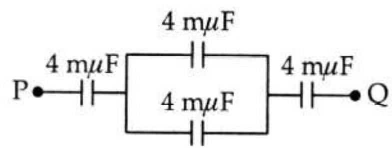
a) 10 V b) 60 V
c) 28 V d) 56 V

326. A circuit is shown in the figure given below. Find out the charge of the condenser having capacity 5 μF



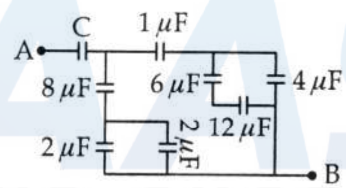
a) 4.5 μC b) 9 μC
c) 7 μC d) 30 μC

327. Four condensers each of capacity 4 m μF are connected as shown in the adjoining figure. If $V_P - V_Q = 15$ V, the energy stored in the system is



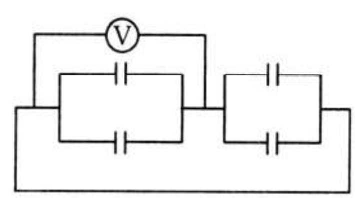
a) 2.4 ergs b) 1.8 ergs
c) 3.6 ergs d) 5.4 ergs

328. In the following figure the resultant capacitance between A and B is 1 μF. The capacitance C is



a) $\frac{32}{11}$ μF b) $\frac{11}{32}$ μF
c) $\frac{23}{32}$ μF d) $\frac{32}{23}$ μF

329. Four capacitors of 25 μF each are connected as shown in figure. If the D.C. voltmeter reads 200V, charge on each plate of the capacitor is



a) 2×10^{-3} C b) 5×10^{-3} C
c) 2×10^{-2} C d) 5×10^{-2} C

330. The electric potential at the surface of an atomic nucleus (Z = 50) of radius 9×10^{-15} m is
a) 4×10^6 V b) 8×10^6 V

c) 4×10^{-6} V   d) 8×10^{-6} V

331. An oil drop is found floating freely between the plates of a parallel plate condenser, the plates being horizontal and the lower plate carrying a charge + Q. The area of each plate is A and the distance of separation between them is D. The charge on oil drop must be (g is acceleration due to gravity)

a) $\frac{mg \in_0}{Q}$ b) $\frac{mg \in_0 A}{Q}$

c) $\frac{mg \in_0 A^2}{Q}$ d) $\frac{mg \in_0 A}{Q^2}$

332. Three charges +4q, Q and q are placed in a straight line of length I at points distant, 0, $l/2$ and l respectively. What should be Q in order to make the net force on q to be zero?

a) Q = –q   b) Q = q

c) Q = q^2 d) Q = 2q

333. Two point charges + ge and +e are kept at a distance 'a' from each other. A third charge is placed at a distance 'x' from +ge on the line joining the above two charges. For the third charge to be in equilibrium 'x' is

a) 3a/4   b) 3a/2

c) a/2   d) a/4

334. An electron of mass me initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p, also initially at rest takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio t_2/t_1 is nearly equal to

a) $\frac{m_P}{m_e}$ b) $\left(\frac{m_P}{m_e}\right)^2$

c) $\left(\frac{m_P}{m_e}\right)^{1/2}$ d) $\left(\frac{m_P}{m_e}\right)^{3/2}$

335. Electrons are caused to fall through a potential difference of 1500 V. If they are initially at rest, their final speed is

a) 23×10^7 m/s   b) 2.3×10^7 m/s

c) 32×10^7 m/s   d) 3.2×10^7 m/s

336. The electric field in a region of space is given by,

$E = 5\,\vec{i} + 2\,\vec{j}$ N/C

The electric flux through an area 2 m^2 lying in the YZ plane in SI unit is

a) 10   b) 20

c) 5   d) 15

337. A given charge situated at a certain distance from an electric dipole in the end on position experiences a force F. If the distance of the charge is doubled, the force acting on the charge will be

a) F/2   b) F/4

c) F/8   d) F/16

338. Two small spheres, each carrying a charge q are placed r m apart and they interact with force F. If one of the sphere is taken around the other once in a circular path, the work done will be equal to

a) 0   b) F

c) 2F   d) F/2

339. A charge q is placed at the centre of the line joining two exactly equal positive charges Q. The system of the three charges will be in equilibrium, if q is equal to

a) Q/4   b) – Q/4

c) – Q/8   d) Q/8

340. n small drops of same size are charged to V volt each. If they coalesce to form a single large drop, then its potential will be

a) V n   b) V n^2

c) V/n   d) $Vn^{2/3}$

341. A charged particle of mass m and charge q is released from rest in an elect field of constant magnitude E. The K.E. of the particle after a time t is

a) $\frac{1}{2}\frac{q^2E^2t^2}{m}$ b) $\frac{q^2E^2t^2}{m}$

c) $\frac{1}{4}\frac{q^2E^2t^2}{m}$ d) $\frac{1}{4}\frac{q^2Et^2}{m}$

342. A H_2 atom consists of a proton and an electron that revolves in a circular orbit around the proton with a radius of 5.3×10^{-9} cm. If the electron moves so that its centrifugal force is just equal to the electrostatic force then the speed is

a) 22×10^7 m/s   b) 2.2×10^6 m/s

c) 3.2×10^7 m/s   d) 3.2×10^7 m/s

343. A parallel plate condenser with air as dielectric has capacity $C_0 = \frac{\in_0 A}{d}$. A thin mica sheet of

dielectric constant K and thickness t is introduced near the first plate and then moved with constant velocity v towards the other plate. The capacity of the condenser will be

a) $\dfrac{\epsilon_0 A}{d - t + \dfrac{t}{k}}$ b) $\dfrac{\epsilon_0 Av}{d - t + \dfrac{t}{k}}$

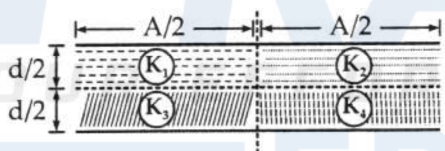
c) $\dfrac{\epsilon_0 Av}{d - t}$ d) $\dfrac{\epsilon_0 A}{d - t}$

344. If K is the dielectric constant of the medium. A is area of insulated charged plates and d is the distance between two plates of parallel plate condenser then its capacity in CGS unit is

a) $\dfrac{KA}{4\pi d}$ b) $\dfrac{KA}{2\pi d}$

c) $\dfrac{KA}{\pi d}$ d) $\dfrac{KA}{d}$

345. The space between parallel plate capacitors is filled with four dielectrics of equal dimensions but of dielectric constants K_1, K_2, K_3 and K_4 respectively. If K is the dielectric constant of a single dielectric that must be filled between capacitor plates to have the same capacitance between A and B. Then we must have



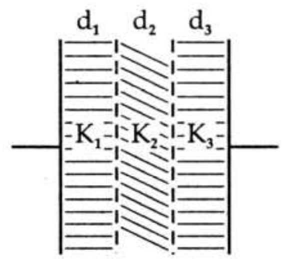
a) $\dfrac{1}{K} = \dfrac{1}{K_1 + K_2} + \dfrac{1}{K_3 + K_4}$

b) $\dfrac{1}{K} = \dfrac{1}{K_1 + K_2} - \dfrac{1}{K_3 + K_4}$

c) $\dfrac{1}{K} = \dfrac{1}{K_1 - K_2} + \dfrac{1}{K_3 - K_4}$

d) $\dfrac{1}{K} = \dfrac{1}{K_1 - K_2} - \dfrac{1}{K_3 - K_4}$

346. The expression for the capacity of the capacitor formed by compound dielectric placed between the plates of a parallel plate capacitor as shown in figure will be



a) $\dfrac{\epsilon_0 A}{\dfrac{d_1}{K_1} + \dfrac{d_2}{K_2} + \dfrac{d_3}{K_3}}$ b) $\dfrac{\epsilon_0 A}{\dfrac{d_1}{K_1} - \dfrac{d_2}{K_2} - \dfrac{d_3}{K_3}}$

c) $\dfrac{\epsilon_0 A^2}{\dfrac{d_1}{K_1} - \dfrac{d_2}{K_2} - \dfrac{d_3}{K_3}}$ d) $\dfrac{\epsilon_0 A^2}{\dfrac{d_1}{K_1} + \dfrac{d_2}{K_2} + \dfrac{d_3}{K_3}}$

347. Two insulated metallic spheres .of capacitances 3 μF and 5 μF are charged to 300 V and 500 V respectively. The energy loss when they are connected by a wire is

a) 0.375 J b) 0.037.5J

c) 0.735 J d) 0.0735 J

348. A 500 μF capacitor is charged at a steady rate 100 μC/s. The potential difference across the capacitor will be 10 V after an interval of

a) 5 s b) 0.5 s

c) 0.05 s d) 50 s

349. An uncharged capacitor with a solid dielectric is connected to a similar air capacitor charged to a potential of V_0. If the common potential after sharing of charges becomes V, then the dielectric constant of the dielectric must be

a) $\dfrac{V_0 - V}{V}$ b) $\dfrac{V_0 + V}{V}$

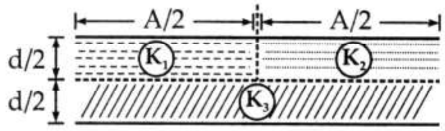
c) $\dfrac{V_0}{V}$ d) $\dfrac{V_0}{2V}$

350. The area of the plates of a parallel plate capacitor is A and the distance between the plates is 10 mm. There are two dielectric sheets in it, one of dielectric constant 10 and thickness 6 mm and the other of dielectric constant 5 and thickness 4 mm. The capacity of the capacitor is

a) $\dfrac{5000}{7}\epsilon_0 A$ b) $\dfrac{500}{7}\epsilon_0 A$

c) $\dfrac{50}{7}\epsilon_0 A$ d) $\dfrac{50}{14}\epsilon_0 A$

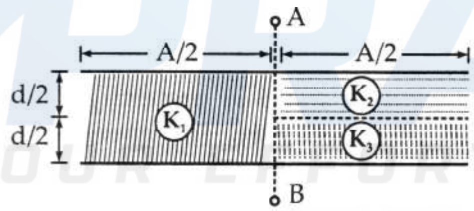
351. A parallel plate capacitor of area A, plate separation d and capacitance C is filled with three different dielectric of dielectric constants K_1, K_2 and K_3 as shown in figure. If a single dielectric material is to be used to have the same capacitance C of this capacitance, then its dielectric constant K is given by



a) $\frac{1}{K_1+K_2}+\frac{1}{2K_3}$ b) $\frac{1}{K_1+K_2}-\frac{1}{2K_3}$

c) $\frac{1}{K_1-K_2}+\frac{1}{2K_3}$ d) $\frac{2}{K_1+K_2}+\frac{1}{2K_3}$

352. A parallel plate capacitor is constructed using three different dielectric materials as shown in figure. The parallel plates across which a potential difference is applied are of area A = 1 cm^2 and are separated by a distance d = 2 mm. If $K_1 = 4$, $K_2 = 6$ and $K_3 = 2$, find capacitance across points A and B



a) 1.56 pF b) 2.56 pF
c) 2.65 pF d) 3 pF

3.10 Van de Graff generator

353. Van de Graff generator produces
a) high voltage and high current
b) high voltage and low current
c) low voltage and high current
d) low voltage and low current

354. Van de Graff generator is
a) an electromagnetic machine
b) an electrostatic machine
c) an electrodynamic machine
d) used to produce charged particles

355. Van de Graff generator is also called
a) high voltage generator
b) low voltage generator
c) ac generator
d) dc generator

356. In Van de Graff generator potential difference is produced which is in the order of
a) 10^7 V b) 10^3 V
c) 10^2 V d) 10^{12} V

357. Which of the following instruments works on the principle of action of sharp points?
a) Van de Graff generator
b) Cyclotron
c) Dynamo
d) Induction coil

358. In Van de Graff generator, the process of spraying the charge is called
a) gases discharge b) corona discharge
c) electron discharge d) none of these

359. Van de Graff generator is used to produce high energetic charged particles of energy of about
a) 10 MeV b) 50 MeV
c) 100 MeV d) 0.5 MeV

360. Van de Graff generator is used to
a) produce radioactive isotopes
b) study nuclear structure
c) study different types of nuclear reactions
d) all of these

361. Van de Graff generator is used to
a) carry out radioactive disintegration
b) produce ac voltage
c) convert ac into de voltage
d) produce total internal reflection

Examples for practice

362. The number of lines of force starting from a point charge of 10 μC in vacuum are
a) 1.2×10^6 Nm^2/C b) 1.3×10^6 Nm^2/C
c) 1.13×10^6 Nm^2/C d) 2.3×10^6 Nm^2/C

363. The number of tubes of force originating from a point charge of 17.7×10^{-8} C placed in dielectric medium of dielectric constant 4 are
a) 3000 Nm^2/C b) 5000 Nm^2/C
c) 6000 Nm^2/C d) 5500 Nm^2/C

364. A plane surface of element of area 1 mm^2 is situated in a uniform electric field of intensity 9×10^6 N/C with its plane making an angle of 30° with the direction of the field. The .electric flux through the surface element is
a) 4.5 Nm^2/C b) 3.5 $N.m^2/C$

c) 0.5 Nm^2/C d) 2.5 Nm^2/C

365. An isolated conducting sphere of diameter 20 cm placed in air carries a charge of 9 μC. The electric intensity at a point at a distance of 10 cm from the surface of the charged sphere is
a) 10.25×10^5 N/C b) 15.25×10^5 N/C
c) 25.25×15^5 N/C d) 20.25×10^5 N/C

366. A charged cylindrical conductor of infinite length has charge per unit length of 10 μC/m. The electric intensity at a point at a distance of 20 cm from its axis in the surrounding medium is 2.5×10^5 N/e. The relative permittivity of the surrounding medium is
a) 3.6 b) 2.6
c) 4.6 d) 3.0

367. An electric cable of diameter 10 cm runs under water (k for water = 81) for a distance of 5 km. If the cable carries a charge of 0.01 C on its surface. The electric intensity at a distance of 95 cm from the surface of the cable is
a) 2.4×10^2 N/C b) 4.4×10^2 N/C
c) 4.4×10^3 N/C d) 4.4×10^{-2} N/C

368. The surface charge density of a conducting sphere is 8.85×10^{-10} C/m^2 and the electric field intensity at a distance of 4 m from the centre of the sphere is 10^{-2} V/m. The radius of the sphere, assuming the sphere to be in vacuum is
a) 3 cm b) 4 mm
c) 4 cm d) 4 km

369. Find the electric field intensity due to a positively charged conducting cylinder with radius 1 cm and surface charge density 10^{-9} C/m^2, at a point at a distance of 2 m from the axis of cylinder. The dielectric constant of the medium surrounding the cylinder is 2.
a) 0.28 V/m b) 1.28 V/m
c) 2.28 V/m d) 1.00 V/m

370. The electric field near the surface of the earth is 300 V/m. The surface density of charge on the earth's surface is
a) 3.65×10^{-9} C/m^2 b) 2.65×10^9 C/m^2
c) 3.65×10^9 C/m^2 d) 2.65×10^{-9} C/m^2

371. A closed conducting sphere is positively charged such that the surface charge density is 17.7×10^{-12} C/m^2. If the dielectric constant of the medium surrounding the conductor is 100, then electric field intensity at a point just outside it will be
a) 1.02 V/m b) 0.02 V/m
c) 1.22 V/m d) 2.22 V/m

372. The outward pull on a metal plate of area 0.01 m^2 having a charge density of 50 $\mu C/m^2$ is
a) 1.4 N b) 2.4 N
c) 0.4 N d) 1.8 N

373. A circular metal plate of radius 10 cm is given a charge of 20 μC. The outward pull on the plate in the vacuum is
a) 560 N b) 370 N
c) 360 N d) 630 N

374. A metal sphere of radius 10 cm is charged to a potential of 100 V. The outward pull per unit area of the surface is
a) 4.4×10^{-6} N/m^2 b) 2.4×10^{-6} N/m^2
c) 4.4×10^6 N/m^2 d) 4.2×10^{-6} N/m^2

375. The energy density at a point in vacuum is 1.77×10^{-7} J/m^3. The intensity of the electric field at the point is
a) 100 V/m b) 200 V/m
c) 300 V/m d) 400 V/m

376. The capacitance of earth, treating it as a spherical conductor of radius 6400 km is
a) 5.1×10^{-4} F b) 6.1×10^{-4} F
c) 7.1×10^4 F d) 7.1×10^{-4} F

377. A parallel plate condenser consists of two plates each of area 100 cm/. They are separated by mica sheet of thickness 8.85 mm. If the relative permittivity of mica is 6. Then capacity of parallel plate condenser is
a) 50 pF b) 40 pF
c) 60 pF d) 30 pF

378. The charge and energy stored in the capacitor of capacity 32 μF, when it is charged to a potential difference of 0.6 kV are respectively
a) 1.92×10^{-2} C, 5.76 J
b) 2.92×10^{-2} C, 5.76 J
c) 1.92×10^2 C, 5.76 J
d) 1.92×10^{-2} C, 4.76 J

379. Four condensers having capacities 2pF, 3pF, 4pF and 6 pF are connected in series. The equivalent capacity of the combination is
a) 8.0 pF b) 0.8 pF
c) 1.8 pF d) 0.4 pF

380. When two capacitors are connected in series, the equivalent capacitance is 1.2 μF. When they are connected in parallel, the equivalent capacitance is 5 μF. The capacitances of the capacitors are

a) 3 μF and 2 μF b) 4 μF and 1 μF
c) 2.5 μF and 2.5 μF d) 3.5 μF and 1.5 μF

381. Parallel combination of two condensers of capacities 2 μF and 4 μF and the series combination of two condensers of capacities 6 μF and 12 μF are connected in series. The equivalent capacity of entire combination is
a) 4.4 μF b) 2.2 μF
c) 2.4 μF d) 1.4 μF

382. Two insulated spherical conductors of capacities 1 μF and 2 μF are charged to 100 V and 200 V respectively. The conductors are then brought in contact. The charges on the sphere after contact are
a) 1.6×10^{-4} C, 3.3×10^{-4} C
b) 2.6×10^{-4} C, 3.3×10^{-4} C
c) 1.6×10^{-4} C, 4.3×10^{-4} C
d) 2.6×10^{-4} C, 4.3×10^{-4} C

383. Two capacitors of capacitances 3 μF and 5 μF respectively are connected in parallel and this combination is connected in series with a third capacitor of capacitance 2 μF. A potential difference of 100 V is applied across the entire combination. The charge and the potential difference across the third capacitor is
a) 100 μC, 40 V b) 100 μC, 80 V
c) 160 μC, 40 V d) 160 μC, 80 V

384. A condenser having a capacity of 50 μF is charged to a potential of 200 V. If the area of each plate of the condenser is 10 cm^2 and the distance between the plates is 0.1 mm. The energy per unit volume of the field between the plates is
a) 106 J/m^3 b) 10^{-6} J/m^3
c) 107 J/m^3 d) 10^{-7} J/m3

385. The cell membrane of a resting nerve in a human body has a thickness of 75 A. If potential difference between the two sides of membrane is 0.06 V. Then intensity of electric field is
a) 8×10^{6} V/m b) 4×10^{6} V/m
c) 8×10^{-6} V/m d) 4×10^{-6} V/m

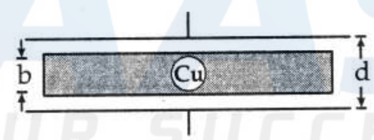
386. A parallel plate capacitor with air between the plates has a capacitance 2 μF. The capacity of the condenser when the distance between the plates is reduced to half of initial distance is
a) 3 μF b) 4.4 μF
c) 2.4 μF d) 4 μF

387. A conductor of capacity 2 μF is charged to a potential of 200 V. If .an additional charge of -2×10^{-4} C is deposited on it, then resultant potential will be
a) 110 V b) 100 V
c) 200 V d) 220 V

388. A plane conductor with very large dimensions is charged such that surface charge density is 1.6×10^{-2} C/m^2. The electric field intensity at a point near it if the conductor is in a medium of dielectric constant 5 is
a) 1.8×10^{8} V/m b) 1.8×10^{-2} V/m
c) 1.8×10^{-6} V/m d) 1.8×10^{2} V/m

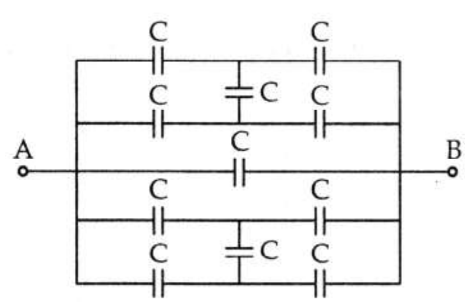
389. Condensers of capacities 5 F and 10 F are connected in parallel in a circuit with a cell of e.m.f. 2 V. The capacity of the condenser to be connected in series with parallel combination of the condensers to get 1 C charge to flow in the circuit is
a) 0.62 F b) 0.52 F
c) 1.62 F d) 0.42 F

390. A slab of copper of thickness b is inserted in between the plates of a parallel plate capacitor as shown in figure. The separation of the plates is d. If b = d/2, then the ratio of capacities of the capacitor after and before inserting the slab will be



a) 1 : 1 b) 1 : $\sqrt{2}$
c) 2 : 1 d) $\sqrt{2}$: 1

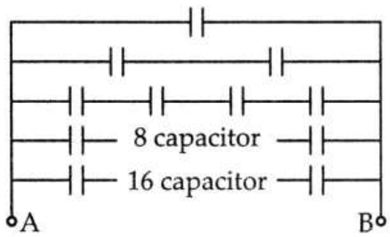
391. In the following diagram, the effective capacitance between A and B is



a) C b) 2 C
c) 3 C d) 4 C

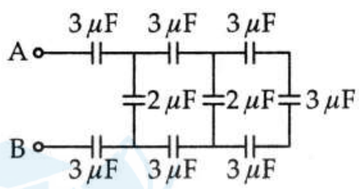
392. An infinite number of identical capacitors, each of capacitance 1 μF, are connected as in the

adjoining figure. Then the equivalent capa– citance between 'A' and 'B' is



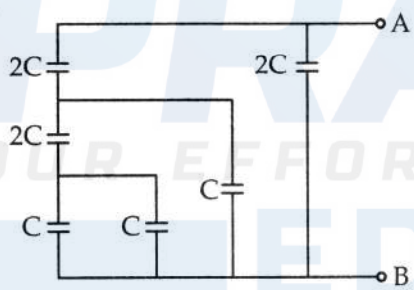
a) 1 μF b) 2 μF
c) 0.5 μF d) ∞

393. The resultant capacitance between A and B in the following figure is



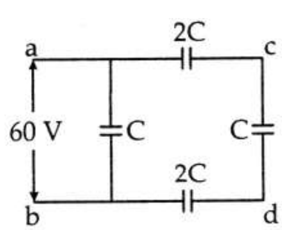
a) 1 μF b) 2 μF
c) 2 μF d) 3 μF

394. The effective capacity between A and B of the given network is



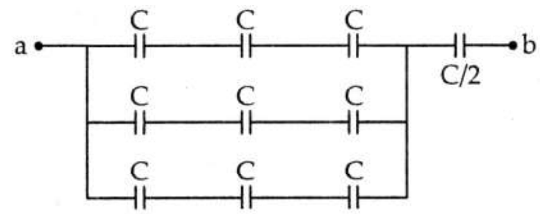
a) 3 C b) 2 C
c) C d) $\frac{C}{3}$

395. In the circuit shown in figure, a potential difference of 60 V is applied between a and b. The potential difference between the points c and d is



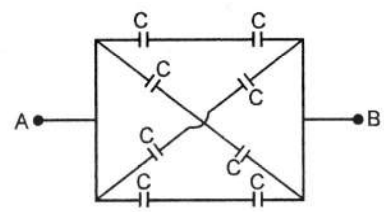
a) 60 V b) 45 V
c) 40 V d) 30 V

396. Refer to network shown in figure. The effective capacitance between a and b is



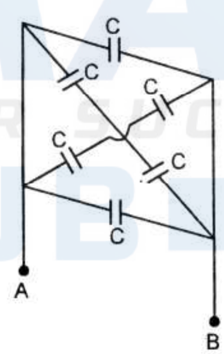
a) C b) $\frac{C}{2}$
c) $\frac{C}{3}$ d) $\frac{C}{4}$

397. In the adjoining circuit, the capacity between the points A and B will be



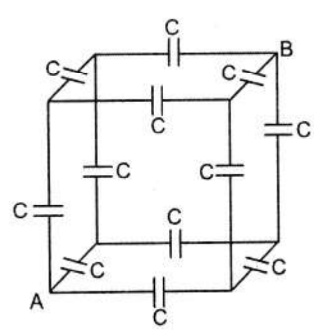
a) C b) 2C
c) 3C d) 4C

398. The resultant capacity between the points A and B in the adjoining circuit will be



a) C b) 2C
c) 3C d) 4C

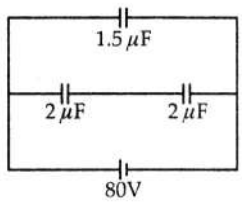
399. Each edge of the cube contains a capacitance C. The equivalent capacitance between the points A and, B will be



a) $\frac{6C}{5}$ b) $\frac{5C}{6}$

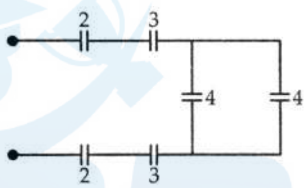
c) $\frac{12C}{7}$ d) $\frac{7C}{12}$

400. If figure (below) the charge on the 1.5 μF capacitor is



a) 60 μC b) 90 μC
c) 120 μC d) 30 μC

401. The effective capacity between A and B in the figure given is (in μF)



a) $\frac{43}{24}$ b) $\frac{24}{43}$

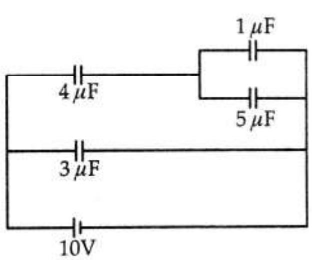
c) $\frac{43}{12}$ d) $\frac{12}{43}$

402. The capacity of a condenser in which a dielectric of dielectric constant 5 has been used, is C. If the dielectric is replaced by another with dielectric constant 20, the capacity will become

a) 4 C b) 2 C

c) $\frac{C}{2}$ d) $\frac{C}{4}$

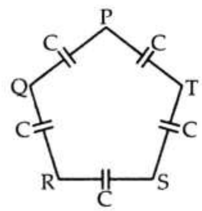
403. The charge on 4 μF capacitor in the given circuit is .... in μC.



a) 12 b) 24
c) 36 d) 42

404. Three capacities of respective capacities 6, 4 and 2 μF are connected in parallel and P.D. of 5 volt applied across it. Its total capacity and the charge on each condenser in order will be
a) 12 μF; 30 μC; 10 μC; 20 μC
b) 12 μF; 10 μC; 30 μC; 20 μC
c) 12 μF; 10 μC; 20 μC; 30 μC
d) 12 μF; 30 μC; 20 μC; 10 μC

405. Five capacitors, each of capacitance value C are connected as shown in the figure. The radio of capacitance between P and R, and the capacitance between P and Q is



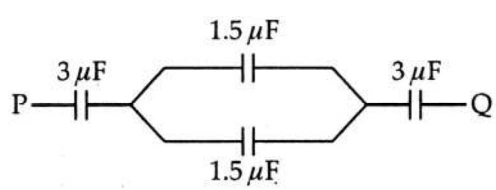
a) 3 : 1 b) 5 : 2
c) 2 : 3 d) 1 : 1

Questions given in MHT–CET

406. The capacity of a parallel plate capacitor increases with the
a) increase of its area
b) decrease of its area
c) increase of distance between plates
d) it is independent on area

407. A capacitor of 20 μF is charged up to 500 volts is connected in parallel with another capacitor of 10 μF which is charged up to 200 V. The common potential is
a) 500 V b) 400 V
c) 300 V d) 200 V

408. The capacitance between the points P and Q in the following circuit is

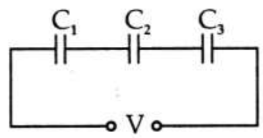


a) 3.5 μF b) 3 μF
c) 2 μF d) 1 μF

409. A 4 μF capacitor is charged to 400 V. If its plates are joined through a resistance of 4 kΩ, then heat produced in the resistance will be

a) 0.16 J b) 0.32 J
c) 0.64 J d) 1.28 J

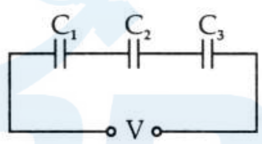
410. In the figure, three capacitors each of capacitance 6 pF are connected in series. The total capacitance of the combination will be



a) 9 pF b) 6 pF
c) 3 pF d) 2 pF

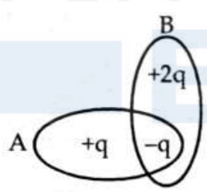
411. A 700 pF capacitor is charged by a 50 V battery. The electrostatic energy stored in it is
a) 6.7×10^{-7} J b) 8.7×10^{-7} J
c) 9.7×10^{7} J d) 6.7×10^{7} J

412. The potential difference across the capacitor C_2 in the adjoining figure is
(C_1 = 20 e.s.u., C_2 = 30 e.s.u., C_3 = 15 e.s.u. and V = 90 e.s.u.)



a) 10 e.s.u. b) 30 e.s.u.
c) 40 e.s.u. d) 20 e.s.u.

413. What is T.N.E.I. through the surface A and B respectively?

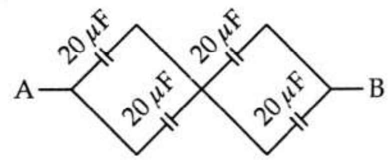


a) (q, 2q) b) (−q, −2q)
c) (0, q) d) (q, 0)

414. The number of tubes of force through a charge 'q' is
a) q b) $q/\in_0$
c) $2q/\in_0$ d) 0

415. A parallel plate capacitor of 6 μF is connected across 18 V battery and charged. The battery is then disconnected and oil of dielectric constant 2.1 is introduced between the plates. What will be the charge on capacitor?
a) 50 μC b) 108 μC
c) 60 μC d) 85 μC

416. Four capacitors are connected as shown in figure. The equivalent capacitance between A and B is



a) 80 μF b) 40 μF
c) 60 μF d) 20 μF

417. Ampere second is unit of
a) capacitance b) charge
c) energy d) power

418. The capacity of a parallel plate condenser is 12 μF. Its capacity, when the separation between plates is doubled and area is halved will be
a) 3 μF b) 12 μF
c) 6 μF d) 1.5 μF

419. A charged conductor has an area of 1 m^2 and charge of $\sqrt{8.85}$ μC. The force acting on unit area of the conductor is
a) 0.05 N/m^2 b) 1.5 N/m^2
c) 0.5 N/m^2 d) 2.5 N/m^2

420. If a 4 μFcapacitor is charged to 1 kV, then energy stored in the capacitor is
a) 1 J b) 4 J
c) 6 J d) 2 J

421. How do you arrange four equal capacitors of 4 μF to get effective capacity of 3 μF?
a) three in series, one in parallel
b) two in parallel, two in series
c) three in parallel, one in series
d) all four in series

422. A cylinder is charged by 10 mC. Length of cylinder is 1 km and radius is 1 mm. Surface density of charge of cylinder is
a) 1.59×10^{-4} C/m^2 b) 1.59×10^{-2} C/m^2
c) 1.59×10^{-3} C/m^2 d) 1.59×10^{-5} C/m^2

423. If charge q is induced on outer surface of sphere of radius R, then intensity at a point P at a distance S from its centre is
a) inversely proportional to $(S + R)^2$
b) inversely proportional to R^2
c) inversely proportional to S^2
d) directly proportional to S^2

424. When three identical capacitors are connected in series, their equivalent capacitance is 2 μF.

Now they are connected in parallel across a source of e.m.f. 200 V. The total energy stored is

a) 0.36 J b) 0.48 J
c) 0.16 J d) 0.08 J

425. In a parallel plate capacitor with air, the distance between the plates is reduced to half and the space is filled with dielectric of constant 4. If initial capacity of capacitor is 2 μF, then final value of capacity is

a) 4 μF b) 8 μF
c) 16 μF d) 2 μF

426. Unit of electric flux is

a) Vm b) V/m
c) Nm/C d) C/Nm

427. Consider a sphere of radius R and cylinder of length L. If both have same charge density c and E_s and E_c are electric intensity at a point at a distance r from axis of sphere and cylinder respectively, then E_s equal to

a) $\frac{E_c R}{r}$ b) $\frac{E_c r}{R}$

c) $\frac{2E_c r}{R}$ d) $\frac{E_c r}{2R}$

428. The energy required to move a charge of 0.25 C between two points 4×10^{20} eV. The potential difference between them is

a) 100 V b) 256 V
c) 200 V d) 128 V

429. A parallel plate capacitor has a capacity C. If a medium of dielectric constant K is introduced between plates, the capacity of capacitor becomes

a) $\frac{C}{K}$ b) $\frac{C}{K^2}$

c) M^2C d) KC

430. Two capacitors of capacities 1 μF and 4 μF are connected in series with battery of 200 V. The voltage across them are in the ratio of

a) $\frac{1}{2}$ b) $\frac{2}{1}$

c) $\frac{1}{4}$ d) $\frac{4}{1}$

431. Energy stored in a condenser of capacity 10 μF, charged to 6 KV is used to lift a mass of 10 gm. The height to which the body call be raised is

a) 180 m b) 18 m
c) 1.8 m d) 1800 m

432. Three charges + 5 C, + 7 C and – 4 C are situated within a body and charges – 5 C, – 7 C and + 4 C are situated outside the body. The T.N.E.I over the closed surface is

a) – 8 C b) 0
c) + 8 C d) 10 C

433. Electric intensity at a point just outside a charged conductor of any shape is

a) $\frac{\sigma}{\epsilon_0 K}$ b) $\frac{\sigma}{2\epsilon_0 K}$

c) $\frac{2\sigma}{\epsilon K}$ d) $\frac{\sigma^2}{2\epsilon K}$

434. A capacitor of 20 μF is given a potential difference of 500 V and a 10 μF capacitor is charged through a potential difference of 200 V. What is the potential across each when they are connected in parallel?

a) 200 V b) 400 V
c) 600 V d) 800 V

435. A string is compressed by 2 mm by a force of 8 N and a condenser is charged through a potential difference of 200 V possess a charge of 80 μC. The ratio of the energy stored in the two bodies is

a) 1 b) 3/2
c) 2 d) 1/2

436. Condenser is a device used to store

a) large charge at low potential
b) large charge at high potential
c) less charge at low potential
d) less charge at high potential

437. Two condensers each of capacity 4 μF are connected in series and third condenser of capacity 4 μF is connected in parallel with the combination. The equivalent capacitance of the arrangement is

a) 12 μF b) 8 μF
c) 6 μF d) 2.65 μF

438. Three capaciter of capacitance C (μF) are connected in parallel to which a capacitor of capacitance C is connected in series. Effective capacitance is 3.75 then capacity of each capacitor is

a) 4 μF b) 5 μF
c) 6 μF d) 8 μF

439. If a dielectric is inserted in charged capacitor (battery removed), the quantity that remains constant is
a) capacitance b) potential
c) intensity d) charge

440. A charged oil drop is suspended in uniform field of 3×10^4 V/m so that it is neither falls nor rises. The charge on the oil drop will be (take mass of charge = 0.9×10^{-15} kg & 9 = 10 m/s²)
a) 3.3×10^{-18} C b) 3.2×10^{-18} C
c) 1.6×10^{-18} C d) 4.8×10^{-18} C

441. In a parallel plate capacitor, the capacity increases if
a) area of plate is decreased
b) distance between plate increases
c) area of plate is increased
d) dielectric constant decreases

442. The electric intensity outside a charged sphere of radius R at a distance r (r > R) is
a) $\frac{\sigma R^2}{\varepsilon_0 r^2}$ b) $\frac{\sigma r^2}{\varepsilon_0 R^2}$
c) $\frac{\sigma R}{\varepsilon_0 r}$ d) $\frac{\sigma r}{\varepsilon_0 R}$

443. Capacity of a capacitor is 48 mF. When it is charged from 0.1 C to 0.5 C change in energy stored is
a) 2500 J b) 2.5×10^{-3} J
c) 2.5×10^6 J d) 2.42×10^{-2}

444. A charged cylinder of radius 3 mm has surface density of charge 4 μC/m². It is placed in a medium of dielectric constant 6.28. The electric intensity at a point at a distance of 1.5 m from its axis is
a) 1.44 V/m b) 2.44 V/m
c) 3 V/m d) 0.5 V/m

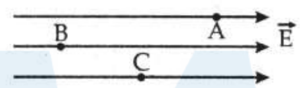
445. If A is the area of each plate, charge on it is q and potential difference is V then the distance between the parallel plate capacitor is
a) $\frac{\varepsilon_0 AV}{2q}$ b) $\frac{\varepsilon_0 AV}{q}$
c) $\frac{2\varepsilon_0 AV}{q}$ d) $\frac{AV}{q}$

446. If n identical capacitors are connected in series and then in parallel then the ratio of effective capacity in parallel and in series combination i.e. $\frac{C_P}{C_S}$ is
a) n b) 1/n
c) n^2 d) $1/n^2$

447. Two identical capacitors are first connected in series and then in parallel. The difference between their effective capacities is 3 μF. The capacity of each capacitor is
a) 3 μF b) 4 μE
c) 2 μF d) 5 μE

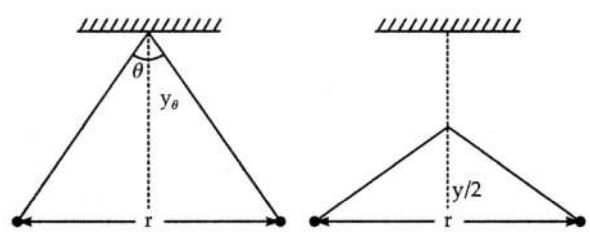
448. Van de Graff generator produces
a) high voltage and high current
b) high voltage and low current
c) low voltage and high current
d) low voltage and low current

449. A, B and C are the points in a uniform electric field. The electric potential is



a) maximum at B
b) maximum at C
c) same at all the three points A, B and C
d) maximum at A

450. Two pith balls carrying equal charges are suspended from a common point by strings of equal length, the equilibrium separation between them is r. Now the strings are rigidly clamped at half the height. The equilibrium seperation on between the balls now become



a) $\left(\frac{r}{\sqrt[3]{2}}\right)$ b) $\left(\frac{2r}{\sqrt{3}}\right)$
c) $\left(\frac{2r}{3}\right)$ d) $\left(\frac{r}{\sqrt{2}}\right)^2$

451. Surface density of charge on a sphere of radius 'R' in terms of electric intensity 'E' at a distance 'r' in free space is (ε_0 = permittivity of free space)

a) $\in_0 E\left(\frac{R}{r}\right)^2$ b) $\frac{\in_0 ER}{r^2}$

c) $\in_0 E\left(\frac{r}{R}\right)^2$ d) $\frac{\in_0 Er}{R^2}$

452. Two concentric spheres kept in air have radii 'R' and 'r'. They have similar charge and equal surface charge density 'σ'. The electric potential at their common centre is

($\in_0$ = permittivity of free space)

a) $\frac{\sigma(R+r)}{\in_0}$ b) $\frac{\sigma(R-r)}{\in_0}$

c) $\frac{\sigma(R+r)}{2\in_0}$ d) $\frac{\sigma(R+r)}{4\in_0}$

453. In air, a charged soap bubble of radius 'r' is in equilibrium having outside and inside pressures being equal. The charge on the drop is ($\in_0$ = permittivity of free space, T = surface tension of soap solution)

a) $4\pi r^2\sqrt{\frac{2T\in_0}{r}}$ b) $4\pi r^2\sqrt{\frac{4T\in_0}{r}}$

c) $4\pi r^2\sqrt{\frac{6T\in_0}{r}}$ d) $4\pi r^2\sqrt{\frac{8T\in_0}{r}}$

454. Two charges of equal magnitude 'q' are placed in air at a distance '2a' apart and third charge '–2q' is placed at midpoint. The potential energy of the system is ($\in_0$ = permittivity of free space)

a) $-\frac{q^2}{8\pi\in_0 a}$ b) $-\frac{3q^2}{8\pi\in_0 a}$

c) $-\frac{5q^2}{8\pi\in_0 a}$ d) $-\frac{7q^2}{8\pi\in_0 a}$

455. The difference in the effective capacity of two similar capacitors when joined in series and then in parallel is 6 µF. The capacity of each capacitor is

a) 2 µF b) 4 µF

c) 8 µF d) 16 µF

456. An electron of mass 'm' and charge 'q' is accelerated from rest in a uniform electric field of strength 'E'. The velocity acquired by it as it travels a distance 'l' is

a) $\left[\frac{2Eql}{m}\right]^{1/2}$ b) $\left[\frac{2Eq}{ml}\right]^{1/2}$

c) $\left[\frac{2Em}{ql}\right]^{1/2}$ d) $\left[\frac{Em}{ml}\right]^{1/2}$

457. The electric field intensity at a point near and outside the surface of a charged conductor of any shape is 'E_1'. The electric field intensity due to uniformly charged infinite thin plane sheet is 'E_2' The relation between 'E_1' and 'E_2' is

a) $2E_1 = E_2$ b) $E_1 = E_2$

c) $E_1 = 2E_2$ d) $E_1 = 4E_2$

458. A capacitor C_1 = 4 µF is connected in series with another capacitor C_2 = 1 µF. The combination is connected across d.c. source of 200 V. The ratio of potential across C_2 to C_1 is

a) 2 : 1 b) 4 : 1

c) 8 : 1 d) 16 : 1

Answers

1.	(a)	2.	(d)	3.	(a)	4.	(d)	5.	(c)	6.	(a)	7.	(b)	8.	(d)	9.	(a)	10.	(a)
11.	(c)	12.	(c)	13.	(a)	14.	(d)	15.	(a)	16.	(b)	17.	(b)	18.	(c)	19.	(b)	20.	(d)
21.	(a)	22.	(b)	23.	(d)	24.	(a)	25.	(c)	26.	(d)	27.	(d)	28.	(b)	29.	(d)	30.	(c)
31.	(b)	32.	(a)	33.	(c)	34.	(c)	35.	(b)	36.	(a)	37.	(b)	38.	(b)	39.	(b)	40.	(a)
41.	(d)	42.	(d)	43.	(b)	44.	(b)	45.	(a)	46.	(a)	47.	(b)	48.	(d)	49.	(c)	50.	(d)
51.	(d)	52.	(a)	53.	(c)	54.	(a)	55.	(b)	56.	(a)	57.	(a)	58.	(a)	59.	(a)	60.	(c)
61.	(a)	62.	(b)	63.	(d)	64.	(b)	65.	(c)	66.	(c)	67.	(b)	68.	(b)	69.	(b)	70.	(b)
71.	(c)	72.	(a)	73.	(b)	74.	(d)	75.	(a)	76.	(b)	77.	(c)	78.	(a)	79.	(b)	80.	(b)
81.	(d)	82.	(b)	83.	(a)	84.	(c)	85.	(d)	86.	(c)	87.	(d)	88.	(a)	89.	(a)	90.	(a)
91.	(c)	92.	(a)	93.	(a)	94.	(a)	95.	(a)	96.	(b)	97.	(c)	98.	(a)	99.	(b)	100.	(b)
101.	(d)	102.	(c)	103.	(a)	104.	(b)	105.	(d)	106.	(a)	107.	(d)	108.	(d)	109.	(a)	110.	(d)
111.	(c)	112.	(a)	113.	(b)	114.	(b)	115.	(a)	116.	(b)	117.	(a)	118.	(d)	119.	(a)	120.	(a)
121.	(b)	122.	(a)	123.	(b)	124.	(b)	125.	(a)	126.	(b)	127.	(a)	128.	(b)	129.	(d)	130.	(a)
131.	(a)	132.	(d)	133.	(d)	134.	(a)	135.	(b)	136.	(a)	137.	(d)	138.	(a)	139.	(a)	140.	(b)
141.	(d)	142.	(a)	143.	(a)	144.	(b)	145.	(a)	146.	(b)	147.	(a)	148.	(a)	149.	(a)	150.	(b)
151.	(c)	152.	(a)	153.	(a)	154.	(d)	155.	(b)	156.	(a)	157.	(b)	158.	(c)	159.	(a)	160.	(b)
161.	(a)	162.	(a)	163.	(a)	164.	(b)	165.	(d)	166.	(c)	167.	(a)	168.	(a)	169.	(d)	170.	(b)
171.	(a)	172.	(d)	173.	(a)	174.	(a)	175.	(d)	176.	(a)	177.	(a)	178.	(c)	179.	(b)	180.	(c)
181.	(a)	182.	(b)	183.	(a)	184.	(b)	185.	(c)	186.	(d)	187.	(d)	188.	(c)	189.	(b)	190.	(a)
191.	(a)	192.	(c)	193.	(a)	194.	(a)	195.	(a)	196.	(c)	197.	(a)	198.	(b)	199.	(c)	200.	(a)
201.	(a)	202.	(b)	203.	(a)	204.	(c)	205.	(a)	206.	(d)	207.	(c)	208.	(c)	209.	(a)	210.	(b)
211.	(d)	212.	(d)	213.	(c)	214.	(c)	215.	(c)	216.	(d)	217.	(d)	218.	(d)	219.	(c)	220.	(b)
221.	(b)	222.	(a)	223.	(a)	224.	(d)	225.	(b)	226.	(b)	227.	(b)	228.	(a)	229.	(d)	230.	(d)
231.	(a)	232.	(b)	233.	(b)	234.	(d)	235.	(a)	236.	(a)	237.	(a)	238.	(a)	239.	(d)	240.	(d)
241.	(b)	242.	(a)	243.	(d)	244.	(b)	245.	(c)	246.	(a)	247.	(c)	248.	(b)	249.	(b)	250.	(b)
251.	(b)	252.	(b)	253.	(b)	254.	(d)	255.	(b)	256.	(a)	257.	(d)	258.	(a)	259.	(b)	260.	(a)
261.	(c)	262.	(d)	263.	(a)	264.	(c)	265.	(a)	266.	(a)	267.	(b)	268.	(c)	269.	(a)	270.	(d)
271.	(d)	272.	(c)	273.	(a)	274.	(a)	275.	(c)	276.	(b)	277.	(a)	278.	(d)	279.	(c)	280.	(d)
281.	(c)	282.	(c)	283.	(a)	284.	(a)	285.	(b)	286.	(a)	287.	(d)	288.	(a)	289.	(b)	290.	(a)
291.	(b)	292.	(b)	293.	(a)	294.	(a)	295.	(b)	296.	(a)	297.	(c)	298.	(a)	299.	(b)	300.	(d)
301.	(d)	302.	(d)	303.	(d)	304.	(d)	305.	(b)	306.	(d)	307.	(c)	308.	(b)	309.	(c)	310.	(b)
311.	(a)	312.	(b)	313.	(a)	314.	(a)	315.	(d)	316.	(a)	317.	(c)	318.	(b)	319.	(b)	320.	(a)
321.	(d)	322.	(d)	323.	(b)	324.	(a)	325.	(b)	326.	(b)	327.	(b)	328.	(d)	329.	(b)	330.	(b)
331.	(b)	332.	(a)	333.	(a)	334.	(c)	335.	(b)	336.	(a)	337.	(c)	338.	(a)	339.	(b)	340.	(d)
341.	(a)	342.	(b)	343.	(a)	344.	(a)	345.	(a)	346.	(a)	347.	(b)	348.	(d)	349.	(a)	350.	(a)
351.	(a)	352.	(a)	353.	(b)	354.	(b)	355.	(a)	356.	(a)	357.	(a)	358.	(b)	359.	(a)	360.	(d)
361.	(a)	362.	(c)	363.	(b)	364.	(a)	365.	(d)	366.	(a)	367.	(b)	368.	(c)	369.	(a)	370.	(d)
371.	(b)	372.	(a)	373.	(c)	374.	(a)	375.	(b)	376.	(d)	377.	(c)	378.	(a)	379.	(b)	380.	(a)
381.	(c)	382.	(a)	383.	(d)	384.	(c)	385.	(a)	386.	(d)	387.	(b)	388.	(a)	389.	(b)	390.	(a)
391.	(c)	392.	(b)	393.	(a)	394.	(a)	395.	(d)	396.	(c)	397.	(b)	398.	(c)	399.	(b)	400.	(c)
401.	(b)	402.	(a)	403.	(b)	404.	(d)	405.	(c)	406.	(a)	407.	(b)	408.	(d)	409.	(b)	410.	(d)

Answers

411.	(b)	412.	(d)	413.	(c)	414.	(b)	415.	(b)	416.	(d)	417.	(b)	418.	(a)	419.	(c)	420.	(d)
421.	(c)	422.	(c)	423.	(c)	424.	(a)	425.	(c)	426.	(a)	427.	(a)	428.	(b)	429.	(d)	430.	(d)
431.	(d)	432.	(c)	433.	(a)	434.	(b)	435.	(a)	436.	(a)	437.	(c)	438.	(b)	439.	(d)	440.	(a)
441.	(c)	442.	(a)	443.	(a)	444.	(a)	445.	(b)	446.	(c)	447.	(c)	448.	(b)	449.	(a)	450.	(a)
451.	(c)	452.	(a)	453.	(d)	454.	(d)	455.	(b)	456.	(a)	457.	(c)	458.	(b)				

Hint / Solutions

21. $q = ne$

$\therefore n = \dfrac{q}{e} = \dfrac{4 \times 10^{-7}}{1.6 \times 10^{-19}} = 2.5 \times 10^{12}$

23. $n = \dfrac{q}{e}$

$\therefore$ mass of n electrons $= \dfrac{q}{e} \times 9.1 \times 10^{-31}$

$= 11.38 \times 10^{-19}$ kg

24. $q = ne = 1500 \times 1.6 \times 10^{-19}$

$= 2.4 \times 10^{-16}$ C

31. $F = \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q_1 q_2}{r^2}$

$= \dfrac{9 \times 10^9 \times 1.6 \times 1.6 \times 10^{-38}}{(5.3 \times 10^{-11})^2}$

$= 8.2 \times 10^{-8}$ N

32. $k = \dfrac{F_a}{F_m}$ $\quad \therefore F_m = \dfrac{F_a}{k} = 2$ N

33. $F = \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q_1 q_2}{r^2}$

$\therefore F = \dfrac{9 \times 10^9 \times 5 \times 10^{-6} \times 2 \times 10^{-6}}{(10 \times 10^{-2})^2} = 9$ N

43. $E = \dfrac{F}{q} = \dfrac{2.25}{15 \times 10^{-4}} = 1500$ N/C

44. $F = mg = eE$

$\therefore E = \dfrac{mg}{e} = \dfrac{9.1 \times 10^{-31} \times 9.8}{1.6 \times 10^{-19}}$

$= 5.573 \times 10^{-11}$ N/C

45. $E = \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q}{r^2}$

$\therefore E = \dfrac{9 \times 10^9 \times 5 \times 10^{-3}}{0.04} = 1.125 \times 10^9$ V/m

46. $E_1 = E_2$

$\therefore \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q_1}{r_1^2} = \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q_2}{r_2^2}$

$\dfrac{r_1}{r_2} = \sqrt{\dfrac{q_1}{q_2}} = \sqrt{\dfrac{4q}{q}} = 2$

Since $r_1 + r_2 = a$

$\therefore r_1 = \dfrac{2}{3} a$

60. $E = \dfrac{V}{d} = \dfrac{10}{10^{-2}} = 1000$ N/C

77. $\tau = pE \sin\theta = 2\,l\,q\,E \sin\theta$

$= 2 \times 10^{-2} \times 1 \times 10^{-6} \times 1 \times 10^5 \times \sin 90$

$= 2 \times 10^{-3}$ Nm

80. $V = \dfrac{1}{4\pi \epsilon_0} \times \dfrac{q}{r} = \dfrac{9 \times 10^9 \times 25 \times 10^{-6}}{10}$

$= 22500$ V

110. $\phi = ds\,E \cos\theta$

$= 100 \times 10^{-4} \times 100 \times \cos 60$

$= 0.5$ Nm^2/C

111. $\phi = \dfrac{q}{\epsilon_0} = \dfrac{10^{-7}}{8.85 \times 10^{-12}} = 1.13 \times 10^4$ Nm^2/C

123. $N = \dfrac{q}{\epsilon_0 k} = \dfrac{8.85 \times 10^{-9}}{8.85 \times 10^{-12} \times 5} = 200$

124. The electric flux through each surface of the cube is given by,

$\phi = \dfrac{1}{6}$ total flux $= \dfrac{30}{6} = 5$

163. $R^2 = \dfrac{E \epsilon_0 k r^2}{\sigma} = \dfrac{4\pi \times 10^4 \times 8.85 \times 10^{-12} \times 4}{64 \times 10^{-7}}$

$\therefore R = 0.83$ m

164. $E = \dfrac{1}{4\pi \epsilon_0 k} \dfrac{q}{r^2} = \dfrac{9 \times 10^9 \times 10^{-7}}{1 \times 0.2 \times 0.2}$

$\therefore E = 2.25 \times 10^4$ N/C

165. $E = \dfrac{\sigma}{\epsilon_0 k} = \dfrac{120 \times 10^{-6}}{8.85 \times 10^{-12} \times 4}$

$= 3.389 \times 10^6$ N/C

166. $E = \dfrac{V}{r} = \dfrac{100}{5 \times 10^{-2}} = 2$ kV/m

167. $E = \dfrac{\sigma R^2}{\epsilon_0 k r^2}$

$\therefore \sigma = \dfrac{10^4 \times 8.85 \times 10^{-12} \times 1}{(25 \times 10^{-2})^2} = 1.416\ \mu$C/m^2

168. $\sigma = \dfrac{q}{4\pi R^2} = \dfrac{8 \times 10^{-6}}{4 \times 3.14 \times (5 \times 10^{-2})^2}$

$= 2.547 \times 10^{-4}$ C/m^2

169. $E = \dfrac{1}{4\pi \epsilon_0 k} \dfrac{2q}{rL} = \dfrac{9 \times 10^9 \times 2 \times 5 \times 10^{-10}}{1 \times 0.2 \times 0.1}$

$= 450$ V/m

170. $E = \frac{1}{4\pi \epsilon_0 k}\frac{2q}{r} = \frac{9\times10^9\times2\times1.77\times10^{-6}}{2\times1}$
$= 1.593 \times 10^3$ V/m

171. $\lambda = \frac{q}{L} = \frac{2\times10^{-2}}{2\times10^3} = 10\ \mu C/m$

172. $E = \frac{\sigma R}{\epsilon_0 kr} = \frac{8.85\times10^{-9}\times2\times10^{-2}}{8.85\times10^{-12}\times5\times4} = 1$ V/m

173. $E = \frac{\sigma}{\epsilon_0 k} = \frac{2\times10^{-4}}{8.85\times10^{-12}\times1}$
$= 2.259 \times 10^7$ N/C

174. $\lambda = \frac{q}{L} = \frac{0.01}{5\times10^3} = 2\ \mu C/m$

175. $\sigma = \frac{q}{2\pi R^2} = \frac{20\times10^{-6}}{2\times3.14\times10^{-2}}$
$= 3.184 \times 10^{-4}\ C/m^2$

176. $\sigma = \frac{q}{4\pi R^2}$
$\therefore q = \sigma 4\pi R^2$
$= 2.65 \times 10^{-9} \times 4 \times 3.14 \times (6.4 \times 10^6)^2$
$= 1.363 \times 10^6$ C

179. $F = \frac{\sigma^2 ds}{2\epsilon_0 k} = \frac{q^2}{2\epsilon_0 kds}$
$= \frac{(\sqrt{8.85}\times10^{-6})^2}{2\times8.85\times10^{-12}\times1\times1} = 0.5$ N

183. $f = \frac{\sigma^2}{2\epsilon_0 k} = \frac{q^2}{2\epsilon_0 kds^2}$
$= \frac{q^2}{32\epsilon_0 k\pi^2R^4}$ $(\because ds = 4\pi R^2)$
$= \frac{(12\times10^{-6})^2}{32\times8.85\times10^{-12}\times1\times9.87\times(10^{-1})^4}$
$= 5.151 \times 10^2\ N/m^2$

186. $u = \frac{1}{2}\epsilon_0 kE^2$
$\therefore E = \sqrt{\frac{2u}{\epsilon_0 k}} = \sqrt{\frac{2\times44.25\times10^{-8}}{8.85\times10^{-12}\times1}}$
$= 316.2$ N/C

188. $u = \frac{1}{2}\epsilon_0 kE^2 = \frac{8.85\times10^{-12}\times3\times10^4}{2}$
$= 13.28 \times 10^{-8}\ J/m^3$

189. Energy $= \frac{1}{2}\epsilon_0 kE^2 \times$ volume
$= \frac{8.85\times10^{-12}\times1\times10^6\times10^{-3}}{2}$
$= 4.425 \times 10^{-9}$ J

190. $u = \frac{1}{2}\epsilon_0 kE^2 = \frac{\epsilon_0 kV^2}{2d^2}$
$= \frac{8.85\times10^{-12}\times1\times2500}{2\times5\times10^{-3}\times5\times10^{-3}}$
$= 4.425 \times 10^{-4}\ J/m^3$

191. $u = \frac{1}{2}\epsilon_0 kE^2$
$\therefore$ Energy $= \frac{1}{2}\epsilon_0 kE^2 \times$ volume
$= \frac{8.85\times10^{-12}\times8\times(3\times10^3)^2\times(5)^3}{2}$
$= 39.82 \times 10^{-3}\ J/m^3$

192. $E = \frac{1}{4\pi\epsilon_0 k}\frac{q}{r^2} = \frac{9\times10^9\times20\times10^{-6}}{1\times625\times10^{-4}}$
$= 0.288 \times 10^7$ N/C
$\therefore u = \frac{1}{2}\epsilon_0 kE^2$
$= \frac{8.85\times10^{-12}\times1\times(0.288\times10^7)^2}{2}$
$= 36.7\ J/m^3$

219. Initially when potential difference is high, hence rate of flow of charge is high. But when potential difference across capacitor reaches the applied potential difference, this rate tends towards zero. Energy drawn from source = QV, but energy stored in capacitor = QV/2.

220. As source is disconnected hence $Q = q_1+q_2$, after disconnecting from the source they are connected in parallel, hence net potential difference $\neq V_1 + V_2$, when charged capacitor at different potentials are connected together their always occurs a loss of energy in the form of heat.

258. $C = \frac{\epsilon_0 A}{d - t\left(1-\frac{1}{k}\right)}$,

For metal k = ∞ and t is negligible.

$\therefore C = \frac{\epsilon_0 A}{d}$ = same

261. $C_m = C_{air} \times k$
$\therefore k = \frac{C_m}{C_{air}} = \frac{110}{50} = 2.2$

262. $V_m = \frac{V_{air}}{k}$ $\therefore k = \frac{V_{air}}{V_m} = \frac{1}{1/8} = 8$

263. $C_m = C_{air} \times k = Ck = kC$

264. If separation between the plates is doubled then capacity of condenser becomes C/2.
Now, $C_m = 3C$

Thus, $C_m = C_{air} \times k \qquad \therefore\ 3C = \frac{C}{2} \times k$

$\therefore\ k = 6$

265. $C_m = C_{air} \times k = 4 \times 5 = 20\ \mu F$

266. $C_m = C_{air} \times k \quad \therefore\ k = 4$

$\in\ = \in_0 k = 8.85 \times 10^{-12} \times 4$

$= 3.54 \times 10^{-11}\ C^2/Nm^2$

275. $$E = \frac{Q^2}{2C} = \frac{(40 \times 10^{-6})^2}{2 \times 10 \times 10^{-6}}$$

$= 80 \times 10^{-6}$ J

$= 800$ erg.

276. $$E = \frac{1}{2}CV^2 = \frac{1}{2} \times 4 \times 10^{-6} \times 10^4 = 0.02\ J$$

277. $$E = \frac{Q^2}{2C}$$

$$\therefore\ C = \frac{Q^2}{2E} = \frac{(6 \times 10^{-7})^2}{2 \times 4.5 \times 10^{-4}} = 4 \times 10^{-10}\ F$$

278. $$\delta E = \frac{1}{2}C_2V^2 - \frac{1}{2}C_1V^2$$

$$= \frac{1}{2} \times 10 \times 10^{-6} \times 10^4 - \frac{1}{2} 2 \times 10^{-6} \times 10^4$$

$= 4 \times 10^{-2}$ J

279. $$E = E_1 + E_2 = \frac{1}{2}(C_1 + C_2)V^2$$

$$= \frac{1}{2} \times 2 \times 10^{-6} \times 4 \times 10^4$$

$= 0.04$ J

280. $$\delta E = \frac{1}{2}CV_2^2 - \frac{1}{2}CV_1^2$$

$$= \frac{C}{2}(V_2^2 - V_1^2)$$

$$= \frac{6 \times 10^{-6}}{2}(400 - 100)$$

$= 9 \times 10^{-4}$ J

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

$$\therefore\ V = \sqrt{\frac{2E}{C}} = \sqrt{\frac{2 \times 1}{10 \times 10^{-6}}} = 447.2\ V$$

282. $$E = \frac{1}{2}QV = \frac{1}{2} \times 0.1 \times 200 = 10\ J$$

300. $$C_s = \frac{C_1C_2}{C_1 + C_2} = \frac{CC}{C + C} = \frac{C}{2}$$

$C_p = C + C = 2C$

Thus, $$\frac{C_s}{C_p} = \frac{C/2}{2C} = \frac{1}{4}$$

$\therefore\ C_p = 4\,C_s$

301. $$C_s = \frac{C_1C_2}{C_1 + C_2} = \frac{2 \times 6}{2 + 6} = \frac{3}{2}\ \mu F.$$

302. $C_p = C_1 + C_2 = 4 + 4 = 8\ \mu F$

303. $C_p = nC = 10 \times 5 = 50\ \mu F$

$C_s = C/n = 5/10 = 0.5\ \mu F$

$\therefore\ C_p/C_s = 50/0.5 = 100/1$

304. $$V_1 = \frac{Q}{C_1} = \frac{C_sV}{C_1} = \left(\frac{C_1C_2}{C_1 + C_2}\right)\frac{V}{C_1}$$

$$= \frac{3 \times 10^{-6} \times 6 \times 10^{-6} \times 120}{9 \times 10^{-6} \times 3 \times 10^{-6}} = 80\ V$$

307. $$V_1 = \frac{Q}{C_1} = \frac{C_sV}{C_1} = \left(\frac{C_1C_2}{C_1 + C_2}\right)\frac{V}{C_1} = \frac{VC_2}{C_1 + C_2}$$

308. $$V_1 = \frac{Q}{C_1} = \frac{VC_2}{C_1 + C_2} = \frac{6 \times 6}{3 + 6} = 4\ V$$

$$E_1 = \frac{1}{2}C_1V_1^2 = \frac{3 \times 10^{-6} \times 16}{2} = 24 \times 10^{-6}\ J$$

$$V_2 = \frac{Q}{C_2} = \frac{VC_1}{C_1 + C_2} = \frac{6 \times 3}{3 + 6} = 2\ V$$

$$E_2 = \frac{1}{2}C_2V_2^2 = \frac{6 \times 10^{-6} \times 4}{2} = 12 \times 10^{-6}\ J$$

$$\therefore\ \frac{E_1}{E_2} = \frac{24 \times 10^{-6}}{12 \times 10^{-6}} = \frac{2}{1}$$

309. Loss of energy $= \frac{1}{2}\left(\frac{C_1C_2}{C_1 + C_2}\right)(V_1 - V_2)^2$

If $V_1 = V_2$, loss of energy $= 0$

310. $$Q = C_sV = \left(\frac{C_1C_2}{C_1 + C_2}\right)V$$

$$= \left(\frac{5 \times 10}{5 + 10}\right) \times 10^{-6} \times 200$$

$= 6.667 \times 10^{-4}$ C

311. $$V_1 = \frac{Q}{C_1} = \frac{VC_2}{C_1 + C_2} = \frac{100 \times 20 \times 10^{-6}}{30 \times 10^{-6}}$$

$= 66.67$ V

$\therefore\ V_2 = V - V_1 = 100 - 66.67 = 33.33$ V

312. $$E = \frac{1}{2}C_sV^2 = \frac{1}{2}\left(\frac{C_1C_2}{C_1 + C_2}\right)V^2$$

$$= \frac{32 \times 10^{-6} \times 10^4}{2 \times 12} = \frac{4}{3} \times 10^{-2}\ J$$

314. $Q_1 = C_1V = 4 \times 10^{-6} \times 100 = 0.4$ mC

$Q_2 = C_2V = 5 \times 10^{-6} \times 100 = 0.5$ mC

315. $Q_1 = C_1V = 4 \times 10^{-6} \times 120 = 0.48$ mC

In parallel combination potential is same.

Therefore, V = 120 V

316. The charge on condenser $C_1 = Q_1 = C_1 V$

If it is connected across uncharged condenser of capacity C_2, then p.d. across C_2 is given by,

$$\text{potential} = \frac{Q_1}{C_2} = V\ \frac{C_1}{C_1+C_2}$$

317. $$\frac{1}{C} = \frac{1}{1}+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+.....$$

$$= 1 + 1 \text{ (approximately)}$$

$$\therefore\ C = 1/2 = 0.5\ \mu F$$

318. $$Q = Cs\ V = \left(\frac{C_1C_2}{C_1+C_2}\right) V = 10^{-8}\ C$$

In parallel, $V = \dfrac{Q}{C_1+C_2} = \dfrac{10^{-8}}{9\times10^{-12}} = 1111\ V$

319. $$u = \frac{1}{2} \epsilon_0 K E^2$$

$$= \frac{8.85\times10^{-12}}{2} \times 1 \times \left(\frac{300}{2\times10^{-3}}\right)^2$$

$$= 0.1\ J/m^3.$$

320. $$Q = C_p V = (C_1+C_2+C_3) V$$

$$= 20 \times 10^{-6} \times 120 = 2.4\ mC$$

321. The given circuit is Wheatstone's bridge of condensers. The bridge is balanced. Thus, effective capacitance between path ACB is,

$$C_{s1} = \frac{CC}{C+C} = \frac{C}{2}.$$

Similarly effective capacitance between path ADB is,

$$C_{s2} = \frac{CC}{C+C} = \frac{C}{2}.$$

Now, C_{s1} and C_{s2} are in parallel.

Therefore, $C_p = C/2 + C/2 = C = 10\ \mu F$

322. Let, $C_1 = C_3 = C_4 = C_5 = C$

The given circuit is Wheatstone's bridge of condensers. The bridge is balanced. Thus, effective capacitance between path ACB is,

$$C_{s1} = \frac{CC}{C+C} = \frac{C}{2}.$$

Similarly effective capacitance between path ADB is, $C_{s2} = \dfrac{CC}{C+C} = \dfrac{C}{2}.$

Now, C_{s1} and C_{s2} are in parallel.

Therefore, $C_p = C/2 + C/2 = C = 4\ \mu F$

324. It is equivalent to a parallel combination of three condensers.

Therefore, $C_p = C_1 + C_2 + C_3 = 9\ \mu F$

325. From figure, equivalent capacity of 3 μF, 6 μF and 3 μF condensers is $C_p = 12\ \mu F$.

Now, C_p and condenser of 2 μF are in series. Thus, p.d. across 2 μF condenser is,

$$V = \left(\frac{VC_p}{C_1+C_p}\right) = \frac{70\times12\times10^{-6}}{14\times10^{-6}} = 60\ V$$

326. From figure, charge on condenser of capacity 3 μF is,

$$Q_1 = C_1V = 3 \times 10^{-6} \times 6 = 18 \times 10^{-6}\ C.$$

Thus, p.d. across C_1 is,

$$V_1 = \frac{VC_p}{C_1+C_p} \quad \text{where } Cp = 2 + 5 = 7\ \mu F$$

$$= \frac{7\times6}{10} = 4.2\ V$$

Thus, p.d. across C_p is, 1.8 V

Now, charge on 5 μF condenser is,

$$Q_2 = 5 \times 10^{-6} \times 1.8 = 9\ \mu C$$

327. From figure, the equivalent capacity of the combination is,

$$\frac{1}{C_s} = \frac{1}{4} + \frac{1}{(4+4)} + \frac{1}{4} = \frac{5}{8}$$

$$\therefore\ C_s = \frac{8}{5}\ m\mu F \qquad \text{Thus,}$$

$$E = \frac{1}{2} C_s V^2 = \frac{1}{2} \times \frac{8}{5} \times 10^{-9} \times 225$$

$$= 1.8 \times 10^{-7}\ J$$

$$= 1.8\ \text{erg}.$$

328. From figure, equivalent capacitance of 6 μF, 12 μF and 4 μF condensers is, $C_1 = 8\ \mu F$.

Similarly equivalent capacitance of 8 μF, 2 μF and 2 μF condensers is, $C_2 = 8/3\ \mu F$.

The equivalent capacitance of 8 μF and 1 μF condensers is, $C_3 = 8/9\ \mu F$.

The equivalent of C_2 and C_3 is, 32/9 μF.

Now, equivalent of C and 32/9 μF condenser is 1 μF.

Thus, C = 32/23 μF.

329. All the capacitors are in parallel and potential difference across each is 200 V.

$$\therefore\ Q = CV$$

$$= 25 \times 10^{-6} \times 200$$

$$= 5 \times 10^{-3}\ C$$

330. $$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r} = \frac{1}{4\pi\epsilon_0} = \frac{Ze}{r} = 8 \times 10^6\ V$$

331. The wt. of oil drop is balanced by force i.e. mg = E q

$$\therefore\ q = \frac{mg}{E} = \frac{mg\,\epsilon_0}{\sigma} = \frac{mg\,\epsilon_0\,A}{Q}$$

332. The net force acting on charge q should be zero.

$$F = \frac{1}{4\pi\epsilon_0}\left[\frac{4q\times q}{l^2}+\frac{Q\,q}{(l/2)^2}\right]=0$$

$\therefore\quad q+Q=0\Rightarrow Q=-q$

333. The net force acting on charge should be zero.

$$F = \frac{1}{4\pi\epsilon_0}\left[\frac{9e.q_0}{x^2}+\frac{q_0 e}{(a-x)^2}\right]=0$$

$$\frac{9}{x^2} = \frac{1}{(a-x)^2} \qquad \therefore \frac{3}{x}=\frac{1}{a-x}$$

$$\therefore\quad x = \frac{3a}{4}$$

334. $S = \frac{1}{2}at^2 = \left(\frac{eE}{m}\right)t^2$

Now, $\frac{t^2}{m}$ = Constant for same distance

Thus, $m \propto t^2$

$$\therefore\quad \frac{m_e}{m_p} = \frac{t_e^2}{t_p^2} \qquad \therefore \frac{t_p}{t_e}=\sqrt{\frac{m_p}{m_e}}$$

i.e. $\frac{t_2}{t_1} = \left(\frac{m_p}{m_e}\right)^{1/2}$

335. $v = \sqrt{\frac{2qV}{m}} = 2.3\times10^7$ m/s

336. Along X axis E is 5 N/C, YZ plane is perpendicular to X axis

$\therefore\quad \phi = E\,ds = 5\times2 = 10$

337. $F\propto\frac{1}{r^3} \qquad \therefore F'=\frac{F}{8}$

338. Work done in equipotential surface is zero.

339. For equilibrium net force must be zero

i.e. $\frac{1}{4\pi\epsilon_0}\frac{Qq}{(r/2)^2}+\frac{1}{4\pi\epsilon_0}\frac{QQ}{r^2} = 0$

$\therefore\quad q = \frac{-Q}{4}$

340. Let q be charge on each drop of radius r.

Thus, pot. of each drop V = q/r $\quad\therefore q = Vr$

Now charge on n drops = n q = n V r = Q

Now volume of n drops = vol. of big drop

$\therefore\quad \frac{4}{3}\pi r^3 n = \frac{4}{3}\pi R^3 \qquad \therefore R = r\,n^{1/3}$

Thus,

pot. of big drop $= \frac{Q}{R} = \frac{nVr}{r\,n^{1/3}} = Vn^{2/3}$

341. $F = qE \;\therefore$ acceleration $= a = \frac{qE}{m}$

Velocity $= v = at = \frac{qEt}{m}$

$\therefore\quad$ K.E. $= \frac{1}{2}mv^2 = \frac{1}{2}\frac{q^2E^2t^2}{m}$

342. $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$

$\therefore\quad v = 2.2\times10^6$ m/s

343. The capacity of parallel plate condenser does not depend upon the velocity of the plate. Thus, if mica sheet of thickness t and dielectric K is introduced between the plates of parallel plate condenser, then its capacity is given by,

$$\frac{\epsilon_0 A}{d-t+\frac{t}{k}}$$

344. The capacity of parallel plate condenser is given by,

$$C = \frac{KA\epsilon_0}{d} = \frac{KA\epsilon_0}{d}\frac{4\pi}{4\pi}$$

$\therefore\quad C = \frac{KA}{4\pi d}$ (in C. G. S. unit)

345. The given capacitor may be supposed to be formed of four component capacitors C_1, C_2, C_3 and C_4. The capacitor C_1 and C_2 are in parallel and C_3 and C_4 are in parallel.

From figure,

$$C_1 = \frac{AK_1\epsilon_0}{2d/2} = \frac{A\epsilon_0K_1}{d}$$

$$C_2 = \frac{A\epsilon_0K_2}{d}$$

$$C_3 = \frac{A\epsilon_0K_3}{d}$$

$$C_4 = \frac{A\epsilon_0K_4}{d}$$

Now,

$$\frac{1}{C} = \frac{1}{C_{P1}}+\frac{1}{C_{P2}}$$

$$\frac{1}{C} = \frac{1}{C_1+C_2}+\frac{1}{C_3+C_4}$$

$$\frac{1}{\frac{AK\epsilon_0}{d}} = \frac{1}{\frac{A\epsilon_0}{d}K_1+\frac{A\epsilon_0}{d}K_2}+\frac{1}{\frac{A\epsilon_0}{d}K_3+\frac{A\epsilon_0}{d}K_4}$$

$$\frac{1}{K} = \frac{1}{K_1+K_2}+\frac{1}{K_3+K_4}$$

346. The given capacitor may be supposed to be formed of three component capacitors C_1, C_2 and C_3 connected in series.

$$\frac{1}{C_s} = \frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$$

$$= \frac{d_1}{AK_1\epsilon_0}+\frac{d_2}{AK_2\epsilon_0}+\frac{d_3}{AK_3\epsilon_0}$$

$$C_s = \frac{\epsilon_0 A}{\frac{d_1}{K_1}+\frac{d_2}{K_2}+\frac{d_3}{K_3}}$$

347. The loss of energy is given by,

$$\Delta E = \frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)(V_1-V_2)^2 = 0.0375\text{ J}$$

348. $V = \frac{q}{C} = \frac{(dq/dt)\times t}{C} \quad \therefore t = \frac{V\cdot C}{(dq/dt)} = 50\text{ s}$

349.
$$V = \frac{C_1V_1+C_2V_2}{C_1+C_2}$$

$$= \frac{CK\times 0+CV_0}{CK+C} = \frac{C\,V_0}{C\,(K+1)} = \frac{V_0}{K+1}$$

$$K = \frac{V_0-V}{V}$$

350.
$$C = \frac{\epsilon_0 A}{\frac{t_1}{K_1}+\frac{t_2}{K_2}} = \frac{\epsilon_0 A}{\frac{6\times10^{-3}}{10}+\frac{4\times10^{-3}}{5}}$$

$$C = \frac{5000}{7}\epsilon_0 A$$

351. The given capacitor may be supposed to be formed of three component capacitors C_1, C_2 and C_3. Let K_1, K_2 and K_3 be dielectric constant of C_1, C_2 and C_3 respectively. Condenser C_1 and C_2 are in parallel. Let $C_p = C_1 + C_2$. Now, C_p and C_3 are connected in series. There equivalent capacitance is given by C_s.

From figure, $C_p = C_1 + C_2$

$$C_p = \frac{AK_1\epsilon_0}{2\frac{d}{2}} + \frac{AK_2\epsilon_0}{2\frac{d}{2}} = \frac{A\epsilon_0}{d}(K_1+K_2)$$

Now C_p and C_3 are in series

$$\frac{1}{C_s} = \frac{1}{C_p}+\frac{1}{C_3} \qquad \left(C_3 = \frac{2AK_3\epsilon_0}{d}\right)$$

$$\frac{1}{C_s} = \frac{1}{\frac{A\epsilon_0}{d}(K_1+K_2)}+\frac{1}{\frac{2A\epsilon_0K_3}{d}}$$

$$\frac{1}{\frac{AK\epsilon_0}{d}} = \frac{1}{\frac{A\epsilon_0}{d}(K_1+K_2)}+\frac{1}{\frac{A\epsilon_0}{d}2K_3}$$

$$\therefore \frac{1}{K} = \frac{1}{K_1+K_2}+\frac{1}{2K_3}$$

352. Let K_1, K_2 and K_3 be the dielectric for C_1, C_2 and C_3 respectively.
From figure,

$$C_1 = \frac{AK_1\epsilon_0}{2d},\ C_2 = \frac{AK_2\epsilon_0}{d} \text{ and } C_3 = \frac{AK_3\epsilon_0}{d}$$

Now, $$\frac{1}{C_s} = \frac{1}{C_2}+\frac{1}{C_3} = \frac{d}{A\epsilon_0K_2}+\frac{d}{A\epsilon_0K_3}$$

$$C_s = \frac{A\epsilon_0}{d}\left(\frac{2K_2K_3}{K_2+K_3}\right) = \frac{A\epsilon_0K'}{d}$$

Where $$K' = \left(\frac{2K_2K_3}{K_2+K_3}\right) = \frac{2\times6\times2}{6+2} = 3$$

Now $$C = C_1+C_s = \frac{A\epsilon_0K_1}{2d}+\frac{A\epsilon_0K^1}{2d}$$

$$= \frac{A\epsilon_0}{d}\left(\frac{K_1+K^1}{2}\right)$$

by putting the values we have,

$$C = 1.56\text{ pF}$$

362. $N = \frac{q}{\varepsilon_0} = \frac{10\times10^{-6}}{8.85\times10^{-12}} = 1.13\times10^6\text{ Nm}^2/\text{C}.$

363. $N = \frac{q}{\varepsilon_0 k} = \frac{17.7\times10^{-8}}{8.85\times^{-12}\times4} = 5000\text{ Nm}^2/\text{C}.$

364. $\phi = dSE \text{ as } \theta = 1\times10^{-6}\times9\times10^6\times\cos 60$
$= 4.5\text{ Nm}^2/\text{C}.$

365. $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = \frac{9\times10^9\times9\times10^{-6}}{(10\times10^{-2})^2}$
$= 20.25\times10^5\text{ N/C}.$

366. $E = \frac{1}{4\pi\varepsilon_0 k}\frac{2q}{r} \quad \therefore k = \frac{1}{4\pi\varepsilon_0}\frac{2q}{Er}$

$$= \frac{9\times10^9\times2\times10\times10^{-6}}{2.5\times10^5\times0.2} = 3.6.$$

367. $E = \frac{1}{4\pi\varepsilon_0 k}\frac{2q}{r} = \frac{1}{4\pi\varepsilon_0 k}\frac{2Q}{rL}$

$$= \frac{9\times10^9\times2\times0.01}{81\times1\times5\times10^3} = 4.4\times10^2\text{ N/C}.$$

368.
$$E = \frac{\sigma R^2}{\varepsilon_0 k r^2}$$

$$\therefore R^2 = \frac{E\varepsilon_0 kr^2}{\sigma} = \frac{10^{-2}\times8.85\times10^{-12}\times1\times16}{8.85\times10^{-10}}$$

$$R = 4\text{ cm}$$

369. $E = \dfrac{\sigma R}{\varepsilon_0 kr} = \dfrac{10^{-9}\times1\times10^{-12}}{8.85\times10^{-12}\times2\times2} = 0.28$ V/m.

370. $E = \dfrac{\sigma}{\varepsilon_0 k}$ $\therefore$ $\sigma = E\,\varepsilon_0 k = 300 \times 8.85 \times 10^{-12} \times 1$

$= 2.65 \times 10^{-9}$ C/m^2

371. $E = \dfrac{\sigma}{\varepsilon_0 k} = \dfrac{17.7\times10^{-12}}{8.85\times10^{-12}\times100} = 0.02$ V/m.

372. $F = \dfrac{\sigma^2 dS}{2\varepsilon_0 k} = \dfrac{(50\times10^{-6})^2\times0.01}{2\times8.85\times10^{-12}\times0.01} = 1.4$ N.

373. $F = \dfrac{q^2}{2\varepsilon_0 kdS} = \dfrac{q}{2\varepsilon_0 k2\pi R^2} = \dfrac{q^2}{4\pi\varepsilon_0 k R^2}$

$= \dfrac{400\times10^{-12}\times9\times10^9}{(10\times10^{-2})^2} = 360$ N.

374. $f = \dfrac{1}{2}\varepsilon_0 k\left(\dfrac{V}{d}\right)^2$

$= \dfrac{8.85\times10^{-12}\times1}{2}\times\left(\dfrac{100}{10\times10^{-2}}\right)^2$

$= 4.4 \times 10^{-6}$ N/m^2.

375. $u = \dfrac{1}{2}\varepsilon_0 kE^2$

$\therefore$ $E = \sqrt{\dfrac{2u}{\varepsilon_0 k}} = \sqrt{\dfrac{2\times1.77\times10^{-7}}{8.85\times10^{-12}\times1}}$

$\therefore$ $E = 200$ V/m.

376. $C = 4\pi\,\varepsilon_0 kR = \dfrac{1\times6400\times10^3}{9\times10^9} = 7.1 \times 10^{-4}$ F.

377. $C = \dfrac{Ak\varepsilon_0}{d} = \dfrac{100\times10^{-4}\times6\times8.85\times10^{-12}}{8.85\times10^{-3}}$

$= 60$ pF.

378. $Q = CV$

$= 32 \times 10^{-6} \times 0.6 \times 10^3 = 1.92 \times 10^{-2}$ C

$E = \dfrac{1}{2}CV^2 = \dfrac{32\times10^{-6}\times(0.6\times10^3)^2}{2} = 5.76$ J.

379. $\dfrac{1}{C_S} = \dfrac{1}{C_1}+\dfrac{1}{C_2}+\dfrac{1}{C_3}+\dfrac{1}{C_4}$

$= \dfrac{1}{2}+\dfrac{1}{3}+\dfrac{1}{4}+\dfrac{1}{6}$

$\therefore$ $C_S = 0.8$ pF.

380. $C_S \cdot C_P = 1.2 \times 5 = 6 = 3 \times 2$

$\therefore$ $C_1 = 3\ \mu$F and $C_2 = 2\ \mu$F.

381. $C_P = 2 + 4 = 6\ \mu$F

$C_S = \dfrac{6\times12}{6+12} = \dfrac{72}{18} = 4\ \mu$F

$C = \dfrac{C_P\cdot C_S}{C_P+C_S} = \dfrac{6\times4}{6+4} = \dfrac{24}{10} = 2.4\ \mu$F.

382. $V = \dfrac{C_1V_1+C_2V_2}{C_1+C_2}$

$= \dfrac{1\times10^{-6}\times100+2\times10^{-6}\times200}{1\times10^{-6}+2\times10^{-6}} = \dfrac{500}{3}$ V

Now, $Q_1{}^1 = C_1V = \dfrac{1\times10^{-6}\times500}{3} = 1.6 \times 10^{-4}$ C

$Q_2{}^1 = C_2V = \dfrac{2\times10^{-6}\times500}{3}$

$= 3.3 \times 10^{-4}$ C

383. $C_P = C_1 + C_2 = 3 + 5 = 8\ \mu$F

$C_S = \dfrac{C_P\cdot C_3}{C_P+C_3} = \dfrac{8\times2}{8+2} = 1.6\ \mu$F

$Q = C_S \cdot V = 1.6 \times 100 = 160\ \mu$C

$V_3 = \left(\dfrac{C_P}{C_P+C_3}\right)V = \left(\dfrac{8}{8+2}\right)100 = 80$ V.

384. $u = \dfrac{\frac{1}{2}CV^2}{A\cdot d} = \dfrac{CV^2}{2Ad}$

$= \dfrac{50\times10^{-6}\times200\times200}{2\times10\times10^{-4}\times0.1\times10^{-3}} = 10^7$ J/m^3.

385. $E = \dfrac{V}{d} = \dfrac{0.06}{75\times10^{-10}} = 8 \times 10^6$ V/m.

386. $C \propto \dfrac{1}{d}$

$\therefore$ $\dfrac{C_2}{C_1} = \dfrac{d_1}{d_2}$ $\therefore$ $C_2 = \dfrac{C_1d_1}{d_2} = \dfrac{2\times d_1}{d_1/2} = 4\ \mu$F.

387. $Q = CV = 2 \times 10^{-6} \times 200 = 4 \times 10^{-4}$ C

$V^1 = \dfrac{Q^1}{C} = \dfrac{4\times10^{-4}-2\times10^{-4}}{2\times10^{-6}} = 100$ V.

388. $E = \dfrac{\sigma}{2\varepsilon_0 k} = \dfrac{1.6\times10^{-2}}{2\times8.85\times10^{-12}\times5} = 1.8 \times 10^8$ V/m.

389. $C_P = C_1 + C_2 = 5 + 10 = 15$ F

$C_S = \dfrac{C\cdot C_P}{C+C_P}$

Now, $Q = C_S \cdot V$

$$Q = \left(\frac{C \cdot C_P}{C + C_P}\right) V$$

$$1 = \left(\frac{C \times 15}{C + 15}\right) \times 2$$

$\therefore$ $C = 0.52$ F.

438. $C_P = C + C + C = 3C$

Now, $C_S = \dfrac{C_P \cdot C}{C_P + C}$

$\therefore$ $3.75 = \dfrac{3C \times C}{3C + C}$ $\quad \therefore C = 5\ \mu F$.

440. $F = mg = qE$

$$\therefore q = \frac{mg}{E} = \frac{9.9 \times 10^{-15} \times 10}{3 \times 10^{4}}$$

$$= 3.3 \times 10^{-18}\ C$$

443. $\Delta E = E_2 - E_1 = \dfrac{Q_2^2}{2C} - \dfrac{Q_1^2}{2C}$

$$= \frac{1}{2C}[Q_2^2 - Q_2^2] = \left(\frac{0.25 - 0.01}{2 \times 48 \times 10^{-6}}\right)$$

$$= 2500\ J$$

444. $E = \dfrac{\sigma R}{\varepsilon_0 kr} = \dfrac{4 \times 10^{-6} \times 3 \times 10^{-3}}{8.85 \times 10^{-12} \times 6.28 \times 1.5}$

$$= 1.44\ V/m.$$

445. $V = E \cdot d$

$$d = \frac{V}{E} = \frac{V}{\frac{\sigma}{\varepsilon_0}}$$

$$= \frac{V}{\frac{q}{A\varepsilon_0}} = \frac{VA\varepsilon_0}{q}.$$

446. $C_P = n^2 C_S$

$$\frac{C_P}{C_S} = n^2$$

447. $C_P - C_S = 3$

$$2C - \frac{C}{2} = 3$$

$$\frac{4C - C}{2} = 3$$

$$3C = 6$$

$$C = 2\ \mu F$$

448. From definition of Van de Graff generator.

449. In the direction of electric field, electric potential decreases.

450. In given fig.,

$$\tan\theta = \frac{F}{mg} = \frac{r/2}{y}$$

$$\Rightarrow \frac{kq^2}{r^2 mg} = \frac{r}{2y}$$

$$\Rightarrow r^3 \propto y$$

$$\Rightarrow r \propto y^{1/3}$$

$$\Rightarrow r' \propto \left(\frac{y}{2}\right)^{1/3}$$

$$\Rightarrow \frac{r'}{r} = \frac{1}{(2)^{1/3}}$$

451. The electric intensity out side the charged sphere in terms of surface charge density is given by,

$$E = \frac{\sigma R^2}{\epsilon_0 K r^2}$$

$$\therefore \sigma = E \epsilon_0 K \left(\frac{r}{R}\right)^2$$

For free space $K = 1$

$$\therefore \sigma = E \epsilon_0 \left(\frac{r}{R}\right)^2$$

452. The potential outside the surface, on the surface and at any point inside the surface is same,

$$\therefore V_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$$

$$\left(\because \sigma = \frac{q}{4\pi R^2} \therefore q = \sigma 4\pi R^2\right)$$

$$\therefore V_1 = \frac{1}{4\pi\varepsilon_0}\frac{\sigma 4\pi R^2}{R}$$

$$V_1 = \frac{\sigma R}{\varepsilon_0}$$

Similarly, $V_2 = \dfrac{\sigma r}{\varepsilon_0}$

Thus, the resultant potential is given by,

$$V = V_1 + V_2$$

$$= \frac{\sigma R}{\varepsilon_0} + \frac{\sigma r}{\varepsilon_0} = \frac{\sigma}{\varepsilon_0}(R + r)$$

453. Excess pressure in a liquid drop of radius r is given by,

$$p = \frac{4T}{r}$$

$$\frac{\sigma^2}{2\varepsilon_0 K} = \frac{4T}{r}$$

$$\frac{q^2}{2\varepsilon_0 K 16\pi^2 r^4} = \frac{4T}{r}$$

$$\frac{q^2}{32\,\varepsilon_0\, K\pi^2 r^3} = 4\,T$$

$$q^2 = 32 \times 4\,\pi^2\, r^3\, \varepsilon_0\, KT$$

$$q^2 = 16 \times 8\,\pi^2\, r^3\, \varepsilon_0\, KT$$

$$q^2 = \frac{16 \times 8\pi^2 r^4 \varepsilon_0 KT}{r}$$

$$q = 4\,\pi r^2 \sqrt{\frac{8\varepsilon_0 KT}{r}}$$

$$q = 4\,\pi r^2 \sqrt{\frac{8\,\varepsilon_0 T}{r}}$$

454. We know that work = potential × charge

The work W_1 required to deposit charge q against no field is given by,

$$W_1 = 0$$

The work W_2 required to deposit charge q at a distance 2a from the first charge is given by,

$$W_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{2a} \times q = \frac{q^2}{4\pi\varepsilon_0 \times 2a}$$

The work W_3 required to deposit charge –2q at a distance a from each charge is given by,

$$W_3 = (V'_1 + V'_2)\,(-2q)$$

where V'_1 is potential due to first charge q_1 and V'_2 is potential due to second charge q_2 at a distance a from each other.

$$\therefore \quad W_3 = \left(\frac{1}{4\pi\varepsilon_0}\frac{q}{a} + \frac{1}{4\pi\varepsilon_0}\frac{q}{a}\right) \times -2\,q$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{2q}{a} \times (-2\,q)$$

$$= -\frac{4q^2}{4\pi\varepsilon_0 a}$$

Thus total work is given by,

$$W = W_1 + W_2 + W_3$$

$$= 0 + \frac{q^2}{4\pi\varepsilon_0 2a} - \frac{4\,q^2}{4\pi\,\varepsilon_0 a}$$

$$= -\frac{7q^2}{8\pi\,\varepsilon_0 a}$$

455. $C_p - C_s = 6$ (But $C_p = n^2\, C_s$)

$$\therefore \quad n^2\, C_s - C_s = 6$$

$$4 \times \frac{C}{2} - \frac{C}{2} = 6$$

$$2C - \frac{C}{2} = 6$$

$$\frac{3C}{2} = 6$$

$$\therefore \quad C = 4\,\mu F$$

456. $v = \sqrt{\dfrac{2qV}{m}}$ $(V = E\,.\,l)$

$$\therefore \quad v = \sqrt{\frac{2qEl}{m}}$$

$$v = \left(\frac{2qEl}{m}\right)^{1/2}$$

457. $\dfrac{E_1}{E_2} = \dfrac{\dfrac{\sigma}{\epsilon_0\, k}}{\dfrac{\sigma}{2\,\epsilon_0\, k}} = \dfrac{2}{1}$ i.e., $E_1 = 2\,E_2$.

458. $V_2 = \left(\dfrac{C_1}{C_1 + C_2}\right) V$ & $V_1 = \left(\dfrac{C_2}{C_1 + C_2}\right) V$

$$\therefore \quad \frac{V_2}{V_1} = \frac{C_1}{C_2} = \frac{4}{1}.$$