Physics

Class 12th

Guess Paper

Guess Questions with answer for CBSE of Year 2020

Electrostatics

MCQ

1. An electric dipole is placed inside a closed surface. The net electric flux linked with closed surface will
   (A) $\frac{q}{\varepsilon_0}$ (B) zero.
   (C) infinity. (D) $\frac{\sigma}{\varepsilon_0}$ Ans.(B)
   Hint: Net charge of dipole = q – q = 0 , hence $\varphi_E = \frac{Q}{\varepsilon_0} = \frac{0}{\varepsilon_0} = 0$

2. A hemisphere is uniformly charged positively. The electric field at a point on a diameter away from the centre is directed
   (A) at an angle tilted towards the diameter.
   (B) parallel to the diameter.
   (C) perpendicular to the diameter.
   (D) at an angle tilted away from the diameter. Ans.(C)

3. A point charge +*q*, is placed at a distance *d* from an isolated conducting plane. The field at a point P on the other side of the plane is
   (A) directed radially towards the point charge.
   (B) directed perpendicular to the plane but towards the plane.
   (C) directed radially away from the point charge.
   (D) directed perpendicular to the plane and away from the plane.
   Ans.(D)

4. The Electric field at a point is
   (A) continuous if there is no charge at that point.
   (B) always continuous.
   (C) discontinuous only if there is a negative charge at that point.
   (D) discontinuous if there is a charge at that point.
   Ans. (A, D)

5. If $\int \vec{E} . \vec{dS} = 0$ over a surface, then
   (A) the electric field inside the surface and on it is zero.
   (B) the number of flux lines entering the surface must be equal to the number of flux lines leaving it.
   (C) the electric field inside the surface is necessarily uniform.
   (D) all charges must necessarily be outside the surface.
   Ans. (B, D)
6. If an electron and a proton are placed in uniform electric field, then
   (A) forces acting on them will equal.
   (B) magnitudes of forces acting on them will equal.
   (C) their acceleration will equal.
   (D) magnitudes of their acceleration will equal.
   Ans.(B)

Hint: Electric force $\vec{F}$ = q$\vec{E}$,

∴ force on electron $\vec{F_e}$ = - e$\vec{E}$

and force on proton $\vec{F_p}$ = + e$\vec{E}$,

Magnitude of force on electron $|\vec{F_e}|$ = eE .... (i)

Magnitude of force on proton $|\vec{F_p}|$ = eE .... (ii)

Acceleration of electron $\vec{a_e} = \frac{\vec{F_e}}{m_e} = \frac{-e\vec{E}}{m_e}$,

Acceleration of proton $\vec{a_p} = \frac{\vec{F_p}}{m_e} = \frac{+e\vec{E}}{m_p}$

Magnitude of acceleration of electron $|\vec{a_e}| = \frac{F_e}{m_e} = \frac{eE}{9.1 \times 10^{-31}}$

Magnitude of acceleration of proton $|\vec{a_p}| = \frac{F_p}{m_p} = \frac{eE}{1.67 \times 10^{-27}}$

From equation (i) and (ii), magnitude of forces acting on them will equal.

7. The distance between two charges is doubled, then force between them will be
   (A) $\frac{1}{2}$ time (B) 2 times
   (C) $\frac{1}{4}$ time (D) 4 times Ans.(C)

Hint: F = $\frac{K \times q_1 \times q_2}{(2r)^2} = \frac{K\, q_1 q_2}{4r^2} = \frac{1}{4} \times \frac{K\, q_1 q_2}{r^2}$

8. The distance between two charges is reduced to half and magnitude of charges are doubled, then force between them will be

(A) 8 times (B) 16 times

(C) $\frac{1}{4}$ times (D) 2 times Ans.(B)

Hint: F = $\frac{K \times 2\, q_1 \times 2\, q_2}{(r/2)^2} = 4 \times 4 \times \frac{K\, q_1 q_2}{r^2} = 16 \times \frac{K\, q_1 q_2}{r^2}$

9. When a glass rod is rubbed with silk, it acquires a charge of +32 Pico coulomb.

The number of lost or gained electrons by glass rod will

(a) 5×10^{-7} (gained) (b) 5×10^{7} (lost)

(c) 2×10^{8} (lost) (d) -8×10^{-12} (lost) Ans.(c)

Hint: The number of lost electrons by glass rod,

$N = \frac{Q}{e} = \frac{32 \times 10^{-12}}{1.6 \times 10^{-19}} = 20 \times 10^{7} = 2 \times 10^{8}$

10. The electrostatic force between two point charges kept at a distance d apart, in a medium $\varepsilon_r = 4$, is 0.8 N. The force between them at the same distance in vacuum will

(a) 20 N (b) 0.5 N

(c) 1.8 N (d) 3.2 N Ans.(d)

Hint: $\varepsilon_r = \frac{F_0}{F_m}$ or $F_0 = \varepsilon_r F_m = 4 \times 0.8 = 3.2$N

11. The electric field intensity at a distance of 4 m from a point charge is 200 V m^{-1} . It will be 400 V m^{-1} at a distance?

(a) 50 cm (b) 4 cm

(c) 4 m (d) $2\sqrt{2}$ m Ans.(d)

Hint: $E = \frac{Kq}{r^2}$. Therefore $\frac{E_1}{E_2} = \frac{Kq}{{r_1}^2} \times \frac{{r_2}^2}{Kq} = \frac{{r_2}^2}{{r_1}^2}$ or ${r_2}^2 = \frac{E_1}{E_2} \times {r_1}^2$

$= \frac{200}{400} \times 4^2 = 8$ or $r_2 = \sqrt{8} = 2\sqrt{2}$ m

12. Two point charges +4q and +2q are placed at distance of 20 cm in vacuum. At what point on the line joining them the electric field is zero?

(a) 12.75 cm from the charge q (b) 7.5 cm from the charge q

(c) 20 cm from the charge 4q (d) 11.71 cm from the charge 4q

Ans.(d)

Hint: $\frac{4qK}{x^2} = \frac{2qK}{(20-x)^2}$ or $2\,(20-x)^2 = x^2$ or $\left\{\sqrt{2}\,(20-x)\right\}^2 = x^2$

Or $\sqrt{2}\,(20 - x) = x$ or $20\sqrt{2} - \sqrt{2}\,x = x$ or $20\sqrt{2} = \sqrt{2}\,x + x$

Or $20\sqrt{2} = (1 + \sqrt{2})\,x$ or $x = \frac{20\sqrt{2}}{(\sqrt{2}+1)} = \frac{20 \times 1.414}{1.414+1} = \frac{28.280}{2.414} = 11.71$ cm

13. An electric dipole is placed in a uniform electric field with its axis parallel to the field. It experiences

(a) only a net force (b) only a torque

(c) both a net force and torque (d) neither a net force nor a torque

Ans.(d)

14. If a point lies at a distance x from the midpoint of the dipole, the electric potential at this point is proportional to

(a) $\frac{1}{x^2}$ (b) $\frac{1}{x^3}$

(c) $\frac{1}{x^4}$ (d) $\frac{1}{x^{\frac{3}{2}}}$ Ans.(a)

Hint: Electric potential at any point due to an electric dipole is

$V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$ or $V \propto \frac{1}{r^2}$

15. Four charges +q, +q, −q and –q respectively are placed at the corners A, B, C and D of a square of side x. The electric potential at the centre O of the square is

(a) $\frac{2q}{4\pi\varepsilon_0 x}$ (b) $\frac{\sqrt{2}q}{4\pi\varepsilon_0 x}$

(c) zero (d) $\frac{4q}{4\pi\varepsilon_0 x}$ Ans.(c)

Hint: $V = \frac{+q}{4\pi\varepsilon_0 x/\sqrt{2}} + \frac{+q}{4\pi\varepsilon_0 x/\sqrt{2}} + \frac{(-q)}{4\pi\varepsilon_0 x/\sqrt{2}} + \frac{(-q)}{4\pi\varepsilon_0 x/\sqrt{2}}$

$= \frac{\sqrt{2}q}{4\pi\varepsilon_0 x} + \frac{\sqrt{2}q}{4\pi\varepsilon_0 x} - \frac{\sqrt{2}q}{4\pi\varepsilon_0 x} - \frac{\sqrt{2}q}{4\pi\varepsilon_0 x} = 0$

16. The work done in moving 200 µC charge between two points A and B on equipotential surface is

(a) zero (b) finite positive

(c) finite negative (d) infinite Ans.(a)

Hint: Potential difference between two points A and B is ,

$V_{AB} = \frac{W_{AB}}{q}$

Or $W_{AB} = V_{AB}\, q = 0 \times q = 0$

17. The number of electric lines of force originating from a charge of 1 C is

(a) 1.6×10^{-19} (b) 1.129×10^{11}

(c) 8.85×10^{-12} (d) 8.85×10^{12} Ans.(b)

Hint: From Gauss' theorem, the number of electric lines of force originating from a charge is,

$$\phi_E = \frac{q}{\varepsilon_0} = \frac{1}{8.85 \times 10^{-12}} = \frac{100 \times 10^{12}}{885} = 0.1129 \times 10^{12} = 1.129 \times 10^{11}$$

18. The capacitance of a parallel plate capacitor increases from 4 μF to 28 μF, when a dielectric is filled in between the plates. The dielectric constant of the dielectric is

(a) 84 (b) 7

(c) 24 (d) $\frac{1}{7}$ Ans.(b)

Hint: The dielectric constant of the dielectric is, $K = \frac{C_m}{C_0} = \frac{28\ \mu F}{4\ \mu F} = 7$

19. A hollow metal ball carrying an electric charge, produces no electric field at points

(a) outside the sphere. (b) on its surface.

(c) inside the sphere. (d) at a distance more than twice.

Ans.(c)

Hint: Electric field inside a hollow charged conductor is zero.

20. Consider a region inside which there are various types of charges but the total charge is zero. At points outside the region

(a) the electric field is necessarily zero.

(b) the electric field is due to the dipole moment of the charge distribution only.

(c) the dominant electric field is $\propto \frac{1}{r^3}$, for large r, where r is the distance from a origin in this region.

(d) the work done to move a charged particle along a closed path, away from the region, will be zero.

Ans. (c, d)

21. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge

(a) remains a constant because the electric field is uniform.

(b) increases because the charge moves along the electric field.
(c) decreases because the charge moves along the electric field.
(d) decreases because the charge moves opposite to the electric field.
Ans. (c)

22. Equipotentials at great distance from a collection of charges whose total sum is not zero are approximately
(a) spheres. (b) planes.
(c) paraboloids. (d) ellipsoids. Ans. (a)

23. The electrostatic potential on the surface of a charged conducting sphere is 100V. Two statements are made in this regard:
S1 : At any point inside the sphere, electric intensity is zero.
S2 : At any point inside the sphere, the electrostatic potential is 100V.
Which of the following is a correct statement?
(a) S1 is true but S_2 is false.
(b) Both S1 & S_2 are false.
(c) S_1 is true, S_2 is also true and S_1 is the cause of S_2.
(d) S_1 is true, S_2 is also true but the statements are independent.
Ans. (c)

24. If the electron of mass m and charge e is accelerated by electric field of intensity E, then velocity of electron after travelling a distance x will
(a) $\sqrt{\frac{Eem}{x}}$ (b) $\sqrt{\frac{Ee}{m}}$
(c) $\sqrt{\frac{2Eex}{m}}$ (d) $\sqrt{\frac{2Eem}{x}}$ Ans.(c)

Hint: F = ma or qE = ma or a = $\frac{qE}{m} = \frac{eE}{m}$
Again from $V^2 = u^2 + 2as$ or $V^2 = 0 + 2ax$
Or $V^2 = 2ax$ or $V = \sqrt{2ax} = \sqrt{2\frac{eE}{m}x} = \sqrt{\frac{2eEx}{m}}$

25. An electric dipole consists of two opposite charges each of magnitude 1μC separated by a distance of 2 cm. The dipole is placed in an external electric field of intensity 1×10^5 N/C. The maximum torque on the dipole is
(a) $0.2X10^{-3}$ Nm (b) $1X10^{-3}$ Nm
(c) 2 X 10^{-3} Nm (d) 4 X 10^{-3} Nm Ans.(c)

Hint: τ_{max} = PE sin 90^0 = PE = $(q \times 2l) \times E$
$= (1 \times 10^{-6} \times 2 \times 10^{-2}) \times 1 \times 10^5$ = 2 X 10^{-3} Nm

26. 64 identical drops each of capacity 5μF combine to form a big drop. The capacity of big drop will be

(A) 164 μF (B) 4 μF

(C) 25 μF (D) 20 μF Ans.(D)

Hint: A/Q $c = 4\pi\varepsilon_0 r = 5\ \mu F$, $C = ?$

Since, Volume of big drop = Volume of 64 small drops

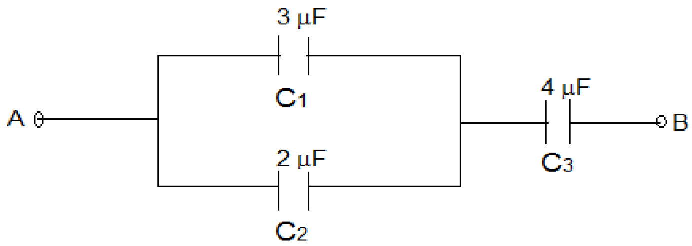
$$\text{Or } 64\,\tfrac{4}{3}\pi r^3 = \tfrac{4}{3}\pi R^3 \Rightarrow 64\, r^3 = R^3 \Rightarrow R = 4r$$

∴ Capacitance of big drop

$$C = 4\pi\varepsilon_0 R = 4\pi\varepsilon_0 \times 4r = 4 \times 4\pi\varepsilon_0 r = 4 \times c$$

$$= 4 \times 5\ \mu F = 20\ \mu F$$

27. The equivalent capacitance between A and B in the given figure is



(a) 6 μF (b) 9 μF

(c) 18 μF (d) $\frac{20}{9}$ μF Ans.(d)

28. Dimensional formula of dielectric strength is

(a) MLT^3A^{-1} (b) ML^3TA^{-1}

(c) $MLT^{-3}A^{-1}$ (d) $MLT^{-3}A$ Ans.(c)

Hint: Dielectric strength $= \frac{V}{l} = \frac{W/q}{l} = \frac{w}{ql} = \frac{F \times l}{ql} = \frac{F}{q} = \frac{F}{It} = \frac{MLT^{-2}}{AT}$

$$= MLT^{-3}A^{-1}$$

29. The electric field intensity at distance r on the axis of an electric dipole is E_1 and on the perpendicular bisector axis of dipole is E_2. The angle between E_1 and E_2 is θ. Then E_1:E_2 and θ will be –

(A) 1:1, π (B) 1:2, π/2

(C) 2:1, π (D) 1:3, π Ans. (C)

Hint: $\frac{E_{axis}}{E_{eq}} = \frac{2}{1} = 2:1$, Again direction of E_{axis} along X-axis,

And direction of E_{eq} is along X'- axis.

Hence $\theta = 180^0 = \pi$

30. N capacitors of same capacitance are connected in parallel and again they are connected in series. The ratios of equivalent capacitances in both cases will

(A) N^2:1 (B) N:1

(C) 1:N (D)1: N^2 Ans.(A)

Hint: $\frac{C_p}{C_s} = \frac{NC}{C/N} = N^2:1$

31. The ratio of electric fields due to an electric dipole at any point on the axil line and equatorial line is

(A) 8:4 (B) 1:2

(C) 1:4 (D) 2:1 Ans.(D)

Hint: $\frac{E_{axis}}{E_{eq}} = \frac{2}{1} = 2:1$

32. The electric potential inside positively charged hollow spherical conductor is

(A) zero (B) positive and unequal

(C) positive and uniform (D) negative and uniform Ans.(C)

33. The work done to taking 2 coulomb charge from one point to another point is 20 joule. The potential difference between these points is

(A) 2 volt (B) 5 volt

(C) 20 volt (D) 10 volt Ans.(D)

Hint $V = \frac{W}{q} = \frac{20}{2} = 10$ volt

34. The capacitance of spherical conductor is proportional to

(A) mass of sphere (B) radius of sphere

(C) volume of sphere (D) area of sphere Ans.(B)

Hint: capacitance of sphere $C = 4\pi\varepsilon_0 R$

35. The capacitance of parallel plate air capacitor does not depend on

(A) shape of plates (B) charge on plates

(C) distance between plates (D) medium in between plates

Ans.(B)

Hint: capacitance of air parallel plate capacitor, C = $\frac{\varepsilon_0 A}{d}$

36. Two capacitors of capacitance 1μF are connected in parallel. A third capacitor of capacitance 0.5 μF is connected in series with this combination. The equivalent capacitance of circuit will

(A) 12 μF (B) 16 μF

(C) 10 μF (D) 0.4 μF Ans.(D)

Hint: $C_{12} = C_1 + C_2 = 1\mu F + 1\mu F = 2\mu F$.

Again C_{12} is connected in series with C_3

$\therefore C_{123} = \frac{C_{12} \times C_3}{C_{12} + C_3} = \frac{2 \times 0.5}{2+0.5} = \frac{2}{5} = 0.4\ \mu F$

37. If a glass plate is placed in between plates of air capacitor, then new capacitance will

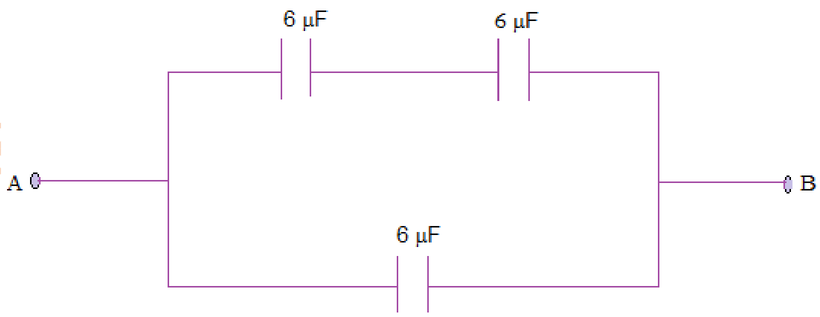
(A) increase (B) constant

(C) decrease (D) zero Ans.(A)

Hint: $C_m = K\,C_0$

where K is dielectric constant of substance placed in between plates of capacitor.

38. The equivalent capacitance between A and B in given figure is



(A) 6 μF (B) 9 μF

(C) 18 μF (D) 4 μF Ans.(B)

Hint: $C_P = C_1 + C_2$ and $C_s = \frac{C_1 C_2}{C_1 + C_2}$

39. The electric field at a point near an infinite thin sheet of charged conductor is:

(a) $\varepsilon_0 \sigma$ (b) $\frac{\sigma}{\varepsilon_0}$

(c) $\frac{\sigma}{2\varepsilon_0}$ (d) $\frac{1}{2}\sigma\varepsilon_0$ Ans. (c)

40. Two capacitors $C_1 = 2\mu F$ and $C_2 = 4\mu F$ are connected in series and a potential difference of 1200V is applied across it. The potential difference across $2\mu F$ will be:

(a) 400V (b) 600V

(c) 800V (d) 900V Ans.(c)

Hint: Equivalent capacitance of C_1 and C_2 will,

$$C_{12} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{2\times4}{2+4} = \frac{4}{3}\ \mu F = \frac{4}{3} \times 10^{-6}\ F$$

and charge on each plate of capacitor will,

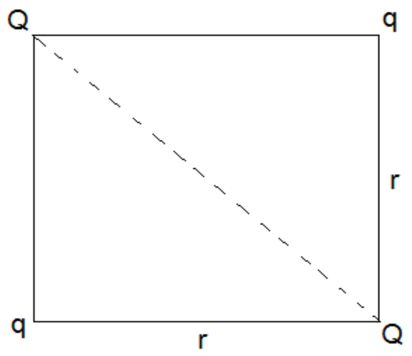
$$q = C_{12}.V = \frac{4}{3} \times 10^{-6} \times 1200$$

$$= 1600 \times 10^{-6}\ C$$

$\therefore$ Potential difference across $2\mu F$ will,

$$V_1 = \frac{q_1}{C_1} = \frac{1600 \times 10^{-6}}{2 \times 10^{-6}} = 800 \text{ volt.}$$

41. In the figure, if net force on Q is zero then value of $\frac{Q}{q}$ is :



(a) $\sqrt{2}$ (b) $2\sqrt{2}$

(c) $\frac{1}{2\sqrt{2}}$ (d) $\frac{1}{\sqrt{2}}$ Ans.(b)

Hint $\because$ Net force on Q due to remaining charges is zero.

$$\therefore\ \vec{F_q} + \vec{F_q} = \vec{F_Q} \text{ or } \sqrt{F_q^{\,2} + F_q^{\,2}} = F_Q \text{ or } \sqrt{2F_q^{\,2}} = F_q$$

$$\text{or } \sqrt{2 \times \left(\frac{KqQ}{r^2}\right)^2} = \frac{KQQ}{(\sqrt{2}\,r)^2} \text{ or } \frac{\sqrt{2}KqQ}{r^2} = \frac{KQQ}{2r^2} \text{ Or } \sqrt{2}\,q = \frac{Q}{2} \text{ or } \frac{Q}{q} = 2\sqrt{2}$$

42. The electric potential due to a small electric dipole at a large distance r from the centre of the dipole is proportional to:

(a) r (b) $\frac{1}{r}$

(c) $\frac{1}{r^2}$ (d) $\frac{1}{r^3}$ Ans.(c)

Hint: Electric potential due to an electric dipole is V = $\frac{Kq}{r^2}$

43. Minimum number of capacitors of 2μF each required to obtain a capacitance of 5μF will be:

(a) 4 (b) 3

(c) 5 (d) 6 Ans.(a)

VSA

1. Why do the electric field lines never cross to each other ?

Ans.

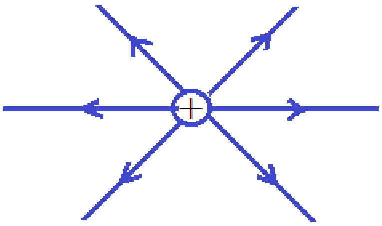
When will do so, there will be two directions of electric field at the point of intersection, which is not possible.

2. An electrostatic field line cannot be discontinuous. Why?

Ans.

It represents the actual path of a unit positive charge, which experience a continuous force.

3. Figure shows the field lines on a positive charge. Is the work done by the field in moving a small positive charge from Q to P, positive or negative ? Give reason.



Ans.

Negative.

Because, the charge is displaced against of the force exerted by the electric field.

4. Define the term 'dielectric constant' of a medium in terms of capacitance of a capacitor.

Ans.

Dielectric constant:- The ratio of electrical capacitance of capacitor with dielectric medium in between plates of a capacitor (C_m) to the electrical capacitance of capacitor with air or vacuum in between plates of capacitor (C_0) is called dielectric constant (K).

i.e. $K = \frac{C_m}{C_0}$

5. What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

Ans.

The net charge of an electric dipole is zero. Hence, the electric flux through a cube of side 1 cm which encloses an electric dipole will be zero?

6. Does the charge given to a metallic sphere depend on whether it is hollow or solid?

Ans.

No, the capacity of spherical conductor is $C = 4\pi\varepsilon_0 R$ i.e. Capacity of spherical conductor depends on radius of spherical conductor.

7. What is the amount of work done in moving a point charge around a circular arc of radius r, where another point charge is located at the centre ?

Ans.

The potential at every point of circular arc is $V = \frac{kq_1}{r}$, i.e. The potential at every point of circular is equal. Therefore, required work done $W = q_2 V = q_2 \times 0$ = zero.

8. Two dipole, made from charges $\pm$ q and $\pm$ Q respectively, have equal dipole moments. Give the (i) ratio between separation of these two pair of charges , (ii) angle between the dipole axis of these two dipoles.

Ans.

(i) since, $p_1 = p_2$ or $q \times l_1 = Q \times l_2$ or $\frac{l_1}{l_2} = \frac{Q}{q}$

(ii) Angle between the dipole axis of these two dipoles is zero.

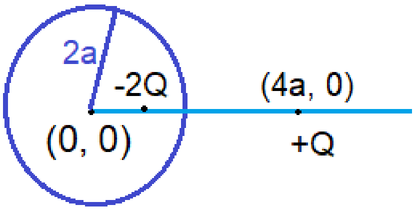
9. How does the electric flux due to point charge enclosed by a spherical Gaussian surface get affected, when its radius is increased ?

Ans.

Electric flux will remain unaffected ?

10. Two charges of magnitudes – 2Q and + Q are located at points (a, 0), (4a, 0) respectively. What is electric flux due to these charges through a sphere of radius 3a with its centre at the origin ?

Ans.



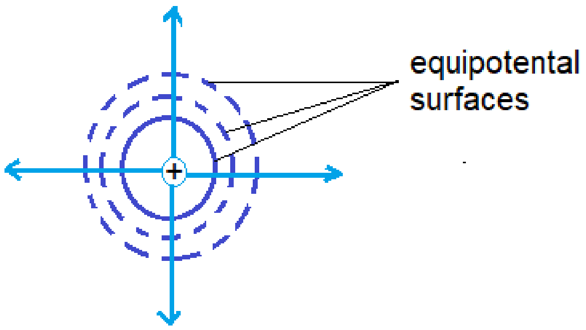
The net charge enclosed by sphere of radius 3a = - 2Q .

∴ Electric flux, $\phi_E = \frac{net\ charge}{\varepsilon_0} = \frac{-2Q}{\varepsilon_0}$

11. What is the geometrical shape of equipotential surface due to a single isolated charge ?

Ans.

Concentric spherical surfaces as shown in the figure.



12. Why are electric field lines perpendicular at a point on an equipotential surface of a conductor ?

Ans.

If it were no so, the presence of a component of the field along the surface would violate its equipotential nature.

13. A charge q is moved from a point A above a dipole of dipole moment p to a point B below the dipole, in equatorial plane without acceleration. Find the work done in the process.

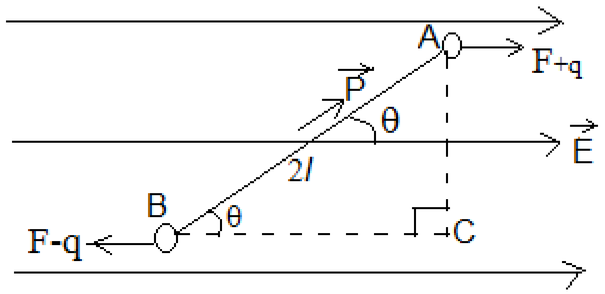
Ans.

On the equatorial line of a dipole, the electric potential is zero. Therefore, required work done without acceleration (W = Vq) will zero.

SA (2 marks)

14. An electric dipole is placed in uniform electric field at an angle θ with the direction of field. Show that dipole will not done translator motion. Then, obtained expression for torque acting on the dipole.

Ans.



According to figure, electric force on charge +q of electric dipole due to uniform electric field will,

F_{+q} = qE [along $\vec{E}$]

And Electric force on charge -q of electric dipole due to uniform electric field will,

F_{-q} = qE [opposite to $\vec{E}$]

∴ Net force on dipole F = F_{+q} + F_{-q} = qE – qE = 0

Hence, electric dipole will not done translator motion.

But, action lines of forces F_{+q} and F_{-q} are different. So, dipole will want to rotate.

∴ Torque acting on the dipole will,

τ = magnitude of either force × perpendicular distance between forces.

= qE × AC = qE × AB sin θ

[From triangle ABC, sin θ = $\frac{AC}{AB}$ ⇒ AC = AB sin θ]

= qE × 2l sin θ = 2ql (E sin θ)

= PE sin θ

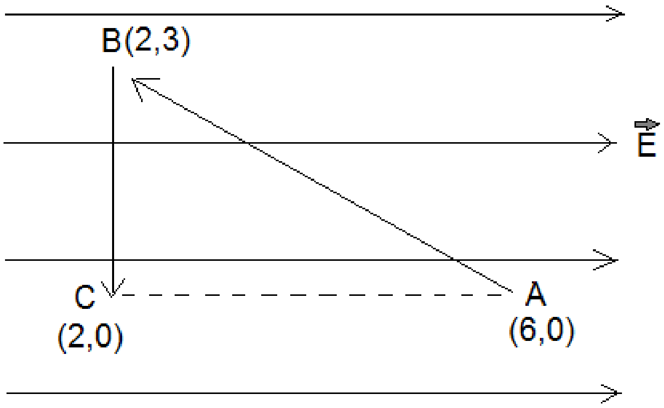
∴ τ = PE sin θ ……….. (i)

In vector form, $\vec{\tau} = \vec{P} \times \vec{E}$ ……………. (ii)

15. A test charge q is moved without acceleration from A to C along the path from A to B and then from B to C in electric field E as shown in the figure,

(i) Calculate the potential difference between A and C will, V_{AC} = E

(ii) At what point (of the two) is the electric potential more and why?



Ans.

(i) Potential difference between A and C will,

$V_{AC} = - Edr = - E(6-4) = -4E$

(ii) At point C, electric potential is more. Because along direction of electric field, electric potential decreases.

16. (a) Define the term 'electric flux'. Write its SI units.

(b) What is the flux due to electric field $\vec{E}$ = 3 x 10^3 $\hat{\imath}$ N/C through a square of side 10 cm, when it is held normal to $\vec{E}$.

Ans.

(a) The electric lines of force (electric field) passing through a surface normally is called electric flux.

Its SI unit is newton metre^2 per coulomb (Nm^2C^{-1}).

(b) Given, E = 3 x 10^3 along X-axis, A = $(0.1)^2$ = 0.01 m^2 ,

θ = angle between $\vec{E}$ and normal drawn on square, ϕ_B = ?

$\therefore \quad \phi_B = EA \cos\theta = 3 \text{ x } 10^3 \times 0.01 \times \cos 0^0 = 30 \ Nm^2C^{-1}$

17. Calculate the amount of work done in arranging a system of three charges 6 μC , 6 μC and −6 μC placed on the vertices of an equilateral triangle of side 10 cm.

Ans.

Given q_1 = 6 μC = 6 x 10^{-6} C, q_2 = 6 μC = 6 x 10^{-6} and q_3 = 6 μC = -6 x 10^{-6} , U = ?

$$\therefore \ U = \frac{K\, q_1 q_2}{r_{12}} + \frac{K\, q_1 q_3}{r_{13}} + \frac{K\, q_2 q_3}{r_{23}}$$

$$= \frac{9 \text{ x } 10^9 \times 6 \text{ x } 10^{-6} \times 6 \text{ x } 10^{-6}}{0.1} + \frac{9 \text{ x } 10^9 \times 6 \text{ x } 10^{-6} \times -6 \text{ x } 10^{-6}}{0.1} +$$

$$\frac{9 \times 10^{9} \times 6 \times 10^{-6} \times -6 \times 10^{-6}}{0.1}$$

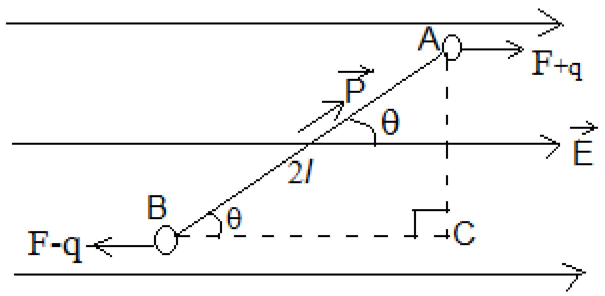
= 3.24 - 3.24 – 3.24 = - 3.24 J

LA-I (3 marks)

1. (a) Obtain an expression for the torque $\vec{\tau}$ experienced by an electric dipole of dipole moment $\vec{p}$ in a uniform electric field $\vec{E}$.
   (b) What will be happen if the field were not uniform?

Ans.

(a)



According to figure, electric force on charge +q of electric dipole due to uniform electric field will,

$F_{+q} = qE$ [along $\vec{E}$]

And Electric force on charge -q of electric dipole due to uniform electric field will,

$F_{-q} = -qE$ [opposite to $\vec{E}$]

∴ Net force on dipole $F = F_{+q} + F_{-q} = qE - qE = 0$

Hence, electric dipole will not done translator motion.

But, action lines of forces F_{+q} and F_{-q} are different. So, dipole will want to rotate.

∴ Torque acting on the dipole will,

τ = magnitude of either force × perpendicular distance between forces.

= qE × AC = qE × AB sin θ

[From triangle ABC, $\sin\theta = \frac{AC}{AB} \Rightarrow AC = AB \sin\theta$]

= qE × 2l sin θ = 2ql (E sin θ)

= PE sin θ

∴ τ = PE sin θ ……….. (i)

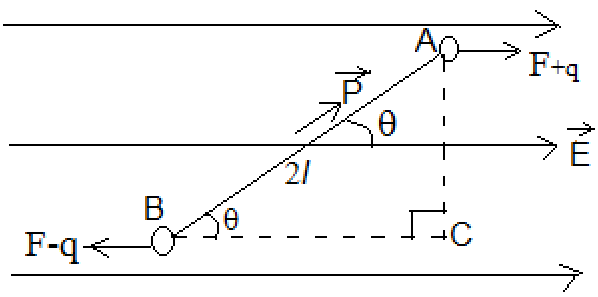
In vector form, $\vec{\tau} = \vec{P} \times \vec{E}$ ……………. (ii)

(b) When electric field is not uniform, then forces acting on the both charges

are not equal. Therefore, net force on the dipole will non-zero.
Hence, dipole will do translator as well as rotatory motion.

2. An electric dipole is placed in uniform electric field at an angle θ with the direction of field.
(a) Show that no translator force act on it.
(b) Derive an expression for the torque acting on the dipole.
(c) Find work done in rotating the dipole through 180^0.

Ans.



(a) According to figure, electric force on charge +q of electric dipole due to uniform electric field will,

$$F_{+q} = qE \quad [\text{ along } \vec{E}]$$

And Electric force on charge -q of electric dipole due to uniform electric field will,

$$F_{-q} = -qE \quad [\text{opposite to } \vec{E}]$$

∴ Net force on dipole $F = F_{+q} + F_{-q} = qE - qE = 0$

Hence no translator force act on the dipole.

(b) But action lines of forces F_{+q} and F_{-q} are different. So, dipole will want to rotate.

∴ Torque acting on the dipole will,

τ = magnitude of either force × perpendicular distance between forces.

$= qE \times AC \; = qE \times AB \sin\theta$

[From triangle ABC, $\sin\theta = \frac{AC}{AB} \Rightarrow AC = AB \sin\theta$]

$= qE \times 2l \sin\theta = 2ql\,(E \sin\theta)$

$= PE \sin\theta$

$\therefore \tau = PE \sin\theta$ ……….. (i)

In vector form $\vec{\tau} = \vec{P} \times \vec{E}$ ……………. (ii)

Now, work done on electric dipole by external torque in turning through small angle dθ will,

$$dw = \tau_{ext}\, d\theta = \tau_r\, d\theta = PE \sin\theta\, d\theta$$

∴ Total work done on electric dipole by external torque in turning anticlockwise through angle 0^0 to 180^0 will,

$$W = \int_{0^0}^{180^0} dw = \int_{0^0}^{180^0} pE\sin\theta \;= PE \int_{0^0}^{180^0} \sin\theta$$

$$= pE\,\{-\cos\theta\}_{0^0}^{180^0} = -pE\,(\cos 180^0 - \cos 0^0)$$

$$= -pE\,(-1-1) \quad = 2pE$$

3. State Gauss' theorem for electrostatics. Applying this theorem, derive an expression for the electric field intensity due to a uniformly charged spherical conducting shell at a point

(i) outside the shell and (ii) inside the shell.

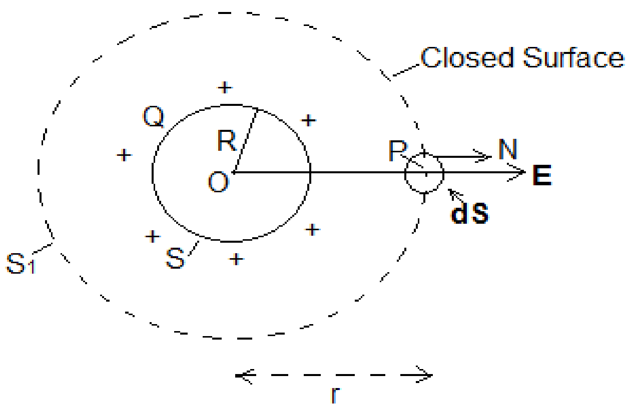
Plot a graph showing variation of electric field as a function of r > R and r < R

Where r is the distance from the centre of the shell.

Ans.

Gauss' theorem: The total electric flux linked with a closed surface is $\frac{1}{\varepsilon_o}$ times of net charge inside the closed surface.

i.e. $\phi_E = \oint_S \vec{E}\,.\vec{dS} = \frac{Q}{\varepsilon_0}$



Consider a charged spherical shell of radius R placed in air or vacuum. Let we have to determine electric field intensity at point P outside the shell at distance r from centre O. For this we imagine a spherical closed surface S_1 of radius r such that point P is on the surface of S_1. The electric field intensity at every point on the surface of S_1 is **E** directed outside along radius. Let surface S_1 is divide into many equal parts of area ds. Again consider one area element **ds**.

Now, total electric flux linked with closed surface S_1 will,

$$\phi_E = \oint \vec{E}\,.\,\overrightarrow{dS} = \oint EdS\cos\theta = \oint EdS\cos 0^0 = \oint E\,dS = \text{E}\oint dS$$

$$= \text{E} \times \text{total area of closed surface } S_1$$

$$\phi_E = \text{E} \times 4\pi\,\text{r}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(i)}$$

According to Gauss' theorem, $\phi_E = \frac{Q}{\varepsilon_0}$ ……………..(ii)

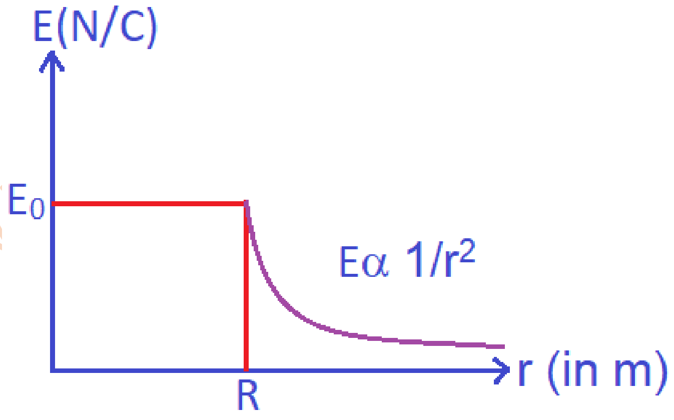
Comparing equations (i) and (ii),we get

$$\text{E} \times 4\pi\,\text{r}^2 = \frac{Q}{\varepsilon_0}$$

$$\therefore \quad \text{E} = \frac{Q}{4\pi\varepsilon_0 r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(iii)}$$

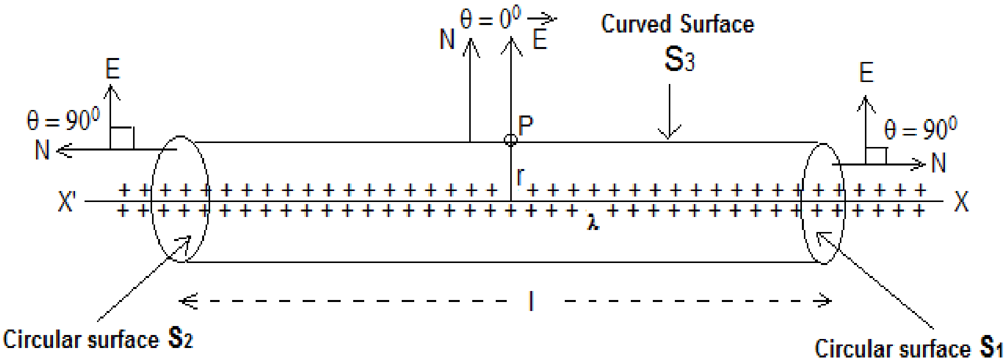
This equation is same as electric field intensity due to a point charge. Hence charged spherical shell can be assumed as a point charge.

A graph showing variation of electric field as a function of r is shown in the figure:



4. State Gauss' theorem in electrostatics. Apply this theorem to obtain the expression for the electric field intensity at a point due to an infinitely long, thin, uniformly charged straight wire.

Ans.



Suppose an infinite long wire is placed in air of surface density of charge λ. We have to calculate electric field intensity at point P at distance r from wire. For this we imagine a cylindrical closed surface of length *l*. The point is situated on this surface as shown in the figure.

Now, electric field flux linked with surface S_1 will,

$\phi_1 = ES_1 \cos\theta$ $\quad [\because \phi_E = ES\cos\theta]$

Or $\phi_1 = ES_1 \cos 90^0 = 0$ ....(i)

Electric field flux linked with surface S_3 will,

$\phi_3 = ES_3 \cos\theta = ES_3 \cos 90^0 = 0$ ....(ii)

And, electric field flux linked with surface S_2 will,

$\phi_2 = ES_2 \cos\theta = ES_2 \cos 0^0 = ES_2$

Or $\phi_2 = E \times 2\pi r l$ ....(iii)

[$\because$ Area of curved surface of cylinder = $2\pi rh$]

$\therefore$ Total electric flux liked with closed surface will,

$\phi_E = \phi_1 + \phi_3 + \phi_2 = 0 + 0 + E \times 2\pi r l$

Or $\phi_E = E \times 2\pi r l$ .... (iv)

According to Gauss's theorem,

$\phi_E = \frac{q}{\varepsilon_0}$

Where q is net charge inside closed surface.

Or $\phi_E = \frac{\lambda l}{\varepsilon_0}$ .... (v)

[$\because$ linear density of charge $\lambda = \frac{q}{l}$ or $q = \lambda l$]

Comparing equations (i) and (ii),we get,

$E \times 2\pi r l = \frac{\lambda l}{\varepsilon_0}$ $\quad$ or $E = \frac{\lambda l}{2\pi\varepsilon_0 r l}$

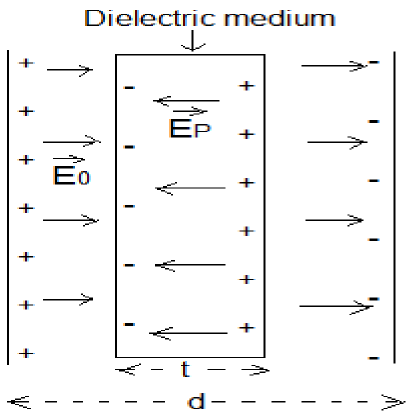
Or $E = \frac{\lambda}{2\pi\varepsilon_0 r}$ .... (vi)

5. (a) Briefly explain the principle of a capacitor.
(b) Derive an expression for the capacitance of a parallel plate capacitor, whose plates are separated by a dielectric medium.

Ans.

(a) **Principle of capacitor:-** when an earthed conductor plate is brought near unearthed conductor, then capacitance of unearthed conductor is increased extremely.

(b)



Suppose a dielectric medium of permittivity K and thickness t is placed in between plates of capacitor, where t < d.

$\therefore \quad K = \frac{E_0}{E} \Rightarrow E = \frac{E_0}{K}$ ..... (iv)

Where E = electric field in dielectric medium and
E_0 = electric field in air.

$\therefore$ Potential difference between plates will,

$V = V_{air} + V_{dielectric}$

$= E_0 (d - t) + E t = E_0 (d - t) + \frac{E_0}{K} t$ [From equation (iv)]

$= E_0 [d - t + \frac{t}{K}] = \frac{\sigma}{\varepsilon_0} [d - t + \frac{t}{K}]$

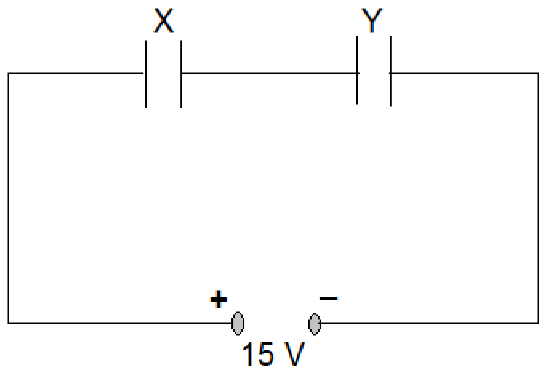
$\Rightarrow V = \frac{q}{\varepsilon_0 A} [d - t + \frac{t}{K}]$ .... (v)

∴ Capacitance of capacitor will,

$$C = \frac{q}{V} = \frac{q}{\frac{q}{\varepsilon_0 A}[d - t + \frac{t}{K}]} = \frac{\varepsilon_0 A q}{q[d - t + \frac{t}{K}]} = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$$

$$\Rightarrow C = \frac{\varepsilon_0 A}{d - t(1 + \frac{1}{K})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (v)$$

6. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric medium of k = 4.



(i) Calculate capacitance of each capacitor if equivalent capacitance of the combination is 4 μF.
(ii) Calculate the potential difference between the plates of X and Y.
(iii) Estimate the ratio of electrostatic energy stored in X and Y.

Ans.

(i) $C_s = 4\ \mu F$ or $\frac{C_1 \times C_2}{C_1 + C_2} = 4\ \mu F$ or $\frac{C \times kC}{C + kC} = 4\ \mu F$ or $\frac{C \times 4C}{C + 4C} = 4\ \mu F$

Or $\frac{4C^2}{5C} = 4\ \mu F$ or $C = \frac{5}{4} \times 4\ \mu F = 5\ \mu F$

$\therefore C_1 = 5\ \mu F$ and $C_2 = 4 \times 5\ \mu F = 20\ \mu F$

(ii) Charge (q) on each capacitor in series combination is same

$$\therefore q = \left(\frac{C_1 \times C_2}{C_1 + C_2}\right)V = \left(\frac{4C^2}{5C}\right)V = \frac{4C}{5} \times V = \frac{4 \times 5 \times 10^{-6}}{5} \times 15$$

$$= 60 \times 10^{-6} \text{ coulomb} = 6 \times 10^{-5} \text{ coulomb}$$

$$\therefore V_1 = \frac{q}{C_1} = \frac{6 \times 10^{-5}}{5 \times 10^{-6}} = 12 \text{ volt}$$

$$\text{And } V_2 = \frac{q}{C_2} = \frac{6 \times 10^{-5}}{20 \times 10^{-6}} = 3 \text{ volt}$$

(iii) $\frac{U_1}{U_2} = \frac{\frac{1}{2}C_1{V_1}^2}{\frac{1}{2}C_1{V_1}^2} = \frac{5\times10^{-6}\times12^2}{20\times10^{-6}\times3^2} = 4{:}1$

7. A parallel plate capacitor of capacitance 20 μF is connected to a 100 V supply. After sometime, the battery is disconnected, and the space between the plates of the capacitor is filled with a dielectric of dielectric constant 5. Calculate the energy stored in the capacitor.
(i) before (ii) after the dielectric has been put in between its plates.
Ans.
(i) C= 20 μF = 20×10^{-6} F , V = 100 volt, E = ?

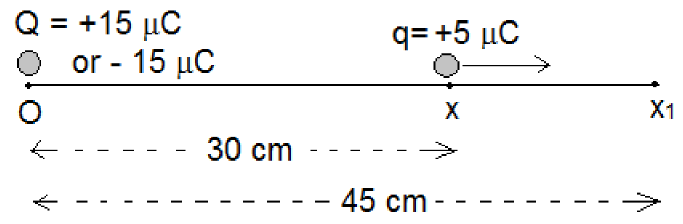
E = $\frac{1}{2}CV^2 = 0.5\times20\times10^{-6}\times100^2 = 0.1$ J

(ii) C= 20 μF = 20×10^{-6} F , K =6 , V = 100 volt, E = ?

E = $\frac{1}{2}C_mV^2 = \frac{1}{2}KCV^2$ [C_m = KC]

= K × $\frac{1}{2}CV^2$ = 5 × 0.1 J = 0.5 J

8. A particle, having a charge +5 μC, is initially at rest at the point x = 30 cm on the x axis. The particle begins to move due to the presence of a charge Q that is kept fixed at the origin. Find the kinetic energy of the particle at the instant it has moved 15 cm from its initial position if
(a) Q =+15μC and (b) Q = -15μC
Ans.



(a) Kinetic energy of the particle at final position (x_1) if Q = + 15 μC,

$E_1 = Q\,(V_i - V_f) = Q\left(\frac{k|q|}{r_i} - \frac{k|q|}{r_f}\right) = kqQ\left(\frac{1}{r_i} - \frac{1}{r_f}\right)$

$= 9\times10^9 \times 5\times10^{-6}\times15\times10^{-6}\left(\frac{1}{30\times10^{-2}} - \frac{1}{45\times10^{-2}}\right)$

$= 45\times15\times10^{-3}\left(\frac{100}{30} - \frac{100}{45}\right) = 45\times15\times10^{-3}\times\frac{100}{90} = 0.75$ J

(b) Kinetic energy of the particle at final position (x_1) if Q = $-15\ \mu C$,

$E_2 = -Q\,(V_i - V_f) = \; -0.75$ J

9. A capacitor of 200 pF is charged by a 300 V battery. The battery is then disconnected and the charged capacitor is connected to another uncharged capacitor of 100 pF. Calculate the difference between the final energy stored in the combination system and the initial energy stored in the single capacitor.

Ans.

The initial energy stored in the single capacitor,

$$E_1 = \frac{1}{2} C_1 {V_1}^2$$

$$= \frac{1}{2} \times (200 \times 10^{-12}) \times 300^2 = 9 \times 10^{-6} J$$

Again, Common potential of combination after connecting with uncharged capacitor,

$$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{200\times10^{-12}\times300+100\times10^{-12}\times0}{200\times10^{-12}+100\times10^{-12}}$$

$$= \frac{6\times10^{-8}}{3\times10^{-10}} = 200 \text{ volt}$$

The final energy stored in the combination system,

$$E_2 = \frac{1}{2} \times (C_1 + C_2)\, V^2$$

$$= \frac{1}{2} \times (200 \times 10^{-12} + 100 \times 10^{-12})\, 200^2$$

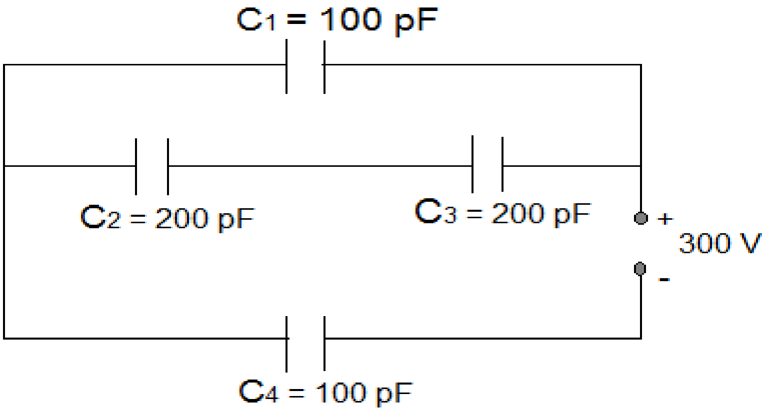
$$= 3\times 10^{-6} \text{ J}$$

∴ The difference between the final energy stored in the combination system and the initial energy stored in the single capacitor.

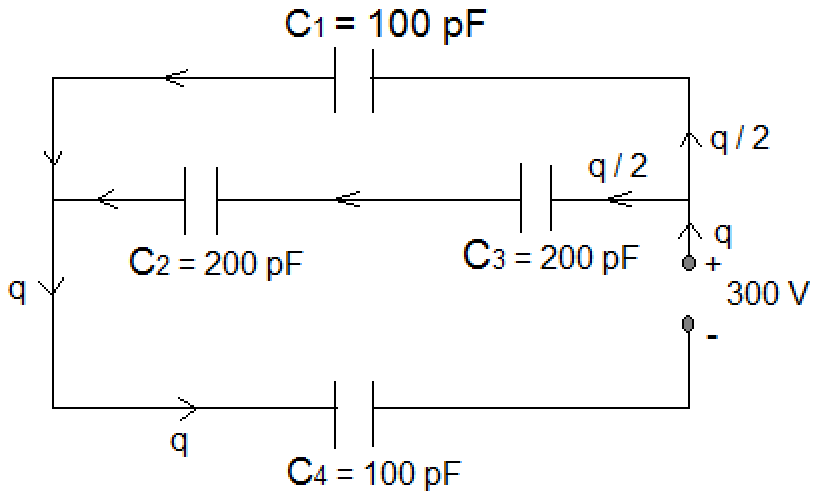
$$E = E_1 - E_2 = -6\times 10^{-6} \text{ J}$$

9. Obtain equivalent capacitance of the following network given in the figure below.

(b) For a v 300 V supply, determine the charge and voltage cross each capacitor.



Ans.



(a) Equivalent capacitance of C_2 and C_3 is

$$C_{23} = \frac{C_2 . C_3}{C_2 + C_3} = \frac{200 \times 200}{200+200} = \frac{200 \times 200}{2 \times 200} = 100 \text{ pF}$$

C_{23} is connected with capacitor C_1 in parallel.

Therefore, equivalent capacitance of C_{23} and C_1 will,

$$C_{123} = C_{23} + C_1 = 100 \text{ pF} + 100 \text{ pF} = 200 \text{ pF}$$

Again, C_{123} is connected with C_4 in series. Therefore, equivalent resistance of Circuit will,

$$C = \frac{C_{123} \times C_4}{C_{123} + C_4} = \frac{200 \times 100}{200+100} = \frac{200 \times 100}{300} = \frac{200}{3} \text{ pF}$$

(b) Charge flowing in the circuit will,

q = CV = $\frac{200}{3}$ pF × 300 V

= $\frac{200}{3} \times 10^{-12} \times 300$ V = 2×10^{-8} coulomb

Since charge does not distribute in series,

∴ Charge on each plate of C_{123} and $C_4 = 2 \times 10^{-8}$ coulomb

i.e. $q_{123} = q_4 = 2 \times 10^{-8}$ coulomb

Again, charge distribute equally in parallel , when they are of equal capacitances

∴ Charge on each plate of C_1 and $C_{23} = \frac{q}{2} = \frac{2 \times 10^{-8}}{2} = 10^{-8}$ coulomb

i.e. $q_1 = q_2 = q_3 = 10^{-8}$ coulomb

Now, voltage across C_1 will, $V_1 = \frac{q_1}{C_1} = \frac{10^{-8}}{100 \times 10^{-12}} = 100$ volt

Voltage across C_2 will, $V_2 = \frac{q_2}{C_2} = \frac{10^{-8}}{200 \times 10^{-12}} = 50$ volt

Voltage across C_3 will, $V_3 = \frac{q_3}{C_3} = \frac{10^{-8}}{200 \times 10^{-12}} = 50$ volt

And voltage across C_4 will, $V_4 = \frac{q_4}{C_4} = \frac{2 \times 10^{-8}}{100 \times 10^{-12}} = 200$ volt

LA-II (5 marks)

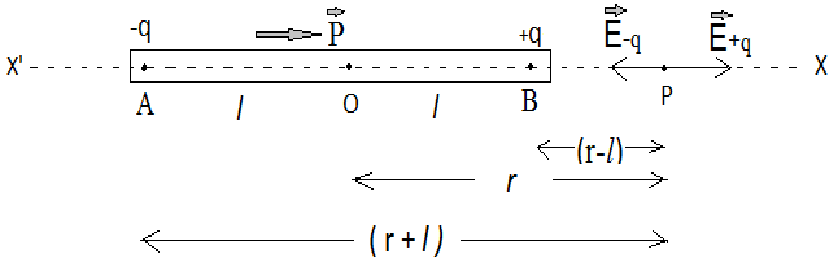
1. (a) An electric dipole of dipole moment $\vec{p}$ consists of point charges +q and –q separated by a distance 2*l* apart. Deduce the expression for the electric field $\vec{E}$ due to the dipole at a distance r from the centre of the dipole on its axial line in terms of the dipole moment $\vec{p}$.
Hence, show that in the limit r >> *l*,

$$\vec{E} = \frac{p}{4\pi\varepsilon_0 r^3}$$

(b) Consider a uniform electric field $\vec{E} = 3 \times 10^3\ \hat{\imath}$ N/C. what is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane?

Ans.

(a) **Electric field at any point P on the axial line**



Suppose an electric dipole AB (Dipole charges ±q, dipole length 2l and dipole moment p) is placed in air. We have to calculate electric field at point P on the axial line at distance r from O. For this we imagine a unit positive charge at point P.

Now, Magnitude of electric field at point P due to charge +q will,

$$E_{+q} = \frac{q}{4\pi\varepsilon_0 (BP)2} = \frac{q}{4\pi\varepsilon_0 (r-l)^2} \quad \ldots\ldots \text{(i)} \quad [\text{along P to X}]$$

And magnitude of electric field at point P due to charge -q will,

$$E_{-q} = \frac{q}{4\pi\varepsilon_0 (AP)2} = \frac{q}{4\pi\varepsilon_0 (r+l)^2} \quad \ldots \text{(ii)} \quad [\text{along P to X'}]$$

∴ Magnitude of net electric field at point P due to whole dipole will,

$$E = E_{+q} - E_{-q} = \frac{q}{4\pi\varepsilon_0 (r-l)^2} - \frac{q}{4\pi\varepsilon_0 (r+l)^2}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right] = \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+l)^2-(r-l)^2}{(r-l)^2(r+l)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4rl}{(r^2-l^2)^2}\right] \quad [\because (a+b)^2 - (a-b)^2 = 4ab]$$

$$= \frac{2r(2ql)}{(r^2-l^2)^2} = \frac{2r \times p}{(r^2-l^2)^2} \quad [\because p = 2ql]$$

$$\therefore \quad E = \frac{2pr}{(r^2-l^2)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

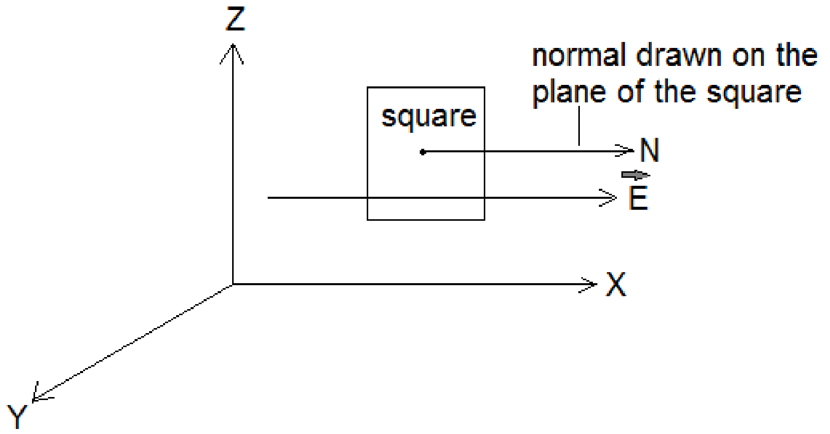
If r ≫ l then neglecting l^2, we get from equation (iii),

$$E = \frac{2pr}{r^4} \quad \text{or} \quad E_A = \frac{2p}{r^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

In vector form, $\vec{E_A} = \frac{2\vec{p}}{r^3}$

Its direction is along P to X.

(b) Given, Electric field intensity $\vec{E} = 3 \times 10^3\ \hat{\imath}$ N/C or E = 3× 10^3 N/C,
Area of square A = side^2 = 10^2 = 100 cm^2 = 100 × 10^{-4} m^2 = 10^{-2} m^2 ,
Electric flux passing through the plane of square ϕ = ?

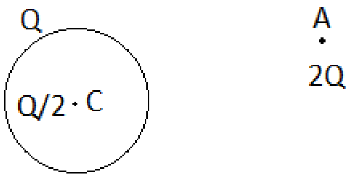


Since, the plane of the square is parallel to the y-z plane and direction of electric field is along X- axis. Therefore, angle between the normal drawn on plane of square and direction of $\vec{E}$ is $\theta = 0^0$.

$\therefore \phi = EA \cos\theta = 3\times\ 10^3 \times 10^{-2} \times \cos 0^0 = 30\ Nm^2C^{-1}$.

2. (a) Explain, using suitable diagrams, the difference in the behavior of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

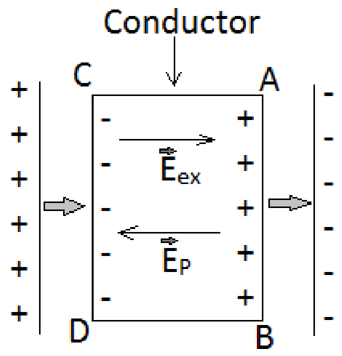
(b) A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $\frac{Q}{2}$ is placed at its Centre C and another charge +2Q is placed outside the shell at a distance x from the Centre as shown in the figure.



Find (i) The force on the charge at the Centre of shell and at the point A, (ii) the electric flux through the shell.

Ans. (a)

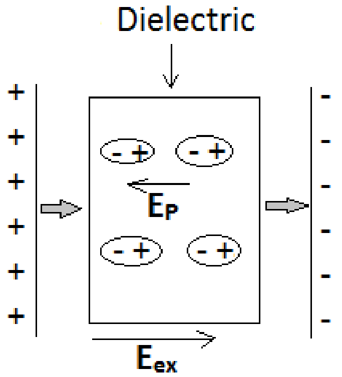
Conductor:



When a conductor ABCD is placed in an external electric field of intensity $\overrightarrow{E_{ex}}$ then free electrons of conductor move from AB side to CD side.

As a result, an opposing electric field $\overrightarrow{E_P}$ induces inside the conductor, which is equal to the external electric field $\overrightarrow{E_{ex}}$. Therefore, net electric field inside the conductor is zero.

Dielectric:



When a dielectric is placed in an external electric field of intensity $\overrightarrow{E_{ex}}$ then some molecules of dielectric are polarized.

As a result, an opposing electric field $\overrightarrow{E_P}$ induces inside the dielectric, which is less than external electric field $\overrightarrow{E_{ex}}$. Therefore, net electric field inside the conductor is not zero.

Polarization:

The dipole moment per unit volume is called *polarization* ($\vec{P}$). For a linear isotropic dielectrics,

$$\vec{P} \propto \vec{E}$$

Or $$\vec{P} = \chi_e \vec{E}$$

where χ_e is a constant characteristic of the dielectric and is known as the *electric susceptibility* of the dielectric medium.

(b) Charge $\frac{Q}{2}$ at Centre induces a charge $-\frac{Q}{2}$ at the inside surface of the shell and $+\frac{Q}{2}$ at the outside surface. Therefore, net charge on the outer surface will be

$(Q + \frac{Q}{2})$.

Now, electric field at point A will be, E = $\frac{K(Q+\frac{Q}{2})}{x^2}$

(i) Since, the electric field inside a hollow conductor is zero. Therefore, force experienced by the charge $\frac{Q}{2}$ at the Centre will be zero.

And, the force on charge 2Q at point A will be,

F =qE = 2Q× $\frac{K(Q+\frac{Q}{2})}{x^2} = \frac{3Q^2K}{x^2}$

(ii) The electric flux through the shell = $\frac{q_{net}}{\varepsilon_0} = \frac{0}{\varepsilon_0} = 0$

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