Summary

- **Electric Charge:**

Charge of a material body or particle is the property (acquired or natural) due to which it produces and experiences electrical and magnetic effects. Some of naturally occurring charged particles are electrons, protons, α-particles etc.

- **Units of Charge:**

C.G.S. unit of charge = electrostatic unit = esu. (or stat coulomb)

$1\,\text{coulomb} = 3\times10^{9}\,\text{esu of charge}$

Dimensional formula of charge = $[M^0L^0T^1T^1]$

[Where, I =Dimension of current]

- **Coulomb force between two point charges**:

$$\vec{F} = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{|\vec{r}|^3}\vec{r} = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{|\vec{r}|^2}\hat{r},$$

$$\text{Where}\frac{1}{4\pi\varepsilon_0\varepsilon_r} = k = 9\times10^9\,N-m^2/C^2$$

- **The electric field intensity at any point is the force experienced by unit positive charge, given**

By $\vec{E} = \frac{\vec{F}}{q_0}$ & $\vec{F} = q\vec{E}$, where $\vec{F}$ is force on q due to $\vec{E}$.

- **Electric Potential:**

If $\left(W_{\infty\to P}\right)_{ext}$ is the work required in moving a point charge q from infinity to a point P, the electric potential of the point P is:

$$V_p = \left.\frac{W_{\infty\to p})ext}{q}\right]_{\Delta k=0}$$

- **Potential Difference:**

$$V_A - V_B = \left.\frac{\left(W_{BA}\right)_{ext}}{q}\right)_{\text{keeping KE constant or } K_i=K_f}$$

- **Potential difference between points A and B:** $V_A - V_B = -\int_B^A \vec{E}.d\vec{r}$

$$\text{or } \vec{E} = *\left[\hat{i}\frac{\partial}{\partial x}V + \hat{j}\frac{\partial}{\partial x}V + \hat{k}\frac{\partial}{\partial z}V\right] = *\left[\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial x} + \hat{k}\frac{\partial}{\partial z}\right]V = -\nabla V = -\text{grad}\,V$$

- **Formulae of E and V:**

(i) For point charge, $\vec{E} = \frac{Kq}{|\vec{r}|^2}.\hat{r} = \frac{Kq}{r^3}\vec{r}$ & $V = \frac{Kq}{r}$ [V is an scalar quantity]

(ii) For infinitely long line charge $\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r} = \frac{2K\lambda\hat{r}}{r}$

V = not defined, $V_B - V_A = -2K\lambda \text{ in}\left(r_B / r_A\right)$

(iii) For uniformly charged ring

$$E_{axis} = \frac{KQx}{\left(R^2 + x^2\right)^{3/2}}, E_{center} = 0$$

$$V_{axis} = \frac{KQ}{\sqrt{R^2 + x^2}}, V_{center} = \frac{KQ}{R}$$

Where, x is the distance from centre along axis.

(iv) For thin uniformly charged disc (surface charge density is σ):

$$E_{axis} = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{R^2 + x^2}}\right] \Rightarrow V_{axis} = \frac{\sigma}{2\varepsilon_0}\left[\sqrt{R^2 + x^2} - x\right]$$

(v) For infinite nonconducting thin sheet, $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$

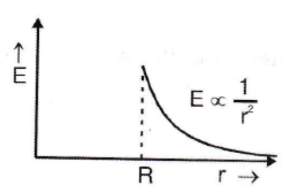
V = not defined, $V_B - V_A = -\frac{\sigma}{2\varepsilon_0}\left(r_B - r_A\right)$

(vi) For uniformly charged hollow conducting / nonconducting / solid conducting sphere:

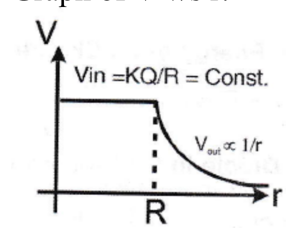
(a) For $r \geq R, \vec{E}_{out} = \frac{KQ}{|\vec{r}|^2}\hat{r}, \ V_{out} = \frac{KQ}{r}$

(b) For $r < R, \vec{E}_{in} = 0, \ V_{in} = \frac{KQ}{R}$

Graph of E v/s r:



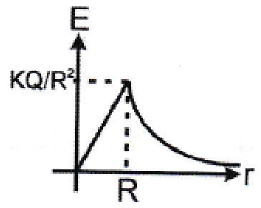
Graph of V v/s r:

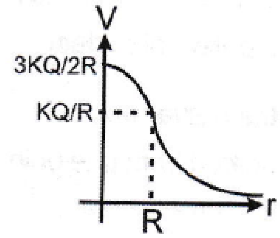


(vii) For uniformly charged solid nonconducting sphere (insulating material)

(a) For $r \geq R, \vec{E}_{out} = \frac{KQ}{|\vec{r}|^2}\hat{r}, \ V_{out} = \frac{KQ}{r}$

(b) For $r \leq R, \vec{E}_{in} = \frac{KQ\vec{r}}{R^3} = \frac{\rho\vec{r}}{3\varepsilon_0}, \ V_{in} = \frac{KQ}{2R^3}\left(3R^2 - r^2\right)$





- **work done by external agent in taking charge from A to B is**

$W_{ext})_{AB} = q\left(V_B - V_A\right) \text{and} \left(W_{el}\right)_{AB} = q\left(V_A - V_B\right)$. where $W_{el} \Rightarrow$ work done by electric field

- **The electrostatic potential energy of a point charge**
  $U = q\,V$

- **U = PE of the system =**

$$\frac{U_1 + U_2 + \ldots\ldots U_n}{2} = \left(U_{12} + U_{13} + \ldots\ldots U_{1n}\right) + \left(U_{23} + U_{34} + \ldots\ldots U_{2n}\right) + \left(U_{34} + U_{35} + \ldots\ldots U_{3n}\right)\ldots.$$

- **Energy Density** $= \frac{1}{2}\varepsilon E^2$; where $\in =$ permittivity of given medium.

- **Sell Energy of a uniformly charged spherical shell** $= U_{self} = \frac{KQ^2}{2R}$

- **Self-Energy of a uniformly charged solid non-conducting sphere** $= U_{self} = \frac{3KQ^2}{5R}$

- **Electric Field Intensity Due to Dipole**

(i) On the axis $\vec{E} = \frac{2K\vec{P}}{r^3}$ i.e (Electric field is along dipole moment)

(ii) On the equatorial position, $\vec{E} = \frac{K\vec{P}}{r^3}$ i.e (Electric field is in a direction opposite to dipole moment $\vec{P}$)

(iii) Total electric field at general point O $\left(r, \theta\right)$ is

$$E_{res} = \frac{KP}{r^3}\sqrt{1 + 2\cos^2\theta}$$

- **Potential Energy of an Electric Dipole in External Uniform Electric Field:**

$U = -\vec{P}.\vec{E}$

- **Electric Dipole in Uniform External Electric Field:**

Torque, $\vec{\tau} = \vec{P} \times \vec{E}; \vec{F} = 0$

- **Electric Potential Due to Dipole at General point (r, θ):**

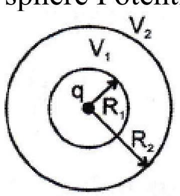
$$V = \frac{P\cos\theta}{4\pi \in_0 r^2} = \frac{\vec{P}.\vec{r}}{4\pi \in_0 r^3}$$

Equipotential Surface:
Definition: lf potential of a surface (imaginary or physically existing) is same throughout, then surface is known as an equipotential surface.

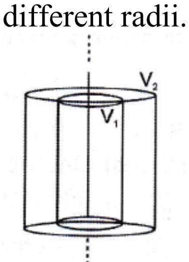
Properties of equipotential surfaces:
(i) When a charge is shifted from one point to another point on an equipotential surface, then work against electrostatic forces is zero.
(ii) Electric field is always perpendicular to equipotential surfaces.
(iii) Two equipotential surfaces do not cross each other.

Examples of equipotential surfaces:

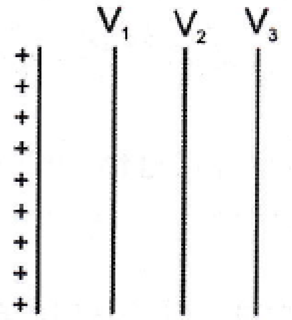
(i) Point charge:
Equipotential surfaces are concentric and spherical as shown in figure. ln figure, we can see that sphere of radius R_1, has potential V_1 throughout its surface and similarly for other concentric sphere Potential is same.



(ii) Line charge: Equipotential surfaces have curved surfaces as that of coaxial cylinders of different radii.



(iii) Uniformly charged large conducting I non conducting sheets: Equipotential surfaces are parallel planes.



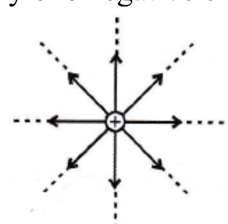
Note: In uniform electric field equipotential surfaces are always parallel planes.

- **Electric Lines of Force (ELOF):**

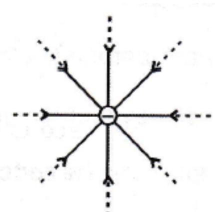
The line of force in an electric field is an imaginary line, the tangent to which at any point on it represents the direction of electric field at the given point.

Properties:

(i) Line of force originates out from a positive charge and terminates on a negative charge. if there is only one positive charge then lines start from positive charge and terminate at ∞. If there is only one negative charge then lines start from ∞ and terminate at negative charge.



ELOF of Isolated positive charge



ELOF of Isolated negative charge

(ii) The electric field intensity or electric intensity at a point is the number of tines of force streaming through per unit area normal to the direction of the intensity at that point. The intensity will be more where the density of lines is more.

(iii) Number of lines originating (terminating) from (on) a charge is directly proportional to the magnitude of the charge.

(iv) ELOF of resultant electric field can never intersect with each other.

(v) Electric lines of force produced by static charges do not form closed loop.

(vi) Electric lines of force end or start perpendicularly on the surface of a conductor.

(vii) Electric lines of force never enter into conductors.

Note: A charged particle need not follow an ELOF.

- **The electric flux over the whole area is given by**

$$\phi_E = \int_S \vec{E}\overrightarrow{dS} = \int_S E_n dS$$

Flux using Gauss's law,

Flux through a closed surface

$$\phi_E = \int_S \vec{E}\overrightarrow{dS} = \frac{q_{in}}{\varepsilon_0}$$

Properties of Electric Flux

(i) Flux through Gaussian surface is independent of its shape.
(ii) Flux through Gaussian surface depends only on total charge present inside Gaussian surface'
(iii) Flux through Gaussian surface is independent of position of charges inside Gaussian surface.
(iv) Electric field intensity at the Gaussian surface is due to all the charges present inside as well as outside the Gaussian surface'
(v) In a closed surface incoming flux is taken negative, while outgoing flux is taken positive, because $\hat{n}$ is taken positive in outward direction.
(vi) ln a Gaussian surface, $\phi = 0$ does not imply E = 0 at every point of the surface but E = 0 at every Point implies $\phi = 0$.

Conductor and it's properties [For electrostatic condition]
(i) Conductors are materials which contain large number of free electrons which can move freely inside the conductor.
(ii) In electrostatics, conductors are always equipotential surfaces.
(iii) Charge always resides on outer surface of conductor.
(iv) If there is a cavity inside the conductor having no charge then charge will always reside only outer surface of conductor.
(v)Electric field is always perpendicular to conducting surface'
(vi) Electric lines of force never enter into conductors.
(vii) Electric field intensity near the conducting surface is given by formula
$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$ [where, σ = charge density of conducting surface near that point
(viii) When a conductor is grounded, it's potential becomes zero.
(ix) When an isolated conductor is grounded then it$ charge becomes zero.
(x)When two conductors are connected there will be charge flow till their potentials become equal.
(xi) **Electric pressure**: Electric pressure at the surface of a conductor is given by formula
$P = \frac{\sigma^2}{2\varepsilon_0}$; where, σ is the local surface charge density

Practical Questions

1. Three concentric metal shells A, B and C of respective radii a, b and c (a < b < c) have surface charge densities $+\sigma, -\sigma$ and $+\sigma$ respectively. The potential of shell B is :

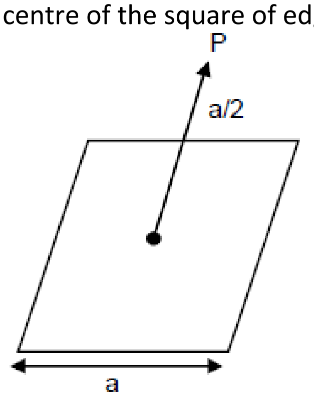
(a) $\frac{\sigma}{\in_0}\left(\frac{b^2-c^2}{c}+a\right)$

(b) $\frac{\sigma}{\in_0}\left(\frac{a^2-b^2}{a}+c\right)$

(c) $\frac{\sigma}{\in_0}\left(\frac{a^2-b^2}{b}+c\right)$

(d) $\frac{\sigma}{\in_0}\left(\frac{b^2-c^2}{b}+a\right)$

2. A charge Q is placed at a distance. The electric flux through the square the surface is a/2 above the centre of the square of edge a as shown in the figure.



(a) $\frac{Q}{6\in_0}$

(b) $\frac{Q}{2\in_0}$

(c) $\frac{Q}{3\in_0}$

(d) $\frac{Q}{\in_0}$

3. Two identical conducting spheres A and B carry equal charge. They are separated by a distance much larger than their diameters and the force between them is F. A third identical conducting sphere C is uncharged. Sphere C is first touched to A then to B and then removed. As a result the force between A and B would be equal to:

(a) $\dfrac{3F}{4}$

(b) $\dfrac{F}{2}$

(c) $\dfrac{3F}{8}$

(d) F

4. An electric dipole has a fixed dipole moment $\vec{p}$ which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric
field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences a torque $\vec{T}_2 = -\vec{T}_1$. The angle θ is

(a) 30^0

(b) 45^0

(c) 60^0

(d) 90^0

5. There is a uniform electrostatic field in a region. The potential at various points on a small sphere centred at P, in the region, is found to vary between the limits 589.0 V to 589.8 V. What is the potential at a point on the sphere whose radius vector makes an angle of 60^0 with the direction of the field ?

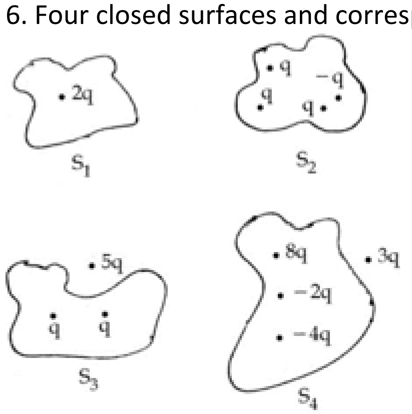
(a) 589.5 V

(b) 589.2 V

(c) 589.4 V

(d) 589.6 V

6. Four closed surfaces and corresponding charge distributions are shown below.



Let the respective electric fluxes through the surfaces be Φ_1, Φ_2, Φ_3 and Φ_4 . Then:

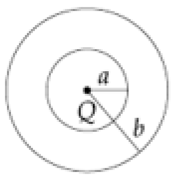
(a) $\Phi_1 < \Phi_2 = \Phi_3 > \Phi_4$

(b) $\Phi_1 > \Phi_2 > \Phi_3 > \Phi_4$

(c) $\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4$

(d) $\Phi_1 > \Phi_3; \Phi_2 < \Phi_4$

7. The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), has volume charge density $\rho = \frac{A}{r}$, where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is :



(a) $\frac{Q}{2\pi a^2}$

(b) $\frac{Q}{2\pi(b^2 - a^2)}$

(c) $\frac{2Q}{\pi(a^2 - b^2)}$

(d) $\frac{2Q}{\pi a^2}$

8. The potential (in volts) of a charge distribution is given by

$V(z) = 30 - 5z^2$ for $|z| \leq 1m$

$V(z) = 35 - 10|z|$ for $|z| \geq 1m$

V(z) does not depend on x and y. If this potential is generated by a constant charge per unit volume ρ_0 (in units of ϵ_0) which is spread over a certain region, then choose the correct statement.

(a) $\rho_0 = 10 \epsilon_0$ for $|z| \leq m$ and $\rho_0 = 0$

(b) $\rho_0 = 20 \epsilon_0$ in the entire region

(c) $\rho_0 = 40 \epsilon_0$ in the entire region

(d) $\rho_0 = 20 \epsilon_0$ for $|z| \leq m$ and $\rho_0 = 0$ elsewhere

9. Within a spherical charge distribution of charge density $\rho(r)$, N equipotential surfaces of potential $V_0, V_0 + \Delta V, V_0 + 2\Delta V, \ldots V_0 + N\Delta V \quad (\Delta V > 0)$, are drawn and have increasing radii $r_0, r_1, r_2, \ldots r_N$, respectively. If the difference in the radii of the surfaces is constant for all values of V0 and Δ V then :

(a) $\rho(r) \propto r$

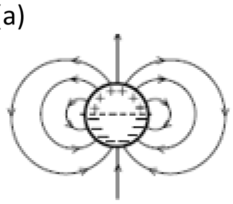
(b) $\rho(r)$ = constant

(c) $\rho(r) \propto \frac{1}{r}$

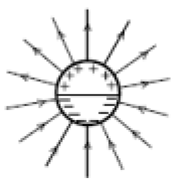
(d) $\rho(r) \propto \frac{1}{r^2}$

10. A long cylindrical shell carries positive surface charge σ in the upper half and negative surface charge – σ in the lower half. The electric field lines around the cylinder will look like figure given in : (figures are schematic and not drawn to scale)

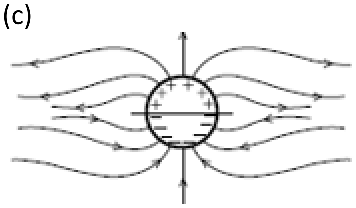
(a)



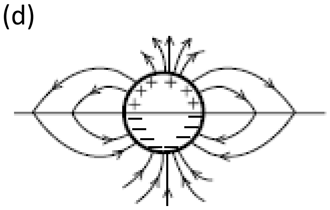
(b)



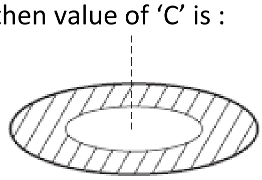
(c)



(d)



11. A thin disc of radius b = 2a has a concentric hole of radius ‘a’ in it (see figure). It carries uniform surface charge ‘σ’ on it. If the electric field on its axis at height ‘h’(h<<a) from its centre is given as ‘Ch’ then value of ‘C’ is :



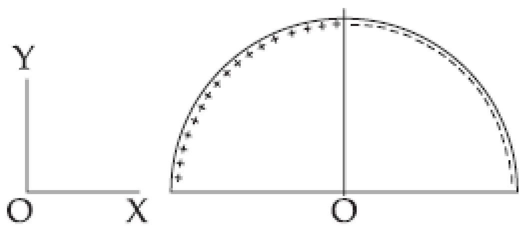
(a) $\frac{\sigma}{a \in_0}$

(b) $\frac{\sigma}{2a \in_0}$

(c) $\frac{\sigma}{4a \in_0}$

(d) $\dfrac{\sigma}{8a \in_0}$

12. A wire, of length L(=20 cm), is bent into a semi-circular arc. If the two equal halves, of the arc, were each of the uniformly charged with charges $\pm$Q, [|Q| = $10^3 \in_0$ Column where $\in_0$ is the permittivity (in SI units) of free space] the net electric field at the centre O of the semi-circular arc would be:

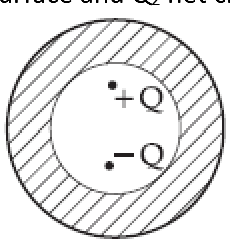


(a) $(50\times 10^3 N/C)\hat{j}$
(b) $(25\times 10^3 N/C)\hat{i}$
(c) $(25\times 10^3 N/C)\hat{j}$
(d) $(50\times 10^3 N/C)\hat{i}$

13. A uniformly charged solid sphere of radius R has potential V_0 (measured with respect to ∞) on its surface. For this sphere the equipotential surfaces with potentials $\frac{3V_0}{2}, \frac{5V_0}{4}, \frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 *and* R_4 respectively. Then

(a) $R_1 = 0$ *and* $R_2 > (R_4 - R_3)$
(b) $R_1 \neq 0$ *and* $(R_2 - R_1) > (R_4 - R_3)$
(c) $R_1 = 0$ *and* $R_2 < (R_4 - R_3)$
(d) $2R < R_4$

14. Shown in the figure are two point charges +Q and -Q inside the cavity of a spherical shell. The charges are kept near the surface of the cavity on opposite sides of the centre of the shell. If σ_1 is the surface charge on the inner surface and Q_1 net charge on it and σ_2 the surface charge on the outer surface and Q_2 net charge on it then :



(a)
$\sigma_1 \neq 0, Q_1 \neq 0$
$\sigma_2 \neq 0, Q_2 \neq 0$
(b)

$\sigma_1 \neq 0, Q_1 = 0$

$\sigma_2 \neq 0, Q_2 = 0$

(c)

$\sigma_1 \neq 0, Q_1 = 0$

$\sigma_2 = 0, Q_2 = 0$

(d)

$\sigma_1 = 0, Q_1 = 0$

$\sigma_2 = 0, Q_2 = 0$

15. An electric field $\vec{E} = (25\hat{i} + 30\hat{j})NC^{-1}$ exists in a region of space. If the potential at the origin is taken to be zero then the potential at x = 2 m, y = 2 m is :

(a) – 130 J

(b) – 120 J

(c) – 140 J

(d) – 110 J

16. Assume that an electric field $\vec{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$, where V_O is the potential at the origin and V_A potential at x = 2 m is

(a) 120 J

(b) – 120 J

(c) – 80 J

(d) 80 J

17. The magnitude of the average electric field normally present in the atmosphere just above the surface of the Earth is about 150 N/C, directed inward towards the center of the Earth. This gives the total net surface charge carried by the Earth to be :

[Given: $\in_0 = 8.85 \times 10^{-12} C^2 / N - m^2, R_E = 6.37 \times 10^6 m$]

(a) + 680 kC

(b) – 680 kC

(c) – 670 kC

(d) + 670 kC

18. A cone of base radius R and height h is located in a uniform electric field $\vec{E}$ parallel to its base. The electric flux entering the cone is :-

(a) 4EhR

(b) $\frac{1}{2}$EhR

(c) EhR

(d) 2EhR

19. Two equally charged small balls placed at a fixed distance experiences a force F. A similar uncharged ball after touching one of them is placed at the middle point between the two balls. The force experienced by this ball is

(a) F/2
(b) F
(c) 2F
(d) 4F

20. The electric field in a region of space is given by, $\vec{E} = E_0\hat{i} + 2E_0\hat{j}$ where $E_0 = 100\ N/C$. The flux of this field through a circular surface of radius 0.02 m parallel to the Y-Z plane is nearly
(a) $0.02\ Nm^2/C$
(b) $0.125\ Nm^2/C$
(c) $3.14\ Nm^2/C$
(d) $0.005\ Nm^2/C$

21. Two charges, each equal to q, are kept at x = - a and x = a on the x-axis. A particle of mass m and charge $q_0 = \frac{q}{2}$ is placed at the origin. If charge q_0 is given a small displacement y(y << a) along the y-axis, the net force acting on the particle is proportional to
(a) y
(b) - y
(c) $\frac{1}{y}$
(d) $-\frac{1}{y}$

22. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at O is double the electric field when only one positive charge of same magnitude is placed at R. Which of the following arrangements of charge is possible for, P, Q, R, S, T and U respectively ?
(a) +, -, +, -, -, +
(b) +, -, +, -, +, -
(c) +, +, -, +, -, -
(d) -, +, +, -, +, -

23. An electron of mass m_e, 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) 1
(b) $(m_p / m_e)^{1/2}$
(c) $(m_e / m_p)^{1/2}$
(d) 1836

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

(a) $-\frac{Q}{2}$

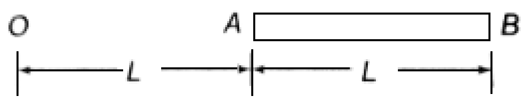
(b) $-\frac{Q}{4}$

(c) $+\frac{Q}{4}$

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

25. Two equal negative charges - q are fixed at points (0, -a) and (0, a) on y-axis. A positive charge Q is released from rest at the point (2a, 0) on the x-axis. The charge Q will
(a) execute simple harmonic motion about the origin
(b) move to the origin and remain at rest
(c) move to infinity
(d) execute oscillatory but not simple harmonic motion

26. A charge Q is uniformly distributed over a long rod AB of length L as shown in the figure. The electric potential at the point O lying at distance L from the end A is



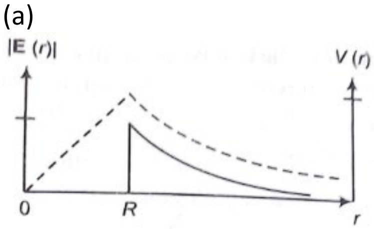
(a) $\frac{Q}{8\pi\varepsilon_0 L}$

(b) $\frac{3Q}{4\pi\varepsilon_0 L}$

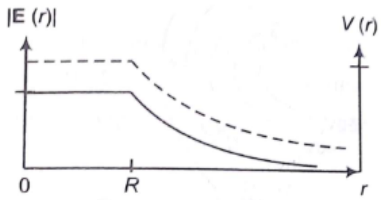
(c) $\frac{Q}{4\pi\varepsilon_0 L\ln 2}$

(d) $\frac{Q\ln 2}{4\pi\varepsilon_0 L}$

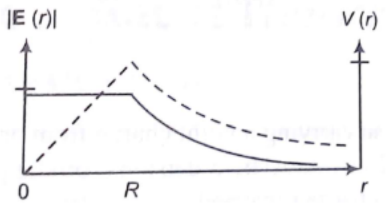
27. Consider a thin spherical shell of radius R with its centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field |E (r)| and the electrical potential V(r) with the distance r from the centre, is best represented by which graph?
(a)



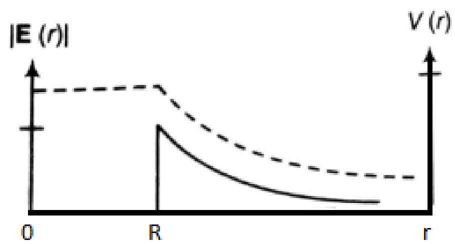
(b)



(c)



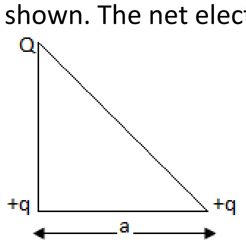
(d)



28. Positive and negative point charges of equal magnitude are kept at (0, 0, a/2) and (0, 0, - a/2), respectively. The work done by the electric field when another positive point charge in moved from (-a, 0, 0) to (0, a, 0) is
(a) positive
(b) negative
(c) zero
(d) depends on the path connecting the initial and final positions

29. A uniform electric field pointing in positive x-direction exists in a region. Let A be the origin, B be the point on the x-axis at x = +1 cm and C be the point on the y-axis at y = +1 cm. Then the potentials at the points A, B and C satisfy
(a) $V_A < V_B$
(b) $V_A > V_B$
(c) $V_A < V_C$
(d) $V_A > V_C$

30. Three charges Q, +q and +q are placed at the vertices of a right angle triangle (isosceles triangle) as shown. The net electrostatic energy of the configuration is zero, if Q is equal to



(a) $\frac{-q}{1+\sqrt{2}}$

(b) $\frac{-2q}{2+\sqrt{2}}$

(c) $-2q$

(d) $+q$

31. A charge +q is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$ ...∞ on the x-axis and a charge – q is fixed at each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$ ...,∞. Here, x_0 is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be $Q / 4\pi\varepsilon_0 r$. Then the potential at the origin due to the above system of charges is

(a) zero

(b) $\frac{q}{8\pi\varepsilon_0 x_0 ln2}$

(c) infinite

(d) $\frac{q\ln(2)}{4\pi\varepsilon_0 x_0}$

32. A non-conducting ring of radius 0.5 m carries a total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field E everywhere in space. The value of the integral $\int_{l=\infty}^{l=0} -E.dl$ (l = 0 being centre of the ring) in volt is

(a) +2

(b) -1

(c) -2

(d) zero

33. An alpha particle of energy 5 MeV is scattered through 180^0 by a fixed uranium nucleus. The distance of closest approach is of the order of

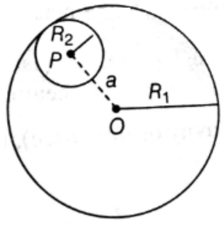
(a) $1\overset{0}{\mathrm{A}}$

(b) 10^{-10} cm

(c) 10^{-12} cm

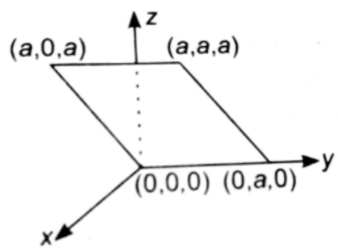
(d) 10^{-15} cm

34. Consider a uniform spherical charge distribution of radius R_1 centred at the origin O. In this distribution, a spherical cavity of radius R_2, centred at P with distance OP = a = R_1 - R_2 (see figure) is made. If the electric field inside the cavity at position r is E (r), then the correct statements is / are



(a) E is uniform, its magnitude is independent of R_2 but its direction depends on r
(b) E is uniform, its magnitude depends on R_2 but its direction depends on r
(c) E is uniform, its magnitude is independent of 'a' but its direction depends on a
(d) E is uniform and both its magnitude and direction depend on a

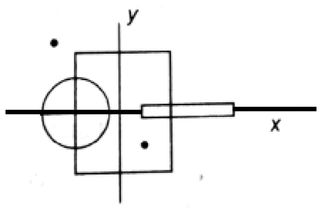
35. Consider an electric field $E = E_0\hat{x}$, where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is



(a) $2E_0a^2$
(b) $\sqrt{2}E_0a^2$
(c) E_0a^2
(d) $\frac{E_0a^2}{\sqrt{2}}$

36. Three concentric metallic spherical shells of radii R, 2R and 3R are given charges Q_1, Q_2 and Q_3, respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1 : Q_2 : Q_3$, is
(a) 1 : 2 : 3
(b) 1 : 3 : 5
(c) 1 : 4 : 9
(d) 1 : 8 : 18

37. A disk of radius $\frac{a}{4}$ having a uniformly distributed charge 6C is placed in the x-y plane with its centre at $\left(\frac{-a}{2},0,0\right)$. A rod of length a carrying a uniformly distributed charge 8C is placed on the x-axis from $x = \frac{a}{4}$ to $x = \frac{5a}{4}$. Two points charges -7C and 3C are placed at $\left(\frac{a}{4},\frac{-a}{4},0\right)$ and $\left(\frac{-3a}{4},\frac{3a}{4},0\right)$, respectively. Consider a cubical surface formed by six surfaces $x = \pm\frac{a}{2}, y = \pm\frac{a}{2}, z = \pm\frac{a}{2}$. The electric flux through this cubical surface is



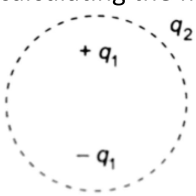
(a) $\frac{-2C}{\varepsilon_0}$

(b) $\frac{2C}{\varepsilon_0}$

(c) $\frac{10C}{\varepsilon_0}$

(d) $\frac{12C}{\varepsilon_0}$

38. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to

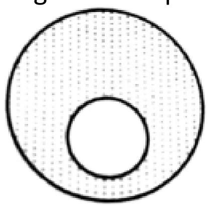


(a) q_2
(b) only the positive charges
(c) all the charges
(d) + q_1 and -q_1

39. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a change of – 3Q, the new potential difference between the same two surfaces is
(a) V
(b) 2V
(c) 4V
(d) – 2V

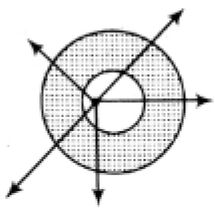
40. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is
(a) zero
(b) 10 V
(c) same as at a point 5 cm away from the surface
(d) same as at a point 25 cm away from the surface

41. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then

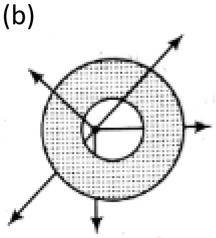


(a) negative and distributed uniformly over the surface of the sphere
(b) negative and appears only at the point on the sphere closest to the point charge
(c) negative and distributed non-uniformly over the entire surface of the sphere
(d) zero

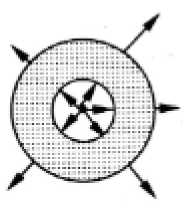
42. A metallic shell has a point charge q kept inside its cavity. Which one of the following diagrams represents the electric lines of forces?
(a)



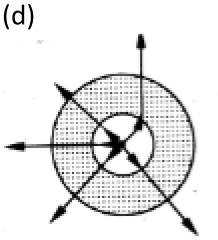
(b)



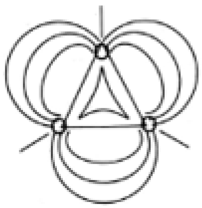
(c)



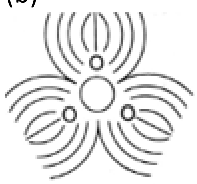
(d)



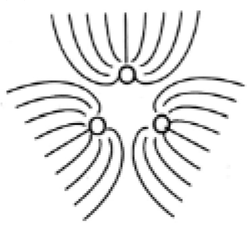
43. Three positive charges of equal value q are placed at the vertices of an equilateral triangle. The resulting lines of force should be sketched as in
(a)



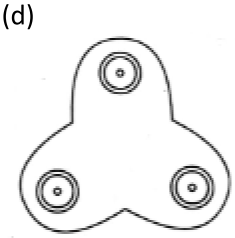
(b)



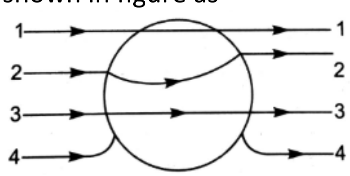
(c)



(d)



44. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path(s) shown in figure as



(a) 1
(b) 2
(c) 3
(d) 4

45. On moving a charge of 20 coulombs by 2 cm, 2J of work is done, then the potential difference between the points is:
(a) 0.1 V
(b) 8 V
(c) 2 V
(d) 0.5 V

ANSWER KEY

1. (c) 2. (a) 3. (c) 4. (c) 5. (a) 6. (c) 7. (a) 8. (a) 9. (c) 10. (a) 11. (c) 12. (b) 13. (c,d) 14. (c) 15. (d) 16. (c) 17. (c) 18. (c) 19. (b) 20. (b) 21. (a) 22. (d) 23. (b) 24. (b) 25. (d) 26. (d) 27. (d) 28. (c) 29. (b) 30. (b) 31. (d) 32. (a) 33. (c) 34. (d) 35. (c) 36. (b) 37. (a) 38. (c) 39. (a) 40. (b) 41. (d) 42. (c) 43. (c) 44. (d) 45. (a)

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