PHYSICS

Crash Course for
JEE Main 2020

ELECTROSTATICS

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Coulomb force between two point charges

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

- **The electric field intensity at any point is the force experienced by unit positive charge, given by $\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{\mathbf{q_0}}$**
- **Electric force on a charge 'q' at the position of electric field intensity $\vec{E}$ produced by some source charges is $\vec{\mathbf{F}} = \mathbf{q}\vec{\mathbf{E}}$**
- **Electric Potential**

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

  $$V_p = \left.\frac{(W_{\infty p})_{ext}}{q}\right]_{acc=0}$$

- **Potential Difference between two points A and B is**
  $V_A - V_B$
- **Formulae of $\vec{\mathbf{E}}$ and potential V**

(i) Point charge $E = \frac{Kq}{|\vec{r}|^2}\cdot\hat{r} = \frac{Kq}{r^3}\vec{r}$, $V = \frac{Kq}{r}$

(ii) Infinitely long line charge $\frac{\lambda}{2\pi\varepsilon_0 r}\hat{r} = \frac{2K\lambda\hat{r}}{r}$

V = not defined, $v_B - v_A = -2K\lambda \ \ln(r_B / r_A)$

(iii) Infinite nonconducting thin sheet $\frac{\sigma}{2\varepsilon_0}\hat{n}$,

V = not defined, $v_B - v_A = -\frac{\sigma}{2\varepsilon_0}(r_B - r_A)$

(iv) Uniformly charged ring

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

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

x is the distance from centre along axis.

(v) Infinitely large charged conducting sheet $\frac{\sigma}{\varepsilon_0}\hat{n}$

V = not defined, $v_B - v_A = -\frac{\sigma}{\varepsilon_0}(r_B - r_A)$

(vi) Uniformly charged hollow conducting/ nonconducting /solid conducting sphere

(a) for $\vec{E} = \frac{kQ}{|\vec{r}|^2}\hat{r}$, $r \geq R$, $V = \frac{KQ}{r}$

(b) $\vec{E} = 0$ for $r < R$, $V = \frac{KQ}{R}$

(vii) Uniformly charged solid nonconducting sphere (insulating material)

(a) $\vec{E} = \frac{kQ}{|\vec{r}|^2}\hat{r}$ for $r \geq R$, $V = \frac{KQ}{r}$

(b) $\vec{E} = \frac{KQ\vec{r}}{R^3} = \frac{\rho\vec{r}}{3\varepsilon_0}$ for $r \leq R$, $V = \frac{\rho}{6\varepsilon_0}(3R^2 - r^2)$

(viii) thin uniformly charged disc (surface charge density is σ)

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

- **Work done by external agent in taking a charge q from A to B is**
  $(W_{ext})_{AB} = q\,(V_B - V_A)$ or $(W_{el})_{AB} = q\,(V_A - V_B)$.

- **The electrostatic potential energy of a point charge**
  $U = qV$

- **U = PE of the system =**
  $\frac{U_1 + U_2 + ...}{2} = (U_{12} + U_{13} + ... + U_{1n}) + (U_{23} + U_{24} + ... + U_{2n})$
  $+ (U_{34} + U_{35} + ... + U_{3n})$ ....

- **Energy Density** = $\frac{1}{2}\varepsilon E^2$

- **Self Energy of a uniformly charged 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 $\vec{E} = \frac{2K\vec{P}}{r^3}$

  (ii) on the equatorial position : $\vec{E} = -\frac{K\vec{P}}{r^3}$

  (iii) Total electric field at general point O (r,θ) is $E_{res} = \frac{KP}{r^3}\sqrt{1 + 3\cos^2\theta}$

- **Potential Energy of an Electric Dipole in External Electric Field:**
  $U = -\vec{p}.\vec{E}$

- **Electric Dipole in Uniform Electric Field :**
  torque $\vec{\tau} = \vec{p} \times \vec{E}$; $\vec{F} = 0$

- **Electric Dipole in Nonuniform Electric Field:**

  torque $\vec{\tau} = \vec{p} \times \vec{E}$; $U = -\vec{p} \cdot \vec{E}$, Net force $|F| = \left| p\frac{\partial E}{\partial r} \right|$

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

  $$V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2} = \frac{\vec{p}\cdot\vec{r}}{4\pi\varepsilon_0 r^3}$$

- **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

  $$\phi_E = \oint \vec{E}\cdot\overrightarrow{dS} = \frac{q_{in}}{\varepsilon_0}.$$

- **Electric field intensity near the conducting surface**

  $$= \frac{\sigma}{\varepsilon_0}\hat{n}$$

- **Electric pressure :** Electric pressure at the surface of a conductor is given by formula

  $P = \dfrac{\sigma^2}{2\varepsilon_0}$ where σ is the local surface charge density.

- Potential difference between points A and B

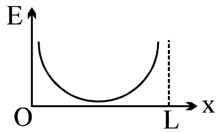
  $$V_B - V_A = -\int_A^B \vec{E}.d\vec{r}$$

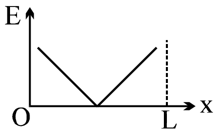
  $$\vec{E} = -\left[\hat{i}\frac{\partial}{\partial x}V + \hat{j}\frac{\partial}{\partial x}V + \hat{k}\frac{\partial}{\partial z}V\right] = --\left[\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial x} + \hat{k}\frac{\partial}{\partial z}\right]V$$

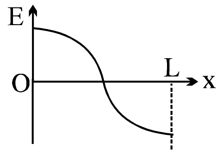
  $$= -\nabla V = -\text{grad } V$$

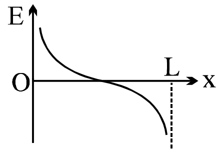
SECTION-1 SCQ

1. Two identical point charges are placed at a separation of l. P is a point on the line joining the charges, at a distance x from any one charge. The field at P is E. E is plotted against x for values of x from close to zero to slightly less than l. Which of the following best represents the resulting curve?

(A) 

(B) 

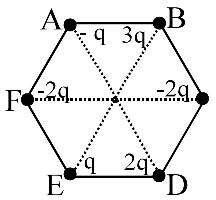
(C) 

(D) 

2. Two free positive charges 4q and q are a distance l apart. What charge Q is needed to achieve equilibrium for the entire system and where should it be placed form charge q?

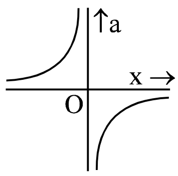
(A) $Q = \frac{4}{9}q$ (negative) at $\frac{l}{3}$
(B) $Q = \frac{4}{9}q$ (positive) at $\frac{l}{3}$
(C) $Q = q$ (positive) at $\frac{l}{3}$
(D) $Q = q$ (negative) at $\frac{l}{3}$

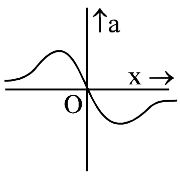
3. Six charges are placed at the corner of a regular hexagon as shown. If an electron is placed at its centre O, force on it will be:

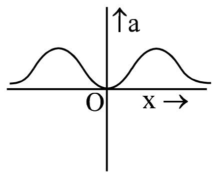


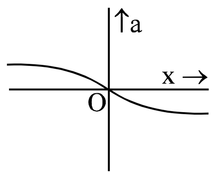
(A) Zero
(B) Along OF
(C) Along OC
(D) None of these

4. Two identical positive charges are fixed on the y-axis, at equal distances from the origin O. A particle with a negative charge starts on the x-axis at a large distance from O, moves along the + x-axis, passes through O and moves far away from O. Its acceleration a is taken as positive along its direction of motion. The particle's acceleration a is plotted against its x-coordinate. Which of the following best represents the plot ?

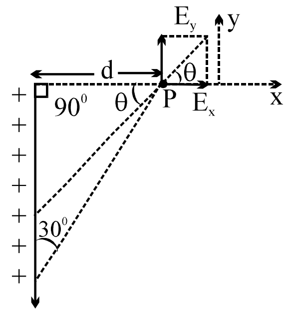
(A) 

(B) 

(C) 

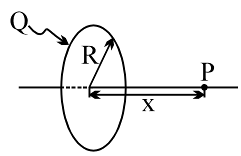
(D) 

5. The direction (θ) of $\vec{E}$ at point P due to uniformly charged finite rod will be



(A) at angle 30^0 from x-axis
(B) 45^0 from x - axis
(C) 60^0 from x-axis
(D) none of these

6. A small particle of mass m and charge –q is placed at point P on the axis of uniformly charged ring and released. If R >> x, the particle will undergo oscillations along the axis of symmetry with an angular frequency that is equal to



(A) $\sqrt{\frac{qQ}{4\pi\varepsilon_0 mR^3}}$
(B) $\sqrt{\frac{qQx}{4\pi\varepsilon_0 mR^4}}$
(C) $\frac{qQ}{4\pi\varepsilon_0 mR^3}$
(D) $\frac{qQx}{4\pi\varepsilon_0 mR^4}$

7. A charged particle having some mass is resting in equilibrium at a height H above the centre of a uniformly charged non-conducting horizontal ring of radius R. The force of gravity acts downwards. The equilibrium of the particle will be stable

(A) for all values of H (B) only if $H > \frac{R}{\sqrt{2}}$ (C) only if $H < \frac{R}{\sqrt{2}}$ (D) only if $H = \frac{R}{\sqrt{2}}$

8. Two identical thin rings, each of radius R meter are coaxially placed at distance R meter apart. If Q_1 and Q_2 coulomb are respectively the charges uniformly spread on the two rings, the minimum work done in moving a charge q from the centre of one ring to that of the other is

(A) zero

(B) $q(Q_1-Q_2)(\sqrt{2}-1)/(\sqrt{2}.4\pi\varepsilon_0 R)$

(C) $q\sqrt{2}(Q_1+Q_2)/4\pi\varepsilon_0 R$

(D) $q(Q_1-Q_2)(\sqrt{2}+1)/(\sqrt{2}.4\pi\varepsilon_0 R)$

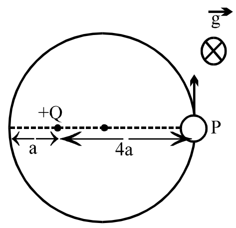
9. Two positively charged particles X and Y are initially far away from each other and at rest. X begins to move towards Y with some initial velocity. The total momentum and energy of the system are p and E.

(A) If Y is fixed, both p and E are conserved.
(B) If Y is fixed, E is conserved, but not p.
(C) If both are free to move, p is conserved but not E.
(D) If both are free, E is conserved, but not p.

10. Two identical particles of mass m carry a charge Q each. Initially one is at rest on a smooth horizontal plane and the other is projected along the plane directly towards first particle from a large distance with speed ν. The closed distance of approach be

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{m\nu}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{4Q^2}{m\nu^2}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{m\nu^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{3Q^2}{m\nu^2}$

11. The diagram shows a small bead of mass m carrying charge q. The bead can freely move on the smooth fixed ring placed on a smooth horizontal plane. In the same plane a charge +Q has also been fixed as shown. The potential atthe point P due to +Q is V. The velocity with which the bead should projected from the point P so that it can complete a circle should be greater than



(A) $\sqrt{\frac{6qV}{m}}$ (B) $\sqrt{\frac{qV}{m}}$ (C) $\sqrt{\frac{3qV}{m}}$ (D) none

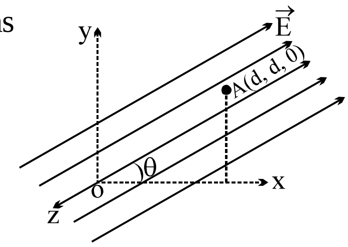
12. A charged particle of charge Q is held fixed and another charged particle of mass m and charge q (of the same sign) is released from a distance r. The impulse of the force exerted by the external agent on the fixed charge by the time distance between Q and q becomes 2r is

(A) $\sqrt{\frac{Qq}{4\pi\in_0 mr}}$ (B) $\sqrt{\frac{Qqm}{4\pi\in_0 r}}$ (C) $\sqrt{\frac{Qqm}{\pi\in_0 r}}$ (D) $\sqrt{\frac{Qqm}{2\pi\in_0 r}}$

13. In a regular polygon of n sides, each corner is at a distance r from the centre. Identical charges are placed at (n – 1) corners. At the centre, the intensity is E and the potential is V. The ratio V/E has magnitude.

(A) r n (B) r (n – 1) (C) (n – 1)/r (D) r(n – 1)/n

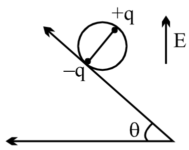
14. A uniform electric field having strength E is existing in -y plane as shown in figure. Find the p.d. between origin O & A(d, d, 0)



(A) Ed (cosθ + sinθ) (B) –Ed (sinθ – cosθ)

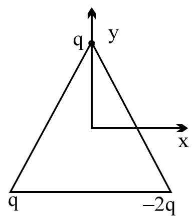
(C) $\sqrt{2}$ Ed (D) none of these

16. A wheel having mass m has charges +q and –q on diametrically opposite points. It remains in equilibrium on a rough inclined plane in the presence of uniform vertical electric field E =



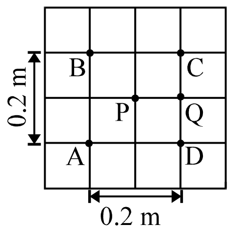
(A) $\frac{mg}{q}$ (B) $\frac{mg}{2q}$ (C) $\frac{mg\tan\theta}{2q}$ (D) none

17. An equilateral triangle wire frame of side L having 3 point charges at its vertices is kept in x-y plane as shown. Component of electric field due to the configuration in z direction at (0, 0, L) is [origin is centroid of triangle]



(A) $\frac{9\sqrt{3}\,kq}{8L^2}$ (B) zero (C) $\frac{9\,kq}{8L^2}$ (D) None

18. A, B, C, D, P and Q are points in a uniform electric field. The potentials a these points are V (A) = 2 volt. V (P) = V (B) = V (D) = 5 volt. V (C) = 8 volt. The electric field at P is



(A) 10 Vm^{-1} along PQ (B) $15\sqrt{2}$ V m^{-1} along PA

(C) 5 V m^{-1} along PC (D) 5 V m^{-1} along PA

19. The dipole moment of a system of charge +q distributed uniformly on an arc of radius R subtending an angle π/2 at its centre where another charge -q is placed is :

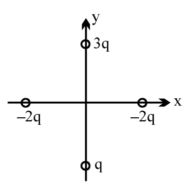
(A) $\frac{2\sqrt{2}qR}{\pi}$ (B) $\frac{\sqrt{2}qR}{\pi}$ (C) $\frac{qR}{\pi}$ (D) $\frac{2qR}{\pi}$

20. Point P lies on the axis of a dipole. If the dipole is rotated by 90° anticlock wise, the electric field vector $\vec{E}$ at P will rotate by

(A) 90° clock wise (B) 180° clock wise

(C) 90° anti clock wise (D) none

21. 4 charges are placed each at a distance 'a' from origin. The dipole moment of configuration is



(A) $2qa\hat{j}$ (B) $3qa\hat{j}$ (C) $2aq[\hat{i}+\hat{j}]$ (D) none

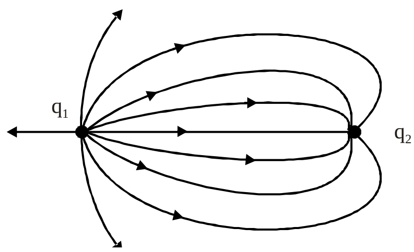
22. The figure shows the electric field lines in the vicinity of two point charges. Which one of the following statements concerning this situation is true?

(A) q_1 is negative and q_2 is positive

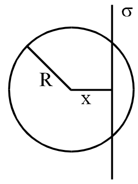
(B) The magnitude of the ratio (q_2/q_1) is less than one

(C) Both q_1 and q_2 have the same sign of charge

(D) The electric field is strongest midway between the charges.



23. An infinite, uniformly charged sheet with surface charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure. The electric flux Φ through the Gaussian surface is



(A) $\frac{\pi R^2 \sigma}{\varepsilon_0}$ (B) $\frac{2\pi\left(R^2 - x^2\right)\sigma}{\varepsilon_0}$

(C) $\frac{\pi(R-x)^2 \sigma}{\varepsilon_0}$ (D) $\frac{\pi\left(R^2 - x^2\right)\sigma}{\varepsilon_0}$

24. A positive charge q is placed in a spherical cavity made in a positively charged sphere. The centres of sphere and cavity are displaced by a small distance $\vec{l}$. Force on charge q is :

(A) in the direction parallel to vector $\vec{l}$

(B) in radial direction

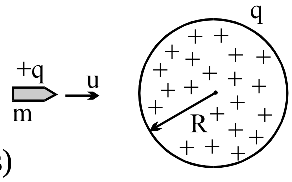
(C) in a direction which depends on the magnitude of charge density in sphere

(D) direction can not be determined.

25. A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?

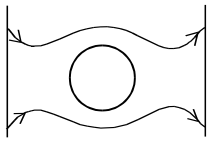
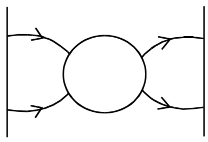
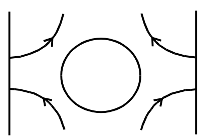
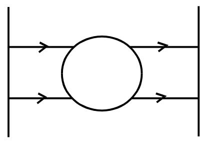
(A) R   (B) R/2   (C) R/3   (D) 2R

26. A bullet of mass m and charge q is fired towards a solid uniformly charged sphere of radius R and total charge + q. If it strikes the surface of sphere with speed u, find the minimum speed u so that it can penetrate through the sphere. (Neglect all resistance forces or friction acting on bullet except electrostatic forces)



(A) $\frac{q}{\sqrt{2\pi\varepsilon_0 mR}}$ (B) $\frac{q}{\sqrt{4\pi\varepsilon_0 mR}}$ (C) $\frac{q}{\sqrt{8\pi\varepsilon_0 mR}}$ (D) $\frac{\sqrt{3}q}{\sqrt{4\pi\varepsilon_0 mR}}$

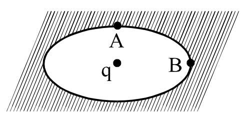
27. An uncharged sphere of metal placed inside a charged parallel plate capacitor. The lines of force look like

(A)  (B)  (C)  (D) 

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

(A) V/n   (B) Vn   (C) $Vn^{1/3}$ (D) $Vn^{2/3}$

29. An ellipsoidal cavity is carved within a perfect conductor. A positive charge q is placed at the center of the cavity. The points A & B are on the cavity surface as shown in the figure. Then :

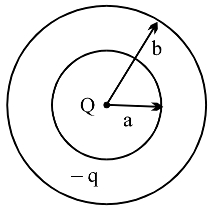


(A) electric field near A in the cavity = electric field near B in the cavity

(B) charge density at A = charge density at B

(C) potential at A = potential at B
(D) total electric field flux through the surface of the cavity is q/ε_0 .

30. Both question (a) and (b) refer to the system of charges as shown in the figure. A spherical shell with an inner radius 'a' and an outer radius 'b' is made of conducting material. A point charge +Q is placed at the centre of the spherical shell and a total charge – q is placed on the shell.



(a) Charge – q is distributed on the surfaces as
(A) – Q on the inner surface, – q on outer surface
(B) – Q on the inner surface, – q + Q on the outer surface
(C) +Q on the inner surface, –q – Q on the outer surface
(D) The charge –q is spread uniformly between the inner and outer surface.

(b) Assume that the electrostatic potential is zero at an infinite distance from the spherical shell. The electrostatic potential at a distance R (a < R < b) from the centre of the shell is

(A) 0 (B) $\frac{KQ}{a}$ (C) $K\frac{Q-q}{R}$ (D) $K\frac{Q-q}{b}$ (where $K = \frac{1}{4\pi\varepsilon_0}$)

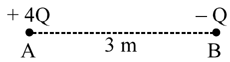
31. There are four concentric shells A, B, C and D of radii a, 2a, 3a and 4a respectively. Shells B and D are given charges +q and –q respectively. Shell C is now earthed. The potential difference $V_A - V_C$ is :

(A) $\frac{Kq}{2a}$ (B) $\frac{Kq}{3a}$ (C) $\frac{Kq}{4a}$ (D) $\frac{Kq}{6a}$

SECTION-2 MCQ

32. Mid way between the two equal and similar charges, we placed the third equal and similar charge. Which of the following statements is correct, concerned to the equilibrium along the line joining the charges ?
(A) The third charge experienced a net force inclined to the line joining the charges
(B) The third charge is in stable equilibrium
(C) The third charge is in unstable equilibrium
(D) The third charge experiences a net force perpendicular to the line joining the charges

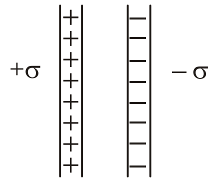
33. Two fixed charges 4Q (positive) and Q (negative) are located at A and B, the distance AB being 3 m.



(A) The point P where the resultant field due to both is zero is on AB outside AB.
(B) The point P where the resultant field due to both is zero is on AB inside AB.
(C) If a positive charge is placed at P and displaced slightly along AB it will execute oscillations.
(D) If a negative charge is placed at P and displaced slightly along AB it will execute oscillations.

34. Three point charges Q, 4Q and 16Q are placed on a straight line 9 cm long. Charges are placed in such a way that the system has minimum potential energy. Then
(A) 4Q and 16Q must be at the ends and Q at a distance of 3 cm from the 16Q.
(B) 4Q and 16Q must be at the ends and Q at a distance of 6 cm from the 16Q.
(C) Electric field at the position of Q is zero.
(D) Electric field at the position of Q is $\frac{Q}{4\pi\varepsilon_0}$.

35. Two infinite sheets of uniform charge density $+\sigma$ and $-\sigma$ are parallel to each other as shown in the figure. Electric field at the

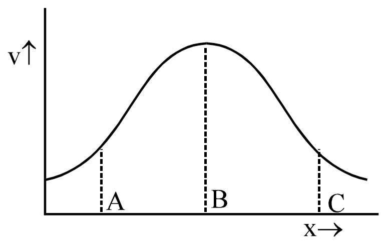


(A) points to the left or to the right of the sheets is zero.
(B) midpoint between the sheets is zero.
(C) midpoint of the sheets is σ / ε_0 and is directed towards right.
(D) midpoint of the sheet is $2\sigma / \varepsilon_0$ and is directed towards right.

36. Potential at a point A is 3 volt and at a point B is 7 volt , an electron is moving towards A from B.
(A) It must have some K.E. at B to reach A
(B) It need not have any K.E. at B to reach A
(C) to reach A it must have more than or equal to 4 eV K. E. at B.
(D) when it will reach A, it will have K.E. more then or at least equal to 4 eV if it was released fromrest at B.

37. A conducting sphere of radius r has a charge. Then
(A) The charge is uniformly distributed over its surface, if there is an external electric field.
(B) Distribution of charge over its surface will be non uniform if no external electric field exist in space.
(C) Electric field strength inside the sphere will be equal to zero only when no external electric field exists
(D) Potential at every point of the sphere must be same

38. Variation of electrostatic potential along x-direction is shown in the graph. The correct statement about electric field is



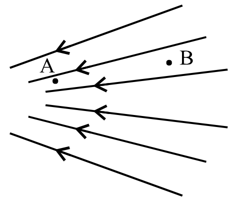
(A) x component at point B is maximum
(B) x component at point A is towards positive x-axis.
(C) x component at point C is along negative x-axis
(D) x component at point C is along positive x-axis

39. A particle of charge 1 μC & mass 1 gm moving with a velocity of 4 m/s is subjected to a uniform electric field of magnitude 300 V/m for 10 sec. Then it's final speed cannot be:
(A) 0.5 m/s (B) 4 m/s (C) 3 m/s (D) 6 m/s

40. A proton and a deuteron are initially at rest and are accelerated through the same potential difference. Which of the following is true concerning the final properties of the two particles ?
(A) They have different speeds (B) They have same momentum
(C) They have same kinetic energy (D) none of these

41. An electric dipole moment $\vec{p} = (2.0\hat{i} + 3.0\hat{j})\ \mu$C. m is placed in a uniform electric field $\vec{E} = (3.0\hat{i} + 2.0\hat{k}) \times 10^5$ N C^{-1}.
(A) The torque that $\vec{E}$ exerts on $\vec{p}$ is $(0.6\hat{i} - 0.4\hat{j} - 0.9\hat{k})$ Nm.
(B) The potential energy of the dipole is –0.6 J.
(C) The potential energy of the dipole is 0.6 J.
(D) If the dipole is rotated in the electric field, the maximum potential energy of the dipole is 1.3 J.

42. Which of the following is true for the figure showing electric lines of force? (E is electrical field, V is potential)



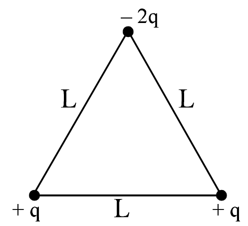
(A) $E_A > E_B$ (B) $E_B > E_A$
(C) $V_A > V_B$ (D) $V_B > V_A$

43. Mark the correct options:
(A) Gauss's law is valid only for uniform charge distributions.
(B) Gauss's law is valid only for charges placed in vacuum.
(C) The electric field calculated by Gauss's law is the field due to all the charges .
(D) The flux of the electric field through a closed surface due to all the charges is equal to the flux due to the charges enclosed by the surface.

44. A hollow closed conductor of irregular shape is given some charge. Which of the following statements are correct ?
(A) The entire charge will appear on its outer surface.
(B) All points on the conductor will have the same potential.
(C) All points on its surface will have the same charge density.
(D) All points near its surface and outside it will have the same electric intensity.

45. Charges Q_1 and Q_2 lies inside and outside respectively of a closed surface S. Let E be the field at any point on S and ϕ be the flux of E over S.
(A) If Q_1 changes, both E and ϕ will change.
(B) If Q_2 changes, E will change but ϕ will not change.
(C) If $Q_1 = 0$ and $q_2 \neq 0$ then $E \neq 0$ but $\phi = 0$.
(D) If $Q_1 \neq 0$ and $Q_2 = 0$ then $E = 0$ but $\phi \neq 0$.

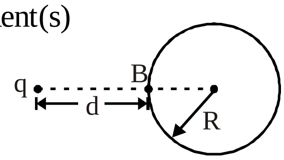
46. Three points charges are placed at the corners of an equilateral triangle of side L as shown in the figure.



(A) The potential at the centroid of the triangle is zero
(B) The electric field at the centroid of the triangle is zero
(C) The dipole moment of the system is $\sqrt{2}\,qL$
(D) The dipole moment of the system is $\sqrt{3}\,qL$

47. A particle of mass m and charge q is thrown in a region where uniform gravitational field and electric field are present. The path of particle
(A) may be a straight line (B) may be a circle
(C) may be a parabola (D) may be a hyperbola

48. For the situation shown in the figure below, mark out the correct statement(s)



Hollow neutral conductor

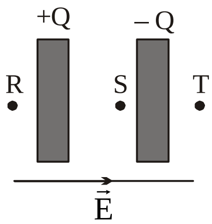
(A) Potential of the conductor is $\dfrac{q}{4\pi\varepsilon_0(d+R)}$

(B) Potential of the conductor is $\dfrac{q}{4\pi\varepsilon_0 d}$

(C) Potential of the conductor can't be determined as nature of distribution of induced charges is not known

(D) Potential at point B due to induced charges is $\frac{-qR}{4\pi\varepsilon_0(d+R)d}$

49. Two large thin conducting plates with small gap in between are placed in a uniform electric field 'E' (perpendicular to the plates). Area of each plate is A and charges +Q and –Q are given to these plates as shown in the figure. If points R,S and T as shown in the figure are three points in space, then the



(A) field at point R is E

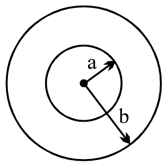
(B) field at point S is E

(C) field at point T is $\left(E+\frac{Q}{\epsilon_0 A}\right)$

(D) field at point S is $\left(E+\frac{Q}{A\epsilon_0}\right)$

SECTION-3 INTEGER

50. If the electric potential of the inner metal sphere is 10 volt & that of the outer shell is 5 volt, then the potential at the centre will be in volt



51. In a certain region of space, the potential is given by : $V = k[2x^2 - y^2 + z^2]$. The electric field at the point (1, 1, 1) has magnitude = $k\sqrt{3x}$ find value of x

52. A charge 3 coulomb experiences a force 3000 N when placed in a uniform electric field. The potential difference between two points separated by a distance of 1 cm along the field lines is, in volt

53. 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

54. Electric flux through a surface of area 100 m^2 lying in the xy plane is $\sqrt{x} \times 10^2$ v-m. If $\vec{E} = \hat{i} + \sqrt{2}\hat{j} + \sqrt{3}\hat{k}$ find value of x.

55. 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 $\vec{E}$ every where in space. The value of the line integral $\int_{\ell=\infty}^{\ell=0} -\vec{E}.d\vec{\ell}$ (l = 0 being centre of the ring) in volts is :

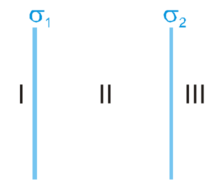
56. Two identical small conducting spheres, having charges of opposite sign, attract each other with a force of 0.108 N when separated by 0.5 m. The spheres are connected by a conducting wire, which is then removed, and thereafter, they repel each other with a force of 0.036 N. The initial charges on the spheres are $\pm$ X μc & $\mp$ Y μc then value of X + Y will be

57. An infinite nonconducting sheet of charge has a surface charge density of 10^{-7} C/m^2. The separation between two equipotential surfaces near the sheet whose potential differ by 5V in mm is

58. In a uniform electric field, the potential is 10V at the origin of coordinates, and 8V at each of the points (1, 0, 0), (0, 1, 0) and (0, 0, 1). The potential at the point (1, 1, 1) in volt will be.

SECTION 4 - MATCH THE COLUMN

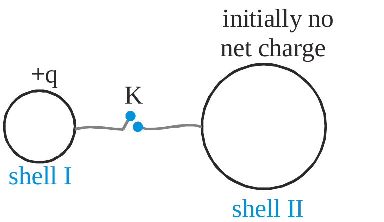
59. Two parallel metallic plates have surface charge densities σ_1 and σ_2 as shown in figure.



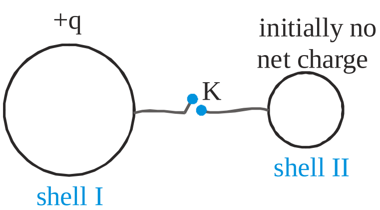
	Column–I		**Column–II**
(A)	If $\sigma_1 + \sigma_2 = 0$	(P)	Electric field in region III is towards right
(B)	If $\sigma_1 + \sigma_2 > 0$	(Q)	Electric field in region I is zero
(C)	If $\sigma_1 + \sigma_2 < 0$	(R)	Electric field in region I is towards right
		(S)	Nothing can be said

60. Column–I gives certain situations involving two thin conducting shells connected by a conducting wire via a key K. In all situations one sphere has net charge +q and other sphere has no net charge. After the key K is pressed, column–II gives some resulting effect.

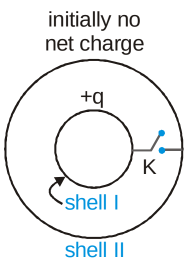
Column I **Column II**

(A) 

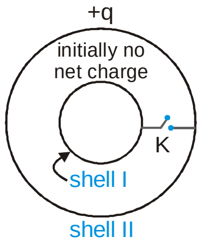
(P) Charge flows through connecting wire

(B) 

(Q) Potential energy of system of spheres decreases

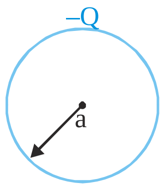
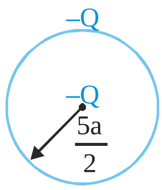
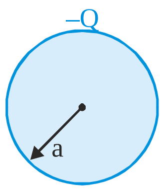
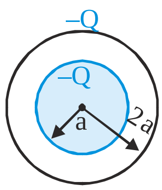
(C) 

(R) No heat is produced

(D) 

(S) The sphere I has no charge after equilibrium is reached

61. In each situation of column–I, some charge distributionsare given with all details explained. The electrostatic potential energy and its nature is given situation in column–II.

Column I		**Column II**
(A) A thin shell of radius a and having a charge –Q uniformly distributed over its surface as shown		(P) $\dfrac{1}{8\pi\epsilon_0}\dfrac{Q^2}{a}$ in magnitude
(B) A thin shell of radius $\dfrac{5a}{2}$ and having a charge –Q uniformly distributed over its surface and a point charge –Q placed at its centre as shown		(Q) $\dfrac{3}{20\pi\epsilon_0}\dfrac{Q^2}{a}$ in magnitude
(C) A solid sphere of radius a and having a charge –Q uniformly distributed throughout its volume as shown		(R) $\dfrac{2}{5\pi\epsilon_0}\dfrac{Q^2}{a}$ in magnitude
(D) A solid sphere of radius a and having a charge –Q uniformly distributed throughout its volume. The solid sphere is surrounded by a concentric thin uniformly charged spherical shell of radius 2a and carrying charge –Q as shown		(S) Positive in sign

ANSWER KEY

SECTION-1
SCQ

1. D	**2.** A	**3.** D	**4.** B	**5.** A	**6.** A	**7.** B	**8.** B	**9.** B	**10.** B	**11.** A	**12.** B	**13.** B	**14.** A
15. B	**16.** B	**17.** B	**18.** B	**19.** A	**20.** A	**21.** A	**22.** B	**23.** D	**24.** A	**25.** C	**26.** B	**27.** B	**28.** D
29. B	**30.** D	**31.** D											

SECTION-2
MCQ

32. B **33.** AD **34.** BC **35.** AC **36.** AC **37.** D **38.** D **39.** A **40.** AC **41.** ABD
42. AD **43.** CD **44.** AB **45.** ABC **46.** AB **47.** AC **48.** AD **49.** AD

SECTION-3
INTEGER

50. 8 **51.** 8 **52.** 10 **53.** 10V **54.** 3 **55.** 2 **56.** 4 **57.** 9 **58.** 4

SECTION-4
MATRIX-MATCH

59. A $\rightarrow$ R ; B$\rightarrow$ R $\rightarrow$ C$\rightarrow$ P
60. A $\rightarrow$ P,Q ; B $\rightarrow$ P,Q ; C $\rightarrow$ P,Q,S; D$\rightarrow$ R,S
61. A $\rightarrow$ P,S; B$\rightarrow$ Q,S ; C $\rightarrow$ Q,S ; D$\rightarrow$ S