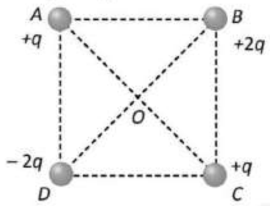
Topicwise Questions

Coulomb's Force

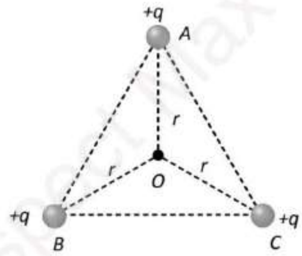
1. When 10^{14} electrons are removed from a neutral metal sphere, the charge on the sphere becomes
   (*a*) 16 μC (*b*) –16 μC
   (*c*) 32 μC (*d*) –32 μC
2. Number of electrons in one coulomb of charge will be $(1e = 1.6 \times 10^{-9})C$
   (*a*) 5.46×10^{29} (*b*) 6.25×10^{18}
   (*c*) 1.6×10^{19} (*d*) 9×10^{11}
3. The ratio of the forces between two small spheres with constant charge (a) in air (b) in a medium of dielectric constant K is:
   (*a*) 1 : K (*b*) K : 1
   (*c*) $1 : K^2$ (*d*) $K^2 : 1$
4. Four charges are arranged at the corners of a square ABCD, as shown in the adjoining figure. The force on the charge kept at the centre O is



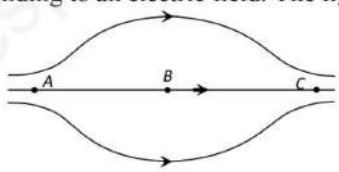
   (*a*) Zero
   (*b*) Along the diagonal AC
   (*c*) Along the diagonal BD
   (*d*) Perpendicular to side AB
5. A total charge Q is broken in two parts Q_1 and Q_2 and they are placed at a distance R from each other. The maximum force of repulsion between them will occur, when
   (*a*) $Q_2 = \frac{Q}{R}, Q_1 = Q - \frac{Q}{R}$ (*b*) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{2Q}{3}$
   (*c*) $Q_2 = \frac{Q}{4}, Q_1 = \frac{3Q}{4}$ (*d*) $Q_1 = \frac{Q}{2}, Q_2 = \frac{Q}{2}$

Electric Field and Field Lines

6. A charge q is placed at the centre of the line joining two equal charges 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*) $+\frac{Q}{2}$
7. ABC is an equilateral triangle. Charges +q are placed at each corner. The electric intensity at O will be

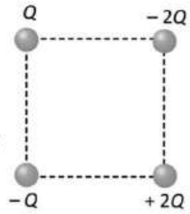


   (*a*) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (*b*) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
   (*c*) Zero (*d*) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{r^2}$
8. The magnitude of electric field intensity E is such that, an electron placed in it would experience an electrical force equal to its weight is given by
   (*a*) mge (*b*) $\frac{mg}{e}$
   (*c*) $\frac{e}{mg}$ (*d*) $\frac{e^2}{m^2}g$
9. The distance between the two charges 25 μC and 36 μC is 11 cm At what point on the line joining the two, the intensity will be zero
   (*a*) At a distance of 5 cm from 25 μC
   (*b*) At a distance of 5 cm from 36 μC
   (*c*) At a distance of 10 cm from 25 μC
   (*d*) At a distance of 11 cm from 36 μC
10. The intensity of the electric field required to keep a water drop of radius 10^{-5} cm just suspended in air when charged with one electron is approximately
   ($g = 10$ Newton/ kg, $e = 1.6 \times 10^{-19}$ coulomb)
   (*a*) 260 volt/cm
   (*b*) 260 Newton/coulomb
   (*c*) 130 volt/cm
   (*d*) 130 Newton/coulomb
11. The figure shows some of the electric field lines corresponding to an electric field. The figure suggests



   (*a*) $E_A > E_B > E_C$ (*b*) $E_A = E_B = E_C$
   (*c*) $E_A = E_C > E_B$ (*d*) $E_A = E_C < E_B$

12. Four charges are placed on corners of a square as shown in figure having side of 5 cm. If Q is one microcoulomb, then electric field intensity at centre will be



(*a*) 1.02×10^7 N/C upwards
(*b*) 2.04×10^7 N/C downwards
(*c*) 2.04×10^7 N/C upwards
(*d*) 1.02×10^7 N/C downwards

Gauss Law and Application

13. A cylinder of radius R and length L is placed in a uniform electric field E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by

(*a*) $2\pi R^2 E$ (*b*) $\pi R^2 / E$
(*c*) $(\pi R^2 - \pi R)/E$ (*d*) Zero

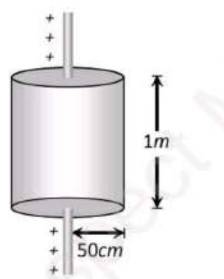
14. Electric field at a point varies as r^0 for

(*a*) An electric dipole
(*b*) A point charge
(*c*) A plane infinite sheet of charge
(*d*) A line charge of infinite length

15. A cube of side l is placed in a uniform field E, where $E = E\hat{i}$. The net electric flux through the cube is

(*a*) Zero (*b*) $l^2 E$
(*c*) $4l^2 E$ (*d*) $6l^2 E$

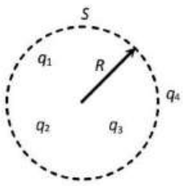
16. Electric charge is uniformly distributed along a long straight wire of radius 1mm. The charge per cm length of the wire is Q coulomb. Another cylindrical surface of radius 50 cm and length 1m symmetrically encloses the wire as shown in the figure. The total electric flux passing through the cylindrical surface is



(*a*) $\frac{Q}{\varepsilon_0}$ (*b*) $\frac{100Q}{\varepsilon_0}$

(*c*) $\frac{10Q}{(\pi\varepsilon_0)}$ (*d*) $\frac{100Q}{(\pi\varepsilon_0)}$

17. q_1, q_2, q_3 and q_4 are point charges located at points as shown in the figure and S is a spherical Gaussian surface of radius R. Which of the following is true according to the Gauss's law?



(*a*) $\oint_S (\vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4) . d\vec{A} = \frac{q_1 + q_2 + q_3}{2\varepsilon_0}$

(*b*) $\oint_S (\vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4) . d\vec{A} = \frac{(q_1 + q_2 + q_3)}{\varepsilon_0}$

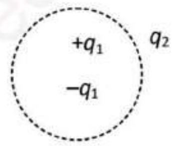
(*c*) $\oint_S (\vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4) . d\vec{A} = \frac{(q_1 + q_2 + q_3 + q_4)}{\varepsilon_0}$

(*d*) None of the above

18. If the electric flux entering and leaving an enclosed surface respectively is ϕ_1 and ϕ_2 the electric charge inside the surface will be

(*a*) $(\phi_1 + \phi_2)\varepsilon_0$ (*b*) $(\phi_2 - \phi_1)\varepsilon_0$
(*c*) $(\phi_1 + \phi_2)/\varepsilon_0$ (*d*) $(\phi_2 - \phi_1)/\varepsilon_0$

19. Consider the charge configuration and 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 $-q_1$

20. An electric dipole is put in north-south direction in a sphere filled with pure water. Which statement is correct

(*a*) Electric flux is coming towards sphere
(*b*) Electric flux is coming out of sphere
(*c*) Electric flux entering into sphere and leaving the sphere are same
(*d*) Water does not permit electric flux to enter into sphere

21. Two infinite plane parallel conducting sheets separated by a distance d have equal and opposite uniform charge densities σ. Electric field at a point between the sheets is

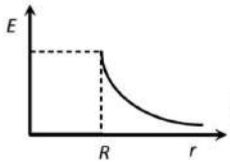
(*a*) Zero

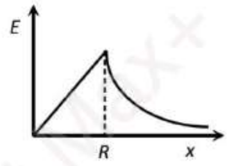
(*b*) $\frac{\sigma}{\varepsilon_0}$

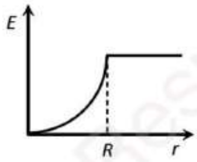
(*c*) $\frac{\sigma}{2\varepsilon_0}$

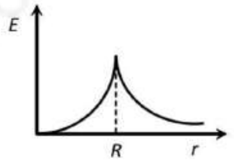
(*d*) Depends upon the location of the point

22. Which of the following graphs shows the variation of electric field E due to a hollow spherical conductor of radius R as a function of distance from the centre of the sphere

(*a*) 

(*b*) 

(*c*) 

(*d*) 

23. A conducting sphere of radius R = 20 cm is given a charge Q = 16 μC. What is $\vec{E}$ at centre

(*a*) 3.6×10^6 N/C (*b*) 1.8×10^6 N/C
(*c*) Zero (*d*) 0.9×10^6 N/C

24. At a point 20 cm from the centre of a uniformly charged dielectric sphere of radius 10 cm, the electric field is 100 V/m. The electric field at 3 cm from the centre of the sphere will be

(*a*) 150 V/m (*b*) 125 V/m
(*c*) 120 V/m (*d*) Zero

ELECTROSTATIC POTENTIAL

Electrostatic Potential and Potential Energy

25. A hollow metal sphere of radius 5 cm is charged so that the potential on its surface is 10 V. The potential at the centre of the sphere is

(*a*) 0 V
(*b*) 10 V
(*c*) Same as at point 5 cm away from the surface
(*d*) Same as at point 25 cm away from the surface

26. If a unit positive charge is taken from one point to another over an equipotential surface, then

(*a*) Work is done on the charge
(*b*) Work is done by the charge
(*c*) Work done is constant
(*d*) No work is done

27. Charges of $+\frac{10}{3}\times 10^{-9}$ C are placed at each of the four corners of a square of side 8 cm. The potential at the intersection of the diagonals is

(*a*) $150\sqrt{2}$ volt (*b*) $1500\sqrt{2}$ volt
(*c*) $900\sqrt{2}$ volt (*d*) 900 volt

28. If E is the electric field intensity of an electrostatic field, then the electrostatic energy density is proportional to

(*a*) E (*b*) E^2
(*c*) $1/E^2$ (*d*) E^3

29. Four equal charges Q are placed at the four corners of a square of each side 'a'. Work done in removing a charge –Q from its centre to infinity is

(*a*) 0 (*b*) $\frac{\sqrt{2}Q^2}{4\pi\varepsilon_0 a}$

(*c*) $\frac{\sqrt{2}Q^2}{\pi\varepsilon_0 a}$ (*d*) $\frac{Q^2}{2\pi\varepsilon_0 a}$

30. Two charge +q and –q are situated at a certain distance. At the point exactly midway between them

(*a*) Electric field and potential both are zero
(*b*) Electric field is zero but potential is not zero
(*c*) Electric field is not zero but potential is zero
(*d*) Neither electric field nor potential is zero

31. In Millikan's oil drop experiment an oil drop carrying a charge Q is held stationary by a potential difference 2400 V between the plates. To keep a drop of half the radius stationary the potential difference had to be made 600 V. What is the charge on the second drop

(*a*) $\frac{Q}{4}$ (*b*) $\frac{Q}{2}$

(*c*) Q (*d*) $\frac{3Q}{2}$

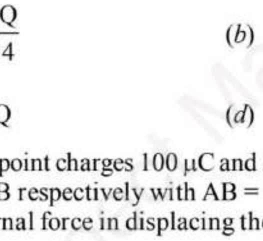
32. Two point charges 100 μC and 5 μC are placed at points A and B respectively with AB = 40 cm. The work done by external force in displacing the charge 5μC from B to C, where BC = 30 cm, angle $ABC = \frac{\pi}{2}$ and

$$\frac{1}{4\pi\varepsilon_0} = 9\times 10^9\ \text{Nm}^2/\text{C}^2$$

(*a*) 9 J (*b*) $\frac{81}{20}$ J

(*c*) $\frac{9}{25}$ J (*d*) $-\frac{9}{4}$ J

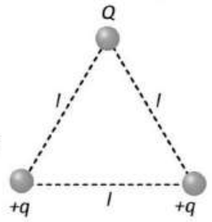
33. Three charges Q, +q and +q are placed at the vertices of a right-angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero if Q is equal to



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

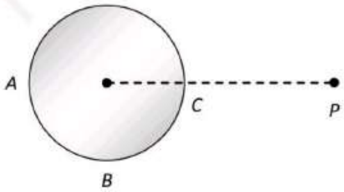
(*c*) –2q (*d*) +q

34. Three charges Q, (+q) and (+q) are placed at the vertices of an equilateral triangle of side l as shown in the figure. If the net electrostatic energy of the system is zero, then Q is equal to



(*a*) $\left(-\frac{q}{2}\right)$ (*b*) (–q)
(*c*) (+q) (*d*) Zero

35. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure. Let V_A, V_B, V_C be the potentials at points A, B and C on sphere Then



(*a*) $V_C > V_B$ (*b*) $V_B > V_C$
(*c*) $V_A > V_B$ (*d*) $V_A = V_C$

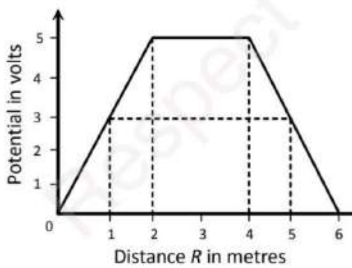
36. If an insulated non-conducting sphere of radius R has charge density ρ. The electric field at a distance r from the centre of sphere (r < R) will be

(*a*) $\frac{\rho R}{3\varepsilon_0}$ (*b*) $\frac{\rho r}{\varepsilon_0}$
(*c*) $\frac{\rho r}{3\varepsilon_0}$ (*d*) $\frac{3\rho R}{\varepsilon_0}$

37. A hollow metallic sphere of radius R is given a charge Then the potential at the centre is

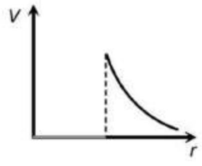
(*a*) Zero (*b*) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{R}$
(*c*) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2Q}{R}$ (*d*) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{2R}$

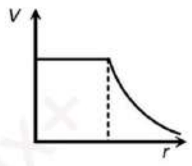
38. The variation of potential with distance R from a fixed point is as shown below. The electric field at R = 5 m is

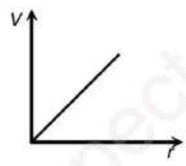


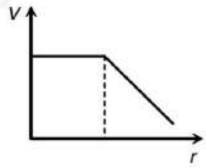
(*a*) 2.5 volt/m (*b*) –2.5 volt/m
(*c*) 2/5 volt/m (*d*) –2/5 volt/m

39. In a hollow spherical shell potential (V) changes with respect to distance (r) from centre

(*a*)


(*b*)


(*c*)


(*d*)


Relation Between Field and Potential

40. The electric potential V at any point O (x, y, z all in metres) in space is given by $V = 4x^2$ volt. The electric field at the point (1m, 0, 2m) in volt/metreis
(*a*) 8 along negative X-axis
(*b*) 8 along positive X-axis
(*c*) 16 along negative X-axis
(*d*) 16 along positive Z-axis

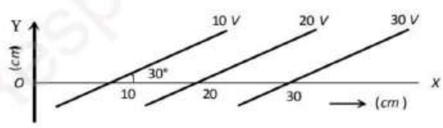
41. A uniform electric field having a magnitude E_0 and direction along the positive X-axis exists. If the potential V is zero at x = 0, then its value at X = + x will be
(*a*) $V_x = +xE_0$ (*b*) $V_x = -xE_0$
(*c*) $V_x = +x^2E_0$ (*d*) $V_x = -x^2E_0$

42. Two plates are 2 cm apart, a potential difference of 10 volt is applied between them, the electric field between the plates is
(*a*) 20 N/C (*b*) 500 N/C
(*c*) 5 N/C (*d*) 250 N/C

43. There is an electric field E in X-direction. If the work done on moving a charge 0.2 C through a distance of 2 m along a line making an angle 60° with the X-axis is 4.0, what is the value of E
(*a*) $\sqrt{3}$ N/C (*b*) 4 N/C
(*c*) 5 N/C (*d*) None of these

44. A charge of 5 C experiences a force of 5000 N when it is kept in a uniform electric field. What is the potential difference between two points separated by a distance of 1 cm along the electric field line.
(*a*) 10 V (*b*) 250 V
(*c*) 1000 V (*d*) 2500 V

45. Equipotential surfaces are shown in figure. Then the electric field strength will be



(*a*) 100 Vm^{-1} along X-axis
(*b*) 100 Vm^{-1} along Y-axis
(*c*) 200 Vm^{-1} at an angle 120° with X-axis
(*d*) 50 Vm^{-1} at an angle 120° with X-axis

Electric Dipole

46. An electric dipole when placed in a uniform electric field E will have minimum potential energy, if the positive direction of dipole moment makes the following angle with E

(*a*) π (*b*) $\pi/2$

(*c*) Zero (*d*) $3\pi/2$

47. An electric dipole of moment $\vec{p}$ is placed normal to the lines of force of electric intensity $\vec{E}$, then the work done in deflecting it through an angle of 180° is

(*a*) pE (*b*) +2pE

(*c*) –2pE (*d*) Zero

48. The electric field due to a dipole at a distance r on its axis is

(*a*) Directly proportional to r^3

(*b*) Inversely proportional to r^3

(*c*) Directly proportional to r^2

(*d*) Inversely proportional to r^2

49. The torque acting on a dipole of moment $\vec{P}$ in an electric field $\vec{E}$ is

(*a*) $\vec{P}\cdot\vec{E}$ (*b*) $\vec{P}\times\vec{E}$

(*c*) Zero (*d*) $\vec{E}\times\vec{P}$

50. Electric potential at an equatorial point of a small dipole with dipole moment P(r, distance from the dipole) is

(*a*) Zero (*b*) $\dfrac{P}{4\pi\varepsilon_0 r^2}$

(*c*) $\dfrac{P}{4\pi\varepsilon_0 r^3}$ (*d*) $\dfrac{2P}{4\pi\varepsilon_0 r^3}$

51. The value of electric potential at any point due to any electric dipole is

(*a*) $k\cdot\dfrac{\vec{p}\times\vec{r}}{r^2}$ (*b*) $k\cdot\dfrac{\vec{p}\times\vec{r}}{r^3}$

(*c*) $k\cdot\dfrac{\vec{p}\cdot\vec{r}}{r^2}$ (*d*) $k\cdot\dfrac{\vec{p}\cdot\vec{r}}{r^3}$

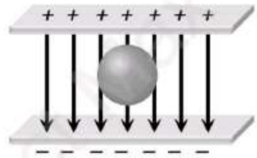
52. Two charges $+3.2\times10^{-19}$ C and -3.2×10^{-9} C kept 2.4 Å apart forms a dipole. If it is kept in uniform electric field of intensity 4×10^5 volt/m then what will be its electrical energy in stable equilibrium

(*a*) $+3\times10^{-23}$ J (*b*) -3×10^{-23} J

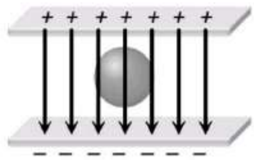
(*c*) -6×10^{-23} J (*d*) -2×10^{-23} J

Conductors and Self-energy and Electrostatic Potential

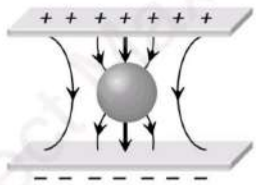
53. An uncharged sphere of metal is placed in between two charged plates as shown. The lines of force look like



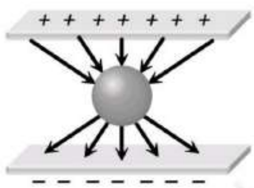
A



B



C



D

(*a*) A (*b*) B

(*c*) C (*d*) D

54. Conduction electrons are almost uniformly distributed within a conducting plate. When placed in an electrostatic field $\vec{E}$, the electric field within the plate

(*a*) Is zero

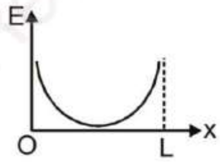
(*b*) Depends upon E

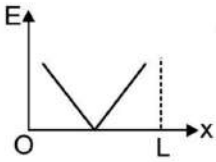
(*c*) Depends upon $\vec{E}$

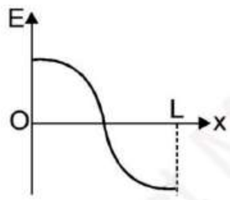
(*d*) Depends upon the atomic number of the conducting element

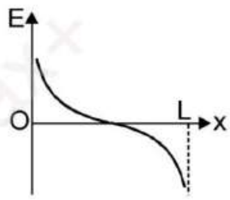
Learning Plus

1. One quantum of charge should be at least equal to the charge in coloumb:
   (*a*) 1.6×10^{-17} C. (*b*) 1.6×10^{-19} C.
   (*c*) 1.6×10^{-10} C. (*d*) 4.8×10^{-10} C.
2. An electron at rest has a charge of 1.6×10^{-19} C. It starts moving with a velocity $v = c/2$, where c is the speed of light, then the new charge on it is -
   (*a*) 1.6×10^{-19} Coulomb
   (*b*) $1.6 \times 10^{-19} \sqrt{1-\left(\frac{1}{2}\right)^2}$ Coulomb
   (*c*) $1.6 \times 10^{-19} \sqrt{\left(\frac{2}{1}\right)^2 - 1}$ Coulomb
   (*d*) $\dfrac{1.6 \times 10^{-19}}{\sqrt{1-\left(\frac{1}{2}\right)^2}}$ Coulomb
3. Which one of the following statement regarding electrostatics is wrong ?
   (*a*) Charge is quantized
   (*b*) Charge is conserved
   (*c*) There is an electric field near an isolated charge at rest
   (*d*) A stationary charge produces both electric and magnetic fields
4. When the distance between two charged particle is halved, the force between them becomes -
   (*a*) One fourth (*b*) One half
   (*c*) Double (*d*) Four times
5. Five balls, numbered 1 to 5, are suspended using separate threads. Pairs (1, 2), (2, 4), (4, 1) show electrostatic attraction, while pairs (2, 3) and (4, 5) show repulsion. Therefore ball 1:
   (*a*) Must be positively charged
   (*b*) Must be negatively charged
   (*c*) May be neutral
   (*d*) Must be made of metal
6. Two small balls having equal positive charge Q (Coulomb) on each are suspended by two insulating strings of equal length 'L' metre, from a hook fixed to a stand. The whole set up is taken in a satellite in to space where there is no gravity (state of weight lessness). Then the angle (θ) between the two strings is-
   (*a*) 0° (*b*) 90°
   (*c*) 180° (*d*) $0^\circ < \theta < 180^\circ$
7. Two charges 4q and q are placed 30 cm. apart. At what point the value of electric field will be zero
   (*a*) 10 cm. away from q and between the charge
   (*b*) 20 cm. away from q and between the charge
   (*c*) 10 cm. away from q and out side the line joining the charge.
   (*d*) 10 cm. away from 4q and out side the line joining them.
8. A total charge of 20 μC is divided into two parts and placed at some distance apart. If the charges experience maximum coulombian repulsion, the charges should be:
   (*a*) $5\,\mu C, 15\,\mu C$ (*b*) $10\,\mu C, 10\,\mu C$
   (*c*) $12\,\mu C, 8\,\mu C$ (*d*) $\frac{40}{3}\mu C, \frac{20}{3}\mu C$
9. Four equal but like charges are placed at four corners of a square. The electric field intensity at the center of the square due to any one charge is E, then the resultant electric field intensity at centre of square will be:
   (*a*) Zero (*b*) 4E
   (*c*) E (*d*) 1/2E
10. 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*)


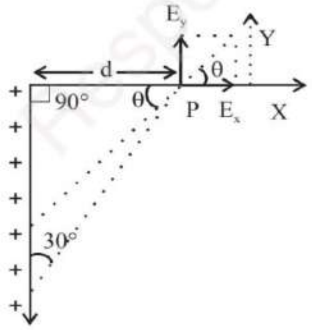
11. A charged particle of charge q and mass m is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after time 't' seconds is
   (*a*) $\frac{Eqm}{t}$ (*b*) $\frac{E^2q^2t^2}{2m}$
   (*c*) $\frac{2E^2t^2}{mq}$ (*d*) $\frac{Eq^2m}{2t^2}$

12. The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will be:

(*a*) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{3\sqrt{3}R^2}$ (*b*) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{2q}{3R^2}$

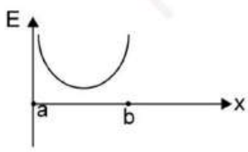
(*c*) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{2q}{3\sqrt{3}R^2}$ (*d*) $\dfrac{1}{4\pi\varepsilon_0}\ i\ \dfrac{3q}{2\sqrt{3}R^2}$

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



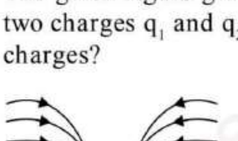
(*a*) at angle 30° from x-axis
(*b*) 45° from x-axis
(*c*) 60° from x-axis
(*d*) None of these

14. Two point charges a & b, whose magnitudes are same are positioned at a certain distance from each other with a at origin. Graph is drawn between electric field strength at points between a & b and distance x from a. E is taken positive if it is along the line joining from a to b. From the graph, it can be decided that



(*a*) a is positive, b is negative
(*b*) a and b both are positive
(*c*) a and b both are negative
(*d*) a is negative, b is positive

15. The given figure gives electric lines of force due to two charges q_1 and q_2. What are the signs of the two charges?



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

16. If electric field is uniform, then the electric lines of forces are:

(*a*) Divergent (*b*) Convergent
(*c*) Circular (*d*) Parallel

17. Electric flux through a surface of area 100 m² lying in the xy plane is (in V-m) if $\vec{E} = \hat{i} + \sqrt{2}\,\hat{j} + \sqrt{3}\,\hat{k}$

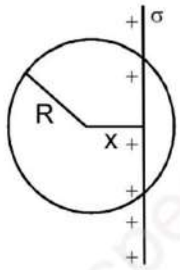
(*a*) 100 (*b*) 141.4
(*c*) 173.2 (*d*) 200

18. A cone of radius (R) and length (L) is placed in a uniform electrical field (E) parallel to the axis of the cone. the total flux for the surface of the cone is given by -

(*a*) $2\pi R^2E$ (*b*) πR^2E

(*c*) $\dfrac{2\pi R^2}{E}$ (*d*) zero

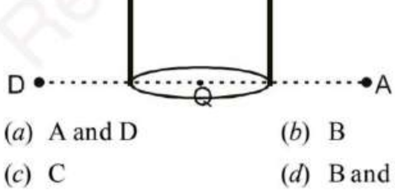
19. An infinite, uniformly charged sheet with surface charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure. The electric flux Φ through the Gaussian surface is



(*a*) $\dfrac{\pi R^2\sigma}{\varepsilon_0}$ (*b*) $\dfrac{2\pi(R^2-x^2)\sigma}{\varepsilon_0}$

(*c*) $\dfrac{\pi(R-x)^2\sigma}{\varepsilon_0}$ (*d*) $\dfrac{\pi(R^2-x^2)\sigma}{\varepsilon_0}$

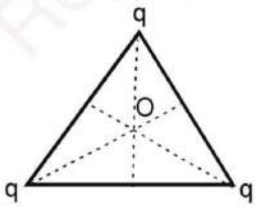
20. Figure shows a charge Q placed at the centre of open face of a cylinder as shown in figure. A second charge q is placed at one of the positions A, B, C and D, out of which positions A and D are lying on a straight line parallel to open face of cylinder. In which position(s) of this second charge, the flux of the electric field through the cylinder remains unchanged?



(*a*) A and D (*b*) B
(*c*) C (*d*) B and C

21. A flat circular fixed disc has a charge +Q uniformly distributed on the disc. A charge +q is thrown with kinetic energy K, towards the disc along its axis. The charge q :
(*a*) may hit the disc at the centre
(*b*) may return back along its path after touching the disc
(*c*) may return back along its path without touching the disc
(*d*) any of the above three situations is possible depending on the magnitude of K

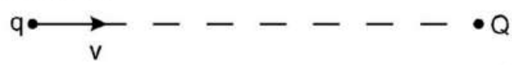
22. Three equal charges are placed at the three corners of an isosceles triangle as shown in the figure. The statement which is true for electric potential V and the field intensity E at the centre of the triangle is-



(*a*) $V=0, E=0$ (*b*) $V=0, E\neq 0$
(*c*) $V\neq 0, E=0$ (*d*) $V\neq 0, E\neq 0$

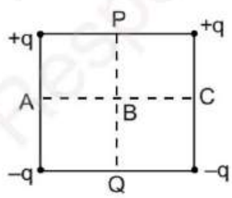
23. A particle A has charge +q and particle B has charge + 4q with each of them having the same mass m. When allowed to fall from rest through same electrical potential difference, the ratio of their speed $v_A : v_B$ will be:
(*a*) 2 : 1 (*b*) 1 : 2
(*c*) 4 : 1 (*d*) 1 : 4

24. A charged particle 'q' is shot from a large distance with speed v towards a fixed charged particle It approaches Q upto a closest distance r and then returns. If q were given a speed '2v', the closest distance of approach would be :



(*a*) r (*b*) 2r
(*c*) $\frac{r}{2}$ (*d*) $\frac{r}{4}$

25. Figure represents a square carrying charges +q, +q, –q, –q at its four corners as shown. Then the potential will be zero at points :



(*a*) A, B, C, P and Q (*b*) A, B and C
(*c*) A, P, C and Q (*d*) P, B and Q

26. The kinetic energy which an electron acquires when accelerated (from rest) through a potential difference of 1 volt is called :
(*a*) 1 joule (*b*) 1 electron volt
(*c*) 1 erg (*d*) 1 watt

27. A particle of charge Q and mass m travels through a potential difference V from rest. The final momentum of the particle is :
(*a*) $\frac{mV}{Q}$ (*b*) $2Q\sqrt{mV}$
(*c*) $\sqrt{2mQV}$ (*d*) $\sqrt{\frac{2QV}{m}}$

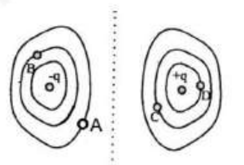
28. If a charge is shifted from a high potential region to low potential region, the electrical potential energy:
(*a*) Increases
(*b*) Decreases
(*c*) May increase or decrease
(*d*) Remains constant

29. A particle of mass 2 g and charge 1 μC is held at rest on a frictionless horizontal surface at a distance of 1 m from a fixed charge of 1 mC. If the particle is released it will be repelled. The speed of the particle when it is at distance of 10 m from the fixed charge is:
(*a*) 100 m/s (*b*) 90 m/s
(*c*) 60 m/s (*d*) 45 m/s

30. When the separation between two charges is decreased, the electric potential energy of the charges
(*a*) increases
(*b*) decreases
(*c*) may increase or decrease
(*d*) remains the same

31. 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 v. The closest distance of approach will be
(*a*) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{mv}$ (*b*) $\frac{1}{4\pi\varepsilon_0}\frac{4Q^2}{mv^2}$
(*c*) $\frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{mv^2}$ (*d*) $\frac{1}{4\pi\varepsilon_0}\frac{3Q^2}{mv^2}$

32. Figure shows equi-potential surfaces for a two charges system. At which of the labelled point will an electron have the highest potential energy?



(*a*) Point A (*b*) Point B
(*c*) Point C (*d*) Point D

33. 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

34. A point positive charge of Q' units is moved round another point positive charge of Q units in circular path. If the radius of the circle is r, then what is the work done on the charge Q' in making one complete revolution i -

(*a*) $\frac{Q}{4\pi \in_0 r}$ (*b*) $\frac{QQ'}{4\pi \in_0 r}$

(*c*) $\frac{Q'}{4\pi \in_0 r}$ (*d*) 0

35. When a negative charge is released and moves in electric field, it moves toward a position of

(*a*) lower electric potential and lower potential energy

(*b*) lower electric potential and higher potential energy

(*c*) higher electric potential and lower potential energy

(*d*) higher electric potential and higher potential energy

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

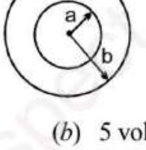
(*d*) $q(Q_1 - Q_2)(\sqrt{2}+1)/(\sqrt{2}.4\pi\varepsilon_0 R)$

37. Two similar conducting spherical shells having charges 40 μC and –20μC are some distance apart. Now they are touched and kept at same distance. The ratio of the initial to the final force between them is :

(*a*) 8 : 1 (*b*) 4 : 1

(*c*) 1 : 8 (*d*) 1 : 1

38. 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:



(*a*) 10 volt (*b*) 5 volt

(*c*) 15 volt (*d*) 0

39. When charge of 3 coulomb is placed in a uniform electric field , it experiences a force of 3000 newton, within this field, potential difference between two points separated by a distance of 1 cm is-

(*a*) 10 Volt (*b*) 90 Volt

(*c*) 1000 Volt (*d*) 3000 Volt.

40. An equipotential surface and a line of force :

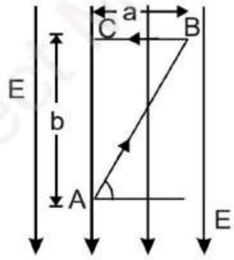
(*a*) never intersect each other

(*b*) intersect at 45°

(*c*) intersect at 60°

(*d*) intersect at 90°

41. The potential difference between points A and B in the given uniform electric field is:



(*a*) Ea (*b*) $E\sqrt{(a^2 + b^2)}$

(*c*) Eb (*d*) $(Eb/\sqrt{2})$

42. An equipotential surface is that surface

(*a*) On which each and every point has the same potential

(*b*) Which has negative potential

(*c*) Which has positive potential

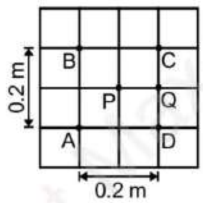
(*d*) Which has zero potential

43. The equation of an equipotential line in an electric field is y = 2x, then the electric field strength vector at (1, 2) may be

(*a*) $4\hat{i} + 3\hat{j}$ (*b*) $4\hat{i} + 8\hat{j}$

(*c*) $8\hat{i} + 4\hat{j}$ (*d*) $-8\hat{i} + 4\hat{j}$

44. A, B, C, D, P and Q are points in a uniform electric field. The potentials at 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*) $15\sqrt{2}$ Vm^{-1} along PA

(*c*) 5 Vm^{-1} along PC

(*d*) 5 Vm^{-1} along PA

45. The electric potential V as a function of distance x (in metre) is given by

$V = (5x^2 + 10x - 9)$ volt.

The value of electric field at x = 1 m would be :

(*a*) – 20 volt/m (*b*) 6 volt/m

(*c*) 11 volt/m (*d*) –23 volt/m

46. The electric field in a region is directed outward and is proportional to the distance r from the origin. Taking the electric potential at the origin to be zero, the electric potential at a distance r :

(*a*) increases as one goes away from the origin.
(*b*) is proportional to r^2
(*c*) is proportional to r
(*d*) is uniform in the region

47. 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 is

(*a*) 0.88 cm (*b*) 0.88 mm
(*c*) 0.88 m (*d*) 5×10^{-7} m

48. If an electric dipole is kept in a uniform electric field, Then it mey experience

(*a*) a force (*b*) a couple and move
(*c*) a couple and rotates (*d*) a force and moves.

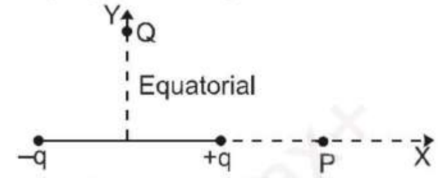
49. An electric dipole consists of two opposite charges each of magnitude 1×10^{-6} C separated by a distance 2cm. The dipole is placed in an external field of 10×10^5N/C. The maximum torque on the dipole is -

(*a*) 0.2×10^{-3} N-m (*b*) 1.0×10^{-3} N-m
(*c*) 2×10^{-2} N-m (*d*) 4×10^{-3} N-m

50. The region surrounding a stationary electric dipole has-

(*a*) electric field only
(*b*) magnetic field only
(*c*) both electric and magnetic fields
(*d*) neither electric nor magnetic field

51. Due to an electric dipole shown in fig., the electric field intensity is parallel to dipole axis :



(*a*) at P only (*b*) at Q only
(*c*) both at P and at Q (*d*) neither at P nor at Q

52. Two opposite and equal charges of magnitude 4×10^{-8} coulomb each when placed 2×10^{-2} cm apart form a dipole. If this dipole is placed in an external electric field of 4×10^8 N/C, the value of maximum torque and the work required in rotating it through 180° from its initial orientation which is along electric field will be : (Assume rotation of dipole about an axis passing through centre of the dipole):

(*a*) 64×10^{-4} N-m and 44×10^{-4} J
(*b*) 32×10^{-4} N-m and 32×10^{-4} J
(*c*) 64×10^{-4} N-m and 32×10^{-4} J
(*d*) 32×10^{-4} N-m and 64×10^{-4} J

53. A neutral spherical metallic object A is placed near a finite metal plate B carrying a positive charge. The electric force on the object will be :

(*a*) away from the plate B
(*b*) towards the plate B
(*c*) parallel to the plate B
(*d*) zero

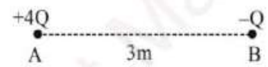
Advanced Level Multiconcept Questions

MCQ/COMPREHENSION/MATCHING/NUMERICAL

1. Two equal negative charges –q each are fixed at the points (0, a) and (0, -a) on the y-axis. A positive charge Q is released from rest at the point (2a, 0) on the x-axis. The charge Q will :

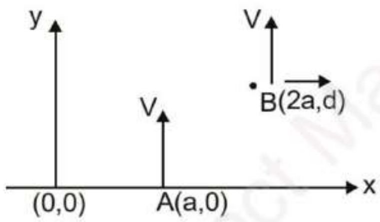
(*a*) Execute simple harmonic motion about the origin
(*b*) At origin velocity of particle is maximum.
(*c*) Move to infinity
(*d*) Execute oscillatory but not simple harmonic motion.

2. 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 oscillation.

3. A uniform electric field of strength E exists in a region. An electron (charge –e, mass m) enters a point A with velocity $V\hat{j}$. It moves through the electric field & exits at point B.Then:



(*a*) $\vec{E} = -\frac{2\,amv^2}{ed^2}\hat{i}$.

(*b*) Rate of work done by the electric field at B is $\frac{4\,ma^2v^3}{d^3}$.

(*c*) Rate of work by the electric field at A is zero.

(*d*) Velocity at B is $\frac{2av}{d}\hat{i} + v\hat{j}$.

4. An oil drop has a charge - 96 × 10^{-19} C and mass 1.6×10^{-15} gm. When allowed to fall, due to air resistance force it attains a constant velocity. Then if a uniform electric field is to be applied vertically to make the oil drop ascend up with the same constant speed, which of the following are correct. ($g = 10\ ms^{-2}$)

(**Assume** that the magnitude of resistance force is same in both the cases)

(*a*) The electric field is directed upward

(*b*) The electric field is directed downward

(*c*) The intensity of electric field is $\frac{1}{3} \times 10^2\ NC^{-1}$

(*d*) The intensity of electric field is $\frac{1}{6} \times 10^5\ NC^{-1}$

5. A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre.

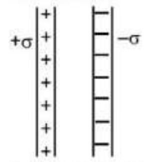
(*a*) increases as r increases, for $r \le R$

(*b*) decreases as r increases, for $0 < r < \infty$.

(*c*) decreases as r increases, for $R < r < \infty$.

(*d*) is discontinuous at r = R

6. 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 sheets is $2\sigma/\varepsilon_0$ and is directed towards right

7. 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 $\phi \neq 0$.

8. An electric field converges at the origin whose magnitude is given by the expression E = 100rN/C, where r is the distance measured from the origin.

(*a*) total charge contained in any spherical volume with its centre at origin in negative.

(*b*) total charge contained at any spherical volume, irrespective of the location of its centre, is negative.

(*c*) total charge contained in a spherical volume of radius 3 cm with its centre at origin has magnitude 3×10^{-13}C.

(*d*) total charge contained in a spherical volume of radius 3 cm with its centre at origin has magnitude 3×10^{-9} C.

9. Which of the following quantities depend on the choice of zero potential or zero potential energy ?

(*a*) Potential at a particular point

(*b*) Change in potential energy of a two-charge system

(*c*) Potential energy of a two - charge system

(*d*) Potential difference between two points

10. At distance of 5cm and 10cm outwards from the surface of a uniformly charged solid sphere, the potentials are 100V and 75V respectively. Then :

(*a*) Potential at its surface is 150V.

(*b*) The charge on the sphere is $(5/3) \times 10^{-9}$C.

(*c*) The electric field on the surface is 1500 V/m.

(*d*) The electric potential at its centre is 225V.

11. The electric potential decreases uniformly from 180 V to 20 V as one moves on the X-axis from x = – 2 cm to x = + 2 cm. The electric field at the origin :

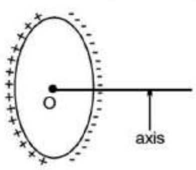
(*a*) must be equal to 40V/cm.

(*b*) may be equal to 40V/cm.

(*c*) may be greater than 40V/cm.

(*d*) may be less than 40V/cm.

12. The figure shows a nonconducting ring which has positive and negative charge non uniformly distributed on it such that the total charge is zero. Which of the following statements is **false**?



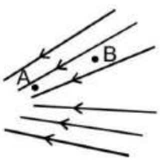
(*a*) The potential at all the points on the axis will be zero.

(*b*) The electric field at all the points on the axis will be zero.

(*c*) The direction of electric field at all points on the axis will be along the axis.

(*d*) If the ring is placed inside a uniform external electric field then net torque and force acting on the ring would be zero.

13. 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*) $V_B > V_A$

14. 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 K.E. more than or equal to 4eV at B.

(*d*) when it will reach A, it will have K.E. more then or at least equal to 4eV if it was released from rest at B.

15. An electric dipole is placed at the centre of a sphere. Mark the correct answer

(*a*) the flux of the electric field through the sphere is zero

(*b*) the electric field is zero at every point of the sphere.

(*c*) the electric potential is zero everywhere on the sphere.

(*d*) the electric potential is zero on a circle on the surface.

16. An electric dipole is kept in the electric field produced by a point charge.

(*a*) dipole will experience a force.

(*b*) dipole will experience a torque.

(*c*) it is possible to find a path (not closed) in the field on which work required to move the dipole is zero.

(*d*) dipole can be in stable equilibrium.

17. An electric dipole moment $\vec{p} = (2.0\hat{i} + 3.0\hat{j})\mu C \cdot m$ is placed in a uniform electric field

$\vec{E} = (3.0\hat{i} + 2.0\hat{k}) \times 10^5 \, N C^{-1}$.

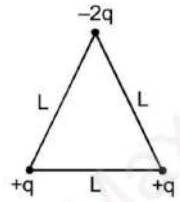
(*a*) The torque that $\vec{E}$ exerts on $\vec{p}$ is $(0.6\hat{i} - 0.4\hat{j} - 0.9\hat{k})$ Nm

(*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.

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



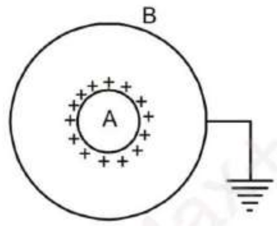
(*a*) The potential at the centroid of the triangle is zero.

(*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 $\sqrt{3}\,qL$

19. A and B are two conducting concentric spherical shells. A is given a charge Q while B is uncharged. If now B is earthed as shown in figure. Then:



(*a*) The charge appearing on inner surface of B is -Q

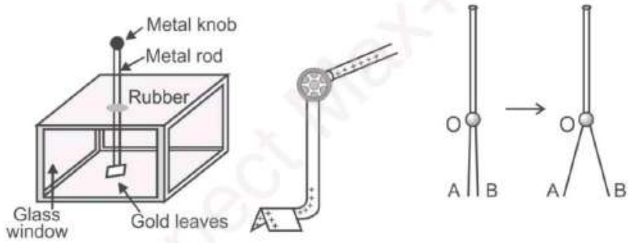
(*b*) The field inside and outside A is zero.

(*c*) The field between A and B is not zero.

(*d*) The charge appearing on outer surface of B is zero.

Comprehension – 1 (No. 20 to 22)

A leaf electroscope is a simple apparatus to detect any charge on a body. It consists of two metal leaves OA and OB, free to rotate about O. Initially both are very slightly separated. When a charged object is touched to the metal knob at the top of the conducting rod, charge flows from knob to the leaves through the conducting rod. As the leaves are now charged similarly, they start repelling each other and get separated, (deflected by certain angle).



The angle of deflection in static equilibrium is an indicator of the amount of charge on the charged body.

20. When a + 20 C rod is touched to the knob, the deflection of leaves was 5°, and when an identical rod of – 40 C is touched, the deflection was found to be 9°. If an identical rod of +30 C is touched, then the deflection may be :

(*a*) 0 (*b*) 2°

(*c*) 7° (*d*) 11°

21. If we perform these steps one by one.

(*i*) A positively charged rod is brought closer to initially uncharged knob (*a*)

(*ii*) Then the positively charged rod is touched to the knob (*b*)

(*iii*) Now the +vely charged rod is removed, and a negatively charged rod of same magnitude is brought closer at same distance (*c*)

In which case, the leaves will converge (come closer), as compared to the previous state ?

(*a*) (*i*)
(*b*) (*i*) and (*iii*)
(*c*) only (*iii*)
(*d*) In all cases, the leaves will diverge

22. In an electroscope, both leaves are hinged at the top point O. Each leaf has mass m, length ℓ and gets charge q. Assuming the charge to be concentrated at ends A and B only, the small angle of deviation (θ) between the leaves in static equilibrium, is equal to :

(*a*) $\left(\frac{4kq^2}{\ell^2 mg}\right)^{1/3}$ (*b*) $\left(\frac{kq^2}{\ell^2 mg}\right)^{1/3}$

(*c*) $\left(\frac{2kq^2}{\ell^2 mg}\right)^{1/2}$ (*d*) $\left(\frac{64kq^2}{\ell^2 mg}\right)^{1/3}$

Comprehension–2 (No. 23 to 25)

A charged particle is suspended at the centre of two thin concentric spherical charged shells, made of non conducting material. Figure A shows cross section of the arrangement. Figure B gives the net flux ϕ through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere.

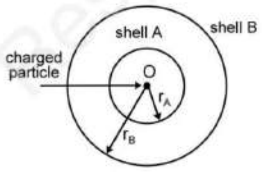


Figure A

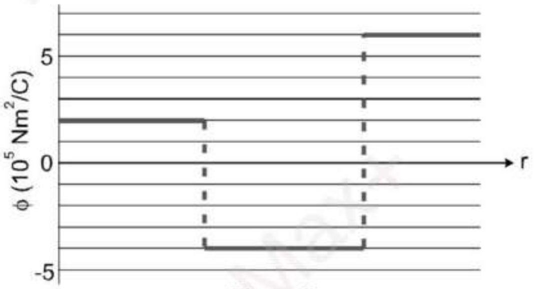


Figure B

23. What is the charge on the central particle ?

(*a*) 0.2 μC (*b*) 2 μC
(*c*) 1.77 μC (*d*) 3.4 μC

24. What is the charge on shell A ?

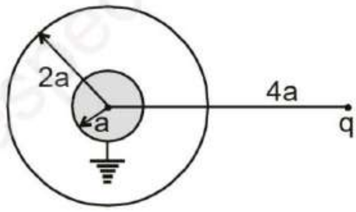
(*a*) 5.31×10^{-6} C (*b*) -5.31×10^{-6} C
(*c*) -3.54×10^{-6} C (*d*) -1.77×10^{-6} C

25. In which range of the values of r is the electric field zero?

(*a*) 0 to r_A
(*b*) r_A to r_B
(*c*) For $r > r_B$
(*d*) For no range of r, electric field is zero.

Comprehension–3 (No. 26 to 28)

A solid conducting sphere of radius 'a' is surrounded by a thin uncharged concentric conducting shell of radius 2a. A point charge q is placed at a distance 4a from common centre of conducting sphere and shell. The inner sphere is then grounded.



26. The charge on solid sphere is :

(*a*) $-\frac{q}{2}$ (*b*) $-\frac{q}{4}$

(*c*) $-\frac{q}{8}$ (*d*) $-\frac{q}{16}$

27. Pick up the correct statement.

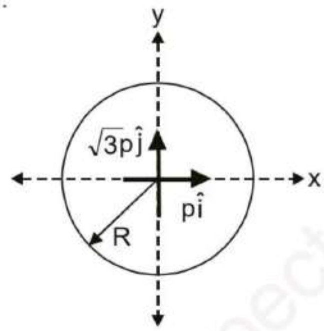
(*a*) Charge on surface of inner sphere is non-uniformly distributed.
(*b*) Charge on inner surface of outer shell is non-uniformly distributed.
(*c*) Charge on outer surface of outer shell is non-uniformly distributed.
(*d*) All the above statements are false.

28. The potential of outer shell is.

(*a*) $\frac{q}{32\pi\varepsilon_0 a}$ (*b*) $\frac{q}{16\pi\varepsilon_0 a}$

(*c*) $\frac{q}{8\pi\varepsilon_0 a}$ (*d*) $\frac{q}{4\pi\varepsilon_0 a}$

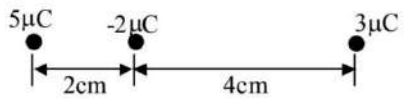
29. Column I gives a situation in which two dipoles of dipole moment $p\hat{i}$ and $\sqrt{3}\,p\,\hat{j}$ are placed at origin. A circle of radius R with centre at origin is drawn as shown in figure. Column II gives coordinates of certain positions on the circle. Match the statements in Column I with the statements in Column II .



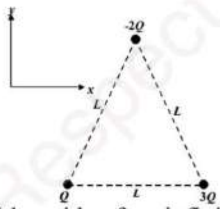
Column I	**Column II**
(*a*) The coordinate(s) of point on circle where potential is maximum :	(p) $\left(\frac{R}{2}, \frac{\sqrt{3}\,R}{2}\right)$
(*b*) The coordinate(s) of point on circle where potential is zero :	(q) $\left(-\frac{R}{2}, -\frac{\sqrt{3}\,R}{2}\right)$
(*c*) The coordinate(s) of point on circle where magnitude of electric field intensity is $\frac{1}{4\pi\varepsilon_0}\frac{4p}{R^3}$:	(r) $\left(-\frac{\sqrt{3}\,R}{2}, \frac{R}{2}\right)$
(*d*) The coordinate(s) of point on circle where magnitude of electric field intensity is $\frac{1}{4\pi\varepsilon_0}\frac{2p}{R^3}$:	(s) $\left(\frac{\sqrt{3}\,R}{2}, -\frac{R}{2}\right)$

NUMERICAL VALUE BASED

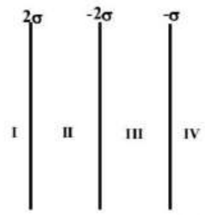
30. Three point charges lie on a straight line, as shown in the figure. Find the magnitude of resultant force exerted on the $-2\mu C$ charge in newton.



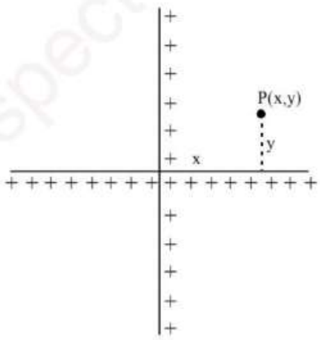
31. Three point charges are held on the corners of an equilateral triangle as shown in the figure.
Take $Q = 2\mu C$ and $L = 3$ cm. What is the magnitude of resultant force exerted on the charge $+3Q$ in N.



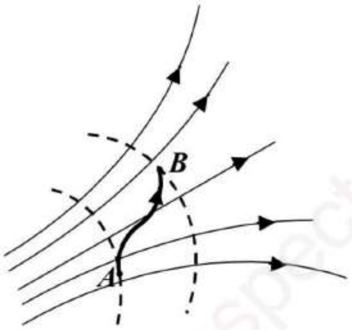
32. The field on either side of an infinite sheet of charge of density of $\sigma\ C/m^2$ is $E = \sigma/2\varepsilon_0$. Electric field in region II is given by $\frac{x\sigma}{\varepsilon_0}$ then x is



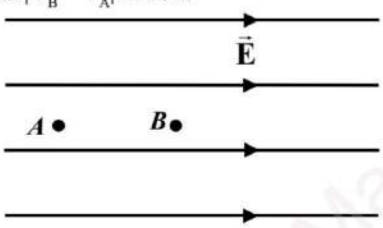
33. Two infinite lines of charge with equal linear charge densities λ C/m are placed along the x and y axes, as in figure. If angle made by resultant electric field with horizontal at pont P is θ then $\tan\theta$ will be equal to (given $y = 2x$)



34. Figure shows two equipotential (dashed) surfaces such that $V_A = -5$V and $V_B = -15$ V. The external work needed to move a -2 μC charge at constant speed from A to B along the indicated path in Joule is given by $x \times 10^{-5}$ then x is -



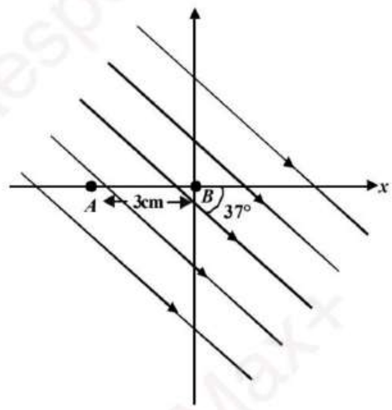
35. In the shown fig. points A and B are 4 cm apart along the lines of a uniform field $\vec{E} = 600\,\hat{i}$ V/m. Find the change in potential $|V_B - V_A|$ in volt.



36. Four point charges of 0.6 μC, 2.2 μC, –3.6 μC and +4.8 μC are placed at the corners of a square of side 10 cm. What is the work done to bring a charge of –5 μC from infinity to the centre of the square in Joule (Assume speed of –5μC charge is kept constant).

37. An electric field is given $\vec{E} = 2x\,\hat{i} - 3y^2\,\hat{j}$ N/C. Find the change in potential in volt from the position $\vec{r}_A = \hat{i} - 2\hat{j}$ m to $\hat{r}_B = 2\hat{i} + \hat{j} + 3\hat{k}$ m.

38. A uniform electric field of 400 V/m is directed at 37° below the x–axis, as shown in figure. Find the changes in potential $V_B - V_A$ in volt.

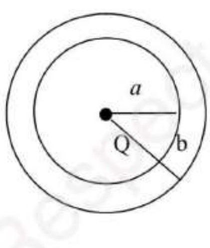


JEE Mains & Advanced Past Years Questions

JEE-MAIN PREVIOUS YEAR'S

1. 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 The value of A such that the electric field in the region between the spheres will be constant, is:

[JEE Main - 2016]



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

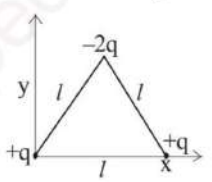
2. An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = -\tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ It experiences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

[JEE Main - 2017]

(a) 60° (b) 90°
(c) 30° (d) 45°

3. Determine the electric dipole moment of the system of three charges, placed on the vertices of an equilateral triangle, as shown in the figure:

[JEE Main - 2019 (January)]



(a) $\sqrt{3}q\ell\frac{\hat{j} - \hat{i}}{\sqrt{2}}$ (b) $(q\ell)\frac{\hat{i} + \hat{j}}{\sqrt{2}}$

(c) $2q\ell\hat{j}$ (d) $-\sqrt{3}q\ell\hat{j}$

4. For a uniformly charged ring of radius R, the electric field on its axis has the largest magnitude at a distance h from its centre. Then value of h is:

[JEE Main - 2019 (January)]

(a) $\frac{R}{\sqrt{5}}$ (b) $\frac{R}{\sqrt{2}}$

(c) R (d) $R\sqrt{2}$

5. Three charges +Q, q, +Q are placed respectively, at distance, 0, d/2 and d from the origin, on the x-axis. If the net force experienced by +Q, placed at x = 0, is zero, then value of q is **[JEE Main - 2019 (January)]**

(a) –Q/4 (b) +Q/2

(c) +Q/4 (d) –Q/2

6. Charge is distributed within a sphere of radius R with a volume charge density $\rho(r) = \frac{A}{r^2}e^{-2r/a}$, where A and a are constants. If Q is the total charge of this charge distribution the radius R is:

[JEE Main - 2019 (January)]

(a) $a\log\left(1-\frac{Q}{2\pi aA}\right)$ (b) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$

(c) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$ (d) $\frac{a}{2}\log\left(1-\frac{1}{2\pi aA}\right)$

7. Two point charge $q_1\left(\sqrt{10}\mu C\right)$ and q2 (– 25μC) are placed on the x-axis at x = 1 m and x = 4 m respectively. The electric field (in V/m) at a point y = 3 m on y-axis is, $\left[\text{take}\frac{1}{4\pi\varepsilon_0} = 9\times10^9\,\text{Nm}^2\text{C}^{-2}\right]$

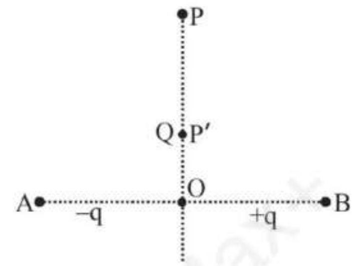
[JEE Main - 2019 (January)]

(a) $\left(63\hat{i}-27\hat{j}\right)\times10^2$ (b) $\left(-63\hat{i}+27\hat{j}\right)\times10^2$

(c) $\left(81\hat{i}-81\hat{j}\right)\times10^2$ (d) $\left(-81\hat{i}+81\hat{j}\right)\times10^2$

8. Charges – q and + q located at A and B, respectively, constitute an electric dipole. Distance AB = 2a, O is the mid point of the dipole and OP is perpendicular to AB. A charge Q is placed at P where OP = y and y >> 2a. the charge Q experiences an electrostatic force F. If Q is now moved along the equatorial line to P' such that $OP' = \left(\frac{y}{3}\right)$, the force on Q will be close to $\left(\frac{y}{2} >> 2a\right)$

[JEE Main - 2019 (January)]



(a) 3F (b) $\frac{F}{3}$

(c) 9F (d) 27F

9. Four point charges –q, +q, +q and –q are placed on y-axis at y = –2d, y = –d, y = +d and y = +2d, respectively. The magnitude of the electric field E at a point on the x-axis at x = D, with D>> d, will behave as:-

[JEE Main-2019 (April)]

(a) $E \propto \frac{1}{D}$ (b) $E \propto \frac{1}{D^3}$

(c) $E \propto \frac{1}{D^2}$ (d) $E \propto \frac{1}{D^4}$

10. The bob of a simple pendulum has mass 2g and a charge of 5.0 μC. It is at rest in a uniform horizontal electric field of intensity 2000V/m. At equilibrium, the angle that the pendulum makes with the vertical is (Take g = 10 m/s^s)

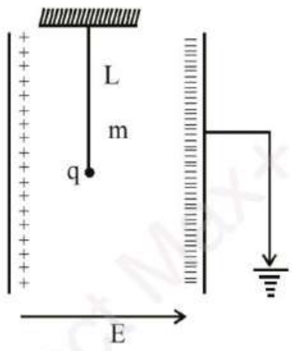
[JEE Main-2019 (April)]

(a) $\tan^{-1}(5.0)$ (b) $\tan^{-1}(2.0)$

(c) $\tan^{-1}(0.5)$ (d) $\tan^{-1}(0.2)$

11. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by :

[JEE Main-2019 (April)]



(a) $2\pi\sqrt{\frac{L}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$ (b) $2\pi\sqrt{\frac{L}{\left(g+\frac{qE}{m}\right)}}$

(c) $2\pi\sqrt{\frac{L}{\left(g-\frac{qE}{m}\right)}}$ (d) $2\pi\sqrt{\frac{L}{\sqrt{g^2-\frac{q^2E^2}{m^2}}}}$

12. An electric dipole is formed by two equal and opposite charges q with separation d. The charges have same mass m. It is kept in a uniform electric field E. If it is slightly rotated from its equilibrium orientation, then its angular frequency ω is : **[JEE Main-2019 (April)]**

(*a*) $\sqrt{\frac{qE}{2md}}$ (*b*) $2\sqrt{\frac{qE}{md}}$

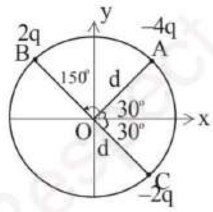
(*c*) $\sqrt{\frac{2qE}{md}}$ (*d*) $\sqrt{\frac{qE}{md}}$

13. Let a total charge 2Q be distributed in a sphere of radius R, with the charge density given by $\rho(r) = kr$, where r is the distance from the centre. Two charges A and B, of –Q each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any force, then : **[JEE Main-2019 (April)]**

(*a*) $a = \frac{3R}{2^{1/4}}$ (*b*) $a = R/\sqrt{3}$

(*c*) $a = 8^{-1/4}R$ (*d*) $a = 2^{-1/4}R$

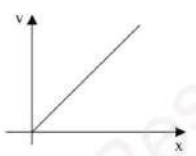
14. Three charged particles A, B and C with charges –4q, 2q and –2q are present on the circumference of a circle of radius d. The charged particles A, C and centre O of the circle formed an equilateral triangle as shown in figure. Electric field at O along x-direction is: **[JEE Main-2020 (January)]**

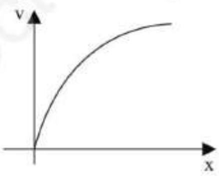


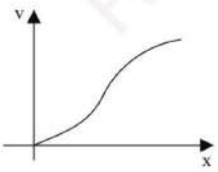
(*a*) $\frac{\sqrt{3}q}{\pi\varepsilon_0 d^2}$ (*b*) $\frac{\sqrt{3}q}{4\pi\varepsilon_0 d^2}$

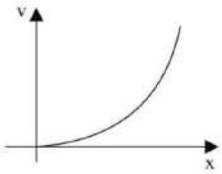
(*c*) $\frac{3\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (*d*) $\frac{2\sqrt{3}q}{\pi\varepsilon_0 d^2}$

15. A particle of mass m and charge q is released from rest in a uniform electric field. If there is no other force on the particle, the dependence of its speed v on the distance x travelled by it is correctly given by (graphs are schematic and not drawn to scale) **[JEE Main-2020 (January)]**

(*a*) 

(*b*) 

(*c*) 

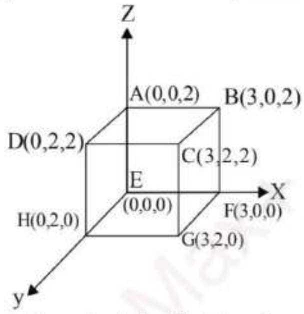
(*d*) 

16. An electric dipole of moment $\vec{p} = (-\hat{i} - 3\hat{j} + 2\hat{k})\, 10^{-29}$ C.m. is at the origin (0,0,0). The electric field due to this dipole at $\vec{r} = (+\hat{i} + 3\hat{j} + 5\hat{k})$ (note that $\vec{r}.\vec{p} = 0$) is parallel to: **[JEE Main-2020 (January)]**

(*a*) $(+\hat{i} + 3\hat{j} - 2\hat{k})$ (*b*) $(-\hat{i} + 3\hat{j} - 2\hat{k})$

(*c*) $(+\hat{i} - 3\hat{j} - 2\hat{k})$ (*d*) $(-\hat{i} - 3\hat{j} + 2\hat{k})$

17. An electric field $\vec{E} = 4x\hat{i} - (y^2 + 1)\hat{j}$ N/C passes through the box shown in figure. The flux of the electric field through surface ABCD and BCGF and marked as ϕ_I and ϕ_{II} respectively. The difference between $(\phi_I - \phi_{II})$ is (in Nm^2/C) **[JEE Main-2020 (January)]**



18. In finding the electric field using gauss law the formula $|\vec{E}| = \frac{q_{enc}}{\varepsilon_0 |A|}$ is applicable. In the formula ε_0 is permittivity of free space, A is the area of Gaussian surface and q_{enc} is charges enclosed by the Gaussian surface. This equation can be used in which of the following situation? **[JEE Main-2020 (January)]**

(*a*) Only when the Gaussian surface in an equipotential surface

(*b*) Only when $|\vec{E}|$ = constant on the surface.

(*c*) Only when the Gaussian surface is an equipotential surface and $|\vec{E}|$ is constant of the surface.

(*d*) For any choice of Gaussian surface

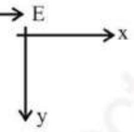
19. Consider two charged metallic spheres S_1 and S_2 of radii R_1 and R_2, respectively. The electric fields E_1 (on S_1) and E_2 (on S_2) on their surfaces are such that $E_1/E_2 = R_1/R_2$. Then the ratio V_1(on S_1)/V_2 (on S_2) of the electrostatic potentials on each sphere is **[JEE Main-2020 (January)]**

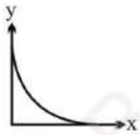
(*a*) $\left(\frac{R_1}{R_2}\right)^3$ (*b*) $\frac{R_1}{R_2}$

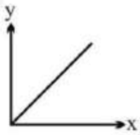
(*c*) $\left(\frac{R_2}{R_1}\right)$ (*d*) $\left(\frac{R_1}{R_2}\right)^2$

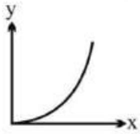
20. A small point mass carrying some positive charge on it, is released from the edge of a table. There is a uniform electric field in this region in the horizontal direction. Which of the following options then correctly describe the trajectory of the mass? (Curves are drawn schematically and are not to scale).

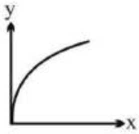
[JEE Main-2020 (September)]



(*a*) 

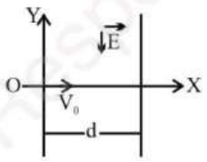
(*b*) 

(*c*) 

(*d*) 

21. A charged particle (mass m and charge q) moves along X-axis with velocity V_0. When it passes through the origin it enters a region having uniform electric field $\vec{E} = -E\hat{j}$ which extends upto x = d. Equation of path of electron in the region x > d is

[JEE Main-2020 (September)]



(*a*) $y = \frac{qEd}{mV_0^2}(x-d)$ (*b*) $y = \frac{qEd^2}{mV_0^2}x$

(*c*) $y = \frac{qEd}{mV_0^2}\left(\frac{d}{2}-x\right)$ (*d*) $y = \frac{qEd}{mV_0^2}x$

22. A particle of charge q and mass m is subjected to an electric field $E = E_0(1-ax^2)$ in the x-direction, where a and E_0 are constants. Initially the particle was at rest at x = 0. Other than the initial position the kinetic energy of the particle becomes zero when the distance of the particle from the origin is

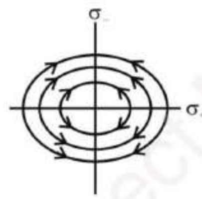
[JEE Main-2020 (September)]

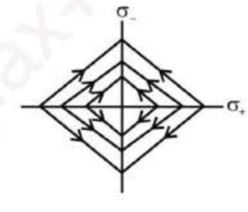
(*a*) $\sqrt{\frac{3}{a}}$ (*b*) $\sqrt{\frac{2}{a}}$

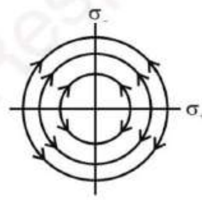
(*c*) $\sqrt{\frac{1}{a}}$ (*d*) a

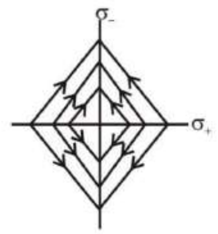
23. Two charged thin infinite plane sheets of uniform surface charge density σ_+ and σ_-, where $|\sigma_+| > |\sigma_-|$, intersect at right angle. Which of the following best represents the electric field lines for this system?

[JEE Main-2020 (September)]

(*a*) 

(*b*) 

(*c*) 

(*d*) 

24. Consider the force F on a charge 'q' due to a uniformly charged spherical shell of radius R carrying charge Q distributed uniformly over it. Which one of the following statements is true for F, if 'q' is placed at distance r from the centre of the shell?

[JEE Main-2020 (September)]

(*a*) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for all r

(*b*) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{R^2} > F > 0$ For r < R

(*c*) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for r > R

(*d*) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{R^2}$ for r < R

25. Two identical electric point dipoles have dipole moments $\vec{p_1} = p\hat{i}$ and $\vec{p_2} = p\hat{i}$ and are held on the x axis at distance 'a' from each other. When released, they move along the x-axis with the direction of their dipole moments remaining unchanged. If the mass of each dipole is 'm', their speed when they are infinitely far apart is

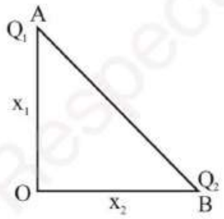
[JEE Main-2020 (September)]

(*a*) $\frac{P}{a}\sqrt{\frac{1}{2\pi\varepsilon_0 ma}}$ (*b*) $\frac{P}{a}\sqrt{\frac{2}{\pi\varepsilon_0 ma}}$

(*c*) $\frac{P}{a}\sqrt{\frac{1}{\pi\varepsilon_0 ma}}$ (*d*) $\frac{P}{a}\sqrt{\frac{3}{2\pi\varepsilon_0 ma}}$

26. Suppose that intensity of a laser is $\left(\frac{315}{\pi}\right)$ W /m The rms electric field, in units of V/m associated with this source is close to the nearest integer is ______.
($\varepsilon_0 = 8.86 \times 10^{-12}\ C^2Nm^{-2}$; $c = 3 \times 10^8\ ms^{-1}$)
[JEE Main-2020 (September)]

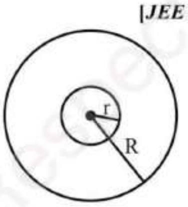
27. Charges Q_1 and Q_2 are at points A and B of a right angle triangle OAB (see figure). The resultant electric field at point O is perpendicular to the hypotenuse, then Q_1/Q_2 is proportional to
[JEE Main-2020 (September)]



(*a*) $\frac{x_1^3}{x_2^3}$ (*b*) $\frac{x_2^2}{x_1^2}$

(*c*) $\frac{x_1}{x_2}$ (*d*) $\frac{x_2}{x_1}$

28. A charge Q is distributed over two concentric conducting thin spherical shells radii r and R (R > r). If the surface charge densities on the two shells are equal, the electric potential at the common centre is
[JEE Main-2020 (September)]



(*a*) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{(R^2+r^2)}Q$ (*b*) $\frac{1}{4\pi\varepsilon_0}\frac{(R+2r)Q}{2(R^2+r^2)}$

(*c*) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{2(R^2+r^2)}Q$ (*d*) $\frac{1}{4\pi\varepsilon_0}\frac{(2R+r)}{(R^2+r^2)}Q$

29. Concentric metallic hollow spheres of radii R and 4R hold charges Q_1 and Q_2 respectively. Given that surface charge densities of the concentric spheres are equal, the potential difference V(R) – V(4R) is *[JEE Main-2020 (September)]*

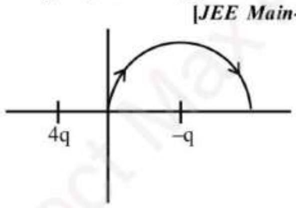
(*a*) $\frac{3Q_2}{4\pi\varepsilon_0 R}$ (*b*) $\frac{3Q_1}{16\pi\varepsilon_0 R}$

(*c*) $\frac{Q_2}{4\pi\varepsilon_0 R}$ (*d*) $\frac{3Q_1}{4\pi\varepsilon_0 R}$

30. Hydrogen ion and singly ionized helium atom are accelerated, from rest, through the same potential difference. The ratio of final speeds of hydrogen and helium ions is close to *[JEE Main-2020 (September)]*

(*a*) 2 : 1 (*b*) 1 : 2
(*c*) 10 : 7 (*d*) 5 : 7

31. A two point charges 4q and –q are fixed on the x- axis at $x = -\frac{d}{2}$ and $x = \frac{d}{2}$, respectively. If a third point charge 'q' is taken from the origin to x = d along the semicircle as shown in the figure, the energy of the charge will
[JEE Main-2020 (September)]



(*a*) Decrease by $\frac{q^2}{4\pi\varepsilon_0 d}$ (*b*) Decrease by $\frac{4q^2}{3\pi\varepsilon_0 d}$

(*c*) Increase by $\frac{2q^2}{3\pi\varepsilon_0 d}$ (*d*) Increase by $\frac{3q^2}{4\pi\varepsilon_0 d}$

32. Ten charges are placed on the circumference of a circle of radius R with constant angular separation between successive charges. Alternate charges 1, 3, 5, 7, 9 have charge (+q) each, while 2, 4, 6, 8, 10 have charge (–q) each. The potential V and the electric field E at the centre of the circle are respectively.

(**Take** V = 0 at infinity)
[JEE Main-2020 (September)]

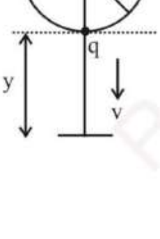
(*a*) V = 0; E = 0

(*b*) $V = \frac{10q}{4\pi\varepsilon_0 R}$; $E = \frac{10q}{4\pi\varepsilon_0 R^2}$

(*c*) $V = \frac{10q}{4\pi\varepsilon_0 R} = E = 0$

(*d*) V = 0; $E = \frac{10q}{4\pi\varepsilon_0 R^2}$

33. A solid sphere of radius R carries a charge Q + q distributed uniformly over its volume. A very small point like piece of it of mass m gets detached from the bottom of the sphere and falls down vertically under gravity. This piece carries charge q. If it acquires a speed v when it has fallen through a vertical height y (see figure), then : (assume the remaining portion to be spherical). *[JEE Main-2020 (September)]*



(*a*) $v^2 = y\left[\frac{qQ}{4\pi\varepsilon_0 R(R+y)m} + g\right]$

(*b*) $v^2 = 2y\left[\frac{qQR}{4\pi\varepsilon_0 (R+y)^3 m} + g\right]$

(*c*) $v^2 = y\left[\frac{qQ}{4\pi\varepsilon_0 R^2 ym} + g\right]$

(*d*) $v^2 = 2y\left[\frac{qQ}{4\pi\varepsilon_0 R(R+y)m} + g\right]$

NUMERICAL BASED QUESTIONS

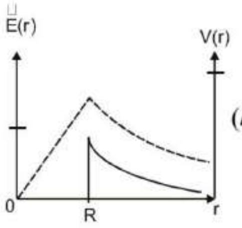
34. An infinite number of point charges, each carrying $1\mu C$ charge, are placed along the y-axis at $y = 1\text{m}, 2\text{m}$, $4\text{m}, 8\text{m}$. The total force on a 1 C point charge, placed at the origin, is $x \times 10^3$ N. The value of x_1 to the nearest integer, is. Take $\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \text{Nm}^2/\text{C}^2$

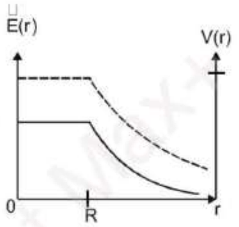
[JEE Main-2021 (March)]

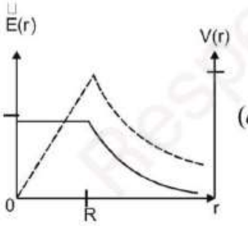
JEE-ADVANCED PREVIOUS YEAR'S

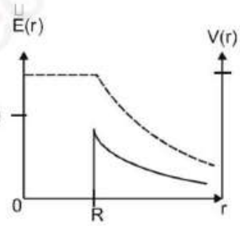
1. Consider a thin spherical shell of radius R with its centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $|\vec{E}(r)|$ and the electric potential V(r) with the distance r from the centre, is best represented by which graph?

[JEE-2012]

(*a*)


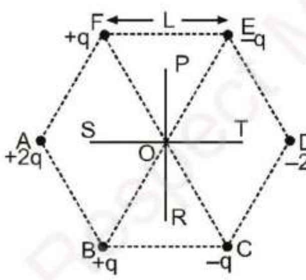
(*b*)


(*c*)


(*d*)


2. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\varepsilon_0}\frac{q}{L^2}$, which of the following statement (s) is (are) correct?

[JEE-2012]



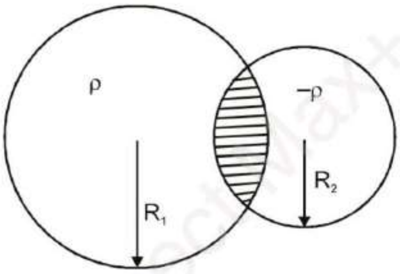
(*a*) the elecric field at O is 6K along OD
(*b*) The potential at O is zero
(*c*) The potential at all points on the line PR is same
(*d*) The potential at all points on the line ST is same.

3. Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ can be ;

(*a*) –4 (*b*) $-\frac{32}{25}$

(*c*) $\frac{32}{25}$ (*d*) 4

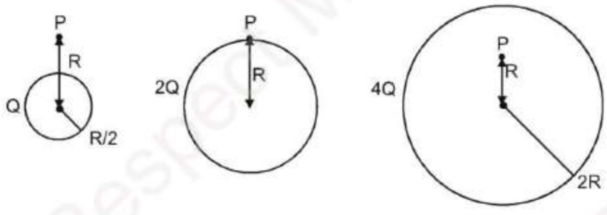
4. Two non–conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region:



(*a*) the electrostatic field is zero
(*b*) the electrostatic potential is constant
(*c*) the electrostatic field is constant in magnitude
(*d*) the electrostatic field has same direction

5. Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii R/2, R and 2R respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1 E_2 and E_3 respectively, then

[JEE Advanced - 2014]



Sphere 1 गोला 1 Sphere 2 गोला 2 Sphere 3 गोला 3

(*a*) $E_1 > E_2 > E_3$ (*b*) $E_3 > E_1 > E_2$
(*c*) $E_2 > E_1 > E_3$ (*d*) $E_3 > E_2 > E_1$