ELECTRIC CHARGES AND FIELDS

FACT/DEFINITION TYPE QUESTIONS

1. Charge is the property associated with matter due to which it produces and experiences
   (a) electric effects only
   (b) magnetic effects only
   (c) both electric and magnetic effects
   (d) None of these
2. Charge is
   (a) transferable (b) associated with mass
   (c) conserved (d) All of these
3. A body is positively charged, it implies that
   (a) there is only positive charge in the body.
   (b) there is positive as well as negative charge in the body but the positive charge is more than negative charge
   (c) there is equal positive and negative charge in the body but the positive charge lies in the outer regions
   (d) negative charge is displaced from its position
4. On rubbing, when one body gets positively charged and other negatively charged, the electrons transferred from positively charged body to negatively charged body are
   (a) valence electrons only
   (b) electrons of inner shells
   (c) both valence electrons and electrons of inner shell
   (d) yet to be established
5. Which of the following is the best insulator?
   (a) Carbon (b) Paper
   (c) Graphite (d) Ebonite
6. If a body is negatively charged, then it has
   (a) excess of electrons (b) excess of protons
   (c) deficiency of electrons (d) deficiency of neutrons
7. When a body is charged by induction, then the body
   (a) becomes neutral
   (b) does not lose any charge
   (c) loses whole of the charge on it
   (d) loses part of the charge on it
8. On charging by conduction, mass of a body may
   (a) increase (b) decreases
   (c) increase or decrease (d) None of these
9. Quantisation of charge implies
   (a) charge cannot be destroyed
   (b) charge exists on particles
   (c) there is a minimum permissible charge on a particle
   (d) charge, which is a fraction of a coulomb is not possible.
10. If an object possesses an electric charge, it is said to be electrified or ... *A* ... When it has no charge, it is said to be ... *B* ... Here, A and B refer to
    (a) charged, neutral (b) neutral, charged
    (c) discharged, charged (d) active, reactive
11. A positively charged rod is brought near an uncharged conductor. If the rod is then suddenly withdrawn, the charge left on the conductor will be
    (a) positive (b) negative
    (c) zero (d) cannot say
12. Two spheres A and B of exactly same mass are given equal positive and negative charges respectively. Their masses after charging
    (a) remains unaffected (b) mass of A > mass of B
    (c) mass of A < mass of B (d) Nothing can be said
13. When a comb rubbed with dry hair attracts pieces of paper. This is because the
    (a) comb polarizes the piece of paper
    (b) comb induces a net dipole moment opposite to the direction of field
    (c) electric field due to the comb is uniform
    (d) comb induces a net dipole moment perpendicular to the direction of field
14. When some charge is transferred to ...*A*... it readily gets distributed over the entire surface of ... *A*... If some charge is put on ... *B*..., it stays at the same place.
    Here, A and B refer to
    (a) insulator, conductor (b) conductor, insulator
    (c) insulator, insulator (d) conductor, conductor
15. Quantisation of charge was experimentally demonstrated by
    (a) Einstein's photoelectric effect
    (b) Frank-Hertz experiment
    (c) Davisson and Germer experiment
    (d) Millikan's oil drop experiment

16. In annihilation process, in which an electron and a positron transform into two gamma rays, which property of electric charge is displayed?
(a) Additivity of charge
(b) Quantisation of charge
(c) Conservation of charge
(d) Attraction and repulsion

17. The law, governing the force between electric charges is known as
(a) Ampere's law (b) Ohm's law
(c) Faraday's law (d) Coulomb's law

18. The value of electric permittivity of free space is
(a) $9 \times 10^9\ NC^2/m^2$ (b) $8.85 \times 10^{-12} Nm^2/C^2$ sec
(c) $8.85 \times 10^{-12}\ C^2/Nm^2$ (d) $9 \times 10^9 C^2/Nm^2$

19. Coulomb's law is true for
(a) atomic distances ($= 10^{-11}$ m)
(b) nuclear distances ($= 10^{-15}$ m)
(c) charged as well as uncharged particles
(d) all the distances

20. What happens when some charge is placed on a soap bubble?
(a) Its radius decreases (b) Its radius increases
(c) The bubble collapses (d) None of these

21. Two point charges + Q and + q are separated by a certain distance. If + Q > + q then in between the charges the electric field is zero at a point
(a) closer to + Q
(b) closer to + q
(c) exactly at the mid-point of line segment joining + Q and + q.
(d) no where on the line segment joining + Q and + q.

22. An electric field can deflect
(a) neutrons (b) X-rays
(c) γ-rays (d) α-particles

23. The unit of electric field is not equivalent to
(a) N / C (b) J / C
(c) V / m (d) J / Cm

24. If an electron has an initial velocity in a direction different from that of an electric field, the path of the electron is
(a) a straight line (b) a circle
(c) an ellipse (d) a parabola

25. A charged particle is free to move in an electric field. It will travel
(a) always along a line of force
(b) along a line of force, if its initial velocity is zero
(c) along a line of force, if it has some initial velocity in the direction of an acute angle with the line of force
(d) none of the above

26. If a linear isotropic dielectric is placed in an electric field of strength E, then the polarization P is
(a) independent of E
(b) inversely proportional to E
(c) directly proportional to $\sqrt{E}$
(d) directly proportional to E

27. A point charge is kept at the centre of metallic insulated spherical shell. Then
(a) electric field out side the sphere is zero
(b) electric field inside the sphere is zero
(c) net induced charge on the sphere is zero
(d) electric potential inside the sphere is zero

28. If one penetrates a uniformly charged spherical cloud, electric field strength
(a) decreases directly as the distance from the centre
(b) increases directly as the distance from the centre
(c) remains constant
(d) None of these

29. Electric lines of force about a negative point charge are
(a) circular anticlockwise
(b) circular clockwise
(c) radial, inwards
(d) radial, outwards

30. Electric lines of force
(a) exist everywhere
(b) exist only in the immediate vicinity of electric charges
(c) exist only when both positive and negative charges are near one another
(d) are imaginary

31. Positive electric flux indicates that electric lines of force are directed
(a) outwards (b) inwards
(c) either (a) or (b) (d) None of these

32. The S.I. unit of electric flux is
(a) weber (b) newton per coulomb
(c) volt × metre (d) joule per coulomb

33. If the flux of the electric field through a closed surface is zero, then
(a) the electric field must be zero everywhere on the surface
(b) the electric field may not be zero everywhere on the surface
(c) the charge inside the surface must be zero
(d) the charge in the vicinity of the surface must be zero

34. Electric flux over a surface in an electric field may be
(a) positive (b) negative
(c) zero (d) All of the above

35. 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) $(\phi_2 + \phi_2) \times \varepsilon_o$ (b) $(\phi_2 - \phi_2) \times \varepsilon_o$
(c) $(\phi_1 + \phi_2) \times \varepsilon_o$ (d) $(\phi_2 - \phi_1) \times \varepsilon_o$

36. For distance far away from centre of dipole the change in magnitude of electric field with change in distance from the centre of dipole is
(a) zero.
(b) same in equatorial plane as well as axis of dipole.
(c) more in case of equatorial plane of dipole as compared to axis of dipole.
(d) more in case of axis of dipole as compared to equatorial plane of dipole.

37. A region surrounding a stationary electric dipoles has
(a) magnetic field only
(b) electric field only
(c) both electric and magnetic fields
(d) no electric and magnetic fields

38. The electric field at a point on equatorial line of a dipole and direction of the dipole moment
(a) will be parallel
(b) will be in opposite direction
(c) will be perpendicular
(d) are not related

39. Debye is the unit of
(a) electric flux (b) electric dipole moment
(c) electric potential (d) electric field intensity

40. An electric dipole will experience a net force when it is placed in
(a) a uniform electric field
(b) a non-uniform electric field
(c) both (a) and (b)
(d) None of these

41. An electric dipole is kept in a non-uniform electric field. It experiences
(a) a force and a torque
(b) a force but not a torque
(c) a torque but no force
(d) neither a force nor a torque

42. The formation of a dipole is due to two equal and dissimilar point charges placed at a
(a) short distance (b) long distance
(c) above each other (d) none of these

43. If a dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$, then torque acting on it is given by
(a) $\vec{\tau} = \vec{p}.\vec{E}$ (b) $\vec{\tau} = \vec{p} \times \vec{E}$
(c) $\vec{\tau} = \vec{p} + \vec{E}$ (d) $\vec{\tau} = \vec{p} - \vec{E}$

44. If E_a be the electric field strength of a short dipole at a point on its axial line and E_e that on the equatorial line at the same distance, then
(a) $E_e = 2E_a$ (b) $E_a = 2E_e$
(c) $E_a = E_e$ (d) None of the above

45. When an electric dipole $\vec{P}$ is placed in a uniform electric field $\vec{E}$ then at what angle between $\vec{P}$ and $\vec{E}$ the value of torque will be maximum?
(a) 90° (b) 0°
(c) 180° (d) 45°

46. An electric dipole is placed at an angle of 30° to a non-uniform electric field. The dipole will experience
(a) a translational force only in the direction of the field
(b) a translational force only in the direction normal to the direction of the field
(c) a torque as well as a translational force
(d) a torque only

47. An electric dipole is placed at the centre of a sphere then
(a) the flux of the electric field through the sphere is not zero.
(b) the electric field is zero at every point of the sphere.
(c) the electric field is not zero anywhere on the sphere.
(d) the electric field is zero on a circle on the sphere.

48. If a dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$, then torque acting on it is given by
(a) $\vec{\tau} = \vec{p}.\vec{E}$ (b) $\vec{\tau} = \vec{p} \times \vec{E}$
(c) $\vec{\tau} = \vec{p} + \vec{E}$ (d) $\vec{\tau} = \vec{p} - \vec{E}$

49. An electric dipole has a pair of equal and opposite point charges q and $-q$ separated by a distance $2x$. The axis of the dipole is
(a) from positive charge to negative charge
(b) from negative charge to positive charge
(c) Perpendicular to the line joining the two charges drawn at the centre and pointing upward direction
(d) Perpendicular to the line joining the two charges drawn at the centre and pointing downward direction

50. Gauss's law states that
(a) the total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the closed surface.
(b) the total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface.
(c) the total electric flux through an open surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the open surface.
(d) the line integral of electric field around the boundary of an open surface is $\frac{1}{\varepsilon_0}$ times the total charge placed near the open surface.

51. The Gaussian surface
(a) can pass through a continuous charge distribution.
(b) cannot pass through a continuous charge distribution.
(c) can pass through any system of discrete charges.
(d) can pass through a continuous charge distribution as well as any system of discrete charges.

52. Gauss's law is valid for
(a) any closed surface
(b) only regular close surfaces
(c) any open surface
(d) only irregular open surfaces

53. The total electric flux emanating from a closed surface enclosing an α-particle is (e-electronic charge)
(a) $\frac{2e}{\varepsilon_0}$ (b) $\frac{e}{\varepsilon_0}$
(c) $e\varepsilon_0$ (d) $\frac{\varepsilon_0 e}{4}$

54. The electric field due to an infinitely long straight uniformly charged wire at a distance r is directly proportional to
(a) r (b) r^2
(c) $\frac{1}{r}$ (d) $\frac{1}{r^2}$

55. For a given surface the Gauss's law is stated as $\oint \vec{E}.d\vec{A} = 0$. From this we can conclude that
(a) E is necessarily zero on the surface
(b) E is perpendicular to the surface at every point
(c) the total flux through the surface is zero
(d) the flux is only going out of the surface

56. The electric field inside a spherical shell of uniform surface charge density is
(a) zero
(b) constant different from zero
(c) proportional to the distance from the curve
(d) None of the above

57. The electric field near a conducting surface having a uniform surface charge density is given by
(a) $\frac{\sigma}{\varepsilon_0}$ and is parallel to the surface
(b) $\frac{2\sigma}{\varepsilon_0}$ and is parallel to the surface
(c) $\frac{\sigma}{\varepsilon_0}$ and is normal to the surface
(d) $\frac{2\sigma}{\varepsilon_0}$ and is normal to the surface

58. A hollow sphere of charge does not have electric field at
(a) outer point (b) interior point
(c) beyond 2 m (d) beyond 100 m

59. Charge motion within the Gaussian surface gives changing physical quantity
(a) electric field (b) electric flux
(c) charge (d) gaussian surface area

60. Gauss's law is true only if force due to a charge varies as
(a) r^{-1} (b) r^{-2}
(c) r^{-3} (d) r^{-4}

61. What about Gauss's theorem is not incorrect?
(a) It can be derived by using Coulomb's Law
(b) It is valid for conservative field obeys inverse square root law
(c) Gauss's theorem is not applicable in gravitation
(d) Both (a) & (b)

STATEMENT TYPE QUESTIONS

62. Study of charges, by scientists, concludes that
I. there are two kinds of electric charges.
II. bodies like plastic, fur acquire elecrtic charge on rubbing.
III. like charges attract, unlike charges repel each other.
IV. the property which differentiates two kinds of charges is called the polarity of the charge.

Which of the above statements is incorrect?
(a) Only I (b) Only II
(c) Only III (d) Only IV

63. Which of the following statements is incorrect?
I. The charge q on a body is always given by q = ne, where n is any integer, positive or negative.
II. By convention, the charge on an electron is taken to be negative.
III. The fact that electric charge is always an integral multiple of e is termed as quantisation of charge.
IV. The quatisation of charge was experimentally demonstrated by Newton in 1912.
(a) Only I (b) Only II
(c) Only IV (d) Only III

64. Select the correct statements Coulomb's law correctly describes the electric force that
I. binds the electrons of an atom to its nucleus
II. binds the protons and neutrons in the nucleus of an atom
III. binds atoms together to form molecules
(a) I and II (b) I and III
(c) II and III (d) I, II and III

65. Select the correct statements from the following
I. Inside a charged or neutral conductor, electrostatic field is zero
II. The electrostatic field at the surface of the charged conductor must be tangential to the surface at any point
III. There is no net charge at any point inside the conductor
(a) I and II (b) I and III
(c) II and III (d) I, II and III

66. In a uniform electric field $\vec{E}$ a charge +q having negligible mass is released at a point. Which of the following statements are correct?
I. Velocity increases with time.
II. A force acts on it in the direction of electric field.
III. Its momentum changes with time.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

67. Field due to multiple charges at a point is found by using
I. superposition principle.
II. Coulomb's law.
III. law of conservation of charges.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

68. Select the incorrect statements about electric field lines.
I. Two electric field lines can never cross each other.
II. They start from positive charge and end at negative charge.
III. Electric field lines form closed loops.
(a) I and II (b) I and III
(c) II and III (c) I, II and III

69. An electric dipole of moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$. Then

I. the torque on the dipole is $\vec{p} \times \vec{E}$.

II. the potential energy of the system is $\vec{p} \cdot \vec{E}$.

III. the resultant force on the dipole is zero.

Which of the above statements is/are correct

(a) I, II and III (b) I and III

(c) Only I (d) I and II

70. Select the incorrect statements from the following.

I. Polar molecules have permanent electric dipole moment.

II. CO_2 molecule is a polar molecule.

III. H_2O is a non-polar molecule.

(a) II and III (b) I and II

(c) I and III (d) I, II and III

71. Select the correct statements from the following.

I. The electric field due to a charge outside the Gaussian surface contributes zero net flux through the surface.

II. Total flux linked with a closed body, not enclosing any charge will be zero.

III. Total electric flux, if a dipole is enclosed by a surface is zero.

(a) I and II (b) II and III

(c) I and III (d) I, II and III

MATCHING TYPE QUESTIONS

72. Match Column I and Column II.

Column I	Column II
(A) Additivity of charge	(1) ${}_0^1n + {}_{92}^{235}U \rightarrow {}_{56}^{144}Ba + {}_{36}^{89}Kr + 3{}_0^1n$
(B) Conservation of charge	(2) $-5\mu C + 15\mu C = 10\mu C$
(C) Quantisation of charge	(3) Gold nucleus repels alpha particle.
(D) Attraction and repulsion	(4) q = ne

(a) (A)→(3), (B)→(2), (C)→(4), (D)→(1)

(b) (A)→(2), (B)→(4), (C)→(1), (D)→(3)

(c) (A)→(2), (B)→(1), (C)→(4), (D)→(3)

(d) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

73. Match the physical quantities in column I and the information related to them in Column II.

Column I	Column II
(A) Electric dipole moment	(1) Vector product
(B) Electric field	(2) Scalar product
(C) Electric flux	(3) Points towards positive charge
(D) Torque	(4) Points away from positive charge

(a) (A)→(3), (B)→(2), (C)→(4), (D)→(1)

(b) (A)→(1), (B)→(3), (C)→(4), (D)→(2)

(c) (A)→(3), (B)→(4), (C)→(2), (D)→(1)

(d) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

74.

Column I	Column II
(A) Linear charge density	(1) $\frac{\text{Charge}}{\text{Volume}}$
(B) Surface charge density	(2) $\frac{\text{Charge}}{\text{Length}}$
(C) Volume charge density	(3) $\frac{\text{Charge}}{\text{Area}}$
(D) Discrete charge distribution	(4) System consisting of ultimate individual charges

(a) A → (2), B → (3), C → (1), D → (4)

(b) A → (1), B → (3), C → (1), D → (4)

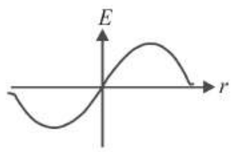
(c) A → (3), B → (1), C → (2), D → (4)

(d) A → (3), B → (2), C → (1), D → (4)

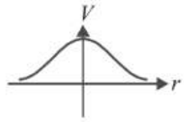
75. Column II describe graph for charge distribution given in column-I. Match the description.

Column I **Column II**

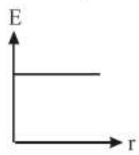
(A) Uniformly charged ring (1)



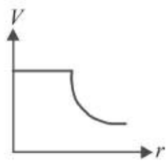
(B) Infinitely large charge conducting sheet (2)



(C) Infinite non conducting (3)



(D) Hollow non conducting sphere (4)



(a) A → (1, 2), B → (3), C → (3), D → (4)

(b) A → (3, 4), B → (2), C → (3, 1), D → (4)

(c) A → (1), B → (2), C → (3), D → (4)

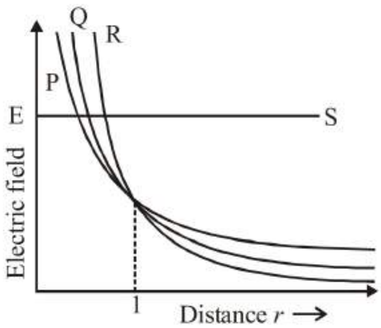
(d) A → (2), B → (3), C → (4), D → (1)

76. Match the entries of column I with that of Column II.

Column I	Column II
(A) Coulomb's law	(1) Total electric flux through a closed surface.
(B) Gauss's law	(2) Vector sum of forces.
(C) Principle of superposition	(3) Force is inversely proportional to square of distance
(D) Quantisation of charge	(4) Discrete nature of charge

(a) (A)→(2), (B)→(3), (C)→(1), (D)→(4)
(b) (A)→(3), (B)→(1), (C)→(2), (D)→(4)
(c) (A)→(1), (B)→(4), (C)→(3), (D)→(2)
(d) (A)→(1), (B)→(2), (C)→(3), (D)→(4)

77. The curves in the graph show the variation of electric field E with distance r for various kinds of charge distributions given in Column I. Match them with their correct curves in Column II.



Column I	Column II
(A) Electric field of a point sized dipole.	(1) P
(B) Electric field due to an infinitely long straight uniformly charged wire.	(2) Q
(C) Electric field due to a uniformly charged plane sheet.	(3) R
(D) Electric field due to a point charge.	(4) S

(a) (A)→(2), (B)→(4), (C)-(3), (D)→(1)
(b) (A)→(4), (B)→(3), (C)→(2), (D)→(1)
(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)
(d) (A)→(3), (B)→(1), (C)→(4), (D)→(2)

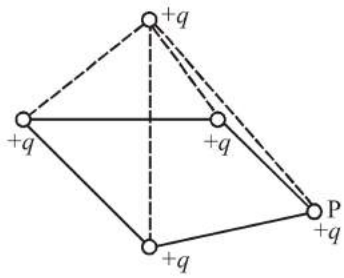
78. Match the source of charge given in Column I with expressions of electric field produced by them in Column II.

Column I	Column II
(A) Point charge	(1) $\frac{\lambda}{2\pi\varepsilon_0 r}$
(B) Infinitely long straight uniformly charged wire	(2) $\frac{\sigma}{2\varepsilon_0}$
(C) Uniformly charged infinite plane sheet	(3) 0
(D) At a point inside a uniformly charged thin spherical shell.	(4) $\frac{q}{4\pi\varepsilon_0 r^2}$

(a) (A)→(1), (B)→(3), (C)→(4), (D)→(2)
(b) (A)→(4), (B)→(3), (C)→(2), (D)→(1)
(c) (A)→(4), (B)→(1), (C)→(2), (D)→(3)
(d) (A)→(2), (B)→(4), (C)→(1), (D)→(3)

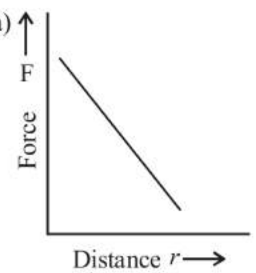
DIAGRAM TYPE QUESTIONS

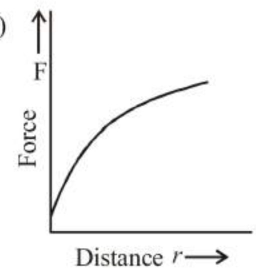
79. The figure shows a charge $+q$ at point P held in equilibrium in air with the help of four $+q$ charges situated at the vertices of a square. The net electrostatic force on q is given by

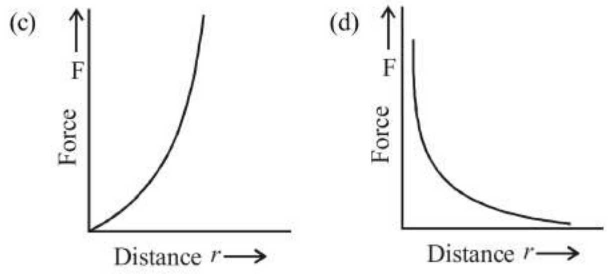


(a) Gauss's law
(b) Coulomb's law
(c) Principle of superposition
(d) net electric flux out the position of $+q$.

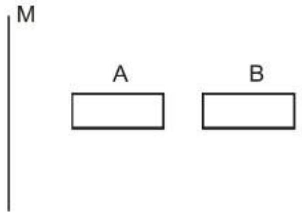
80. Which of the following graphs shows the correct variation of force when the distance r between two charges varies ?

(a)


(b)


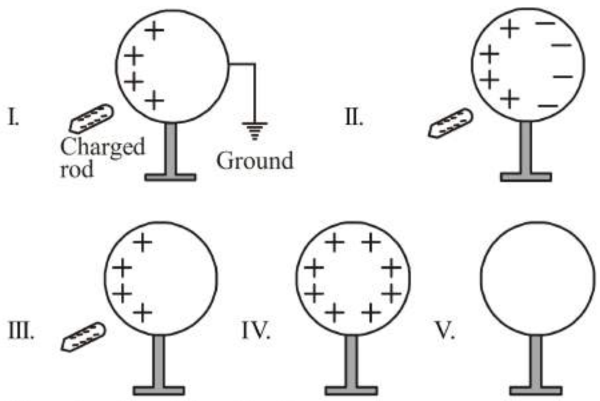


81. A large nonconducting sheet M is given a uniform charge density. Two uncharged small metal rods A and B are placed near the sheet as shown in figure. Then



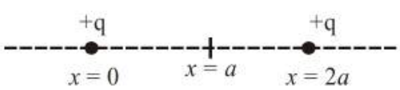
(a) M attracts A (b) M attracts B
(c) A attracts B (d) All of the above

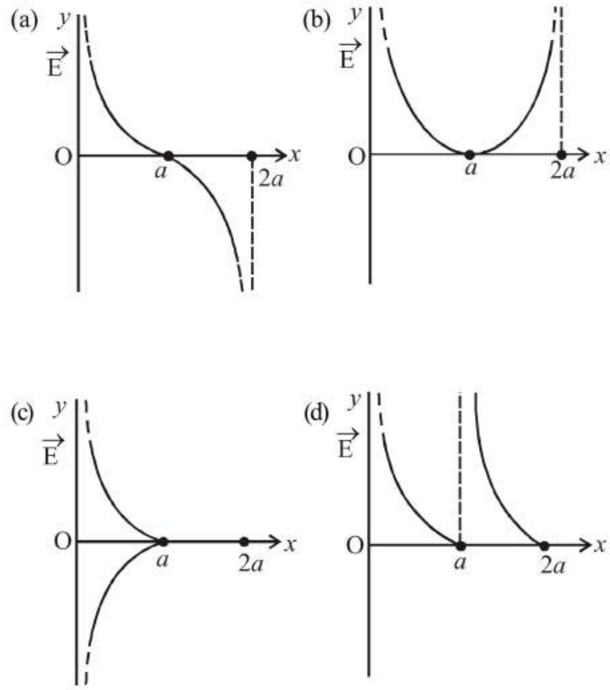
82. A metal sphere is being charged by induction using a charged rod, but the sequence of diagrams showing the process misplaced.



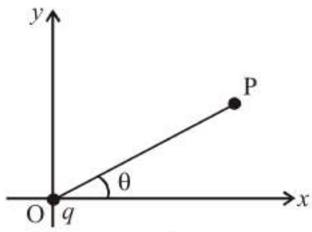
Correct order of charging is
(a) I → II → III → IV → V
(b) V → II → III → I → IV
(c) V → II → I → III → IV
(d) IV → II → III → I → V

83. Figure shows two charges of equal magnitude separated by a distance 2a. As we move away from the charge situated at x = 0 to the charge situated at x = 2a, which of the following graphs shows the correct behaviour of electric field ?





84. In the figure, charge q is placed at origin O. When the charge q is displaced from its position the electric field at point P changes



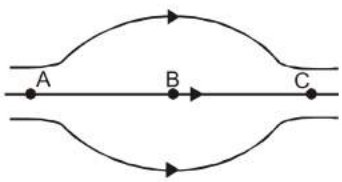
(a) at the same time when q is displaced.

(b) at a time after $\frac{OP}{c}$ where c is the speed of light.

(c) at a time after $\frac{OP\cos\theta}{c}$.

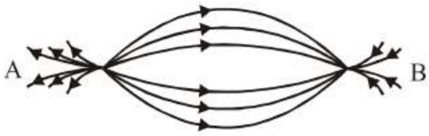
(d) at a time after $\frac{OP\sin\theta}{c}$

85. Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that



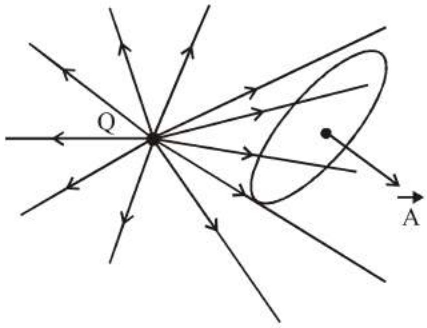
(a) $E_A > E_B > E_C$ (b) $E_A = E_B = E_C$
(c) $E_A = E_C > E_B$ (d) $E_A = E_C < E_B$

86. The spatial distribution of electric field due to charges (A, B) is shown in figure. Which one of the following statements is correct ?



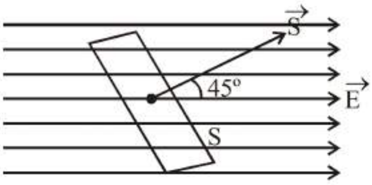
(a) A is +ve and B –ve, |A| > |B|
(b) A is –ve and B +ve, |A| = |B|
(c) Both are +ve but A > B
(d) Both are –ve but A > B

87. In the figure the net electric flux through the area A is $\phi = \vec{E} \cdot \vec{A}$ when the system is in air. On immersing the system in water the net electric flux through the area

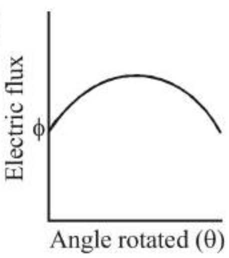


(a) becomes zero
(b) remains same
(c) increases
(d) decreases

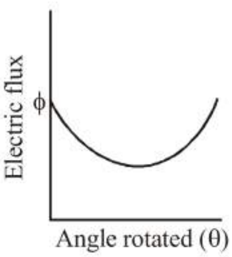
88. Which of the following graphs shows the correct behaviour of electric flux through the surface S when it is rotated by an angle 90° clockwise in a uniform electric field?



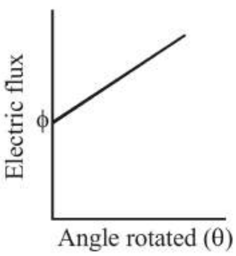
(a)



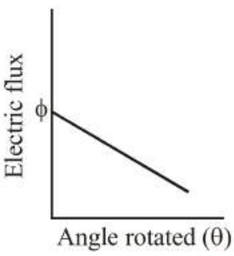
(b)



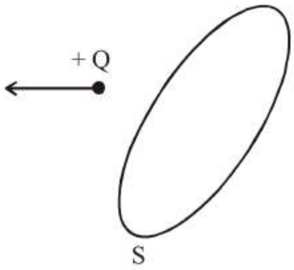
(c)



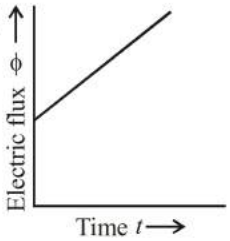
(d)



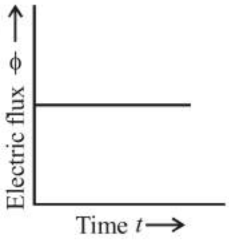
89. Which of the following graphs correctly show the change of electric flux ϕ with time t through the surface S when the charge +Q is moved away from the surface?



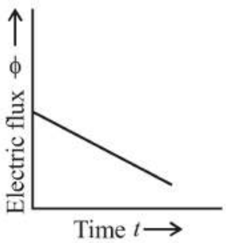
(a)



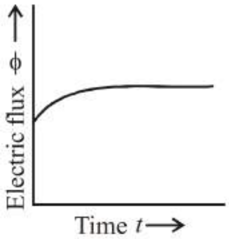
(b)



(c)

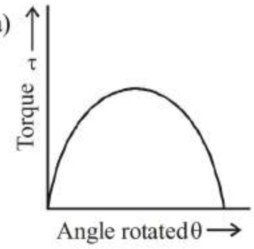


(d)

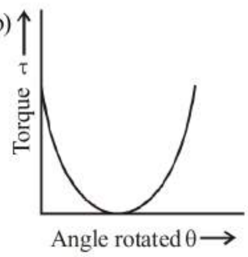


90. Which of the following graphs shows the correct variation in magnitude of torque on an electric dipole rotated in a uniform electric field from stable equillibrium to unstable equillibrium?

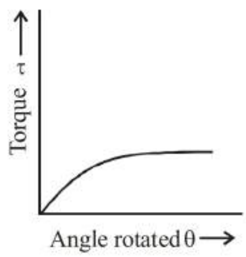
(a)



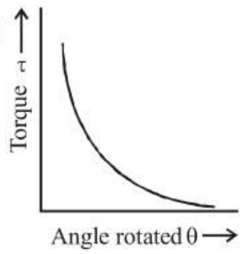
(b)



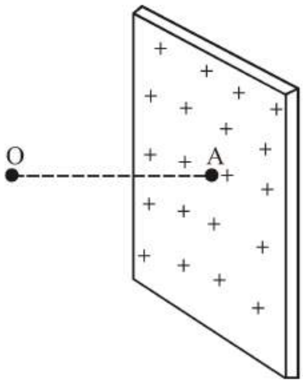
(c)



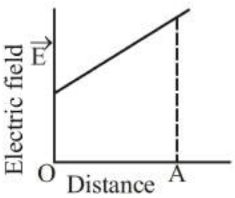
(d)

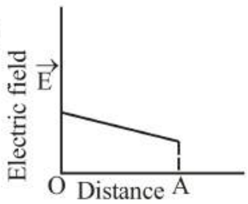


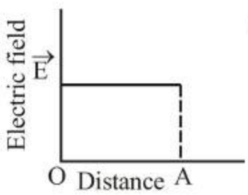
91. Figure shows the part of an infinite plane sheet of charge.

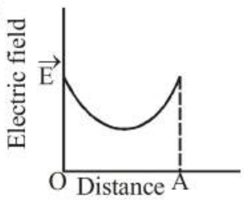


Which of the following graphs correctly shows the behaviour of electric field intensity as we move from point O to A.

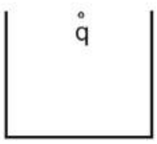
(a)


(b)


(c)


(d)


92. A charge q is placed at the centre of the open end of a cylindrical vessel. The flux of the electric field through the surface of the vessel is



(a) zero
(b) q/ε_o
(c) $q/2\varepsilon_o$
(d) $2q/\varepsilon_o$

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

93. **Assertion :** When bodies are charged through friction, there is a transfer of electric charge from one body to another, but no creation or destruction of charge.
Reason : This follows from conservation of electric charges.

94. **Assertion :** The tyres of aircraft are slightly conducting.
Reason : If a conductor is connected to ground, the extra charge induced on conductor will flow to ground.

95. **Assertion :** Some charge is put at the centre of a conducting sphere. It will move to the surface of the sphere.
Reason : Conducting sphere has no free electrons at the centre.

96. **Assertion :** Coulomb force and gravitational force follow the same inverse-square law.
Reason : Both laws are same in all aspects.

97. **Assertion :** The coulomb force is the dominating force in the universe.
Reason : The coulomb force is weaker than the gravitational force.

98. **Assertion :** If there exists coulomb attraction between two bodies, both of them may not be charged.
Reason : In coulomb attraction two bodies are oppositely charged.

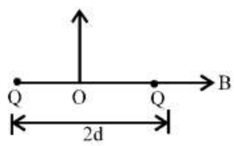
99. **Assertion :** A deuteron and an α-particle are placed in an electric field. If F_1 and F_2 be the forces acting on them and a_1 and a_2 be their accelerations respectively then, $a_1 = a_2$.
Reason : Forces will be same in electric field.

100. **Assertion :** The property that the force with which two charges attract or repel each other are not affected by the presence of a third charge.
Reason : Force on any charge due to a number of other charge is the vector sum of all the forces on that charge due to other charges, taken one at a time.

101. **Assertion :** A metallic shield in form of a hollow shell may be built to block an electric field.
Reason : In a hollow spherical shield, the electric field inside it is zero at every point.

102. **Assertion :** A point charge is brought in an electric field, the field at a nearby point will increase or decrease, depending on the nature of charge.
Reason : The electric field is independent of the nature of charge.

103. **Assertion :** Consider two identical charges placed distance 2d apart, along x-axis.



The equilibrium of a positive test charge placed at the point O midway between them is stable for displacements along the x-axis.
Reason: Force on test charge is zero.

104. **Assertion :** When a conductor is placed in an external electrostatic field, the net electric field inside the conductor becomes zero after a small instant of time.

Reason : It is not possible to set up an electric field inside a conductor.

105. **Assertion :** A uniformly charged disc has a pin hole at its centre. The electric field at the centre of the disc is zero.

Reason : Disc can be supposed to be made up of many rings. Also electric field at the centre of uniformly charged ring is zero.

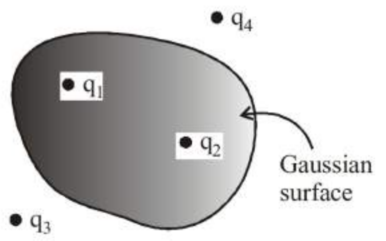
106. **Assertion :** Electric lines of field cross each other.

Reason : Electric field at a point superimpose to give one resultant electric field.

107. **Assertion :** On bringing a positively charged rod near the uncharged conductor, the conductor gets attracted towards the rod.

Reason : The electric field lines of the charged rod are perpendicular to the surface of conductor.

108. **Assertion :** Four point charges q_1, q_2, q_3 and q_4 are as shown in figure. The flux over the shown Gaussian surface depends only on charges q_1 and q_2.



Reason : Electric field at all points on Gaussian surface depends only on charges q_1 and q_2.

109. **Assertion :** On disturbing an electric dipole in stable equillibrium in an electric field, it returns back to its stable equillibrium orientation.

Reason : A restoring torque acts on the dipole on being disturbed from its stable equillibrium.

110. **Assertion :** On going away from a point charge or a small electric dipole, electric field decreases at the same rate in both the cases.

Reason : Electric field is inversely proportional to square of distance from the charge or an electric dipole.

111. **Assertion :** The electric flux of the electric field $\oint \vec{E} \cdot d\vec{A}$ is zero. The electric field is zero everywhere on the surface.

Reason : The charge inside the surface is zero.

112. **Assertion :** On moving a distance two times the initial distance away from an infinitely long straight uniformly charged wire the electric field reduces to one third of the initial value.

Reason : The electric field is inversely proportional to the distance from an infinitely long straight uniformly charged wire.

CRITICAL THINKING TYPE QUESTIONS

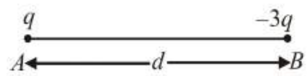
113. The metal knob of a gold leaf electroscope is touched with a positively charged rod. When it is taken away the leaves stay separated. Now the metal knob is touched by negatively charged rod. The separation between the leaves
   (a) increases
   (b) decreases
   (c) remains same
   (d) first increases then decreases.

114. Two identical metal spheres A and B are supported on insulating stands and placed in contact. What kind of charges will A and B develop when a negatively charged ebonite rod is brought near A?
   (a) A will have a positive charge and B will have a negative charge
   (b) A will have a negative charge and B will have a positive charge
   (c) Both A and B will have positive charges
   (d) Both A and B will have negative charges

115. The force of repulsion between two electrons at a certain distance is F. The force between two protons separated by the same distance is ($m_p = 1836\, m_e$)
   (a) 2 F (b) F
   (c) 1836F (d) $\frac{F}{1836}$

116. The force between two small charged spheres having charges of 1×10^{-7} C and 2×10^{-7} C placed 20 cm apart in air is
   (a) 4.5×10^{-2} N (b) 4.5×10^{-3} N
   (c) 5.4×10^{-2} N (d) 5.4×10^{-3} N

117. Two charge q and $-3q$ are placed fixed on x–axis separated by distance d. Where should a third charge $2q$ be placed such that it will not experience any force ?



   (a) $\frac{d - \sqrt{3}\,d}{2}$ (b) $\frac{d + \sqrt{3}\,d}{2}$
   (c) $\frac{d + 3d}{2}$ (d) $\frac{d - 3d}{2}$

118. Two insulated charged metalic sphere P and Q have their centres separated by a distance of 60 cm. The radii of P and Q are negligible compared to the distance of separation. The mutual force of electrostatic repulsion if the charge on each is 3.2×10^{-7} C is
   (a) $5.2 \times 10^{-4}\, N$ (b) $2.5 \times 10^{-3}\, N$
   (c) $1.5 \times 10^{-3} N$ (d) $3.5 \times 10^{-4}\, N$

119. If a charge q is placed at the centre of the line joining two equal charges Q such that the system is in equilibrium then the value of q is
   (a) Q/2 (b) –Q/2
   (c) Q/4 (d) –Q/4

120. Two positive ions, each carrying a charge q, are separated by a distance d. If F is the force of repulsion between the ions, the number of electrons missing from each ion will be (e being the charge of an electron)

(a) $\frac{4\pi\varepsilon_0 Fd^2}{e^2}$ (b) $\sqrt{\frac{4\pi\varepsilon_0 Fe^2}{d^2}}$

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

121. Three charge q, Q and 4q are placed in a straight line of length l at points distant 0, $\frac{1}{2}$ and l respectively from one end. In order to make the net froce on q zero, the charge Q must be equal to

(a) −q (b) − 2q

(c) $\frac{-q}{2}$ (d) q

122. Force between two identical charges placed at a distance of r in vacuum is F. Now a slab of dielectric of dielectric contrant 4 is inserted between these two charges. If the thickness of the slab is r/2, then the force between the charges will become

(a) F (b) $\frac{3}{5}F$

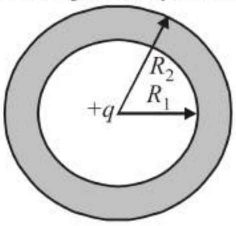
(c) $\frac{4}{9}F$ (d) $\frac{F}{2}$

123. Two particle of equal mass m and charge q are placed at a distance of 16 cm. They do not experience any force. The value of $\frac{q}{m}$ is

(a) 1 (b) $\sqrt{\frac{\pi\varepsilon_0}{G}}$

(c) $\sqrt{\frac{G}{4\pi\varepsilon_0}}$ (d) $\sqrt{4\pi\varepsilon_0 G}$

124. A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge is placed at the centre of the shperical cavity. The surface charge density on the inner surface is



(a) $\frac{q}{4\pi R_1^2}$ (b) $\frac{-q}{4\pi R_1^2}$

(c) $\frac{q^2}{4\pi R_2^2}$ (d) $\frac{q}{4\pi R_2^2}$

125. A uniformly charged conducting sphere of 4.4 m diameter has a surface charge density of 60 $\mu C\,m^{-2}$. The charge on the sphere is

(a) $7.3 \times 10^{-3} C$ (b) 3.7×10^{-6} C

(c) $7.3 \times 10^{-6} C$ (d) $3.7 \times 10^{-3} C$

126. A rod of length 2.4 m and radius 4.6 mm carries a negative charge of 4.2×10^{-7} C spread uniformly over it surface. The electric field near the mid–point of the rod, at a point on its surface is

(a) -8.6×10^5 N C^{-1} (b) 8.6×10^4 N C^{-1}

(c) -6.7×10^5 N C^{-1} (d) 6.7×10^4 N C^{-1}

127. If electric field in a region is radially outward with magnitude E = Ar, the charge contained in a sphere of radius r centred at the origin is

(a) $\frac{1}{4\pi\varepsilon_o}Ar^3$ (b) $4\pi\varepsilon_o Ar^3$

(c) $\frac{1}{4\pi\varepsilon_o}\frac{A}{r^3}$ (d) $\frac{4\pi\varepsilon_o A}{r^3}$

128. The electric field intensity just sufficient to balance the earth's gravitational attraction on an electron will be: (given mass and charge of an electron respectively are 9.1×10^{-31}kg and 1.6×10^{-19}C.)

(a) -5.6×10^{-11} N/C (b) -4.8×10^{-15} N / C

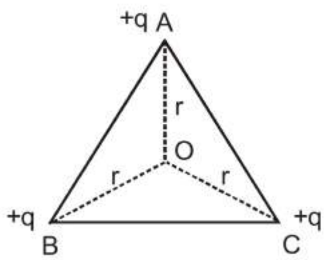
(c) -1.6×10^{-19} N/C (d) -3.2×10^{-19} N / C

129. The insulation property of air breaks down when the electric field is 3×10^6 Vm^{-1}. The maximum charge that can be given to a sphere of diameter 5 m is approximately

(a) 2×10^{-2} C (b) 2×10^{-3} C

(c) 2×10^{-4} C (d) 2×10^{-5} C

130. ABC is an equilateral triangle. Charges +q are placed at each corner as shown in fig. The electric intensity at centre O will be



(a) $\frac{1}{4\pi\epsilon_o}\frac{q}{r}$ (b) $\frac{1}{4\pi\epsilon_o}\frac{q}{r^2}$

(c) $\frac{1}{4\pi\epsilon_o}\frac{3q}{r^2}$ (d) zero

131. A hollow insulated conduction sphere is given a positive charge of 10 μC. What will be the electric field at the centre of the sphere if its radius is 2 m?

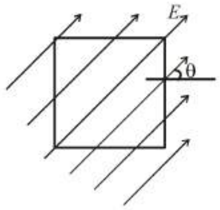
(a) Zero (b) 5 μCm^{-2}

(c) 20 μCm^{-2} (d) 8 μCm^{-2}

132. The number of electric lines of force that radiate outwards from one coulomb of charge in vacuum is

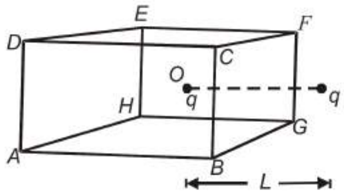
(a) 1.13×10^{11} (b) 1.13×10^{10}
(c) 0.61×10^{11} (d) 0.61×10^{9}

133. A square surface of side L meter in the plane of the paper is placed in a uniform electric field E (volt/m) acting along the same plane at an angle θ with the horizontal side of the square as shown in Figure. The electric flux linked to the surface is



(a) EL^2 (b) $EL^2 \cos\theta$
(c) $EL^2 \sin\theta$ (d) zero

134. A charged particle q is placed at the centre O of cube of length L ($ABCDEFGH$). Another same charge q is placed at a distance L from O. Then the electric flux through $ABCD$ is



(a) $q/4\pi\epsilon_0 L$ (b) zero
(c) $q/2\pi\epsilon_0 L$ (d) $q/3\pi\epsilon_0 L$

135. 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) $(\phi_2 + \phi_2) \times \varepsilon_o$ (b) $(\phi_2 - \phi_2) \times \varepsilon_o$
(c) $(\phi_1 + \phi_2) \times \varepsilon_o$ (d) $(\phi_2 - \phi_1) \times \varepsilon_o$

136. In a region of space having a uniform electric field E, a hemispherical bowl of radius r is placed. The electric flux ϕ through the bowl is

(a) $2\pi RE$ (b) $4\pi R^2E$
(c) $2\pi R^2E$ (d) πR^2E

137. A cylinder of radius R and length ℓ is placed in a uniform electric field E parallel to the axis of the cylinder. The total flux over the curved surface of the cylinder is

(a) zero (b) πR^2E
(c) $2\pi R^2E$ (d) $E/\pi R^2$

138. At the centre of a cubical box + Q charge is placed. The value of total flux that is coming out a wall is

(a) Q/ε_o (b) $Q/3\varepsilon_o$
(c) $Q/4\varepsilon_o$ (d) $Q/6\varepsilon_o$

139. The electric intensity due to a dipole of length 10 cm and having a charge of 500 μC, at a point on the axis at a distance 20 cm from one of the charges in air, is

(a) 6.25×10^7 N/C (b) 9.28×10^7 N/C
(c) 13.1×10^{11} N/C (d) 20.5×10^7 N/C

140. Intensity of an electric field (E) depends on distance r, due to a dipole, is related as

(a) $E \propto \frac{1}{r}$ (b) $E \propto \frac{1}{r^2}$
(c) $E \propto \frac{1}{r^3}$ (d) $E \propto \frac{1}{r^4}$

141. An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in uniform electric field E. If its dipole moment is along the direction of the field, the force on it and its potential energy are respectively.

(a) q.E and max. (b) 2 q.E and min.
(c) q.E and min (d) zero and min.

142. An electric dipole of moment $'p'$ is placed in an electric field of intensity $'E'$. The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when = 90°, the torque and the potential energy of the dipole will respectively be

(a) $pE\sin\theta, -pE\cos\theta$ (b) $pE\sin\theta, -2pE\cos\theta$
(c) $pE\sin\theta, 2pE\cos\theta$ (d) $pE\cos\theta, -pE\cos\theta$

143. If the dipole of moment 2.57×10^{-17} cm is placed into an electric field of magnitude 3.0×10^4 N/C such that the fields lines are aligned at 30° with the line joining P to the dipole, what torque acts on the dipole?

(a) 7.7×10^{-13} Nm (b) 3.855×10^{-13} Nm
(c) 3.855×10^{-15} Nm (d) 7.7×10^{-15} Nm

144. An electric dipole is placed at an angle of 30° with an electric field of intensity 2×10^5 NC^{-1}, It experiences a torque of 4 Nm. Calculate the charge on the dipole if the dipole length is 2 cm.

(a) 8mC (b) 4mC
(c) 8μC (d) 2mC

145. On decreasing the distance between the two charges of a dipole which is perpendicular to electric field and decreasing the angle between the dipole and electric field, the torque on the dipole

(a) increases (b) decreases
(c) remains same (d) cannot be predicted.

146. An electric dipole is put in north-south direction in a sphere filled with 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

147. The surface density on the copper sphere is σ. The electric field strength on the surface of the sphere is

(a) σ (b) σ/2
(c) $Q/2\varepsilon_o$ (d) Q/ε_o

148. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward electric flux will

(a) increase four times (b) be reduced to half
(c) remain the same (d) be doubled

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (c) 2. (d)
3. (b) When we say that a body is charged, we always mean that the body is having excess of electrons (negatively charged) or is of deficient of electrons (positively charged).
4. (a) Valence electrons are outermost electrons these can get transferred on rubbing.
5. (d) 6. (a) 7. (b) 8. (c) 9. (d)
10. (a) A body with charge is called charged body. A body without charge is called neutral body. When we say that a body is charged, either it has excess electrons or it has lesser elctrons as compared to number of protons inside body.
11. (c) 12. (c)
13. (a) Comb induces charge on paper due to which paper is attracted towards the comb.
14. (b) When some charge is given to conductor it spreads on its surface. When some charge is given to insulator, it remains there, it do not spread, Free charges in conductor interact with added charge, so added charge spreads on surface to be in equilibrium.
15. (d)
16. (c) Electron having a charge of -1.6×10^{-19}C undergoes annihilation with it's antiparticle positron having a charge of $+1.6 \times 10^{-19}$C as

$$e^- + e^+ \rightarrow \gamma + \gamma$$

Net charge before annihilation

$$= -1.6\times10^{-19}C + 1.6\times10^{-19}C = 0$$

Net charge after annihilation $= 0 + 0 = 0$

i.e., net charge remains same.

17. (d) 18. (c) 19. (d) 20. (b)
21. (b) Electric field is directly proportional to the magnitude of charge and inversely proportional to the square of the distance from the charge. Therefore charge +Q produce a comparatively stronger electric field than +q which get at cancelled with each other at a point closer to +q.
22. (d) 23. (b) 24. (d)
25. (b) If charge particle is put at rest in electric field, then it will move along line of force.
26. (d) For linear isotropic dielectric,

polarization $P = \chi_e E$,

$P \propto E$,

27. (c) By Gauss Law
28. (a) 29. (c) 30. (d) 31. (a)
32. (c) S.I. unit of electric flux is $\frac{N \times m^2}{C} = \frac{J \times m}{C}$

= Volt × m.

33. (c) 34. (d) 35. (d)
36. (d) For distances far away from centre of dipole

$$E_{axis} = E_a = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$

$$E_{equa} = E_e = \frac{1}{4\pi\varepsilon_0} - \frac{p}{r^3}$$

$$\frac{d}{dr}(E_a) = \frac{1}{4\pi\varepsilon_0}2p\frac{d}{dr}(r^{-3})$$

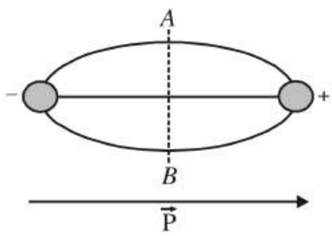
$$= -6\cdot\frac{1}{4\pi\varepsilon_0}\frac{p}{r^4} \quad ...(i)$$

$$\frac{d}{dr}(E_e) = \frac{1}{4\pi\varepsilon_0}p\frac{d}{dr}(r^{-3})$$

$$= -3\frac{1}{4\pi\varepsilon_0}\frac{p}{r^4} \quad ...(ii)$$

From equation (i) and (ii) the magnitude of change in electric field w.r.t. distance is more in case of axis of dipole as compared to equatorial plane.

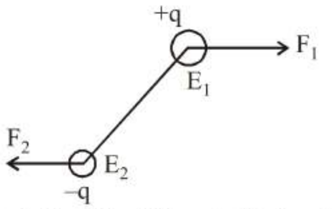
37. (b)
38. (b) The direction of electric field at equatorial point *A* or *B* will be in opposite direction, as that of direction of dipole moment.



39. (b) 40. (b) 41. (a)
42. (a) Dipole is formed when two equal and unlike charges are placed at a short distance.
43. (b) **Given :** Dipole moment of the dipole = $\vec{p}$ and uniform electric field = $\vec{E}$. We know that dipole moment (p) = q.a (where q is the charge and a is dipole length). And when a dipole of dipole moment $\vec{p}$ is placed in uniform electric field $\vec{E}$, then Torque (τ) = Either force × perpendicular distance between the two forces = qaEsinθ or $\tau = pE\sin\theta$ or $\vec{\tau} = \vec{p} \times \vec{E}$ (vector form)
44. (b) We have $E_a = \frac{2kp}{r^3}$ and $E_e = \frac{kp}{r^3}$; $\therefore E_a = 2E_e$

45. **(a)**

46. **(c)**



The electric field will be different at the location of force on the two charges. Therefore the two charges will be unequal. This will result in a force as well as torque.

47. **(c)**

48. **(b)** **Given :** Dipole moment of the dipole = $\vec{p}$ and uniform electric field = $\vec{E}$. We know that dipole moment (p) = q.a (where q is the charge and a is dipole length). And when a dipole of dipole moment $\vec{p}$ is placed in uniform electric field $\vec{E}$, then Torque (τ) = Either force × perpendicular distance between the two forces = qaEsinθ or $\tau = pE\sin\theta$ or $\vec{\tau} = \vec{p} \times \vec{E}$ (vector form)

49. **(b)**

50. **(b)** Gauss's law is applicable only for closed surface and for the charge placed inside it not near it.

Total electric flux, $\phi_{\epsilon} = \frac{1}{\varepsilon_0} Q$

51. **(a)** Gaussian surface cannot pass through any discrete charge because electric field due to a system of discrete charges is not well defined at the location of the charges. But the Gaussian surface can pass through a continuous charge distribution.

52. **(a)** Gauss's law is valid for any closed surface, no matter what its shape or size.

53. **(a)** According to Gauss's law total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge inside that surface.

Electric flux, $\phi_E = \frac{q}{\varepsilon_0}$

Charge on α-particle = 2e

$\phi_E = \frac{2e}{\varepsilon_0}$

54. **(c)** The electric field due to an infinitely straight uniformly charged wire at any distance r

$E = \frac{\lambda}{2\pi\varepsilon_0 r} \quad \therefore \ E \propto \frac{1}{r}$

55. **(c)** $\oint \vec{E}.d\vec{A} = 0$, represents charge inside close surface is zero. Electric field as any point on the surface may be zero.

56. **(a)** Electric charge resides only on the surface of a spherical shell. According to Gauss's theorem the total electric flux over a closed surface is equal to the $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface.

57. **(c)** Electric field near the conductor surface is given by $\frac{\sigma}{\varepsilon_0}$ and it is perpendicular to surface.

58. **(b)** **59.** **(a)** **60.** **(b)** **61.** **(d)**

STATEMENT TYPE QUESTIONS

62. **(c)** Like charges repel ⟵ ⊕ ⊕ ⟶

Unlike charges attract ⊕ ⟶ ⟵ ⊖

To specify particular charge on body, term used is polarity.

On rubbing, plastic rod acquires negative charge, cat's fur acquires positive charge. There are only two kinds of charges: +, –.

63. **(c)** Milikan demonstrated the quantisation of charge experimentally. Charge on electron = – e = -1.6×10^{-19}C. Addition of charge can occur in integral multiples of *e*.

64. **(b)** Nuclear force binds the protons and neutrons in the nucleus of an atom.

65. **(b)** (i) Electrostatic field is zero inside a charged conductor or neutral conductor.

(ii) Electrostatic field at the surface of a charged conductor must be normal to the surface at every point.

(iii) There is no net charge at any point inside the conductor and any excess charge must reside at the surface.

66. **(d)**

67. **(a)** Consider a system of charges $q_1, q_2, ..., q_n$ with position vectors $r_1, r_2 ..., r_n$ relative to some origin O. Like the field due to a single charage, electric field at a point in space due to the system of charges is defined to be the force experienced by a unit test charge placed at that point,, without disturbing the original position of charges $q_1, q_2, ..., q_n$. We can use Coulomb's law and the superposition principle to determine this field.

68. **(a)** Electric field lines start from positive charge and end at negative charge so they do not form closed loops.

69. **(b)** In a uniform electric field $\vec{E}$, dipole experiences a torque $\vec{\tau}$ given by

$$\vec{\tau} = \vec{p} \times \vec{E}$$

And potential energy of the dipole is

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

70. **(a)** Polar molecules have permanent electric dipole moment.

71. **(d)**

MATCHING TYPE QUESTIONS

72. **(c)** (A) → (2); (B) → (1) because total charge on L.H.S. is equal to total charge on R.H.S. (C) → (4) charge q is integer times the charge on an electron (D) → (3) because both are positively charged.

73. **(a)** Electric dipole moment points from negative charge to positive charge. Electric field points away from positive charge. Electric flux is the scalar product of electric field and area vector and torque is vector product of electric dipole moment and electric field.

74. (a) Linear charge density, $\lambda = \frac{\text{charge}}{\text{Length}}$

Surface charge density, $\sigma = \frac{\text{charge}}{\text{Area}}$

Volume charge density, $\rho = \frac{\text{charge}}{\text{volume}}$

75. (a) 76. (b)

77. (d) For a point sized dipole $E \propto \frac{1}{r^3}$, for an infinitely long straight uniformly charged wire $E \propto \frac{1}{r}$ and for a point charge $E \propto \frac{1}{r^2}$.
Therefore as distance decreases the increase in electric field is maximum for dipole [curve(c)], then for point charge [curve (b)] and then for charged wire (curve (a)). The electric field is constant for a uniformly charged plane sheet.

78. (c)

DIAGRAM TYPE QUESTIONS

79. (c) The weight mg of the charge hold in air is in equillibrium with net electrostatic force exerted by the four charges situated at the corners. The net electrostatic force is given by the vector sum of the individual forces exerted by the charges at the corners. This is principle of superposition.

80. (d) From Coulomb's law $F = \frac{Kq_1q_2}{r^2}$ i.e., $F \propto \frac{1}{r^2}$ which is correctly shown by graph (d).

81. (d)

82. (c) When charged rod is brought near uncharged conductor near end of conductor has opposite charge.When for end of this conductor is connected is ground (i.e., earthed), charge of far end flows down to ground when for end connection and rod are removed charge on conductor spreads uniformly on surface.

83. (a) For the distances close to the charge at x = 0 the field is very high and is in positive direction of x-axis. As we move towards the other charge the net electric field becomes zero at x = a thereafter the influence of charge at x = 2a dominates and net field increases in negative direction of x-axis and grows unboundedly as we come closer and closer to the charge at x = 2a.

84. (b) The electric field around a charge propagates with the speed of light away from the charge. Therefore the required time $= \frac{\text{distance}}{\text{speed}} = \frac{OP}{c}$.

85. (c)

86. (a) Since lines of force starts from A and ends at B, so A is +ve and B is –ve. Lines of forces are more crowded near A, so A > B.

87. (d) Since electric field $\vec{E}$ decreases inside water, therefore flux $\phi = \vec{E}.\vec{A}$ also decreases.

88. (a) The flux through the surface S is given by $\phi = ES\cos\theta$. When surface is rotated θ takes values $45° \to 0° \to -45°$ cos θ has maximum value at 0° therefore. The flux first increases, attain a maximum value and then decreases.

89. (c) Since electric field due to a point charge is inversely proportional to the square of distance therefore the field decreases at the place of surface S as the charge +Q moves away. Therefore the flux given by $\phi = \vec{E}\cdot\vec{S}$ also decreases.

90. (a) Torque is given by t = pE sin q. When the dipole is rotated from stable equillibrium to unstable equillibrium, θ takes values as $0° \to 90° \to 180°$ and sin θ takes corresponding values as $0 \to 1 \to 0$. Therefore torque increases from 0, attains maximum value and then again decreases to zero.

91. (c) The electric field due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ which is independent of distance from the sheet. Therefore field remains constant.

92. (a) The flux is zero according to Gauss' Law because it is a open surface which enclosed a charge q.

ASSERTION- REASON TYPE QUESTIONS

93. (a) Conservation of electric charge states that the total charge of an isolated system remains unchanged with time

94. (b) Both the statements are independently correct.

95. (a) Because of repulsion, the free electrons will mole to the outer surface.

96. (c) Coulomb force and gravitational force follow the same inverse-square law. But gravitational force has only one sign which is always attractive, while coulomb force can be of both signs which are attractive and repulasive.

97. (d) Gravitational force is the dominating force in nature and not coulomb's force. Gravitational force is the weakest force. Also, Coulomb's force > > gravitational force.

98. (b) Coulomb attraction exists even when one body is charged, and the other is uncharged.

99. (c) $q_d = e,\ m_d = 2m_p = 2m$
$q_\alpha = 2e,\ m_\alpha = 4m_p = 4m$
$F_1 = F_\alpha = eE,\ F_2 = F_\alpha = 2eE \neq F_1$

Further, $a_1 = \frac{F_1}{2m} = \frac{eE}{2m}$

and $a_2 = \frac{F_2}{2m} = \frac{2eE}{4m} = \frac{eE}{2m} = a_1$ s

100. (b) Force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to the other charges, taken one at a time. The individual force are unaffected due to the presence of other charges. This is the principle of superposition of charges.

101. (a) The electrostatic shielding is possible by metallic conductor.

102. (c) The electric field will increase if positive charge is brought in an electric field.

103. (b) If +ve charge is displaced along x-axis, then net force will always act in a direction opposite to that of displacement and the test charge will always come back to its original position.

104. (c) Statement-1 is correct. The induced field cancels the external field. Statement-2 is false. When a current is set up in a conductor, there exists an electric field inside it.

105. (a) The electric field due to disc is superposition of electric field due to its constituent ring as given in Reason.

106. (d) Two field lines never intersect.

107. (b) Though the net charge on the conductor is still zero but due to induction negatively charged region is nearer to the rod as compared to the positively charged region. That is why the conductor gets attracted towards the rod.

108. (d) Electric field at any point depends on presence of all charges.

109. (a) The restoring torque brings it back to its stable equillibrium.

110. (d) The rate of decrease of electric field is different in the two cases. In case of a point charge, it decreases as $1/r^2$ but in the case of electric dipole it decreases more rapidly, as $E \propto 1/r^3$.

111. (d) $\oint \vec{E}.\vec{A} = EA\cos\theta$, this value can be zero, if either E is zero or $\theta = 90°$. But it must show that net charge inside close surface is zero.

112. (a) Since for an infinitely long straight uniformly charged wire, $E = \frac{\lambda}{2\pi\varepsilon_0 r}$ on moving a distance two times the initial distance away from wire, the distance from wire becomes 3r. Therefore final value of electric field

$$E' = \frac{\lambda}{2\pi\varepsilon_0 (3r)} = \frac{E}{3}.$$

CRITICALTHINKING TYPE QUESTIONS

113. (b) On touching the metal knob with a positively charged rod some electrons from the gold leaves get transferred to the rod making gold leaves positively charged and they get separated. When a negatively charged rod is touched with metal knob some negative charge flows to the gold leaves lessening the positive charge there and the separation between the leaves decreases.

114. (a)

115. (b) Electrostatic force is given by

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

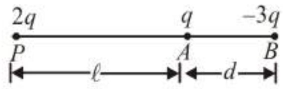
Here, charge and distance are same. So, force between two protons will be same

116. (b) Here, $q_1 = 1 \times 10^{-7}$C, q_2 and 2×10^{-7} C, $r = 20$ cm $= 20 \times 10^{-2}$ m

As $F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$

$$= \frac{9\times10^9 \times 1\times10^{-7} \times 2\times10^{-7}}{(20\times10^{-2})^2} = 4.5 \times 10^{-3}\ N$$

117. (b)



Let a charge $2q$ be placed at P, at a distance l from A where charge q is placed, as shown in figure. The charge $2q$ will not experience any force, when force, when force of repulsion on it due to q is balanced by force of attraction on it due to $-3q$ at B where AB $= d$

or $\frac{(2q)(q)}{4\pi\varepsilon_0 \ell^2} = \frac{(2q)(-3q)}{4\pi\varepsilon_0 (\ell + d)^2}$

$(\ell + d)^2 = 3\ell^2$

or $2\ell^2 - 2\ell d - d^2 = 0$

$$\therefore \quad \ell = \frac{2d \pm \sqrt{4d^2 + 2d^2}}{4} = \frac{d}{2} \pm \frac{\sqrt{3}d}{2}$$

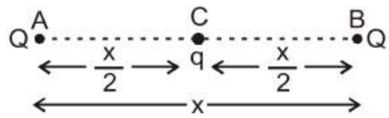
$$\ell = \frac{d + \sqrt{3}d}{2}$$

118. (b) Here $q_1 = q_2 = 3.2 \times 10^{-7}$ C, $r = 60$ cm $= 0.6$ m

Electrostatic force, $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

$$= \frac{9\times10^9 (3.2\times10^{-7})^2}{(0.6)^2} = 2.56 \times 10^{-3}\ N$$

119. (d) Let q charge is situated at the mid position of the line AB. The distance between AB is x. A and B be the positions of charges Q and Q respectively.



Let $AC = \frac{x}{2}$, $BC = \frac{x}{2}$

The force on A due to charge q at C,

$$\vec{F}_{CA} = \frac{1}{4\pi\varepsilon_0}.\frac{Q.q}{(x/2)^2} \text{ along } \overrightarrow{AC}$$

The force on A due to charge Q at B

$$\vec{F}_{AB} = \frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{x^2} \text{ along } \overrightarrow{BA}$$

The system is in equilibrium, then two oppositely directed force must be equal, i.e., total force on A is equal to zero.

$$\vec{F}_{CA} + \vec{F}_{AB} = 0 \Rightarrow \vec{F}_{CA} = -\vec{F}_{AB}$$

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{4Q.q}{x^2} = \frac{-1}{4\pi\varepsilon_0} \cdot \frac{Q^2}{x^2}$$

$$\Rightarrow q = -\frac{Q}{4}$$

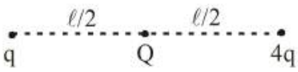
120. (c) Let n be the number of electrons missing.

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{d^2} \Rightarrow q = \sqrt{4\pi\varepsilon_0 d^2 F} = ne$$

$$\therefore \quad n = \sqrt{\frac{4\pi\varepsilon_0 F d^2}{e^2}}$$

121. (a) $(F_{net})_q = 0$

$$\Rightarrow k\frac{Qq}{\left(\frac{\ell}{2}\right)^2} + k\frac{4q^2}{\ell^2} = 0$$



where $k = \frac{1}{4\pi\varepsilon_0}$

$\Rightarrow 4Qq + 4q^2 = 0$

$\Rightarrow Q = -q$

122. (c) In vacuum, $F = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{r^2}$ ...(i)

Suppose, force between the chrages is same when charges are r′ distance apart in dielectric.

$\therefore \quad F' = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{kr'^2}$ ...(ii)

From (i) and (ii), $kr'^2 = r^2$ or, $r = \sqrt{kr'}$

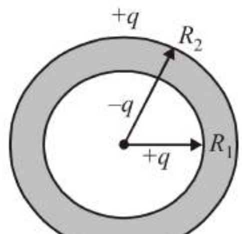
In the given situation, force between the charges would be

$$F' = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{\left(\frac{r}{2} + \sqrt{4}\frac{r}{2}\right)^2} = \frac{4}{9}\frac{q^2}{4\pi\varepsilon_0 r^2} = \frac{4F}{9}$$

123. (d) They will not experience any force if $|\vec{F}_G| = |\vec{F}_e|$

$$\Rightarrow G\frac{m^2}{(16\times10^{-2})^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{(16\times10^{-2})^2} \Rightarrow \frac{q}{m} = \sqrt{4\pi\varepsilon_0 G}$$

124. (b) When a charge $+q$ is placed at the centre of spherical as shown in figure.



Charge induced on the inner surface of shell

$= -q$ ...(i)

Charge induced on the outer surface of shell

$= +q$ ...(ii)

$\therefore$ Surface charge density on the inner surface $= \frac{-q}{4\pi R_1^2}$

125. (d) Here, $D = 2r = 4.4\ m$, or $= r = 2.2\ m$

$\sigma = 60\ \mu C\ m^{-2}$

Charge on the sphere, $q = \sigma \times 4\pi r^2$

$$= 60 \times 10^{-6} \times 4 \times \frac{22}{7} \times (2.2)^2 = 3.7 \times 10^{-3}\ C$$

126. (c) Here, $\ell = 2.4\ m$, $r = 4.6\ mm = 4.6 \times 10^{-3}\ m$

$q = -4.2 \times 10^{-7}\ C$

Linear charge density, $\lambda = \frac{q}{\ell}$

$$= \frac{-4.2\times10^{-7}}{2.4} = -1.75 \times 10^{-7}\ C\ m^{-1}$$

Electric field, $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

$$= \frac{-1.75\times10^{-7}}{2\times3.14\times8.854\times10^{-12}\times4.6\times10^{-3}}$$

$= -6.7 \times 10^5\ N\ C^{-1}$

127. (b) $E = \frac{q}{4\pi\varepsilon_o r^2} \Rightarrow Ar = \frac{q}{4\pi\varepsilon_0 r^2} \Rightarrow q = 4\pi\varepsilon_o Ar^3$

128. (a) $-eE = mg$

$$\vec{E} = -\frac{9.1\times10^{-31}\times10}{1.6\times10^{-19}} = -5.6\times10^{-11}\ N/C$$

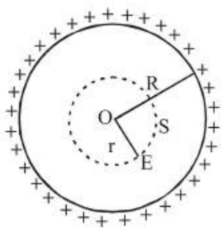
129. (b) $E = \frac{kQ}{r^2} \Rightarrow Q = \frac{E\times r^2}{k} = \frac{3\times10^6\times(2.5)^2}{9\times10^9}$

$$= 2\times10^{-3}\ C$$

130. (d) Unit positive charge at O will be repelled equally by three charges at the three corners of triangle. By symmetry, resultant $\vec{E}$ at O would be zero.

131. (a) Charge resides on the outer surface of a conducting hollow sphere of radius R. We consider a spherical surface of radius r < R.

By Gauss theorem



$\int_s \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0} \times$ charge enclosed or $E \times 4\pi r^2 = \frac{1}{\varepsilon_0} \times 0$

$\Rightarrow E = 0$

i.e electric field inside a hollow sphere is zero.

132. (a) Here, q = 1 C, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$

Number of lines of force = Electric force

$$= \frac{q}{\varepsilon_0} = \frac{1}{8.85 \times 10^{-12}} = 1.13 \times 10^{11}$$

133. (d) Electric flux, $\phi = EA \cos\theta$, where θ = angle between E and normal to the surface.

Here $\theta = \frac{\pi}{2}$

$\Rightarrow \phi = 0$

134. (b) The flux for both the charges exactly cancels the effect of each other.

135. (d)

136. (c) $\phi = E(ds)\cos\theta = E(2\pi r^2)\cos 0° = 2\pi r^2 E$.

137. (a) For the curved surface, $\theta = 90°$

$\therefore \phi = E\ ds \cos 90° = 0$.

138. (d) According to Gauss' Law

$$\oint E.ds = \frac{Q_{\text{enclosed by closed surface}}}{\varepsilon_0} = \text{flux}$$

so total flux = Q/ε_0

Since cube has six face, so flux coming out through one wall or one face is $Q/6\varepsilon_0$.

139. (a) **Given :** Length of the dipole $(2l)$ = 10cm = 0.1m or l = 0.05m

Charge on the dipole (q) = 500 μC = 500 × 10^{-6} C and distance of the point on the axis from the mid-point of the dipole (r) = 20 + 5 = 25 cm = 0.25 m.

We know that the electric field intensity due to dipole on the given point (E)

$$= \frac{1}{4\pi\varepsilon_0} \times \frac{2(q.2l)r}{(r^2 - l^2)^2}$$

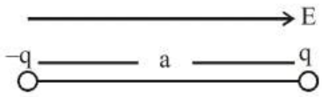
$$= 9 \times 10^9 \times \frac{2(500 \times 10^{-6} \times 0.1) \times 0.25}{[(0.25)^2 - (0.05)^2]^2}$$

$$= \frac{225 \times 10^3}{3.6 \times 10^{-3}} = 6.25 \times 10^7\ N/C \text{ (k = 1 for air)}$$

140. (c) Intensity of electric field due to a Dipole

$$E = \frac{p}{4\pi\varepsilon_0 r^3}\sqrt{3\cos^2\theta + 1} \Rightarrow E \propto \frac{1}{r^3}$$

141. (d) When the dipole is in the direction of field then net force is qE + (–qE) = 0



and its potential energy is minimum = – p.E.
= – qaE

142. (a) The torque on the dipole is given as

$\tau = PE \sin\theta$

The potential energy of the dipole in the electric field is given as

$U = -\ PE\cos\theta$

143. (b) $\tau = \left(2.57 \times 10^{-17}\text{Cm}\right)\left(3.0 \times 10^4 \frac{N}{C}\right)\left(\frac{1}{2}\right)$

$= 3.855 \times 10^{-13}$ Nm.

144. (d) Torque, $\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\theta$

$4 = p \times 2 \times 10^5 \times \sin 30°$

or, $p = \frac{4}{2 \times 10^5 \times \sin 30°} = 4 \times 10^{-5}$ Cm

Dipole moment, $p = q \times l$

$$q = \frac{p}{l} = \frac{4 \times 10^{-5}}{0.02} = 2 \times 10^{-3}\text{C} = 2\text{mC}$$

145. (b) Since $\tau = pE\sin\theta$ on decreasing the distance between the two charges, and on decreasing angle θ between the dipole and electric field, sin θ decreases therefore torque decreases.

146. (c) If electric dipole, the flux coming out from positive charge is equal to the flux coming in at negative charge *i.e.* total charge on sphere = 0. From Gauss law, total flux passing through the sphere = 0.

147. (d) According to Gauss's theorem,

$$E\oint ds = \frac{q}{\epsilon_0}\left[\text{Here} \oint ds = 4\pi R^2\right]$$

$$\therefore E = \frac{q/4\pi R^2}{\epsilon_0}\quad [\because q/4\pi R^2 = \sigma]$$

or $E = \sigma/\varepsilon_0$

148. (c) By Gauss's theorem, $\phi = \frac{Q_{in}}{\epsilon_0}$

Thus, the net flux depends only on the charge enclosed by the surface. Hence, there will be no effect on the net flux if the radius of the surface is doubled.