OTHER IMPORTANT QUESTIONS

(A) Very Short Answer Type Questions (1 mark each)

Q.1. What is electric charge ?

Ans. Electric charge is something possessed by material objects that makes it possible for them to exert electrical force and to respond to electrical force.

Q.2. Name any two basic properties of electric charge.

Ans. (*i*) Electric charge is quantised (*ii*) Electric charge is additive in nature.

Q.3. What does $q_1 + q_2 = 0$, signify in electrostatics ?

Ans. It signifies that $|q_1| = |q_2|$ but signs of q_1 and q_2 are mutually opposite.

Q.4. A glass rod rubbed with silk acquires a charge + 1.6×10^{-12} C. What is the charge on the silk ?

Ans. -1.6×10^{-12} C.

Q.5. Define the term 'dielectric constant' of a medium. **[Delhi 2005]**

Ans. Dielectric constant of a medium

$$K = \frac{\text{Force between two electric charges separated by a finite distance in free space or air}}{\text{Force between same charges separated by equal distance in given medium}}$$

Q.6. Define the dielectric constant of a medium. What is its unit ? **[Delhi 2011 C]**

Ans. For definition, see Very Short Answer Type Question Number 5. Dielectric constant is a unit-less and dimensionless term.

Q.7. Two point charges having equal charges separated by 1 m distance experience a force of 8 N. What will be the force experienced by them, if they are held in water at the same distance ?
(Given : $K_{water} = 80$) [A.I. 2011 C]

Ans. In free space force between two equal point charges separated by 1 m is, $F = 8$ N.

Hence in water (dielectric constant $K = 80$) force between these very point charges separated by same distance will be

$$F_{water} = \frac{F}{K_{water}} = \frac{8\text{ N}}{80} = 0.1\text{ N}$$

Q.8. What is quantisation of electric charge ?

Ans. Charge on any body is an integer multiple of the charge of an electron or proton *i.e.*, $q = \pm ne$, where $n = 0, 1, 2, 3, \ldots$

Q.9. Does the coulombian force, that one charge exerts on another charge, change, if other charges are brought nearby ?

Ans. No, it does not change. The force between two given charges is independent of presence of other charges, if any.

Q.10. In an electric field an electron is kept freely. If the electron is replaced by a proton, what will be the relationship between the forces experienced by them ? **[Delhi 2000]**

Ans. Magnitude of force will be same but direction will be reversed.

Q.11. Give the SI unit of electric field. Is electric field a scalar or a vector quantity ? [Delhi 2000]

Ans. $N C^{-1}$ (or $V m^{-1}$). Electric field is a vector quantity.

Q.12. Which physical quantity has unit newton (coulomb)$^{-1}$? Is it a vector or scalar quantity ? [Delhi 2002]

Ans. Electric field, which is a vector quantity.

Q.13. Write the SI unit of (*i*) electric field, and (*ii*) electric dipole moment. [A.I. 2003]

Ans. (*i*) $N C^{-1}$ or $V m^{-1}$ (*ii*) C-m

Q.14. Define the term electric dipole moment of a dipole. State its SI unit. [A.I. 2006, 2008, 2011]

Ans. See Point Numbers 31 and 32 under the heading "Chapter At A Glance".

Q.15. Two charges, one + 5 μC, and another – 5 μC, are placed 1 mm apart. Calculate the dipole moment.

Ans. Dipole moment $p = q.2a = (5\ \mu C)(1\ mm) = 5 \times 10^{-6}\ C \times 10^{-3}\ m = 5 \times 10^{-9}$ C-m.

Q.16. What is the direction of dipole moment ?

Ans. From negative charge towards positive charge.

Q.17. The dimensions of an atom are of the order of an angstrom. Thus, there must be large electric fields between the protons and electrons. Why, then is the electrostatic field inside a conductor zero ? [NCERT Exemplar]

Ans. Inside a conductor, the electric fields bind the atoms so as to make them electrical neutral entity. As there are no excess charge inside a conductor, hence electrostatic field is zero there.

Q.18. How does the coulombian force between two point charges depend upon the dielectric constant of the intervening medium ? [A.I. 2005]

Ans. Inversely proportional to the dielectric constant of intervening medium *i.e.*, $F \propto \frac{1}{K}$.

Q.19. Define relative permittivity of a medium.

Ans. Relative permittivity (ϵ_r) of a medium is defined as the ratio of the permittivity of given medium (ϵ) to the permittivity of free space (ϵ_0), Thus, $\epsilon_r = \frac{\epsilon}{\epsilon_0}$.

Q.20. Consider the situation shown in the Fig. 1.17 given below. What are the signs of q_1 and q_2? [Delhi 2002]

Ans. q_1 is –ve but q_2 is +ve. It is because electric field lines start from +ve charge and end at –ve charge.

Q.21. Draw electrostatic field lines for an isolated positive point charge + Q (*i.e.*, $Q > 0$). [Delhi 2008]

Ans. See Fig. 1.18.

Q.22. Draw electrostatic field lines due to a small conducting sphere having negative charge on it.

Ans. See Fig. 1.19. **[A.I. 2011 C]**

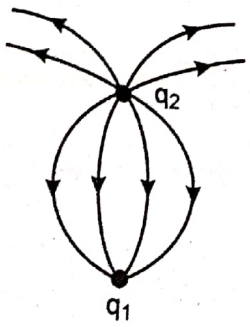


Fig. 1.17

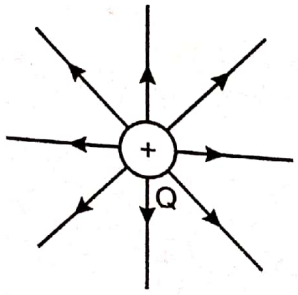


Fig. 1.18

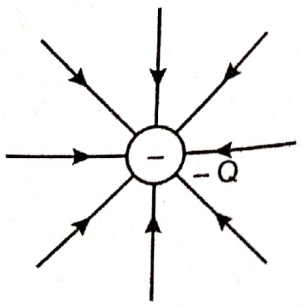


Fig. 1.19

Q.23. Sketch the electric field lines for a uniformly charged hollow cylinder shown in Fig. 1.20. [NCERT Exemplar]

Ans. Electric field lines are shown in Fig. 1.21(*a*) and (*b*).

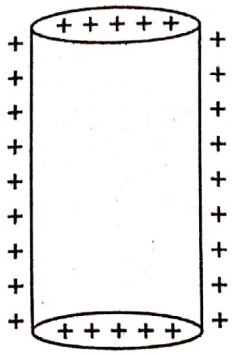
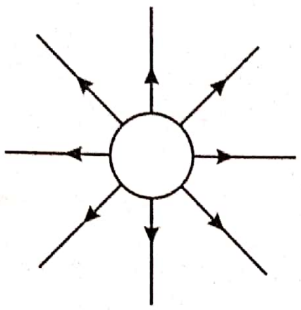
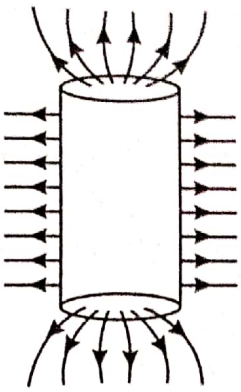


Fig. 1.20



(a) Top view



(b) Side view

Fig. 1.21

Q.24. Sketch the pattern of electric field lines due to an electric dipole. [A.I. 2011 C]

Ans. See Fig. 1.22.

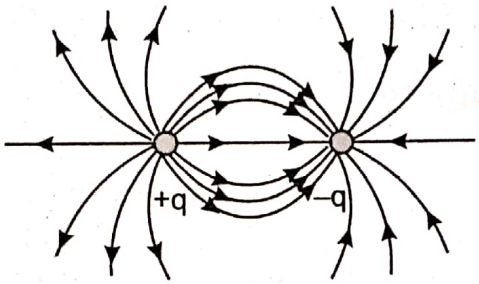


Fig. 1.22

Q.25. Why do the electrostatic field lines not form closed loops ? [A.I. 2012 C, 2015]

Ans. Electrostatic field lines cannot form closed loops because electrostatic field is a conservative field.

Q.26. A proton is placed in a uniform electric field directed along the positive *x*-axis. In which direction will it tend to move ? [Delhi 2011 C]

Ans. Proton will tend to move along the positive *x*-axis in the direction of uniform electric field.

Q.27. How does electric field strength change with distance '*r*' from a short dipole ?

Ans. $E \propto \frac{1}{r^3}$.

Q.28. Which orientation of an electric dipole in a uniform electric field corresponds to stable equilibrium ? [A.I. 2008]

Ans. When dipole has its dipole moment $\vec{p}$ along the direction of electric field $\vec{E}$ *i.e.*, when $\vec{p}$ and $\vec{E}$ are parallel.

Q.29. Is the electric field due to a charge configuration with total charge zero necessarily zero ? [A.I. 2012 C, NCERT Exemplar]

Ans. No, not necessarily zero. As an example total charge on an electric dipole is zero but electric field due to the dipole is finite at a given point.

Q.30. Two point charges q_1 and q_2 are placed at a distance '*d*' apart as shown in Fig. 1.23. The electric field intensity is zero at a point *P* on the line joining them as shown. Write two conclusions you can draw from this. [Delhi 2014 C]

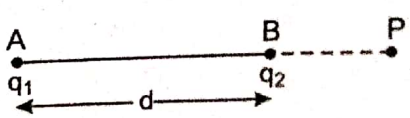


Fig. 1.23

Ans. We can draw following two conclusions :

(*i*) Signs of charges q_1 and q_2 are mutually opposite.

(*ii*) $|q_2| < |q_1|$.

Q.31. What is the net force on a dipole placed in a uniform electric field ?

Ans. Zero.

Q.32. A dipole of dipole moment $\vec{p}$, is present in a uniform electric field $\vec{E}$. Write the value of the angle between $\vec{p}$ and $\vec{E}$ for which the torque experienced by the dipole is minimum.

[Delhi 2009]

Ans. Torque $\vec{\tau}$ is minimum when angle between $\vec{p}$ and $\vec{E}$ is either zero or π rad, because $\vec{\tau} = \vec{p} \times \vec{E}$.

Q.33. At what points, is the field due to an electric dipole parallel to the line joining the charges ?

[A.I. 2003]

Ans. At any point on its axial line as well as its equatorial line.

Q.34. What is the angle between the directions of electric field at any (*i*) axial point, and (*ii*) equatorial point due to an electric dipole ?

Ans. 180° or π rad.

Q.35. In which case are the electric field lines parallel to one another ?

Ans. For a uniform electric field.

Q.36. When is the torque acting on an electric dipole placed in a uniform electric field maximum ?

Ans. When electric dipole is placed perpendicular to the direction of uniform electric field.

Q.37. In Fig. 1.24, given below, at which point electric field is maximum and why ?

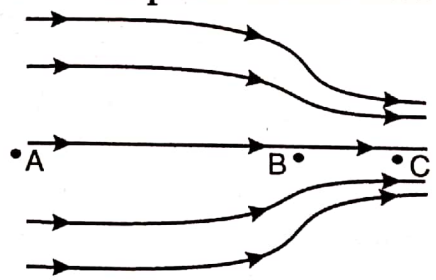


Fig. 1.24

Ans. Electric field is maximum at point *C*, because relative separation between electric field lines is less there.

Q.38. Distinguish between a dielectric and a conductor. **[Delhi 2012 C]**

Ans. (*i*) Conductors easily allow passage of electric charge through them but dielectrics do not allow passage of electric charge through them.

(*ii*) When placed in an external electric field E_0 there is polarisation of charges in dielectrics and electric field inside the dielectric is less than E_0. Electric field inside a conductor is always zero.

Q.39. Write an expression for the flux $\Delta\phi$ of the electric field $\vec{E}$ through an area element $\vec{\Delta s}$.

[Delhi 2010 C]

Ans. Electric flux $\Delta\phi = \vec{E} \cdot \vec{\Delta s}$.

Q.40. Define electric flux. Write its SI unit. [A.I. 2012 C, Delhi 2012, 2015]

Ans. Electric flux ϕ_E passing through a surface area $\vec{s}$ placed in an electric field $\vec{E}$ is given by :

$$\phi_E = \vec{E} \cdot \vec{s} = Es\cos\theta$$

where θ is the angle between $\vec{E}$ and $\vec{s}$.
SI unit of electric flux is N m^2 C^{-1}.

Q.41. Is electric flux a vector or a scalar ?

Ans. A scalar.

Q.42. State Gauss' law in electrostatics. [Delhi 2008]

Ans. See Point Number 50 under the heading "Chapter At A Glance".

Q.43. A charge q is placed at the centre of a cube. What is the total electric flux passing through the entire cube ?

Ans. $\phi_E = \frac{q}{\epsilon_0}$.

Q.44. A charge 'q' is placed at the centre of a cube of side 'l'. What is the electric flux passing through each face of the cube ? [A.I. 2012]

Ans. As per Gauss' law total electric flux passing through entire cube is $\frac{q}{\epsilon_0}$. As the cube has 6 faces in all and charge q is situated symmetrically, hence electric flux passing through each face

$$\phi_E = \frac{1}{6}\frac{q}{\epsilon_0}.$$

Q.45. Two charges of magnitudes – 2Q and + Q are located at points (a, 0) and ($4a$, 0) respectively. What is the electric flux due to these charges through a sphere of radius $3a$ with its centre at the origin ? [A.I. 2013]

Ans. As shown in Fig. 1.25, in accordance with Gauss' law the electric flux through the sphere surface

$$\phi_E = -\frac{2Q}{\epsilon_0}$$

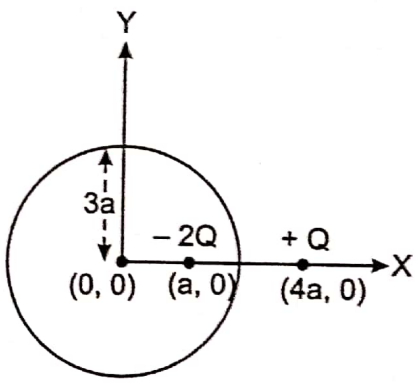


Fig. 1.25

Q.46. Figure 1.26 shows three point charges, + 2q, – q and + 3q. Two charges + 2q and – q are enclosed within a surface 'S'. What is the electric flux due to this configuration through the surface 'S' ? [Delhi 2010]

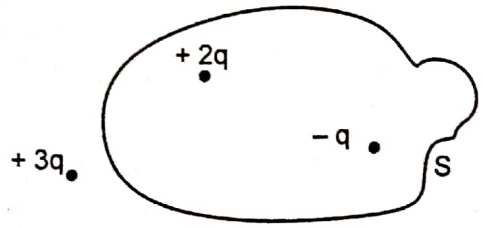


Fig. 1.26

Ans. As per Gauss theorem, total electric flux over a closed surface S is

$$\phi_E = \frac{1}{\epsilon_0}\Sigma\,(\text{charge enclosed within the surface}) = \frac{1}{\epsilon_0}[2q - q] = +\frac{q}{\epsilon_0}$$

Q.47. How is Gauss's law modified if a medium of dielectric constant K is present ?

Ans. Total electric flux $\phi_E = \frac{q}{K\epsilon_0}$.

Q.48. What is the net flux through a closed surface due to a charge located outside it ?

Ans. Zero.

Q.49. An arbitrary surface encloses an electric dipole of dipole moment 20×10^{-6} C-m. What is the electric flux through this surface ? [A.I. 2012, NCERT Exemplar]

Ans. Zero, because net charge within the closed surface is zero.

Q.50. If the radius of the Gaussian surface enclosing a surface is halved, how does the electric flux through the Gaussian surface change ? [A.I. 2008]

Ans. As the charge enclosed by the Gaussian surface remains unchanged, hence the electric flux also remains unchanged.

Q.51. If Coulomb's law had $\frac{1}{r^3}$ dependence instead of $\frac{1}{r^2}$, would Gauss's theorem had been still valid ?

Ans. No, because Gauss's theorem is essentially based on inverse square law dependence of Coulomb's law.

Q.52. What is the electric flux through a cube of side 1 cm which encloses an electric dipole ? [Delhi 2015]

Ans. Total flux is zero because net charge enclosed within the cube is zero.

Q.53. A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge Q is placed at the centre of the spherical cavity. What will be surface charge density on (*i*) the inner surface, and (*ii*) the outer surface ? [NCERT Exemplar]

Ans. Due to presence of a charge Q at the centre of spherical cavity, a charge $-Q$ is induced on the inner surface of shell and a charge $+Q$ is induced on the outer surface as shown in Fig. 1.27.

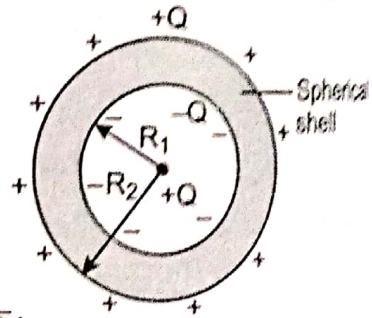


Fig. 1.27

(*i*) $\therefore$ Surface charge density on inner surface $\sigma_1 = \frac{-Q}{A_1} = \frac{-Q}{4\pi R_1^2}$

(*ii*) $\therefore$ Surface charge density on the outer surface $\sigma_2 = \frac{+Q}{A_2} = +\frac{Q}{4\pi R_2^2}$.

Q.54. A sphere S_1 of radius r_1 encloses a total charge Q. If there is another concentric sphere S_2 of radius r_2 ($> r_1$) and there be no additional charge between S_1 and S_2, find the ratio of electric flux through S_1 and S_2.

Ans. $\frac{\phi_2}{\phi_1} = \frac{q_1/\epsilon_0}{q_2/\epsilon_0} = \frac{q_1}{q_2} = \frac{Q}{Q} = 1$. [Since charge within both spheres is same = Q]

(B – I) Short Answer Type Questions (2 marks each)

Q.1. Two charged spherical conductors, each of radius R, are distant d ($d > 2R$). They carry charges $+q$ and $-q$. Will the force of attraction between them be exactly $\frac{q^2}{4\pi\epsilon_0 d^2}$? [A.I. 2000]

Ans. No, the force of attraction between charged spherical conductors will be more than $\frac{q^2}{4\pi\epsilon_0 d^2}$. On account of mutual attractive force there will be a redistribution of charges on the spheres as shown in Fig. 1.28. As a result, effective distance between them is reduced and the force increases.

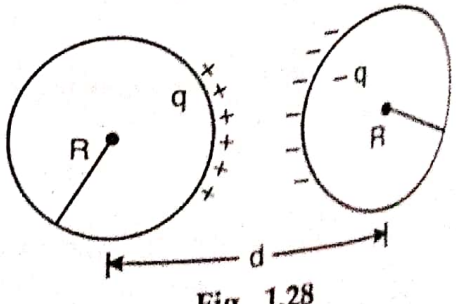


Fig. 1.28