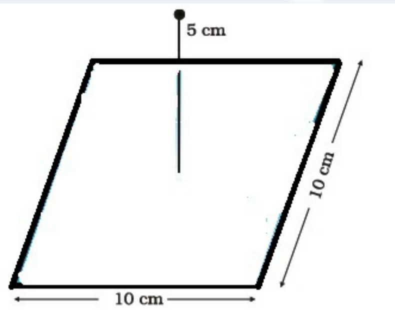
**CBSE Test Paper-02**

**Class - 12 Physics (Electric Charges and Fields)**

1. A charge q is placed at the center of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to
   a. $\frac{Q}{5}$
   b. $\frac{Q}{2}$
   c. $\frac{Q}{4}$
   d. $\frac{-Q}{4}$

2. A half ring of radius R has a charge of $\lambda$ per unit length. The field at the center is
   a. $2\frac{k\lambda}{R}$
   b. $\frac{k\lambda}{R}$
   c. zero
   d. $\frac{n\lambda}{R}$

3. A point charge +10 $\mu\mathrm{C}$ is a distance 5 cm directly above the centre of a square of side 10 cm, as shown in Figure. What is the magnitude of the electric flux through the square?




   a. $2.4 \times 10^5 \mathrm{Nm}^2/\mathrm{C}$
   b. $1.9 \times 10^5 \mathrm{Nm}^2/\mathrm{C}$
   c. $2.2 \times 10^5 \mathrm{Nm}^2/\mathrm{C}$
   d. $2.0 \times 10^5 \mathrm{Nm}^2/\mathrm{C}$

4. When a negatively charged conductor is connected to earth

a. Electrons flow from the earth to the conductor
b. Protons flow from the conductor to the earth
c. No charge flow occurs
d. Electrons flow from the conductor to the earth

5. Eight dipoles of charges of magnitude e are placed inside a cube. The total electric flux coming out of the cube will be

    a. $\frac{16e}{\epsilon_o}$
    b. $\frac{e}{\epsilon_o}$
    c. Zero
    d. $\frac{8e}{\epsilon_o}$

6. Define dipole moment of an electric dipole. Is it a scalar quantity or a vector quantity?

7. A proton is placed in a uniform electric field directed along the positive X-axis. In which direction, will it tend to move?

8. A charge q is placed at the centre of a cube of side I. What is the electric flux passing through each face of the cube?

9. Sketch lines of force due to two equal positive charges placed at a small distance apart in air.

10. Plot a graph showing the variation of Coulomb force (F) versus $1/r^2$, where r is the distance between the two charges of each pair of charges (1μC, 2μC) and (1μC, -3μC). Interpret the graphs obtained.

11. An electric dipole of length 4 cm when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $4\sqrt{3}N-m.$
    Calculate the potential energy of the dipole if it has charge of ± 8nC.

12. i. Obtain the expression for the torque $\tau$ experienced by an electric dipole of dipole moment p in a uniform electric field, E.
    ii. What will happen, if the field were not uniform?

13. Suppose that the particle in an electron projected with velocity $v_x = 2.0\times10^6 ms^{-1}$.

If E between the plates separated by 0.5 cm is $9.1 \times 10^2 N/C$, where will the electron strike the upper plate? $(|e| = 1.6 \times 10^{-19}\ C, m_e = 9.1 \times 10^{-31} kg)$.

14. Two concentric metallic spherical shells of radii R and 2R are given charge $Q_1$ and $Q_2$ respectively. The surface charge densities on the outer surfaces of the shells are equal. Determine the ratio $Q_1$:$Q_2$.

15. Find the magnitude of the resultant force on a charge of $1\mu C$ held at P due to two charges of $+2 \times 10^{-8} C$ and -$10^{-8}$C at A and B respectively. Given AP = 10 cm and BP = 5 cm $\angle APB = 90°$.

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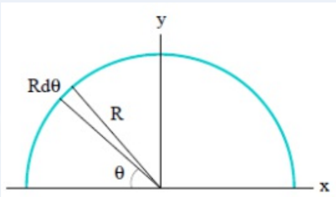
## Class - 12 Physics (Electric Charges and Fields)
## Answers

1. d. $\frac{-Q}{4}$

   **Explanation**: Let the separation between the two particles of charges Q be 2a. Coulomb's forces on the charge q due to the other two charges are equal and opposite.
   Hence, charge q is always in equilibrium irrespective of its sign and magnitude. Coulomb's force on a charge Q due to another charge Q is repulsive in nature and has magnitude $F_q = \frac{Q^2}{16\pi\varepsilon_o a^2} = -\frac{Qq}{4\pi\varepsilon_o a^2}$ . Which gives $q = \frac{-Q}{4}$

2. a. $2\frac{k\lambda}{R}$

   **Explanation:** Consider a uniformly charged thin rod bent into a semicircle of radius R.




   Charge per unit length: $\lambda = \frac{Q}{\pi R}$
   Charge on slice: $dq = \lambda R d\theta$ (taken positive) Electric field generated by slice:
   $dE = \frac{k|dq|}{R^2} = \frac{k|\lambda|d\theta}{R}$ directed radially (inward for λ > 0)
   Components of dE, $dE_x$ = dE cos θ,

   dEy = −dE sin θ

   Electric field from all slices added up: $E_x = \frac{k\lambda}{R}\int_0^{\pi} cos\theta\ d\theta = \frac{k\lambda}{R}[sin\pi - sin\ 0] = 0$

   $E_y = -\frac{k\lambda}{R}\int_0^{\pi} Sin\theta\ d\theta = \frac{k\lambda}{R}[cos\pi - cos\ 0] = -\frac{2k\lambda}{R}$

3. c. $2.2 \times 10^5 \mathrm{Nm}^2/\mathrm{C}$

   **Explanation**: The square can be considered as one face of a cube of edge 10 cm with a centre where charge q is placed.
   According to Gauss's theorem for a cube,
   total electric flux $\phi = \frac{q}{\epsilon_0}$ is through all its six faces.
   Since the charge lies at the centre of cube,

so by symmetry flux through each of the 6 faces will be equal.

Hence, electric flux through one face of the cube i.e., through the square,

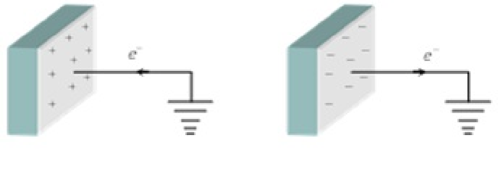
$\phi = \frac{q}{6\epsilon_0}$

Where, $\epsilon_o$ = Permittivity of free space = $8.854 \times 10^{-12}\ N^{-1}C^2\ m^{-2}$ q = 10 μC = $10 \times 10^{-6}$ C

$\therefore \phi = \frac{q}{6\epsilon_0} = \frac{10\times10^{-6}}{6\times8.854\times10^{-12}} = 2.2\ \times 10^5 Nm^2C^{-1}$

4. d. Electrons flow from the conductor to the earth

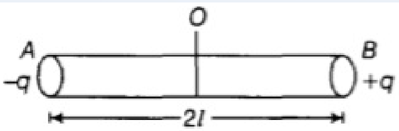
**Explanation:** After earthing a positively charged conductor electrons flow from earth to conductor and if a negatively charged conductor is earthed then electrons flows from conductor to earth.



5. c. Zero

**Explanation:** On all the dipoles net charge = 0, hence net charge enclosed within the surface = 0. so the total electric flux coming out of the surface

6. The electric dipole moment of an electric dipole is equal to the product of its either charge and the length of the electric dipole. It is denoted by p. Its SI unit is coulomb-metre.




$\mathbf{p} = q \times 2l$

It is a vector quantity and its direction is from a negative charge to positive charge. For electric dipoles magnitude of distance between the charges should be very less as compared to separation between them.

7. Force on positive charge is always in the direction of electric field So, proton being positive will tend to move along the X-axis in the direction of a uniform electric field.

**F** = q **E**

**F** will be in the direction of E for a positive point charge.

8. Applying Gauss' theorem which states that total electric flux linked with a closed

surface is given by $\phi = \frac{q}{\varepsilon_0}$

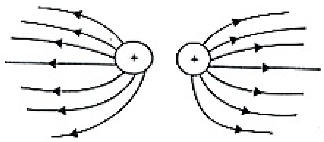
where, q is the total charge enclosed by the closed surface and $\varepsilon_0$ is permittivity of free space.

$\therefore$ Total electric flux linked with cube, $\phi = \frac{q}{\varepsilon_0}$

As charge is at centre, therefore, electric flux will be symmetrically distributed through all 6 faces of the cube so each face will receive 1/6 of the total electric flux.

Flux linked with each face of the cube = Total Flux/6 $= \frac{1}{6}\phi = \frac{1}{6} \times \frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$

Unit of Electric flux is Weber and it is a scalar quantity.

9. 

Electric lines of force of two equal positive charges.

10. As per Coulomb's law, the force acting between two stationary point charges will be given by -

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

For fixed charges $q_1 q_2$,

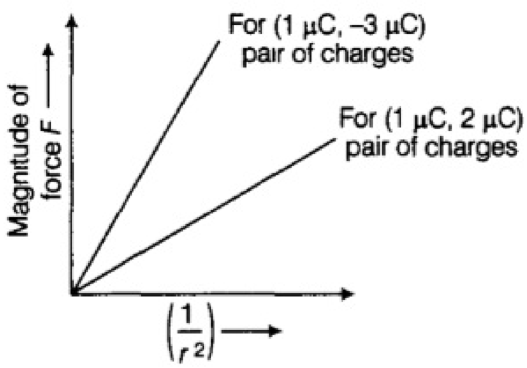
$$F \propto \left(\frac{1}{r^2}\right)$$

The slope of F versus, $\frac{1}{r^2}$ graph depends on $q_1$ $q_2$.

Magnitude of $q_1 * q_2$ is higher for the second pair as higher the product of charges more will be the force at fixed distance r according to coulomb's law -

$\therefore$ Slope of F versus $\frac{1}{r^2}$ graph corresponding to second pair (1μC,- 3μC)is greater.

Higher the magnitude of product of charges $q_1$ and $q_2$, higher the slope of the graph between F and $1/r^2$.




that's how we can compare the product of charges from the graph for given F and r for given stationary charges.

11. Data Given,

Length of the dipole (2a) = 4 cm $= 4 \times 10^{-2} \mathrm{m}$

Dipole moment, p = Q(2a)

Angle, $\theta = 60^\circ$

Torque, $\tau = 4\sqrt{3}\mathrm{N} - \mathrm{m}$

Charge, $Q = 8 \times 10^{-9}\mathrm{C}$

We know that, $\tau = Q(2a)E\sin\theta$

Electric field, $E = \frac{\tau}{Q(2a)\sin\theta}$

$E = \frac{4\sqrt{3}}{8\times10^{-9}\times4\times10^{-2}\times\sin 60^\circ}$

$E = 2.5 \times 10^{10}\mathrm{NC}^{-1}$

$\therefore$ Potential energy of a dipole placed in an electric field is given by -

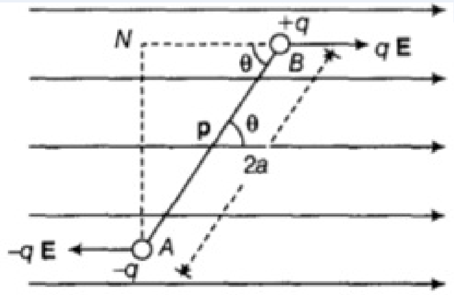
$U = -pE\cos\theta = -Q(2a)E\cos\theta$

$U = -8 \times 10^{-9} \times 4 \times 10^{-2} \times 25 \times 10^{10} \cos 60^\circ$

U = - 4 Joule.

So the potential energy of the dipole will be - 4 Joule and negative sign shows that interaction between electric field and dipole will be attractive in nature and work must be done to overcome this attraction.

12. i. The dipole in a uniform electric field




According to the figure, if we consider an electric dipole consisting of charges -q and +q and of length 2a placed in a uniform electric field E making an angle $\theta$ with electric field, then force exerted on a charge -q at A will be given by , F = -q E (opposite to E)(towards left in the diagram. Force exerted on charge +q at A= q E (along E) (towards right in the diagram). Hence, the net translating force on a dipole in a uniform electric field is zero. But the two equal and opposite forces act at different points and form a couple which exerts a torque $\tau$ on a dipole in clockwise direction.

$\tau$ = Force $\times$ Perpendicular distance between the two forces

$\tau = qE(AN) = qE(2a\sin\theta)$

$\tau = q(2a)E\sin\theta \Rightarrow \tau = pE\sin\theta \Rightarrow \tau = p \times E$

ii. When the dipole is placed in a non-uniform electric field, it experiences a net force and torque, which will depend on the magnitude of electric field at those points.

13. Acceleration, $a = \frac{qE}{m}$

$= \frac{1.6\times10^{-19}\times9.1\times10^{2}}{9.1\times10^{-31}} = 1.6 \times 10^{14} m/s^2$

Using formula $y = ut + \frac{1}{2}at^2$

We get, $0.005 = 0 + \frac{1}{2} \times 1.6 \times 10^{14} \times t^2$

Simplifying for value of t, we get

$t = 8 \times 10^{-9} s$

The electron covers vertical distance is shown as

$y = v_x t$

$= 2.0 \times 10^6 \times 8 \times 10^{-9}$

$= 1.6 \times 10^{-2} m$

= 1.6 cm

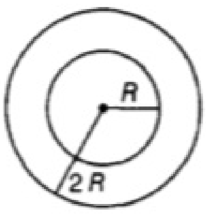
14. Surface charge density(σ) is Charge per unit area on the surface of any conductor,

$\sigma = \frac{Q}{4\pi R^2}$

According to the question, surface charge density is constant on both the surfaces

$\sigma$ = constant

Let $Q_1$ and $Q_2$ are two charges




Hence,

Charge $Q_1 = 4\pi R^2\sigma$ ..... (i)

Charge $Q_2 = 4\pi(2R)^2\sigma$ ....... (ii)

On dividing Eq. (i) with Eq (ii),

$\therefore \quad \frac{Q_1}{Q_2} = \frac{4\pi R^2\sigma}{4\pi(2R)^2\sigma} = \frac{1}{4}$

So, from the answer we can conclude that in order to have uniform surface charge densities on the surfaces of spherical shell, charge $Q_1$ should be quarter to that of charge $Q_2$.

15. Here, F = ?

Charge at P, $q = 1\mu C = 10^{-6}C$

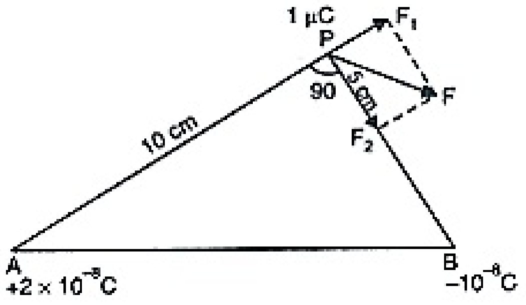
Charge at A, $q_1 = +2 \times 10^{-8}C$

Charge at B, $q_2 = -10^{-8}C$

AP = 10 cm = 0.1 m,

BP = 5 cm = 0.05 m

$\angle$APB = 90°




Force at P due to $q_1$ charge at A,

$F_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q}{AP^2}$ along AP produced

$= \frac{9\times10^9\times2\times10^{-8}\times10^{-6}}{(0.1)^2}$

$= 18 \times 10^{-3}N$

Force at P due to $q_2$ charge at B,

$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q}{BP^2}$ along BP

$= \frac{9\times10^9\times10^{-8}\times10^{-6}}{(0.05)^2}$

$= 36 \times 10^{-3}N$

As angle between $\overrightarrow{F_1}$ and $\overrightarrow{F}_2$ is 90°,

$\therefore$ Resultant Force $F = \sqrt{F_1^2 + F_2^2}$

$F = \sqrt{(18 \times 10^{-3})^2 + (36 \times 10^{-3})^2}$

$= 18 \times 10^{-3} \times 2.236$

$F = 4.024 \times 10^{-2}N$