Part – I
Class –XII Physics
Chapter-1 ELECTRIC CHARGES AND FIELDS

Answer 1:

Repulsive force of magnitude $6\times10^{-3}\ N$

Charge on the first sphere, $q_1 = 2\times10^{-7}\ C$

Charge on the second sphere, $q_2 = 3\times10^{-7}\ C$

Distance between the spheres, r = 30 cm = 0.3 m

Electrostatic force between the spheres is given by the relation,

$$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$$

Where, $\in 0$ = Permittivity of free space

$$s\frac{1}{4\pi\epsilon_0} = 9\times10^9\, Nm^2C^2$$

$$F = \frac{9\times10^9\times2\times10^{-7}\times3\times10^{-7}}{(0.3)^2} = 6\times10^{-3}\, N$$

Hence, force between the two small charged spheres is $6\times10^{-3}\ N$. The charges are of same nature. Hence, force between them will be repulsive.

Answer 2:

(a) Electrostatic force on the first sphere, F = **0.2 N**

Charge on this sphere, $q^1 = 0.4\ \mu C = 0.4\times10^{-6}\ C$

Charge on the second sphere, $q^2 = -0.8\ \mu C = -0.8\times10^{-6}\ C$

Electrostatic force between the spheres is given by the relation,

$$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2} \quad And\ \frac{1}{4\pi\epsilon_0} = 9\times10^9\, Nm^2C^{-2}$$

Where, ϵ_0 = Permittivity of free space

$$And, \frac{1}{4\pi\epsilon_0} = 9\times10^9\, Nm^{-2}C^{-2}$$

$$r^2 = \frac{q_1 q_2}{4\pi\epsilon_0 F}$$

$$= 144\times10^{-4}$$

$$r = \sqrt{144\times10^{-4}} = 0.12m$$

The distance between the two spheres is 0.12m.

(b) Both the spheres attract each other with the same force. Therefore, the force on the second sphere due to the first is 0.2N.

Answer 3:

The given ratio is $\frac{ke^2}{Gm_c m_p}$.

Where,

G = Gravitational constant

Its unit is $N\ m^2\ kg^{-2.}$

$m_e\ andm_p$ = Masses of electron and proton.

Their unit is kg.

e = Electric charge.

Its unit is C.

$\in 0$ = Permittivity of free space

Its unit is $Nm^2\ C^{-2}$

$Therefore, unit\ of\ the\ given\ ratio \frac{ke^2}{Gm_c m_p}$

$$=\frac{\left[Nm^2C^{+2}\right]\left[C^{+2}\right]}{\left[Nm^2kg^{-2}\right]\left[kg\right]\left[kg\right]}$$

$= M^0L^0T^0$

Hence, the given ratio is dimensionless.

$e = 1.6\times10^{-19}C$

G = $6.67\ \times\ 10^{-11}\ Nkg^{-2}$

$me = 9.1\times10^{-31}kg$

$mp = 1.66\times10^{-27}\ kg$

Hence, the numerical value of the given ratio is

$$\frac{ke^2}{Gm_e m_p} = \frac{9\times10^9\times\left(1.6\times10^{-19}\right)^2}{6.67\times10^{-11}\times9.1\times10^{-3}\times1.67\times10^{-22}} \approx 2.3\times10^{39}$$

This is the ratio of electric force to the gravitational force between a proton and an electron, keeping distance between them constant.

Answer 4:

(a) Electric charge of a body is quantized. This means that only integral (1, 2, …., *n*) number of electrons can be transferred from one body to the other. Charges are not transferred in fraction. Hence, a body possesses total charge only in integral multiples of electric charge.

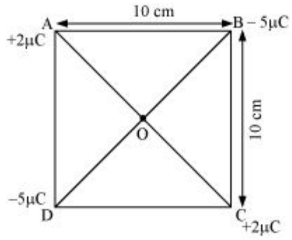
(b) In macroscopic or large scale charges, the charges used are huge as compared to the magnitude of electric charge. Hence, quantization of electric charge is of no use on macroscopic scale. Therefore, it is ignored and it is considered that electric charge is continuous.

Answer 5:

Rubbing produces charges of equal magnitude but of opposite nature on the two bodies because charges are created in pairs. This phenomenon of charging is called charging by friction. The net charge on the system of two rubbed bodies is zero. This is because equal amount of opposite charges annihilate each other. When a glass rod is rubbed with a silk cloth, opposite natured charges appear on both the bodies. This phenomenon is in consistence with the law of conservation of energy. A similar phenomenon is observed with many other pairs of bodies.

Answer 6

The given figure shows a square of side 10 cm with four charges placed at its corners. O is the centre of the square.



Where,

(Sides) $AB = BC = CD = AD = 10\ cm$

(Diagonals) $AC = BD = 10\sqrt{2}cm$

$AO = OC = DO = OB \ = 5\sqrt{2}cm$ s

A charge of amount 1μ C is plasced at point O.

Force of repulsion between charges placed at corner A and centre O is equal in magnitude but opposite in direction relative to the force of repulsion between the charges placed at corner C and centre O. Hence, they will cancel each other. Similarly, force of attraction between charges placed at corner B and centre O is equal in magnitude but opposite in direction relative to the force of attraction between the charges placed at corner D and centre O. Hence, they will also cancel each other. Therefore, net force caused by the four charges placed at the corner of the square on 1 μ C charge at centre O is zero.

Answer 7:

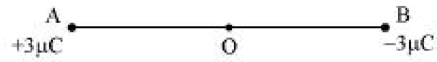
(a) An electrostatic field line is a continuous curve because a charge experiences a continuous force when traced in an electrostatic field. The field line cannot have sudden breaks because the charge moves continuously and does not jump from one point to the other.

(b) If two field lines cross each other at a point, then electric field intensity will show two directions at that point. This is not possible. Hence, two field lines never cross each other.

Answer 8:

(a) The situation is represented in the given figure. O is the mid-point of line AB.

Distance between the two charges, $AB = 20\ cm$



$\therefore AO = OB = 10\ cm$

Net electric field at point $O = E$

Electric field at point O caused by $+3\mu C$ charge,

$$E1 = \frac{3\times10^{-6}}{4\pi\in_0 (AO)^2} = \frac{3\times10^{-6}}{4\pi\in_0 \left(10\times10^{-2}\right)^2} N/C \text{ along OB}$$

Where,

$\in_0$ = Permittivity of free space

$$\frac{1}{4\pi\in_0} = 9\times10^9\ Nm^2C^{-2}$$

Magnitude of electric field at point O caused by - $3\mu C$ charge,

$$E2 = \frac{-3\times10^{-6}}{4\pi\in_0 (OB)^2} = \frac{3\times10^{-6}}{4\pi\in_0 (10\times10^{-2})} N/C \text{ along OB}$$

$$\therefore E = E_1 + E_2$$

$$= 2\times[\left(9\times10^9\right)\times\frac{3\times10^{-6}}{(10\times10^{-2})^2}] \quad [\text{Since the values of } E_1 \text{and } E_2 \text{are same, the value is multiplied with} 2]$$

$$= 5.4\times10^6\ N/C\ along\ OB$$

Therefore, the electric field at mid-point O is $5.4\times10^6\ NC^{-1}\ along\ OB$

(b) A test charge of amount $1.5\times10^{-9}\ C$. is placed at mid-point O.

$q = 1.5\times10^{-9}\ C$

Force experienced by the test charge = F

$\therefore F = qE$

$= 1.5\times10^{-9}\times5.4\times10^6$

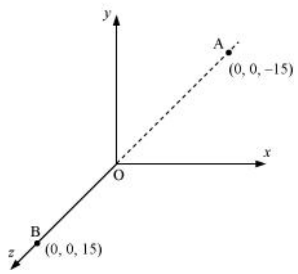
$= 8.1\times10^{-3}\ N$

The force is directed along line OA. This is because the negative test charge is repelled by the charge placed at point B but attracted towards point A.

Therefore, the force experienced by the test charge is $8.1\times10^{-3}\ N$ along OA.

Answer 9:

Both the charges can be located in a coordinate frame of reference as shown in the given figure.



At A, amount of charge, $q_A \;=\; 2.5 \times 10^{-7} C$

At B, amount of charge, $q_B \;=\; -2.5 \times 10^{-7}\; C$

Total charge of the system,

$q = q_A \;+ q_B$

$= \;2.510^{7}\; C \;-\; 2.510^{-7}\; C$

$= \;0$

Distance between two charges at points A and B,

$d = \;15\; +\; 15 \;=\; 30\; cm \;=\; 0.3\; m$

Electric dipole moment of the system is given by,

$p = q_A \times d \;= q_B \times d$

$= \;2.5 \times 10^{-7} \times 0.3$

$= \;7.5 \times 10^{-8}\; Cm$ along positive z-axis

Therefore, the electric dipole moment of the system is $7.5 \times 10^{-8} C$ m along positive z-axis.

Answer 10:

Electric dipole moment, $p = \;4 \times 10^{-9}\; Cm$

Angle made by p with a uniform electric field, $\theta \;=\; \mathbf{30}°$

Electric field, $E = \;5 \times 10^{4}\; N\; C^{-1}$

Torque acting on the dipole is given by the relation,

$\mathrm{T} = pEsin\theta$

$= 4 \times 10^{-9} \times 5 \times 10^{4} \times \sin 30$

$= 20 \times 10^{-5} \times \frac{1}{2}$

$= 10^{-4} Nm$

Therefore, the magnitude of the torque acting on the dipole is 10^{-4} N m.