RAVI MATHS TUITION & TEST PAPERS , WHATSAPP 8056206308

ELECTRIC CHARGES AND FIELDS DPP 1

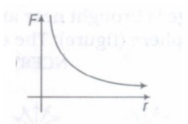
12th Standard

Physics

Time : 01:00:00 Hrs

Total Marks : 50

10 x 1 = 10

1) (d) mass of B increases
2) (c) to keep the body of the carrier in contact with the earth
3) (c) body to be charged must be a conductor
4) (a) 5×10^{19}
5) (d) $C^2N^{-1}m^{-2}$
6) (c) 
7) (c) 1 : 1
8) (b) -Q/ 4
9) (a) shall increase along the positive x-axis
10) (c) 1500 NC^{-1}

5 x 2 = 10

11) Let us assume that the mass of one cup of water is 250 g. The molecular mass of water is 18g. Thus, one mole (= 6.02×10^{23} molecules) of water is 18 g. Therefore the number of molecules in one cup of water is (250/18) x 6.02×10^{23}.
Each molecule of water contains two hydrogen atoms and one oxygen atom, i.e., 10 electrons and 10 protons. Hence the total positive and total negative charge has the same magnitude. It is equal to $(250/18) \times 6.02 \times 10^{23} \times 10 \times 1.6 \times 10^{-19}$ C = 1.34×10^{7} C.

12) (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.

13) When a glass rod is rubbed with a silk cloth, charges appear on both.These charges are equal in magnitude and opposite in sign, so that algebraic sum of the charges produced on both is zero. The net charge on the two bodies was zero even before rubbing them. Thus, we find that charges can be created only in equal and unlike pairs. This is consistent with the law of conservation of charge.

14) (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) The tangent to a line of electric field at any point gives the direction of the electric field at that point. If any two lines of electric field cross each other, then at the intersection point, there would be two tangents and hence two directions for electric field, which is not possible. Hence, the electric field lines do not cross each other

15) As we know that, the number of field lines entering in the cube is the same as that the number of field lines leaving the cube So, no flux is remained on the cube and hence, the net flux over the cube is zero.

5 x 3 = 15

16) In one second 10^9 electrons move out of the body. Therefore the charge given out in one second is $1.6 \times 10^{-19} \times 10^9$ C = 1.6×10^{-10} C. The time required to accumulate a charge of 1 C can then be estimated to be 1 C ÷ (1.6×10^{-10} C/s) = 6.25×10^9 s = 6.25×10^9 ÷ (365 x 24 x 3600) years = 198 years. Thus to collect a charge of one coulomb, from a body from which 10^9 electrons move out every second, we will need approximately 200 years. One coulomb is, therefore, a very large unit for many practical purposes.
It is, however, also important to know what is roughly the number of electrons contained in a piece of one cubic centimetre of a material. A cubic piece of copper of side 1 cm contains about 2.5×10^{24} electrons.

17) Repulsive force of magnitude 6×10^{-3} N
Charge on the first sphere, $q_1 = 2 \times 10^{-7}$ C
Charge on the second sphere, $q_2 = 3 \times 10^{-7}$ 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, ϵ_0 = Permittivity of free space

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2C^{-2}$$

$$F = \frac{9\times10^9\times2\times10^{-7}\times3\times10^{-7}}{(0.3)^2} = 6 \times 10^{-3}N$$

Hence, force between the two small charged spheres is 6×10^{-3} N. The charges are of same nature. Hence, force between them will be repulsive.

18) Distance between the spheres, A and B, r = 0.5 m
Initially, the charge on each sphere, $q = 6.5 \times 10^{-7}$ C
When sphere A is touched with an uncharged sphere C, $\frac{q}{2}$ amount of charge from A will transfer to sphere C. Hence, charge on each of the spheres, A and C, is $\frac{q}{2}$
When sphere C with charge $\frac{q}{2}$ is brought in contact with sphere B with charge q, total charges on the system will divide into two equal halves given as,

$$\frac{\left(\frac{q}{2}\right)+q}{2} = \frac{3q}{4}$$

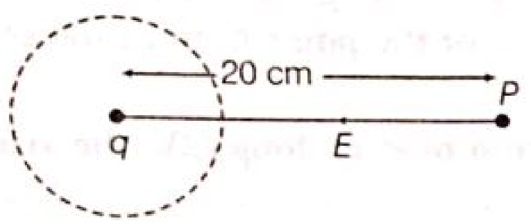
Each sphere will share each half. Hence, charge on each of the spheres, C and B, is $\frac{3q}{4}$
Force of repulsion between sphere A having charge $\frac{q}{2}$ and sphere B having charge

$$\frac{3q}{4} = \frac{\left(\frac{q}{2}\right)\times\frac{3q}{4}}{4\pi\epsilon_0 r^2} = \frac{3q^2}{8\times4\pi\epsilon_9 r^2}$$

$$= 9 \times 10^9 \times \frac{3\times\left(6.5\times10^{-7}\right)^2}{8\times(0.5)^2}$$

= 5.073×10^{-3}N
Therefore, the force of attraction between the two spheres is 5.703×10^{-3} N.

19) Let the value of unknown charge be q.
Electric field at 20 cm away, E = 1.5×10^3 N/C



From the formula, electric field,

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

$$\Rightarrow 1.5 \times 10^3 = \frac{9 \times 10^9 \times q}{\left(20 \times 10^{-2}\right)^2}$$

$$\therefore \quad q=\frac{1.5\times10^{3}\times20\times20\times10^{-4}}{9\times10^{9}}$$
$$=6.67\times10^{-9}\mathrm{C}$$

As the electric field is radially inwards which shows that the nature of unknown charge q is negative

$$\mathrm{E}_i=\lim_{q_0\to0}\frac{\mathrm{F}_i}{q_0}=\lim_{q_0\to0}\left[\frac{1}{q_0}\left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_iq_0}{r_i^2}\hat{\mathrm{r}}_i\right)\right]$$

$$\mathrm{E}_i=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_i}{r_i^2}\hat{\mathrm{r}}_i$$

If E is electric field at point P due to the system of charges, then by principle of superposition of electric fields, E = E_1 + E_2 + E_3 + ... + E_n = $\sum_{i=1}^{n} E_i$

Using Eq. (i), we get $\mathrm{E}=\sum_{i=1}^{n}\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_i}{r_i^2}\hat{\mathbf{r}}_i$

or $\mathrm{E}=\frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_i^2}\hat{\mathbf{r}}_i$

$\therefore$ E is a vector quantity.

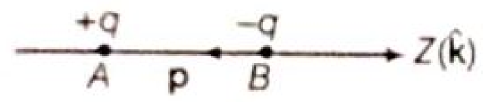
20) Here, E = 9 $\times10^4$ N/C, r = 2 cm = 2 $\times10^{-2}$ m and λ= ?

As, $E=\frac{\lambda}{2\pi\varepsilon_0 r}\Rightarrow\lambda=2\pi\varepsilon_0 rE$

$=\frac{1}{2\times9\times10^{9}}\times2\times10^{-2}\times9\times10^{4}=10^{-7}Cm^{-1}$

3 x 5 = 15

21) Two charges q_A and q_B are located at points A(0, 0, -15 cm) and B(0, 0, 15 cm) on Z-axis. They form an electric dipole.



Total charge, q = q_A + q_B
= 2.5 $\times$ 10^{-7} - 2.5 $\times10^{-7}$
$\Rightarrow$ q = 0
Also, AB = 15 + 15
= 30 cm
or AB = 30 $\times$ 10^{-2} m
Electric dipole moment
p = Either charge $\times$ BA
= 2.5 $\times$ 10^{-7} $\times$ (30 $\times$ 10^{-2}) ($-\hat{k}$)
= -7.5 $\times$ 10^{-8} $\hat{k}$ C-m

22) (i) Here, q_1 = q_2 = 6.5 $\times10^{-7}$ C, r = 50 cm = 0.5 m
Electrostatic force of repulsion,

$$F=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}=\frac{9\times10^{9}\times\left(6.5\times10^{-7}\right)^2}{(0.5)^2}$$
$$=1.521\times10^{-2}\,\mathrm{N}$$

(ii) Now, q_1, q_2 both are doubled and r is halved in
$F=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$, then
F becomes 16 times, i.e. F' = 16 F.
F' = 16 $\times$ 1.521 $\times$ 10^{-2} N or F' = 0.24 N

23) i) Electric flux over an area in an electric field represents the total number of electric field lines crossing the area. The SI unit of electric flux is N - m^2C^{-1}
According to Gauss' law in electrostatics, the surface integral of electrostatic field E produced by any source over any closed surface S enclosing a volume V in vacuum, i.e. total electric flux over the closed surface S in vacuum, is 1/ E_0 times the total charge (q) contained inside S, i.e.

$\phi_E = \oint_S \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$

Gauss' law in electrostatics is true for a closed surface, no matter what its shape or size is.

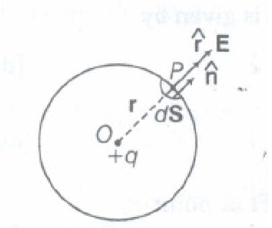
So, in order to justify the above statement, suppose in isolated positive charge q is situated at the centre 0 of a sphere of radius r.

According to Coulomb's law, electric field intensity at any point P on the surface of the sphere is

$\mathbf{E} = \frac{q}{4\pi\varepsilon_0} \cdot \frac{\hat{\mathbf{r}}}{r^2}$

where, $\hat{r}$ is unit vector directed from O to P.

Consider a small area element dS ofthe sphere around P. Let it be represented by the vector dS + $\hat{n}$.d S. where, n is unit vector along out drawn normal to the area element.



$\therefore$ Electric flux over the area element,

$d\phi_E = \mathbf{E} \cdot d\mathbf{S} = \left(\frac{q}{4\pi\varepsilon_0} \cdot \frac{\hat{\mathbf{r}}}{r^2}\right) \cdot (\hat{\mathbf{n}} \cdot d\mathbf{S})$

$\mathrm{E} \cdot d\,\mathrm{S} = \frac{q}{4\pi\varepsilon_0} \cdot \frac{d\,\mathrm{S}}{r^2} \cdot \hat{\mathbf{r}} \cdot \hat{\mathbf{n}}$

As normal to a surface of ever;: point is along the radius vector at that point, therefore $\hat{r}$.$\hat{n}$= 1

$\mathbf{E} \cdot d\mathbf{S} = \frac{q}{4\pi\varepsilon_0} \cdot \frac{d\mathbf{S}}{r^2}$

Integrating over the closed surface area of the sphere, we get total normal electric flux over the entire sphere,

$\phi_E = \oint_S \mathbf{E} \cdot d\mathbf{S} = \frac{q}{4\pi\varepsilon_0 r^2} \oint d\mathbf{S}$

$= \frac{q}{4\pi\varepsilon_0 r^2} \times$ total area of surface of sphere.

$= \frac{q}{4\pi\varepsilon_0 r^2}\left(4\pi r^2\right) = \frac{q}{\varepsilon_0}$

Hence, $\oint_S \mathrm{E} \cdot d\,\mathrm{S} = \frac{q}{\varepsilon_0}$ which proves Gauss' theorem.