DCAM classes

Dynamic Classes for Academic Mastery

Explanations

1. (d) Given, charge, $q = 1\text{ C}$

Number of electrons gained , $n = 5\times10^{18}$

$\therefore$ Total charge gained, $q' = ne = 5\times10^{18}\times1.6\times10^{-19}$

$$= 8\times10^{-1} = 0.80\text{ C}$$

Since, electron is negatively charged, so net charge on the object becomes

$$q_{net} = q - q' = 1 - 0.8 = +0.20\text{ C}$$

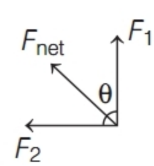
2. (c) The force on charge q_0 due to $-q$ is

$$F_1 = K\frac{(-q)(q_0)}{a^2}, \text{ towards } + Y\text{-axis} \quad \ldots\text{(i)}$$

Force on q_0 due to q is

$$F_2 = K\frac{(q)(q_0)}{a^2}, \text{ towards } - X\text{-axis} \quad \ldots\text{(ii)}$$

So, the resultant or net force on the charge at O is



$$F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

Since, $F_1 = -F_2$

$$\therefore \quad F_{net} = \sqrt{F_2^2 + F_2^2 + 2(-F_2)(F_2)\cos 90^\circ} = \sqrt{2}F_2$$

$$= \frac{\sqrt{2}Kqq_0}{a^2}$$

3. (c) Since X is repelled by Y. So, object Y is positively charged. As object Z is attracted to object Y. So, it must either be neutral or positively charged.

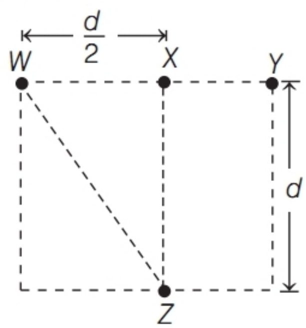
4. (b) Since charge is quantised in a system, so total charge $= q_1 + q_2 + q_3 = +3e + 5e - 3e = +5e$

Among given options, only option (b) gives this value i.e. $+6e + 6e - 7e = +5e$

Therefore, the possible values for the final charge on the spheres are $+6e, +6e, -7e$.

5. (b) The electrostatic force exerted by object W on object X is

$$F = K\frac{q^2}{(d/2)^2} = \frac{4Kq^2}{d^2} \quad \ldots \text{(i)}$$



The distance between W and Z is

$$r = \sqrt{d^2 + \left(\frac{d}{2}\right)^2} = \frac{\sqrt{5}}{2}d$$

So, force exerted by object W on Z is

$$F' = K\frac{q^2}{\left(\frac{\sqrt{5}}{2}d\right)^2} = \frac{4Kq^2}{5d^2} = \frac{F}{5} \quad \text{[using Eq. (i)]}$$

6. (a) Given, $\mathbf{E} = cz^2\,\hat{\mathbf{k}}$

As, electric flux, $\phi = \int_s \mathbf{E} \cdot d\mathbf{s}$

$$= \int_s cz^2\hat{\mathbf{k}}\, dx\, dy\hat{\mathbf{k}}$$

$$= \int_s cz^2 dx\, dy = cz^2\int_0^a dx\int_0^a dy$$

$$= cz^2 \times a^2 = cz^2 \times a^2$$

Here, $z = a$ so, $\phi = ca^4$

7. (c) The electric field due to a point charge $2q$ at a distance r is

$$E = K\frac{(2q)}{r^2} \quad \ldots \text{(i)}$$

The electric field due to a uniformly charged thin sphere shell of charge q and of radius R at distance $\frac{r}{2}$ $(r >> R)$ is

$$E' = K\frac{q}{(r/2)^2} = \frac{4Kq}{r^2} \quad \ldots \text{(ii)}$$

From Eqs. (i) and (ii), we get

$$E' = 2E$$

8. (a) According to the Gauss' law, the net electric flux through any closed Gaussian surface is equal to the net charge enclosed by it divided by permittivity of the medium.

Mathematically, $\phi_E = \oint_s \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$

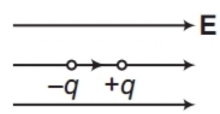
This law is true for any closed surface, no matter what is its shape or size.

9. (c) Torque on dipole in a uniform electric field, $\tau = p \times E\sin\theta$
The direction of torque is perpendicular to the plane of paper and maximum at $\theta = 90°$.

So, torque is maximum if $\mathbf{p}$ is perpendicular to $\mathbf{E}$.

10. (a) Non-uniform electric field causes both rotational and translational motion. So, both torque and net force act on the dipole.

11. (c) For stable equilibrium, the angle θ should be zero.



$$\tau = pE\sin\theta$$
$$= pE\sin\theta$$
$$= 0$$

12. (a) The electric dipole moment is equal to

$$p = 1.6 \times 10^{-19} \times 4.3 \times 10^{-9} \quad [\because p = q \times 2l]$$
$$= 6.88 \times 10^{-28} \text{ C-m}$$

13. (d) The Gauss' law in electrostatic gives a relation between electric flux through any closed hypothetical surface (called a Gaussian surface) and the charge enclosed by the surface.

So, the nature of Gaussian surface is vector.

14. (d) The electric field at any point on S (Gaussian surface) is due to all the charges which put the flux through the S is only charges $-q_1$ and $+q_1$ enclosed by S.

15. (d) Given, $\mathbf{E} = (2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + \hat{\mathbf{k}})\ \text{NC}^{-1}$ and $\mathbf{S} = 10\,\hat{\mathbf{i}}\ \text{m}^2$

We know that,

Electric flux, $\phi = \mathbf{E} \cdot \mathbf{S} = (2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + \hat{\mathbf{k}}) \cdot (10\,\hat{\mathbf{i}})$

$$= 20\ \text{N-m}^2\text{C}^{-1}$$

16. (d) A negative charge in an electric field moves in the direction opposite to the electric field as the force acting on it is in opposite direction to the field. So, A is false and R is also false.

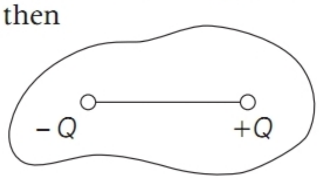
17. (b) Charge is always conserved but energy is lost in the form of heat.

18. (d) Gravitational force is the dominating force in nature. It is the weakest force.

Also, Coulomb's force >> gravitational force.

19. (d) At the centre of the line joining two equal and opposite charge, $E \neq 0$. For similar charge, $E = 0$.

20. (a) If a dipole is enclosed by a surface as shown in figure, then



$$Q_{\text{enclosed}} = 0$$

$$\therefore \quad \phi = 0 \quad \text{(from Gauss's law)}$$

21. (a) Flux, $\phi_{\text{net}} = \dfrac{q_{\text{in}}}{\varepsilon_0}$

If a closed body is placed in an electric field (either uniform on non-uniform), total flux linked with it will be zero.

i.e. $\phi_{\text{net}} = 0 \Rightarrow q_{\text{in}} = 0$

22. (d) With the help of Gauss's theorem, we can find electric flux at any point and it is true that Gauss's theorem can be applied for any symmetric of charge distribution.

23. (i) (b) Charge on one electron, $e = -1.6 \times 10^{-9}$C

Charge on body having 40 electrons

$= 40\,e$

$= 40 \times (-1.6 \times 10^{-19}) - 6.4 \times 10^{-18}$ C

(ii) (c) According to quantisation of charge, charge on every body must be an integral multiple of charge on one electron.

i.e. $q = \pm\, ne$

Here, in option (c),

$$q = 9.6 \times 10^{-20}$$

$$= 6 \times 1.6 \times 10^{-20}\ \text{C}$$

$$= 0.6 \times 1.6 \times 10^{-19}\ \text{C} = 0.6\,e$$

which is not possible.

(iii) (b) A body is negatively charged, it implies that there is negative as well as positive charge in the body but negative charge is more than positive charge.

(iv) (c) Electric lines of forces do not intersect to each other because if they intersect, then at the point of intersection, there are two directions of electric field, which is not possible.

(v) (d) Two unlike charges attract to each other whereas two like charges repel to each other.

24. (i) (c) Inside the metallic conductor, net electric field is zero. Hence, metallic conductors can be used to make a Faraday cage.

(ii) (d) Outer surface of car is made of metal, therefore car behaves like a Faraday cage.

(iii) (b) When a isolated point charge $-q$ is inside the Faraday cage, then due to induction phenomenon, $+q$ charge develops at surface of Faraday cage.

(iv) (a) $q = 1$C

The number of electric field lines passing through cube normally will be equal to electric flux ϕ, which is given as

$$\phi = \frac{q}{\varepsilon_0} = \frac{1}{9 \times 10^{-9}}$$

$$= 1.1 \times 10^{8}\ \text{N-m}^2/\text{C (leaving the surface)}$$

(v) (d) No electric force acts inside the Faraday cage during struct by lightning.