Electric Charges and Field

DPP-07

1. A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then electric field at Q is proportional to

(A) p^{-1} and r^{-2} (B) p and r^{-2}
(C) p^2 and r^{-3} (D) p and r^{-3}

2. The electric field due to an electric dipole at a distance r from its centre in axial position is E. If the dipole is rotated through an angle of 90° about it perpendicular axis, the electric field at the same point will be

(A) E (B) E/4
(C) E/2 (D) 2E

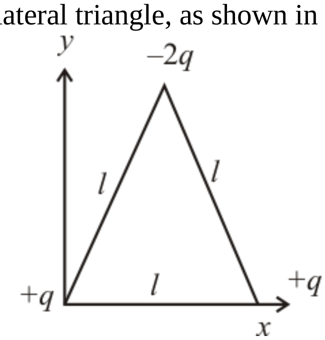
3. A region surrounding a stationary electric dipoles has

(A) Magnetic field only
(B) Electric field only
(C) Both electric and magnetic fields
(D) No electric and magnetic fields

4. A water molecule has an electric dipole moment 6.4×10^{-30} cm when it is in vapour state. The distance in metre between the centre of positive and negative charge of the molecule is

(A) 4×10^{-10} (B) 4×10^{-11}
(C) 4×10^{-12} (D) 4×10^{-13}

5. Determine the electric dipole moment of the system of three charges, placed on the vertices of an equilateral triangle, as shown in the figure.



(A) $-\sqrt{3}ql\hat{j}$ (B) $(ql)\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}$
(C) $2ql\hat{j}$ (D) $\sqrt{3}ql\dfrac{\hat{j}-\hat{i}}{\sqrt{2}}$

6. A given charge is situated at a certain distance from an electric dipole in the end-on position experiences a force F. If the distance c the charge is doubled, the force acting on the charge will be

(A) 2F (B) F/2
(C) F/4 (4)F/8

7. If the magnitude of intensity of electric field at a distance x on axial line and at a distance y on equatorial line on a given dipole are equal, then $x : y$ is

(A) 1 : 1 (B) $1 : \sqrt{2}$
(C) 1 : 2 (D) $\sqrt[3]{2} : 1$

8. Two electric dipoles of moment P and 8P are placed in opposite direction on a line at a distance of 15 cm. The electric field will be zero at point between the dipoles whose distance from the dipole of moment P is

(A) 5 cm (B) $\dfrac{25}{9}$ cm
(C) 10 cm (D) $\dfrac{4}{13}$ cm

9. Two points charge $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of (X, Y) coordinate system. Then:

(A) the electric field E at all points on the X-axis has the same direction.
(B) the electric field at all point on the Y-axis is along $\hat{i}$.
(C) work has to be done in bringing a test charge from infinity to the origin.
(D) the dipole moment is 2qd directed along $\hat{i}$.

10. Three point charge $+q$, $-2q$ and $+q$ are placed at points $(x = 0, y = a, z = 0)$, $(x = 0, y = 0, z = 0)$ and $(x = a, y = 0, z = 0)$, respectively. The magnitude and direction of the electric dipole moment vector of this charge assembly are:

(A) $\sqrt{2}\,qa$ along $+\,y$ direction
(B) $\sqrt{2}\,qa$ along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(C) qa along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(D) $\sqrt{2}\,qa$ along $+\,x$ direction

Answer Key

1. **(D)**
2. **(C)**
3. **(B)**
4. **(B)**
5. **(A)**
6. **(D)**
7. **(D)**
8. **(A)**
9. **(B)**
10. **(B)**

Hints and Solutions

1. **(D)**

$$\vec{E}_{equatorial} = \frac{-K\vec{p}}{r^3}$$

$E \propto p$ and $E \propto r^{-3}$.

2. **(C)**

$$E_{axis} = \frac{2Kp}{r^3}$$

$$E_{equatorial} = \frac{Kp}{r^3} \qquad \Rightarrow E_e = \frac{E_a}{2}.$$

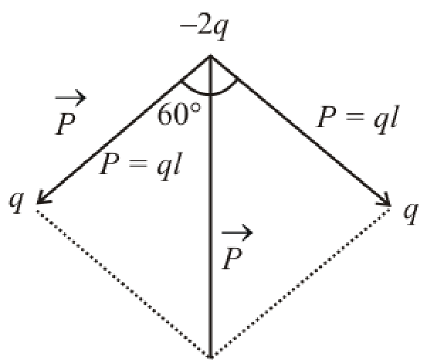
3. **(B)**

Electric dipole creates only electric field because charge is at rest.

4. **(B)**

$$p = q(2a) \Rightarrow (2a) = \frac{p}{q} = \frac{6.64\times10^{-30}}{1.6\times10^{-19}} = 4\times10^{-11}\,m.$$

5. **(A)**



$$\left|\vec{P}\right| = 2P\cos\frac{60°}{2} = 2ql\cos30° = \sqrt{3}ql$$

$\vec{P} = -\sqrt{3}ql\hat{j}$.

6. **(D)**

For on charge $F = q(E_a) = q\times\frac{k.2p}{r^3} \Rightarrow F \propto \frac{1}{r^3}$

Where $r \to 2r$

$F \to \frac{F}{8}$

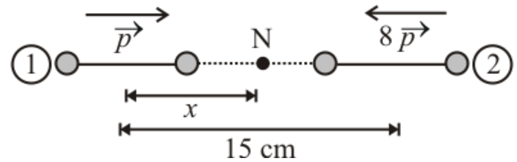
7. **(D)**

$$E_{axial} = E_{equatorial} \Rightarrow k.\frac{2p}{x^3} = \frac{kp}{y^3}$$

$$\Rightarrow \frac{x}{y} = \frac{2^{1/3}}{1} = \sqrt[3]{2}:1$$

8. **(A)**

Suppose neutral point N lies at a distance x from dipole of moment p or at a distance x^2 from dipole of $8p$.



At $N|E.F.$ due to dipole 1$|= E.F.$ due to dipole 2$|$

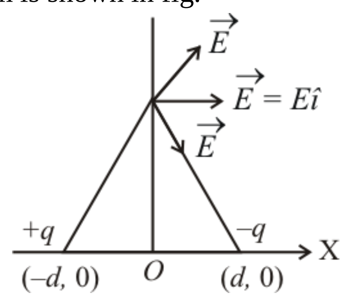
$$\Rightarrow \frac{1}{4\pi\varepsilon_0}.\frac{2p}{x^3} = \frac{1}{4\pi\varepsilon_0}.\frac{2(8p)}{(15-x)^3}$$

$$\Rightarrow \frac{1}{x^3} = \frac{8}{(15-x)^3}$$

$\Rightarrow x = 5$

9. **(B)**

The diagrammatic representation of the given problem is shown in fig.



The electrical field at all points on the X-axis does not have the same direction.

The electrical field at all point on the Y-axis will be parallel to the X-axis (i.e., $\hat{i}$ direction). The electric potential at the origin due to both the charge is zero, hence, no work is done in bringing a test charge from infinity to the origin.

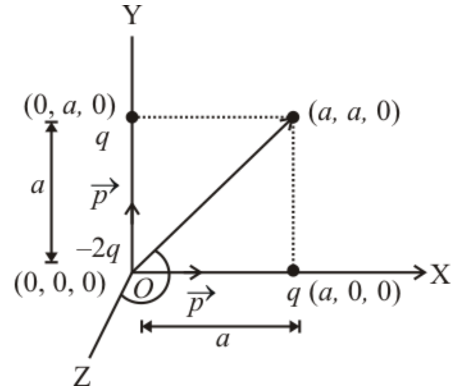
Dipole moment is directed from the $-q$ charge to the $+q$ charge (i.e., $-x$ direction).

10. **(B)**

Electric dipole moment is a vector quantity directed from negative charge to the similar positive charge.

Choose the three coordinates axes as x, y and z and plot the charges with the given coordinates as shown. O is the origin at which $-2q$ charge is placed. The system is equivalent to two dipoles along x and y-directions respectively. The dipole moments of two dipoles are shown in the figure.

The resultant dipole moment will be directed along OP where $P = (a, a, 0)$. The magnitude of resultant dipole moment is



$$P' = \sqrt{P^2 + P^2} = \sqrt{(qa)^2 + (aq)^2} = \sqrt{2}qa$$