DPP – 01

CLASS – 12th

TOPIC – POTENTIAL ENERGY POTENTIAL

Q.1 If 100 joule of work must be done to move electric charge equal to 4 C from a place, where potential is –10 volt to another place, where potential is V volt, find the value of V.

Q.2 (a) Calculate the potential at a point P due to a charge of 4×10^{-7} C located 9 cm away as shown in Fig. 4.17.

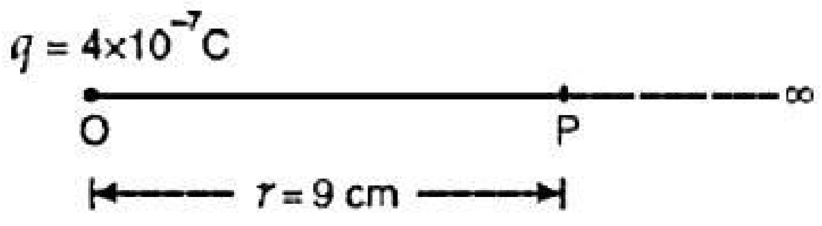

Fig. 4.17

(b) Hence, obtain the work done in bringing a from charge of 2×10^{-9} C from infinity to the point P. Does the answer depend on the path along which the charge is brought?

Q.3 A charge of 20 μC produces an electric field. Two points are 10 cm and 5 cm from this charge. Find the values of potentials at these points and also find the amount of work done to take an electron from one point to the other.

Q.4 At a point due to a point charge, the values of electric field intensity and potential are 32 N C^{-1} and 16J C^{-1} respectively. Calculate magnitude of charge and distance of the charge from the point of observation.

Q.5 Calculate the potential at the centre of a square ABCD of each side $\sqrt{2}$ m due to charges 2, –2, –3 and 6μ C at four corners of it.

Q.6 Two charges 3 x 10^{-8} C and -2×10^{-8} C are located 15 cm apart. At what point on the line joining the two charges is the electrical potential zero? Take the potential at infinity to be zero.

Q.7 Two point charges + 10 μC and -10μC are separated by a distance of 40 cm in air.

(a) Calculate the electrostatic potential energy of the system, assuming the zero of the potential energy to be at infinity.

(b) Draw an equipotential surface of the system.

(c) How much work is required to separate the two charges infinitely away from each other?

Q.8 What is the work done in moving a 2 μC point charge from corner A to corner B of a square ABCDas shown in Fig. 4.34, when a 10 μC charge exists at the centre of the square?

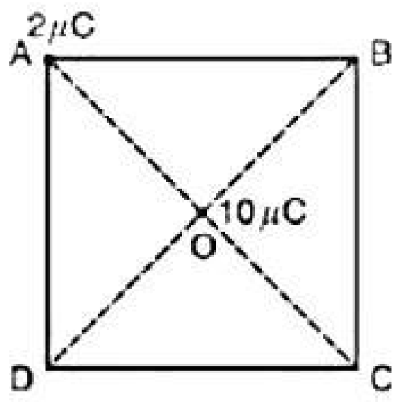

Fig. 4.34

Q.9 A point charge Q is placed at point O as shown in Fig. 4.36.

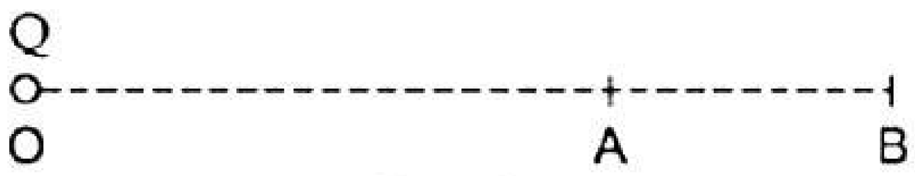

Fig. 4.36

Q.10 Name the physical quantity, whose SI unit is J C^{-1}. Is it scalar or vector?

Q.11 Define electric potential difference between two points. Is it scalar or vector ?

SOLUTION

(PHYSICS) ELECTRIC POTENTIAL & CAPACITANCE

DPP – 01

CLASS – 12th

TOPIC – POTENTIAL ENERGY POTENTIAL

Sol.1 Here, $q_0 = 4$ C; $V_A = -10$ volt; $V_B = V =$ volt;

$W_{AB} = 100$ joule

Now, $V_B - V_A = \frac{W_{AB}}{q_0}$

Or $V - (-10) = \frac{100}{4} = 25$

Or $V = 15$ volt

Sol.2 Here, $q = 4 \times 10^{-7}$ C; r = 9 cm = 0.09 m

(a) Potential at point P due to charge q,

$V_P = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$

$9 \times 10^9 \times \frac{4 \times 10^{-7}}{0.09}$

$= 4 \times 10^4$V

(b) From the definition, the potential at point P equals the work done in bringing a unit positive charge from infinity to point P. Therefore, the work done in bringing a charge of 2×10^{-9} C from infinity to point P,

$W = 2 \times 10^{-9} \times$ potential at point P

$= 2 \times 10^{-9} \times 4 \times 10^4$

$= 8 \times 10^{-5}$ J

The work done in bringing the charge from infinity to point P does not depend on the path along which the charge is brought.

Sol.3 Here, $q = 20\ \mu C = 20 \times 10^{-6}$ C

Let A and B be two points at distances 10 cm and 5 cm from the charge. Thus,

$r_1 = 10$ cm $= 0.1$ m ; $r_2 = 5$ cm $= 0.05$ m

Now, $VA = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_1} = 9 \times 10^9 \times \frac{20 \times 10^{-6}}{0.1}$

$= 1.8 \times 10^6$ V

$\therefore V_B - V_A = 3.6 \times 10^6 - 1.8 \times 106 = 1.8 \times 10^6$ V

Work done to take an electron from A to B,

W_{AB} $(V_B - V_A) \times$ charge on electron

$= 1.8 \times 10^6 \times 1.6 \times 10^{-19}$

$= 2.88 \times 10^{-13}$ J

Sol.4 Let the observation point be at a distance r from the given point charge q. Since at the observation point, the electric field is 32 N C $^{-1}$,

$$\frac{1}{4\pi\ \varepsilon_0} \cdot \frac{q}{r^2} = 32 \qquad \text{.................(i)}$$

Also, as the electric potential at the observation point is 16 J C^{-1},

$$\frac{1}{4\pi\ \varepsilon_0} \cdot \frac{q}{r} = 16 \qquad \text{... ....(ii)}$$

Dividing the equation (ii) by (i), we have

$$q = \frac{16 \times 0.5}{9 \times 10^9} = 8.89 \times 10^{-10}\text{ C}$$

In the equation (ii), substituting for r, we have

$$\frac{1}{4\pi\ \varepsilon_0} \cdot \frac{q}{0.5} = 16$$

Or $9 \times 10^9 \times \frac{q}{0.5} = 16$

Or $q = \frac{16 \times 0.5}{9 \times 10^9} = 8.89 \times 10^{-10}$ C

Sol.5 Four charges q1, q2, q3 and q4 are placed at the four corners of the square ABCD as shown in Fig. 4.18.

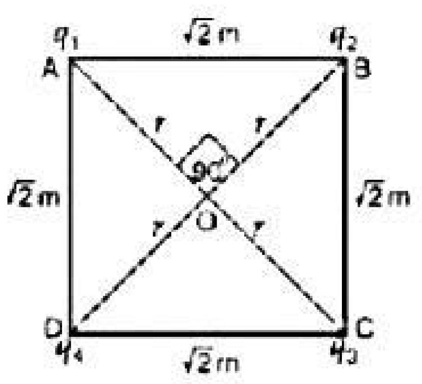

Fig. 4.18

Here, $q_1 = 2\mu C = 2 \times 10^{-6} C$;

$q_2 = -2\mu C = -2 \times 10^{-6} C$;

$q_3 = -3\mu C = -3 \times 10^{-6} C$;

$q_4 = 6\mu C = 6 \times 10^{-6} C$;

and AB = BC = CD = AD = $\sqrt{2}$ m

Let r be the distance of each charge from the centre O of the square.

Then, $\sqrt{r^2 + r^2} = \sqrt{2}$

Or = 1 m

Potential at point O due to charges at the four corners,

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r} + \frac{q_2}{r} + \frac{q_3}{r} + \frac{q_4}{r}\right)$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{r} \quad q_1 + q_2 + q_3 + q_4$$

$$= \frac{9 \times 10^9}{1} \quad 2 \times 10^{-6} + \quad -2 \times 10^{-6} \quad + \quad -3 \times 10^{-6} \quad + 6 \times 10^{-6}$$

$= 2.7 \times 10^4$ V

Sol.6 Here, $q_A = 3 \times 10^{-8}$ C; $q_B = -2 \times 10^{-8}$ C;

r = 15 cm = 0.15 m

Let O be the point, where the electric potential is zero due to the two charges as shown in Fig. 4.19.

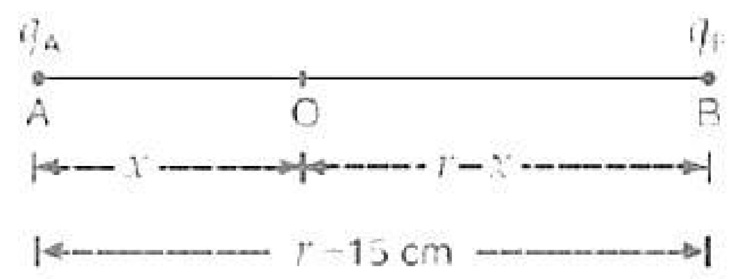

Fig. 4.19

Suppose that the distance AO = x. Then,

BO = r – x = 0.15 – x

Electric potential at point O due to q_A

$$V_A = \frac{1}{4\pi\ \varepsilon_0}\frac{q_A}{AO}$$

$$= 9\times10^9 \times \frac{3\times10^{-8}}{0.15x} = \frac{270}{x}$$

Electric potential at point O due to q_B

$$V_B = \frac{1}{4\pi\ \varepsilon_0}\frac{q_B}{BO}$$

$$= 9\times10^9 \times \frac{-2\times10^{-8}}{0.15x} = \frac{180}{0.15-x}$$

Since the electric potential at point O is zero, we have

or $$\frac{270}{x} + \left(-\frac{180}{0.15-x}\right) = 0$$

or $$\frac{270}{x} = \frac{180}{0.15-x}$$

or x = 0.09 m = 9 cm (from charge of 3×10^{-8} C)

Sol.7 Here, $q_1 = 10\ \mu C = 10 \times 10^{-6}$ C;

$q_2 = -10\mu C = -10 \times 10^{-6}$ C; r_{12} = 40 cm = 0.4m

(a) Electrostatic potential energy of the system of two charges,

$$U = \frac{1}{4\pi\ \varepsilon_0}.\frac{q_1 q_2}{r_{12}}$$

$$= 9\times10^9 \times \frac{10\times10^{-6} \times -10\times10^{-6}}{0.4}$$

= –2.25 J

(b) For equipotential surface, refer to Fig. 4.13.

(c) When the two charges are separated infinitely away ($r_{12} = \infty$) from each other, the electrostatic potential energy of the system becomes zero. Therefore, work required to separate the two charges infinitely away from each other,

W = final P.E. - initial P.E.

=0-(-2·25) = 2.25 J

Sol.8 The points A and B are at the same distance from 10 μC charge. Since $V_A = V_B$, no work will be done in moving a 2 μC charge from point A to B.

Sol.9 (i) Positive (ii) Negative

Sol.10 Electric potential difference. It is a scalar quantity.

Sol.11 Refer to section 4.03.