DPP – 03

CLASS – 12th

TOPIC –Relation between E & V

Q.1 What is the work done in moving a 2 μC point charge from corner A to corner B of a square ABCD as shown in Fig. 4.34, when a 10 μC charge exists at the centre of the square?

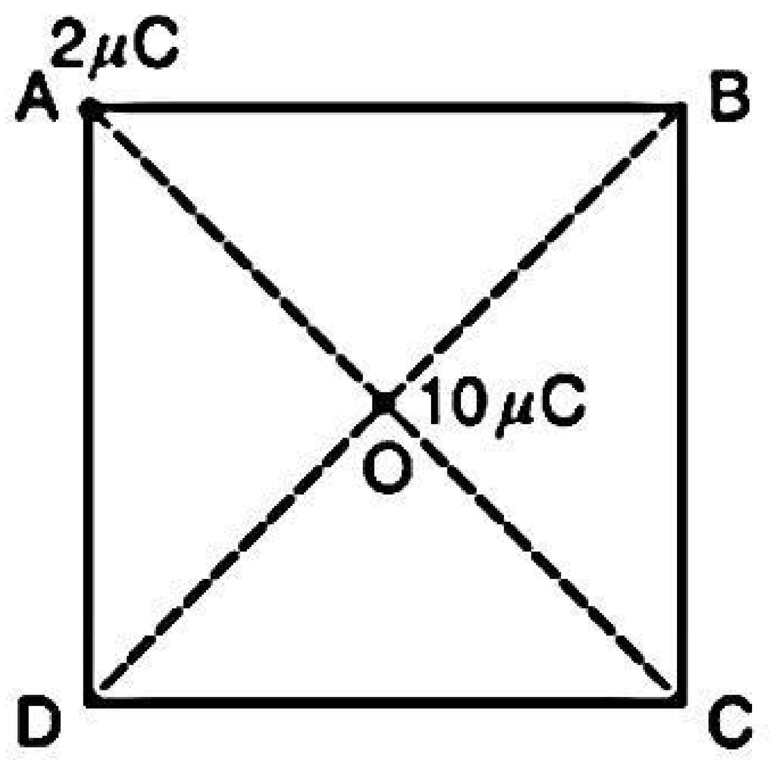

Fig. 4.34

Q.2 Define the unit of electric potential.

Q.3 A charge of 2 C moves between two plates maintained at a potential difference of 1 volt. What is the energy acquired by the charge?

Q.4 How is electric field at a point related to potential gradient ?

Q.5 Potential difference between two given points, 5 cm apart, is 20 V. What is the value of electric field ?

Q.6 How much work is done in moving a 500 μC charge between two points on an equipotential surface?

Or

No work is done in moving a test charge over an equipotential surface. Explain, why.

Q.7 What is the direction of electric field w.r.t. an equipotential surface ?

Q.8 The electric field inside a parallel plate capacitor is E as shown in Fig 4.38.

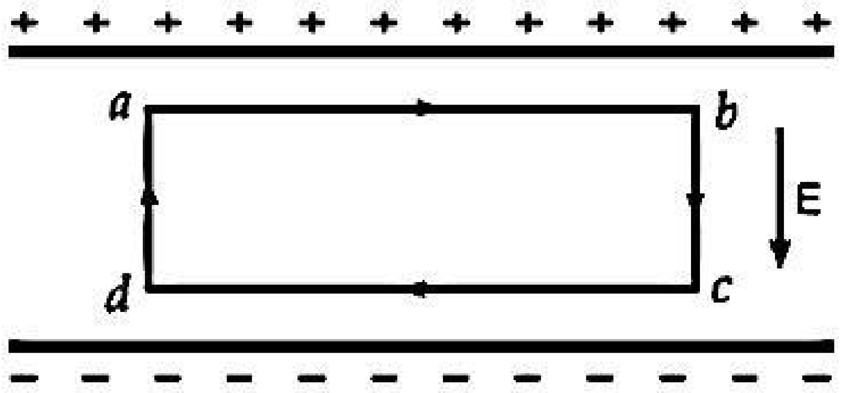

Fig. 4.38

Find the amount of work done in moving a charge q over a closed loop abcda.

Q.9 Fig. 4.39 (a) and 4.39 (b) show the field lines of a single positive and negative charge respetively:

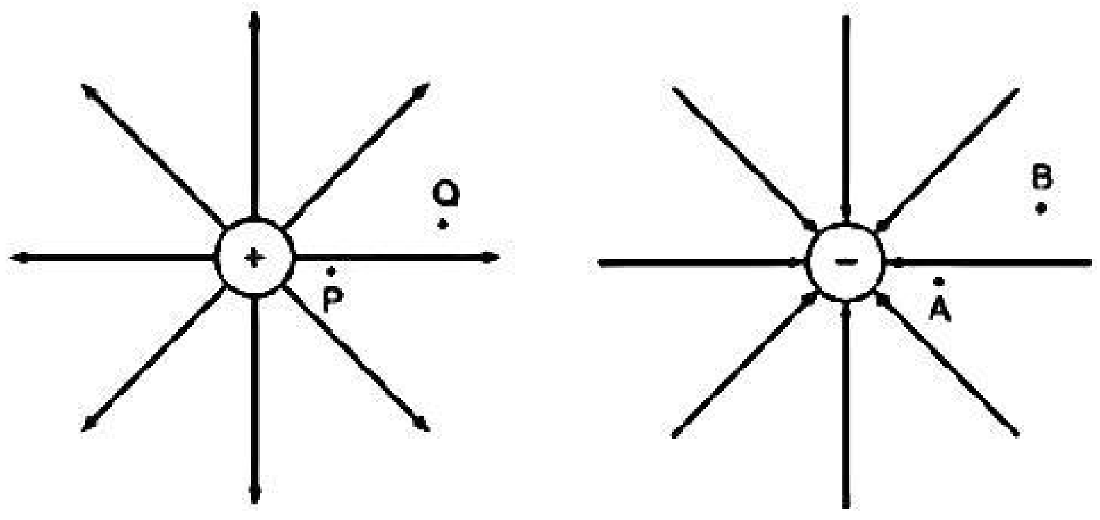

Fig. 4.39 (a) Fig. 4.39 (b)

(i) Give the sign of the potential difference $V_P - V_Q$ and $V_B - V_A$

(ii) Give the sign of the potential energy difference of a small negative charge between the points Q and P;A and B.

(iii) Give the sign of the work done by the field in moving a small positive charge from point Q to P.

(iv) Give the sign of the work done by an external agency in moving a small negative charge from point B to A.

(v) Does the kinetic energy of a small negative charge increase or decrease in going from point B to A?

Q.10 A test charge q is moved without acceleration from A to C along the path from the point A to B and then from B to C in electric field as shown in Fig 4.42.

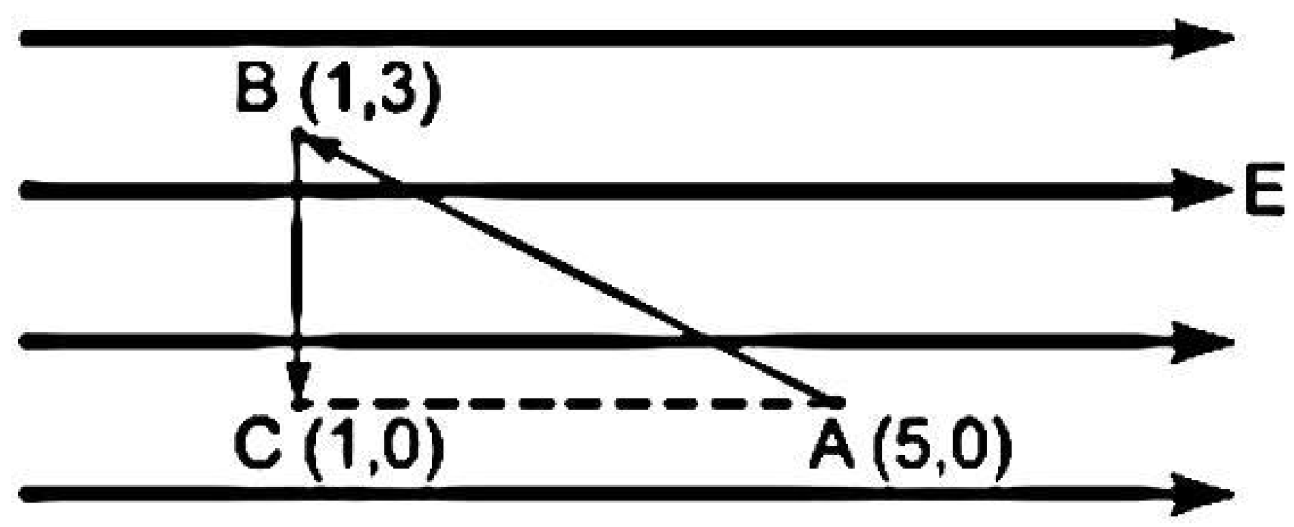

Fig. 4.42

(i) Calculate the potential difference between A and C.

(ii) At which point (of the two) is the electric r potential more and why?

Q.11 What is an equipotential surface ? Show that the electric field is always directed perpendicular to an equipotential surface.

Q.12 What is an equipotential surface ? Draw an equipotential surface for a point charge $(Q > 0)$.

SOLUTION

(PHYSICS) **Electric Potential & Capacitance**

DPP – 03

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TOPIC – Relation between E & V

Sol.1 The points A and B are at the same distance from 10 μ C charge. Since $V_A = V_B$, no work will be done in moving a 2 μ C charge from point A to B.

Sol.2 Refer to section 4.03.

Sol.3 Energy gained by charge,

W= V. q = 1 × 2 = 2J

Sol.4 Electric field at any point is equal to the negative of potential gradient at that point i.e.

$$E = -\frac{dv}{dr}$$

Sol.5 Here, dV = 20 V ; dr = 5 cm = 0.05m

Now, $E = -\frac{dv}{dr}$

$$= -\frac{20}{0.05} = -400 V\, m^{-1}$$

The negative sign indicates that the direction of electric field is always in the direction of decrease of electric potential.

Sol.6 As the two points on an equipotential surface are at the same potential, no work is done in moving a charge between two points.

Sol.7 It is along the normal to the equipotential surface.

Sol.8 The direction of electric field $\vec{E}$ is from positive plate of the capacitor to its negative plate.

Therefore, force on the charge *q*,

$$\vec{F} = q\vec{E}$$

Therefore, the amount of work done in a moving a charge *q* over a closed loop abcda,

$W = W_{ab} + W_{bc} + W_{cd} + W_{da}$

$= q\vec{E}.\overrightarrow{ab} + q\vec{E}.\overrightarrow{bc} + q\vec{E}.\overrightarrow{cd} + q\vec{E}.\overrightarrow{da}$

= q E ab cos90° + q E bc cos 0° + q E cd cos90° + q E da cos 180°

= 0 + q E bc + 0 – q E da

= 0

Sol.9 In Fig. 439 (a), as the field is due to positive charge,

$V_p - V_Q > 0$.

In Fig. 4.39 (b), as the field is due to negative charge,

$V_A - V_B < 0$

Or $V_B - V_A > 0$.

(ii) The potential energy of a negative charge at point Q will be negative and at point P, it will be still more negative. Therefore,

$$(P.E.)Q - (P.E.)_P > 0$$

For similar reasons,

$$(P.E.)_A - (P.E.)_B > 0$$

(iii) A small positive charge will tend to move from point P to Q and the work done by the field in moving the charge from point P to Q will be positive. Therefore, work done by electric field in moving a small positive charge from point Q to P will be negative.

(iv) For the reasons as given in (iii), work done by external agency in moving a small negative charge from B to A will be positive.

(v) As the potential energy of the negative charge oks.in eases, kinetic energy of the negative charge decreases in going from point B to A.

Sol.10 (i) The work done in moving a test charge between two points in an electric field depends only on the initial and final positions of the charge. Let dV be the potential difference between A and C. If AC = dr, then

$$dV = E\,dr \qquad \text{(in magnitude)}$$

Here, $dr = 5 - 1 = 4$ units

$$dV = E \times 4 = 4E$$

(ii) The potential at C is greater than that at A i.e. $V_C > V_A$. It is because, the direction of electric field is in the direction of decrease of potential difference.

Sol.11 Let $\vec{E}$ be electric field at a point on equipotential surface. Then, small work done in moving a test charge $q0$ through a small displacement $\overrightarrow{dr}$ along the surface,

$$dW = \vec{F}.\overrightarrow{dr} = (-q_0\vec{F}).\overrightarrow{dr}$$

Since work done in moving a test charge along an equipotential surface is always zero,

$$(-q_0\vec{E}).\overrightarrow{dr} = 0$$

Or

$$\vec{E}.\overrightarrow{dr} = 0$$

Hence, electric field is directed perpendicular to the surface.

Sol.12 Any surface, which has same electrostatic potential at every point, is called an equipotential surface.

For a point charge, equipotential surface is a spherical shell with the charge lying at the centre of the shell.

For a point charge Q > 0, the equipotential surface is as shown in Fig. 4.11.