Two point charges (+10.0 μC and -10.0 μC) are located 8.00 cm apart.

a) Find the electric potential energy when a point charge of -4.2 μC is placed at point A.

\[ U_A = \frac{k q_1 q_2}{r_{12}} \]

\[ U_A = k \left( \frac{q_1 q_2}{r_{1A}} + \frac{q_1 q_2}{r_{2A}} + \frac{q_1 q_2}{r_{12}} \right) \]

\[ U_A = 8.99 \times 10^9 \left( \frac{(-4.2 \times 10^{-6})(10 \times 10^{-6})}{0.4} + \frac{(-4.2 \times 10^{-6})(-10 \times 10^{-6})}{0.85} + \frac{(10 \times 10^{-6})(-10 \times 10^{-6})}{0.75} \right) \]

\[ U_A = -1.70 \text{ J} \]

b) Find the electric potential energy when a point charge of -4.2 μC is placed at point B.

\[ U_B = \frac{k q_1 q_2}{r_{12}} \]

\[ U_B = k \left( \frac{q_1 q_2}{r_{1B}} + \frac{q_1 q_2}{r_{2B}} + \frac{q_1 q_2}{r_{12}} \right) \]

\[ U_B = 8.99 \times 10^9 \left( \frac{(-4.2 \times 10^{-6})(10 \times 10^{-6})}{1.1} + \frac{(-4.2 \times 10^{-6})(-10 \times 10^{-6})}{0.35} + \frac{(10 \times 10^{-6})(-10 \times 10^{-6})}{0.75} \right) \]

\[ U_B = -4.63 \times 10^{-1} \text{ J} = -0.463 \text{ J} \]

c) What is the change in electric potential energy when the -4.2 μC point charge is moved from A to B? Does it increase or decrease? Why?

\[ \Delta U_{A \rightarrow B} = U_B - U_A = -0.463 \text{ J} - (-1.70 \text{ J}) = 1.24 \text{ J} \]

The potential energy increases since the -4.2 μC charge moves closer to another negative charge and farther from the positive charge.

d) How much work is done by the electric force in moving the charge from A to B? Is it positive or negative? Explain.

\[ \Delta U_{A \rightarrow B} = -W_{A \rightarrow B} = 1.24 \text{ J} \]

The work done by the electric force is negative because work must be done AGAINST the electric force to move the charge to a higher potential energy. This is like gravity doing negative work on you as you climb the stairs.
e) What is the electric potential at point A?

\[ V_A = \frac{kQ}{r_A} \]

\[ V_A = \frac{8.99 \times 10^9}{0.4} \left( \frac{10 \times 10^{-6}}{0.4} + \frac{-10 \times 10^{-6}}{0.85} \right) \]

\[ V_A = 1.19 \times 10^5 \text{ V} = 119 \text{ kV} \]

f) What is the electric potential at point B?

\[ V_B = \frac{kQ}{r_B} \]

\[ V_B = \frac{8.99 \times 10^9}{1.1} \left( \frac{10 \times 10^{-6}}{1.1} + \frac{-10 \times 10^{-6}}{0.35} \right) \]

\[ V_B = -1.75 \times 10^5 \text{ V} = -175 \text{ kV} \]

g) What is the change in electric potential if you were to move a test charge from A to B? Does it increase or decrease? Why?

\[ \Delta V_{A \rightarrow B} = V_B - V_A = -175 \text{ kV} - 119 \text{ kV} = -294 \text{ kV} \]

The potential decreases since the + test charge moves closer to a negative charge and farther from the positive charge.