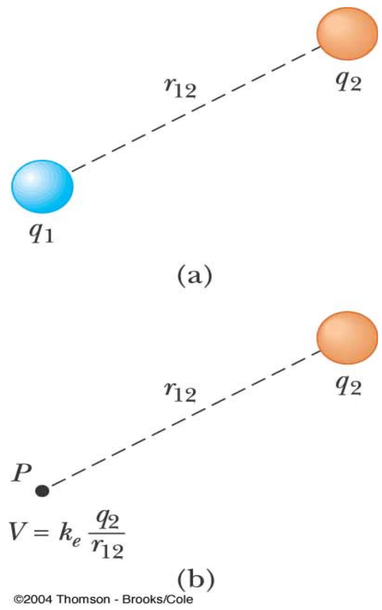
25.3 Electric Potential and electric energy due to a point charge:

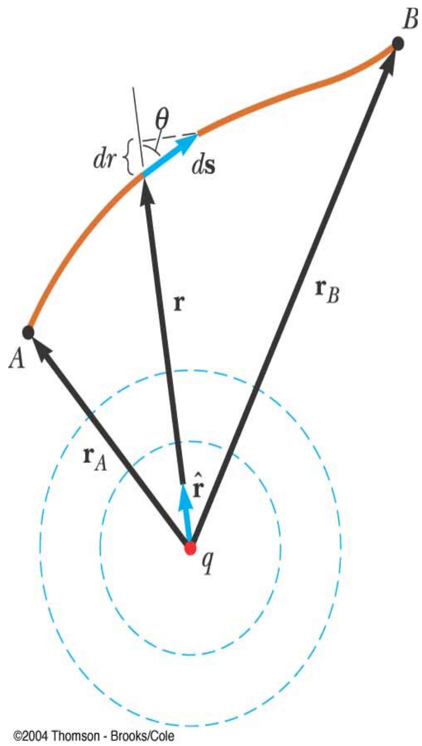
The electric potential created by a point charge at any distance r is given by:

$$V = K\frac{q}{r}$$



For a group of point charges, we can write the potential energy as follows:

$$V = k\frac{q_1}{r_1} + k\frac{q_2}{r_2} + \ldots = K\sum\frac{q_n}{r_n}$$



$$V_{AB} = V_B - V_A = -\int_A^B Edl\cos_\theta = -k\int_{r_A}^{r_A}\frac{q}{r^2}dr\cos_\theta = kq[\frac{1}{r_B} - \frac{1}{r_A}]$$

Potential energy is also given by:

$$U = K\frac{q_1\, q_2}{r_{12}}$$

Or, $$U = K\left[\frac{q_1\, q_2}{r_{12}} + \frac{q_1\, q_3}{r_{13}} + \frac{q_2\, q_3}{r_{23}} + \cdots\right]$$

EXAMPLE 25.3 The Electric Potential Due to Two Point Charges

A charge $q_1 = 2.00\ \mu C$ is located at the origin, and a charge $q_2 = -6.00\ \mu C$ is located at (0, 3.00) m, as shown in Figure 25.11a. (a) Find the total electric potential due to these charges at the point *P*, whose coordinates are (4.00, 0) m.

Solution For two charges, the sum in Equation 25.12 gives

$$V_P = k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$$

$$= 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\left(\frac{2.00 \times 10^{-6}\text{ C}}{4.00\text{ m}} + \frac{-6.00 \times 10^{-6}\text{ C}}{5.00\text{ m}}\right)$$

$$= -6.29 \times 10^3\text{ V}$$

(b) Find the change in potential energy of a 3.00-μC charge as it moves from infinity to point *P* (Fig. 25.11b).

Solution When the charge is at infinity, $U_i = 0$, and when the charge is at *P*, $U_f = q_3V_P$; therefore,

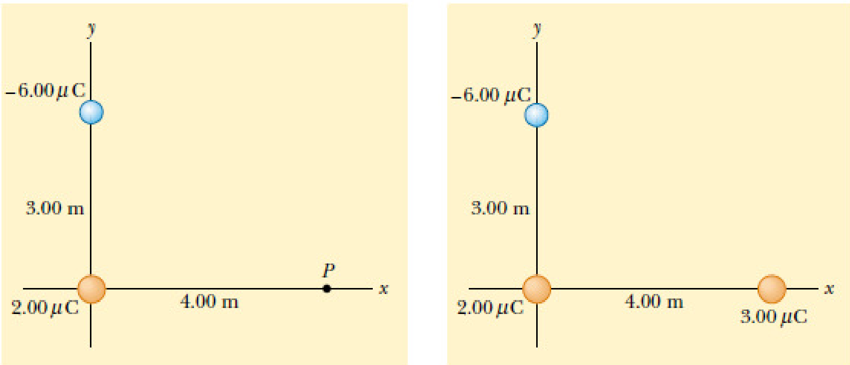
$$\Delta U = q_3V_P - 0 = (3.00 \times 10^{-6}\text{ C})(-6.29 \times 10^3\text{ V})$$

$$= -18.9 \times 10^{-3}\text{ J}$$

Therefore, because $W = -\Delta U$, positive work would have to be done by an external agent to remove the charge from point *P* back to infinity.

Exercise Find the total potential energy of the system illustrated in Figure 25.11b.

Answer -5.48×10^{-2} J.



(a) (b)