Answer on Question 57903, Physics, Electromagnetism

Question:

Ten electrons have been removed from each atom to form ions. Find the electrostatic force between two such ions when separated by a distance of 4 angstrom in a medium of dielectric constant 4.

Solution:

We can find the electrostatic force between two such ions from the Coulomb's law:

$$F_e = \frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2},$$

here, $q_1 = q_2 = 10 \cdot 1.6 \cdot 10^{-19}\ C = 16 \cdot 10^{-19}\ C$ is the charges of two ions, r is the distance between two ions, ε is the permittivity of the medium in which the charges of ions are located.

The permittivity ε of the medium is related to the dielectric constant K of the medium by:

$$\varepsilon = K\varepsilon_0,$$

here, ε_0 is the permittivity of the vacuum.

Substituting ε into the first formula we get:

$$F_e = \frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2} = \frac{1}{4\pi K\varepsilon_0}\frac{q_1 q_2}{r^2} = \frac{k}{K}\frac{q_1 q_2}{r^2},$$

here, $k = \frac{1}{4\pi\varepsilon_0} = 9 \cdot 10^9\ \frac{N \cdot m^2}{C^2}$ is the Coulomb's constant.

Finally, we can substitute known variables into the previous formula and find the electrostatic force between two such ions:

$$F_e = \frac{k}{K}\frac{q_1 q_2}{r^2} = \frac{9 \cdot 10^9\ \frac{N \cdot m^2}{C^2} \cdot 16 \cdot 10^{-19}\ C \cdot 16 \cdot 10^{-19}\ C}{4 \cdot (4 \cdot 10^{-10}\ m)^2} = 3.6 \cdot 10^{-8}\ N.$$

Answer:

$F_e = 3.6 \cdot 10^{-8}\ N.$