Part K Problems

1. What is the electric force on an up quark in a proton due to the other up quark, assuming their separation is 1.0×10^{-15} m?

2. What is the electric force of attraction between a Ca^{++} ion in $CaCl_2$, and one of the two chloride ions (Cl^-), assuming their separation is one angstrom?

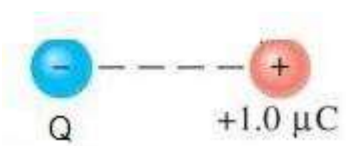
3. Suppose the electric force between two charges is 640 pico-newtons. What would be the new force if the separation between the charges is quadrupled?

4. Two protons are placed at two opposite vertices of a square, and two electrons are placed at the other two vertices. The side length of the square is 5.0×10^{-11} m. At the center of the square is a third proton. What is the net force on the center proton?

5. What would have to be the separation in meters between two objects, each having the same charge, 6×10^{-5} C, in order that the repulsive force each exerts on the other be 7.2 N?

6. An object having a charge $q_1 = 3$ C is on the x-axis. A second object having a charge $q_2 = 4$ C is also on the x-axis, 7 meters to the right of q_1. How far to the right of q_1 may a charge q_o be placed without it experiencing a net electric force?

7. The charge of the object on the right below is 1 μC; separation between this charge and the unknown charge Q is 3.0 cm. The electric force 1 μC charge exerts on the unknown charge Q is 12.0 newtons. What is the magnitude of the charge Q (in μC)?



8. What would have to be the charge of each of two identical charges separated by 1.8 m in order that the repulsive force each exerts on the other be 8.0 N?

9. What must be separation between two one-coulomb charges in order that the force that one exerts on the other is one newton?

10. An 8-C charge is at the left end of line segment 4 m long. At the right end of the line segment is a -7 C charge. How far from the right end may another electric charge be placed without experiencing a net electric force?

11. The force between two charged objects is 100 N. What would be the new force between the objects if the charge on one object were quadrupled, the charge on the other

reduced to one-half, and the separation between the objects reduced to one-third of its previous value?

12. Three protons are at three of the vertices of a square of 2-angstrom side-lengths. What is the net force on the proton that is equidistant from the other two?

Solutions

1. $Q = (2/3)\ e$

$= (2/3)\ (1.6 \times 10^{-19})\ C$

$r = 1.0 \times 10^{-15}\ m$

$F = kQ^2/r^2$

$= 9 \times 10^9\ [(2/3) \times 1.6 \times 10^{-19}]^2 / (1.0 \times 10^{-15})^2$

$= 102\ N$

2. Calcium Ion: $Q_1 = 2\ e$

$= 2\ (1.6 \times 10^{-19})\ C$

Chloride Ion: $Q_2 = e$

$= 1.6 \times 10^{-19}\ C$

$F = kQ_1Q_2/r^2$

$= 9x10^9\ (2)(1.6 \times 10^{-19})\ (1.6 \times 10^{-19}) /(1.0 \times 10^{-10})^2$

$= 4.6 \times 10^{-8}\ N$

3. $F_{old} = k\ Q_1Q_2/r_{old}^2$

$= 640\ pN$

$r_{new} = 4r_{old}$

$F_{new} = k\ Q_1Q_2/r_{new}^2$

$= k\ Q_1Q_2/(4x_{old})^2$

$= (1/16)\ kQ_1Q_2/(16\ r_{old}^2)$

$= (1/16)\ kQ_1Q_2/\ r_{old}^2$

$= (1/16)\ F_{old}$

$= (1/16)\ 640$

$= 40\ pN$

Faster: separation is quadrupled, so denominator increases to a value sixteen times as great, so the new force is one-sixteen times the old one.

4. Pushes by the opposite vertex protons cancel; pulls by the opposite vertex electrons cancel.

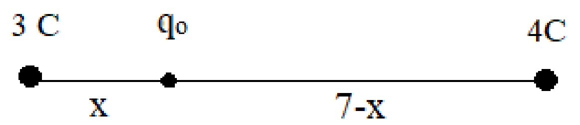
Net force = 0.

5. $F = kQ_1Q_2/r^2$

$7.2 = 9x10^9(6x10^{-5})^2/r^2$

$r = 2.12\ m$

6.



Assume q_o is positive: the two pushes on it by the two positive charges must cancel. If q_o is negative, then the two *pulls* on it by the two charges also must cancel. Either way, the relevant equation is:

$k(3)q_o/x^2 = k(4)q_o/(7-x)^2$

Cancel the kq_o:
$3/x^2 = 4/(7-x)^2$
Multiply by $x^2\,(7-x)^2$:

$3(7-x)^2 = 4x^2$
$x = 3.25$ m

7. $9\text{x}10^9\,Q(1\text{x}10^{-6})\,/0.03^2 = 12$
$Q = 1.2 \text{ x } 10^{-6}$
$= 1.2\ \mu C$

1.0 micro-coulombs (μC) = $1.0 \text{ x } 10^{-6}$ C

8. $F = kQ_1Q_2/r^2$
$8 = 9\text{x}10^9\,(Q)(Q)/1.8^2$
$Q = 5.37 \text{ x } 10^{-5}$ C

9. $Q_1 = 1.0$ C
$Q_2 = 1.0$ C
$F = 1.0$ N

$F = kQ_1Q_2/r^2$

$1.0 = 9 \text{ x } 10^{-9}\,(1.0)^2/r^2$
$r = 9.49 \text{ x } 10^4$ m

10.

Assume q_o is positive. The pull by -7 C must equal the push by 8 C:

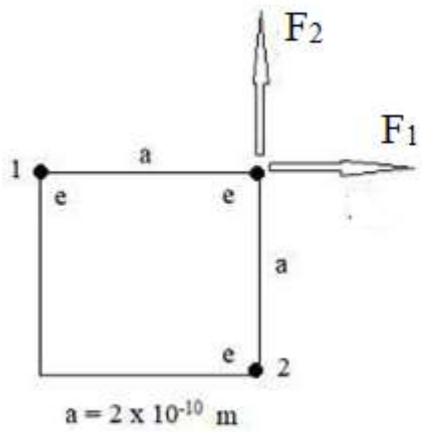
$k(7)q_o/x^2 = k(8)q_o/(x+4)^2$
Cancel kq_o:
$7/x^2 = 8/(x+4)^2$
Multiply by $x^2\,(x+4)^2$:
$7(x+4)^2 = 8x^2$
$x = 57.9$ m
Note: q_o cannot be between the two charges or the two forces on it would each point to the right.

11. Quadrupling one charge changes the force to 400 N.

Halving the other charge, reduces the force to 200 N.

Reducing the separation to one-third makes the denominator $(1/3)^2$, or one ninth, of its previous value, which makes the ratio nine times its previous value:

New force is
9(200) = 1800 N

12.  $F_1 = ke^2/a^2$ $F_2 = ke^2/a^2$ $= F_1$ $= ke^2/a^2$ $F = (F_1^2 + F_2^2)^{1/2}$ $= (F_1^2 + F_1^2)^{1/2}$ $= \sqrt{2}\, F_1$ $= \sqrt{2}\, ke^2/a^2$ $= 8.15 \times 10^{-9}$ N = 8.15 nN	