Unit 7: Periodicity (Electrostatics)

Coulomb's Law

This worksheet will cover Coulomb's Law, highlighting how to calculate the distance, force, or attraction between two atoms based on their charge and size. The basic laws of physics state that opposite charges attract and like charges repel. We can calculate the force of attraction and repulsion with Coulomb's law. **Coulomb's law** states:

"*Like charges repel; opposite charges attract. The force is proportional to the magnitude of the charges and inversely proportional to the square of the distance between them.*"

"Coulomb's Law Review: AP® Chemistry Crash Course." Albert Resources, 1 Mar. 2022, www.albert.io/blog/coulombs-law-review-ap-chemistry-crash-course/.

In simple terms, the **higher** the charge of a particle the **greater** the force they exert on one another, and the **greater** the distance, the **less** force the particles exert on one another.

Coulomb's Law Equation:

$$F = k\frac{q_1 q_2}{r^2}$$

F = Electrostatic force in **Newtons**

k = **Coulomb's constant** (approximately $9 * 10^9$ $N*m^2/C^2$)

$\mathbf{q_1}$ and $\mathbf{q_2}$ = The magnitude of the charges in **Coulombs** (the charge will be negative if the charge is negative). Charges will often be in micro coulombs. 1 micro coulomb (μC) is $1*10^{-6}$ coulombs.

r = Distance between the charges in **meters**.

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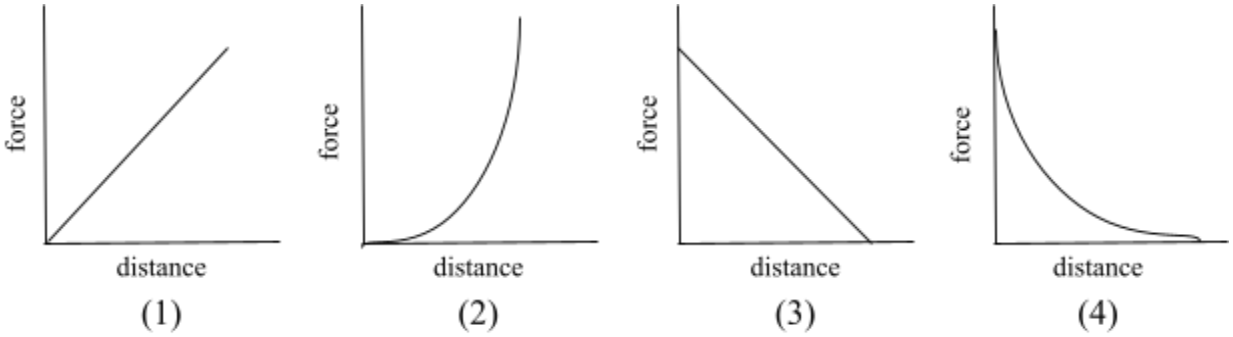
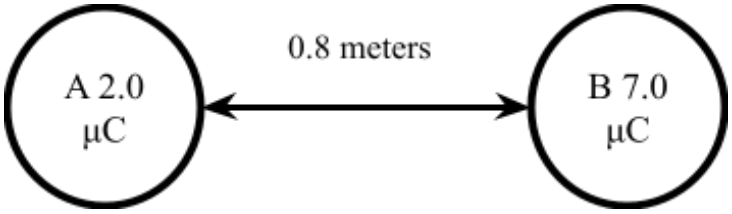
1. Circle the graph that correctly depicts the relationship between distance and the magnitude of the electrostatic force between 2 charged particles.



2. Two metal spheres A and B possess charges of 2.0 microcoulombs and 7.0 micro coulombs respectively. Spheres A and B are 0.8 meters apart.



   a. Will sphere B attract or repel sphere A? Explain.

   b. Calculate the force Sphere B exerts on Sphere A. Round your answer to the nearest hundredth.

3. Two charged Particles C and D possess charges of -19 nanocoulombs and 4.0 microcoulombs respectively. Particles C and D are 0.03 meters apart.

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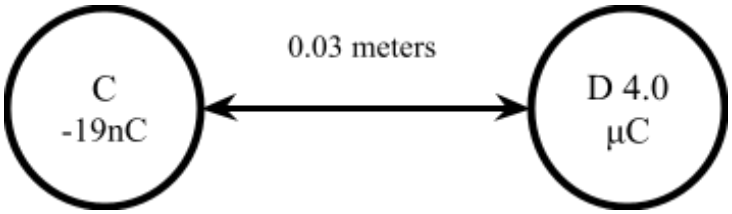
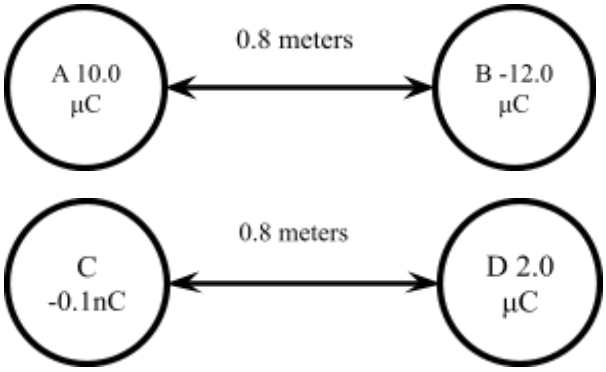


a. Will Particle C attract or repel Particle D? Explain.

b. Calculate the force Particle C exerts on Particle D. Round your answer to the nearest hundredth.

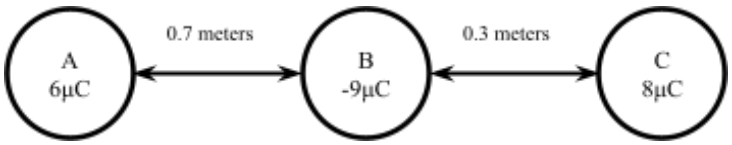
4. Without using Coulomb's equation, determine which pair of charged particles will have a greater attractive force. (Figures not drawn to scale)



Unit 7: Periodicity (Electrostatics)

Challenge Question:

Three charged particles A, B, and C possess charges of 6 microcoulombs, -9 microcoulombs and 8 microcoulombs respectively. The distances between the particles are shown below. Calculate the total force exerted on Particle C. Round your answer to the nearest thousandth.



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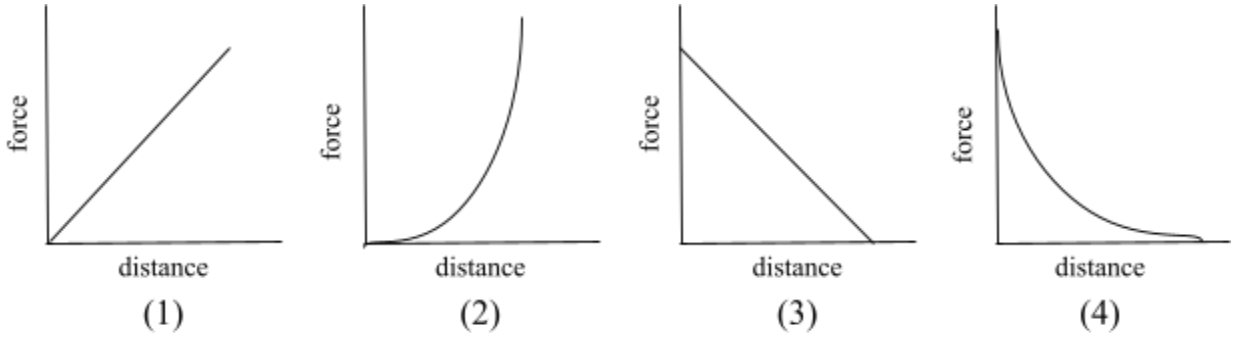
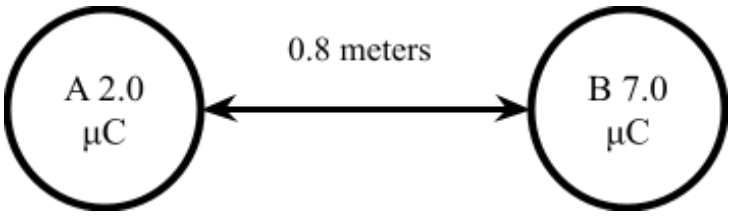
ANSWER KEY

Circle the graph that correctly depicts the relationship between distance and the magnitude of the electrostatic force between 2 charged particles.



Answer is: 4. Choice 4 depicts a graph that shows that as the distance increases the force decreases but never reaches 0. Additionally it shows the relationship is not linear but dependent on r^2 or the distance between the two particles.

Two metal spheres A and B possess charges of 2.0 microcoulombs and 7.0 microcoulombs respectively. Spheres A and B are 0.8 meters apart.



a. Will sphere B attract or repel sphere A? Explain.

Sphere B will repel Sphere A, as they are both positive charges and like charges repel one another.

b. Calculate the force Sphere B exerts on Sphere A. Round your answer to the nearest hundredth.

Use the Coulomb's Law equation. Convert the charges to coulombs.

$kq1q2/r^2 = force\ exerted\ in\ Newtons$

k =$9*10^9$

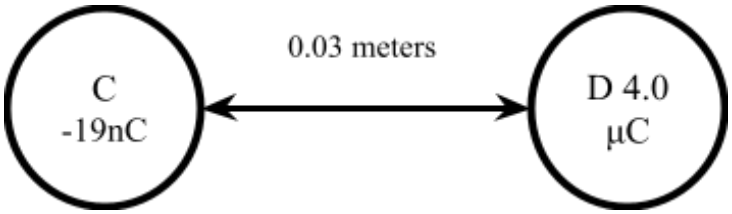
q1 = $2.0 * 10^{-6}$ Coulombs

q2 = $7.0 * 10^{-6}$ Coulombs

r = 0.8 meters

$(9 * 10^{9}) * (2.0 * 10^{-6}) * (7.0 * 10^{-6})/(0.8)^{2} = 0.20\ Newtons$

Two charged Particles C and D possess charges of -19 nanocoulombs and 4.0 microcoulombs respectively. Particles C and D are 0.3 meters apart.



c. Will Particle C attract or repel Particle D? Explain.

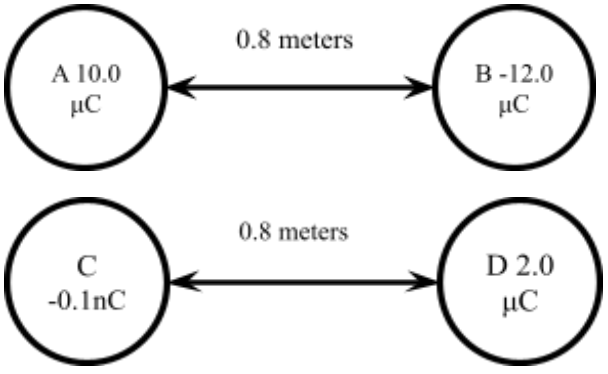
Particle C will attract particle D because particle C is negatively charged and particle D is positively charged; Opposite charges attract one another.

d. Calculate the force Particle C exerts on Particle D. Round your answer to the nearest hundredth.

Use Coulomb's law to solve for the force. Make sure to put the charges in coulombs.
-19nC = -19 *10^{-9} C and 4μC = 4 *10^{-6} C

$(9 * 10^{9}) * (-19 * 10^{-9}) * (4.0 * 10^{-6}) / (0.03)^{2} = -0.76\ newtons$

4. Without using Coulomb's equation, determine which pair of charged particles will have a greater attractive force.(Figures not drawn to scale)

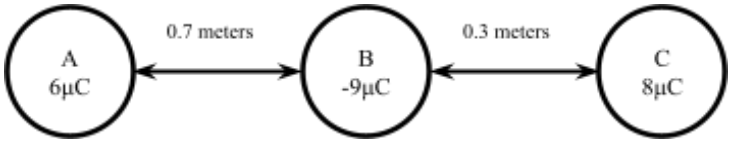


The first pair of charged particles will have a greater attractive force. This can be determined without using Coulomb's equation by looking at the units of charge. In the second pair of

particles, particle C has units of nano Coulombs which is $1x10^{-9}$ C which is smaller than micro Coulombs. Given this and that particle D has a lower value than both particle A and B, it is a valid assumption that the second pair of molecules has a lower attractive force.
This is also backed up by solving with Coulomb's equation. It is important to note that both pairs of particles are the same distance apart, so we can ignore the factor of distance when considering which pair has a greater attractive force.

Challenge Question:

Three charged particles A, B, and C possess charges of 6 microcoulombs, -9 microcoulombs and 8 microcoulombs respectively. The distances between the particles are shown below. Calculate the total force exerted on Particle C. Round your answer to the nearest thousandth.



The total force on C will be the force exerted by B plus the force exerted by A. So we break the problem up into three parts. Remember to make sure you have the correct units.

Step 1. Calculate how much repulsive force A applies to C
The distance here is 1.0m because it is 0.3m + 0.7m.

$$(9 * 10^{9}) * (6.0 * 10^{-6}) * (8.0 * 10^{-6}) / (1.0)^{2} = 0.43\ newtons$$

Step 2 Calculate how much attractive force B applies on C

$$(9 * 10^{9}) * (-9.0 * 10^{-6}) * (8.0 * 10^{-6}) / (0.30)^{2} = -7.2\ newtons$$

Step 3. Add forces to find net force.
-7.2 + 0.432 = -6.768 or -6.77
-6.77 newtons is the total force on C.