Atoms and Static Electricity

1. Explain how there can be charge inside matter yet the matter is electrically neutral.
   - The charges are balanced. Neutral atoms have equal numbers of protons and electrons.

2. Explain the difference between an electrically charged object and a neutral object.
   - An electrically charged object has an imbalance of protons and electrons, while an electrically neutral object has equal numbers of protons and electrons.

3. Is an object’s net charge positive or negative if it loses electrons?
   - An object that has lost electrons is considered positive. It is known as an ion.

4. Why can’t an atom lose protons to become an ion?
   - The number of protons determines the atomic number and the identity of the atom. Only electrons can be lost or gained to form ions.

5. What flows when there is a current in a wire?
   - Current in a wire is the result of the flow of free electrons through the metal.

6. What kind of force is there between like charges? Opposite charges?
   - Like charges have a repulsive force. Opposite charges have an attractive force.

7. Why do you feel a shock when you touch a doorknob? What causes this phenomenon?
   - You build up charges then touch a doorknob, those charges transfer from your hand to the metal doorknob. This is a process of static electricity.

8. Can you feel a shock from static electricity if you touch the wooden part of a door? Explain based on your past observations in lab.
   - The wooden part of a door should not produce a spark because wood is an insulator and will not conduct electricity.
Coulomb’s Law

1. In terms of attraction and repulsion, how do negative particles affect negative particles? How do negatives affect positives?

   • **Negative particles repel other negative particles, but attract positive particles.**

2. Consider the electric force between a pair of charged particles a certain distance apart. By Coulomb's law:

   a. If the charge on one of the particles is doubled, the force is **doubled**

   b. If, instead, the charge on both particles is doubled, the force is **quadrupled**

   c. If instead the distance between the particles is halved, the force is **quadrupled**

   d. If the distance is halved, *and* the charge of both particles is doubled, the force is **16 times** as great.

3. Two particles, each with a charge of 1 C, are separated by a distance of 1 meter. What is the force between the particles?

   • \( F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right) \frac{(1 \text{ C})(1 \text{ C})}{(1 \text{ m})^2} = 9 \times 10^9 \text{ N} \)

4. Calculate the force between a 0.05 C charge and a 0.03 C charge 2 meters apart.

   • \( F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right) \frac{(0.05 \text{ C})(0.03 \text{ C})}{(2 \text{ m})^2} = 3.38 \times 10^6 \text{ N} \)

5. Calculate the force between a 0.05 C charge and a 0.03 C charge 4 meters apart.

   • \( F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2\right) \frac{(0.05 \text{ C})(0.03 \text{ C})}{(4 \text{ m})^2} = 8.44 \times 10^5 \text{ N} \)
6. Joann has rubbed a balloon with wool to give it a charge of \(-1.0 \times 10^{-6}\) C. She then acquires a plastic golf tube with a charge of \(+4.0 \times 10^{-6}\) C localized at a given position. She holds the location of charge on the plastic golf tube a distance of 50.0 cm above the balloon. Determine the electrical force of attraction between the golf tube and the balloon. Is it an attractive or repulsive force?

- \(F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \frac{N \cdot m^2}{C^2}\right) \frac{(1.0 \times 10^{-6} \text{ C})(4.0 \times 10^{-6} \text{ C})}{(0.500 \text{ m})^2} = 0.144 \text{ N}\)
- It is an attractive force

7. Determine the electrical force of attraction between two balloons which are charged with the opposite type of charge. The charge on both balloons is \(6.0 \times 10^{-7}\) C and they are separated by a distance of 0.50 m.

- \(F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \frac{N \cdot m^2}{C^2}\right) \frac{(6.0 \times 10^{-7} \text{ C})(6.0 \times 10^{-7} \text{ C})}{(0.50 \text{ m})^2} = 0.013 \text{ N}\)

8. When sugar is poured from the box into the sugar bowl, the rubbing of sugar grains creates a static electric charge that repels the grains, and causes sugar to go flying out in all directions. If two sugar grains each acquire a charge of \(3.0 \times 10^{-11}\) C at a separation of \(8.0 \times 10^{-5}\) m, with what force will they repel each other?

- \(F_E = k \frac{q_1 q_2}{r^2} = \left(9 \times 10^9 \frac{N \cdot m^2}{C^2}\right) \frac{(3.0 \times 10^{-11} \text{ C})(3.0 \times 10^{-11} \text{ C})}{(8.0 \times 10^{-5} \text{ m})^2} = 1.01 \times 10^{-7} \text{ N}\)

9. The force between two charges is 2 N. The distance between the charges is \(2 \times 10^{-4}\) m. If one of the charges is \(3 \times 10^{-6}\) C, what is the strength of the other charge?

- \(F_E = k \frac{q_1 q_2}{r^2}
- q_2 = \frac{F_E r^2}{K q_1} = \frac{(2 \text{ N})(2 \times 10^{-4} \text{ m})^2}{9 \times 10^9 \frac{N \cdot m^2}{C^2}(3 \times 10^{-6})} = 3.0 \times 10^{-12} \text{ C}\)

10. How far apart are two protons if they exert a force of repulsion of 1 N? The charge on a single proton: \((q_p) = +1.6 \times 10^{-19} \text{ Coulomb} \).

- \(r = \sqrt{k \frac{q_1 q_2}{F_E}} = \sqrt{\left(9 \times 10^9 \frac{N \cdot m^2}{C^2}\right) \frac{(1.6 \times 10^{-19} \text{ C})(1.6 \times 10^{-19} \text{ C})}{1 \text{ N}}} = 1.5 \times 10^{-14} \text{ C}\)
Methods of Charging

1. A glass rod stroked with silk becomes positively charged because
   a. the silk removes electrons from the rod
   b. the rod removes electrons from the silk
   c. the friction creates a positive charge
   d. the silk gains protons

2. Explain how an object that is electrically neutral can be attracted to an object that is charged.
   • When you bring an uncharged body near a charged body, the electrons in the uncharged body move toward, or away from the charged body depending on the polarity of the charge on the charged body. This causes the side of the uncharged body closest to the charged body to have an opposite charge so they attract.

3. In the examples below, electric charge is transferred by which method?
   a) [Diagram of Conduction]
   b) [Diagram of Induction / Conduction]

Use the following diagram to answer questions 4 & 5:

4. If you observe that the charge on balloon B is negative, what can you conclude about the charge on balloon A?
   a. It has a positive charge, or it is neutral.
   b. It has a negative charge.
   c. It has no charge.
   d. It has a negative or neutral charge.

5. What can you conclude about the charge on balloon C?
   a. It has a positive charge.
   b. It has a negative charge.
   c. It has no charge.
   d. It has a negative or neutral charge.
6. A positively charged balloon will stick to a wooden wall. It does this by polarizing molecules in the wooden wall to create an oppositely-charged surface. Draw the appropriate diagram, illustrating charges on both the balloon and in the wall.

![Diagram of charges on balloon and wall]

7. Which of the diagrams below represents the effect of bringing a positively charged rod near (but not touching) an electroscope.

- **Diagram 3 is the answer.**

![Diagrams of electroscope](image)

8. A negatively charged balloon is brought near a neutral conducting sphere as shown below. As it approaches, charge within the sphere will distribute itself in a very specific manner. Which one of the diagrams below properly depicts the distribution of charge in the sphere?

- **Diagram c is the answer.**

![Diagrams of charge distribution](image)

9. Consider below a single metal insulated sphere, initially uncharged. The diagrams show a charging procedure with a positive rod. Draw the correct charges in the diagrams.

**Charging a Single Sphere by Induction**

- **Diagram 1:** A metal sphere is mounted on a stand.
- **Diagram 2:** A balloon induces a movement from the left side to the right side of the balloon.
- **Diagram 3:** When touched, the electrons leave the sphere through the hand and enter the ground.
- **Diagram 4:** The sphere is now charged positively, with an excess charge attracted to the balloon.
- **Diagram 5:** The positive charge eventually distributes itself over the sphere.