University of Al-Mustaqbal
College of Science
Department of Medical Physics

Electrical Material

First Stage

Lecture name : Charge and Matter

Lecture number : 1

Name of lecturer

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Introduction

The concept of **charge and matter** is one of the cornerstones of physics. Matter constitutes all physical substances in the universe, while electric charge is a fundamental property of matter responsible for electrical and electromagnetic interactions. Understanding charge and matter is essential for studying electricity, electronics, atomic physics, and modern technological applications.

This lecture aims to explain the nature of matter, the origin and types of electric charge, methods of charging, and the role of charge in physical phenomena using clear explanations, examples, and illustrations.

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1. Matter

1.1 Definition of Matter

Matter is defined as anything that has **mass** and occupies **space**. All objects around us, from air and water to metals and living organisms, are forms of matter.

1.2 States of Matter

Matter exists in four fundamental states:

- **Solid:** Fixed shape and volume
- **Liquid:** Fixed volume, variable shape
- **Gas:** Variable shape and volume
- **Plasma:** Ionized gas with free charges

The behavior of matter in each state depends on particle motion and intermolecular forces.

2. Atomic Structure of Matter

2.1 Structure of the Atom

All matter is composed of atoms. An atom consists of:

- **Protons:** Positively charged particles
- **Neutrons:** Neutral particles
- **Electrons:** Negatively charged particles

Protons and neutrons form the nucleus, while electrons move around the nucleus in energy levels.

2.2 Electrical Neutrality

An atom is electrically neutral when:

Number of electrons=Number of protons

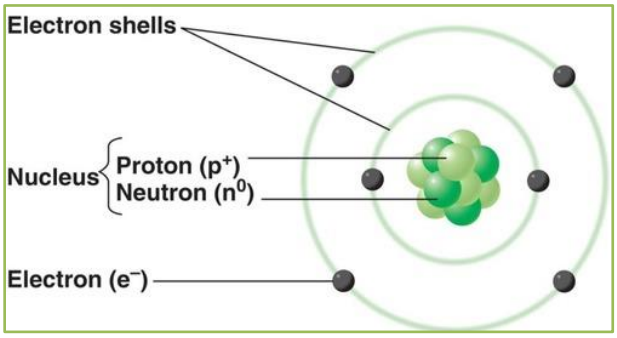

Figure 1: Atomic Structure

Description:

Central nucleus containing protons (+) and neutrons (0) with electrons (–) orbiting around it in shells.

3. Electric Charge

3.1 Definition of Electric Charge

Electric charge is a fundamental property of matter that causes it to experience a force in the presence of other charges or electric fields.

3.2 Types of Electric Charge

There are two types:

- **Positive charge**
- **Negative charge**

Basic rule:

- Like charges repel
- Unlike charges attract

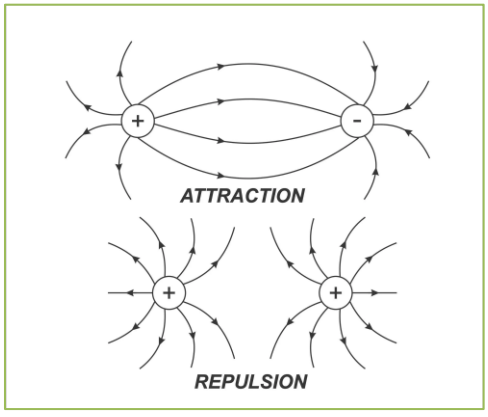

Figure 2: Interaction of Electric Charges

Description:
Illustration showing repulsion between two positive charges and attraction between a positive and a negative charge.

4. Origin and Quantization of Charge

Electric charge originates from subatomic particles:

- Protons carry positive charge
- Electrons carry negative charge

The smallest unit of charge is the **elementary charge**:

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

Quantization of Charge

All observable charges are integer multiples of the elementary charge:

$Q = n \times e$

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5. Methods of Charging

5.1 Charging by Friction

When two neutral objects are rubbed together, electrons transfer from one object to another.

5.2 Charging by Conduction

Occurs when a charged object touches a neutral object, allowing electrons to flow.

5.3 Charging by Induction

Charging without contact by redistributing charges inside a conductor.

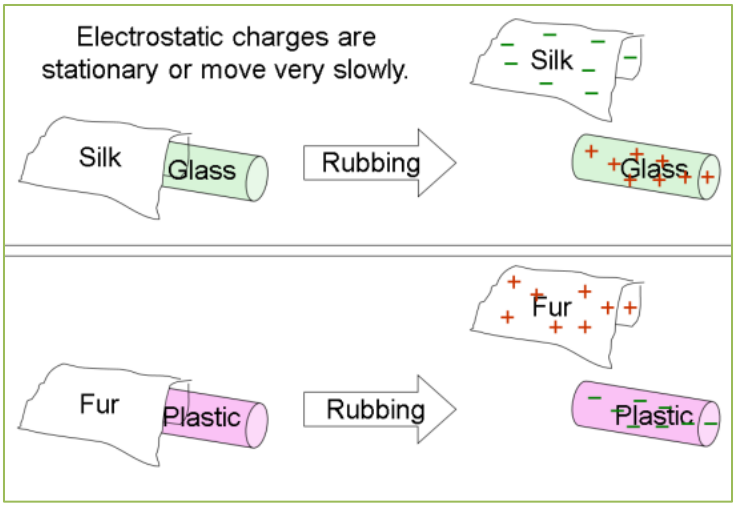

Figure 3: Charging by Friction

Plastic rod rubbed with wool, showing electron transfer.

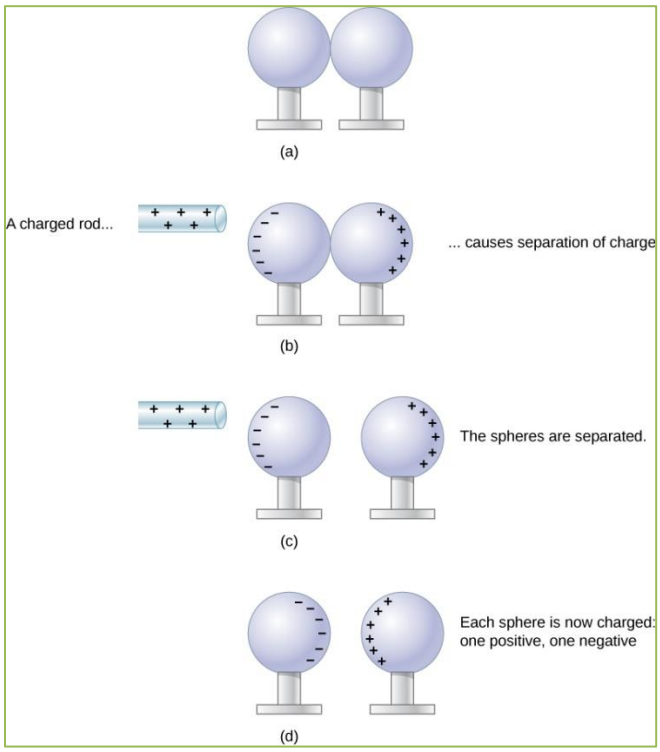

Figure 4: Charging by Induction

Charged rod near a neutral metal sphere causing separation of charges.

6. Conservation of Electric Charge

Law of Conservation of Charge

Electric charge cannot be created or destroyed; it can only be transferred from one body to another.

$Q_{\text{total before}} = Q_{\text{total}}$

This law applies to all electrical processes.

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7. Conductors, Insulators, and Semiconductors

7.1 Conductors

Allow free movement of electrons.
Examples: Copper, aluminum.

7.2 Insulators

Restrict movement of electrons.
Examples: Rubber, glass.

7.3 Semiconductors

Intermediate behavior.
Examples: Silicon, germanium.

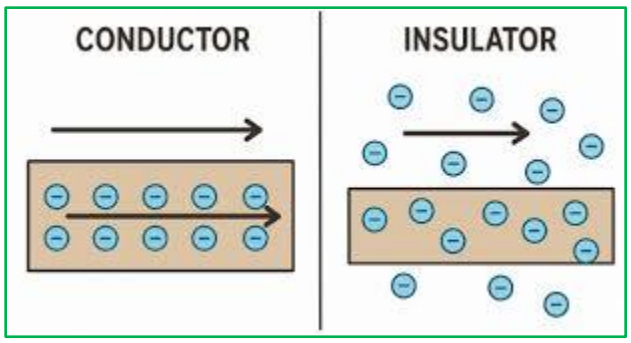

Figure 5: Conductors vs Insulators

Diagram comparing free electrons in conductors and bound electrons in insulators.

8. Solved Numerical Problems

Problem 1

How many electrons produce a charge of:

-3.2×10^{-19} C

Solution:

n=Q/e=2 electrons

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9. Applications of Charge in Matter

- Static electricity
- Lightning
- Electronic devices
- Chemical bonding
- Electrical circuits

Conclusion

Charge and matter are inseparable concepts in physics. Matter is composed of atoms containing charged particles, and electric charge governs interactions at both microscopic and macroscopic levels. Understanding these principles provides a foundation for advanced studies in physics, engineering, and technology