Department of biology

((Biophysics))

1 Stage

LEC 1

Material and charge

By

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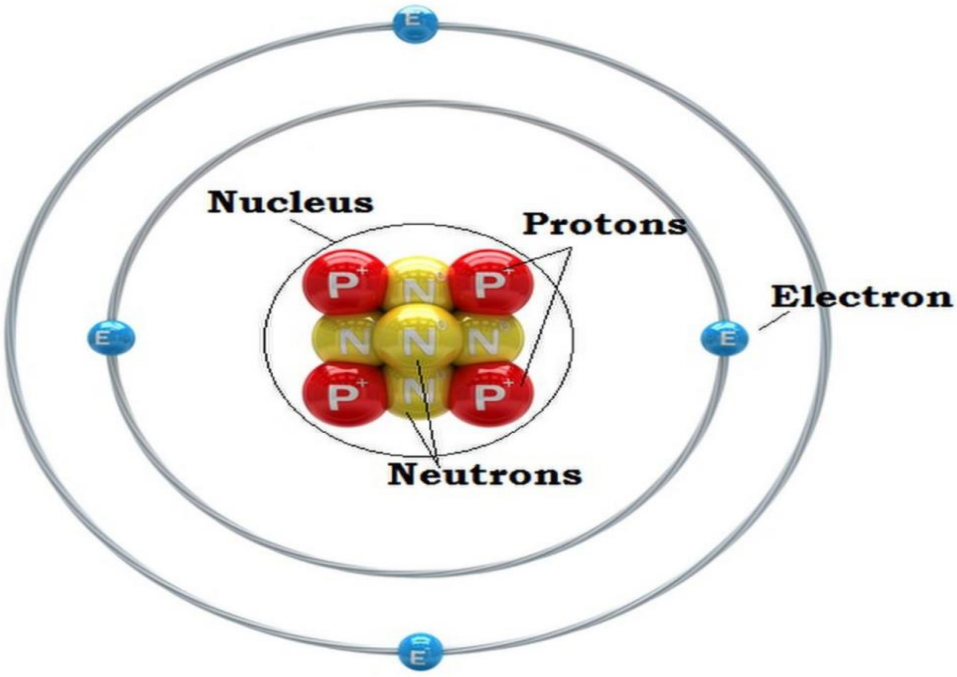
1.Material and Charge

Matter is anything that has mass and occupies space. Matter is composed of very small particles known as atoms, and each atom contains a central nucleus surrounded by electrons. The nucleus is made up of protons and neutrons.

Basic Properties of Matter

- **Mass**: The amount of matter in an object. Measured in kilograms (kg).
- **Volume**: The space occupied by matter. It can exist as a solid, liquid, or gas.
- **Electric Charge**: Some types of matter carry charge, such as electrons (negative) and protons (positive).



The Relationship Between Matter and Charge

- All matter is made up of atoms, and every atom contains **electric charges**:
  - **Protons**: Positively charged (+e).
  - **Electrons**: Negatively charged (−e).
  - **Neutrons**: Neutral (carry no charge).

Under normal conditions, most matter has an equal number of protons and electrons, resulting in **electrical neutrality**

The study of electromagnetism dates back to the early Greek philosophers, who made an intriguing observation: when a piece of amber is rubbed and brought close to small bits of straw, the straw is attracted to the amber. Today, we understand this phenomenon as an electric force acting between the amber and the straw.

For centuries, the studies of electricity and magnetism progressed independently. However, in 1820, Hans Christian Oersted discovered the connection between them. He found that an electric current flowing through a wire could deflect the needle of a magnetic compass, linking the two fields.

2.Electric Charge

A simple experiment can help us understand the concept of electric charge. If a glass rod is rubbed with a silk cloth and suspended using a thread tied around its center, it can be used to demonstrate some key properties of electric charge:

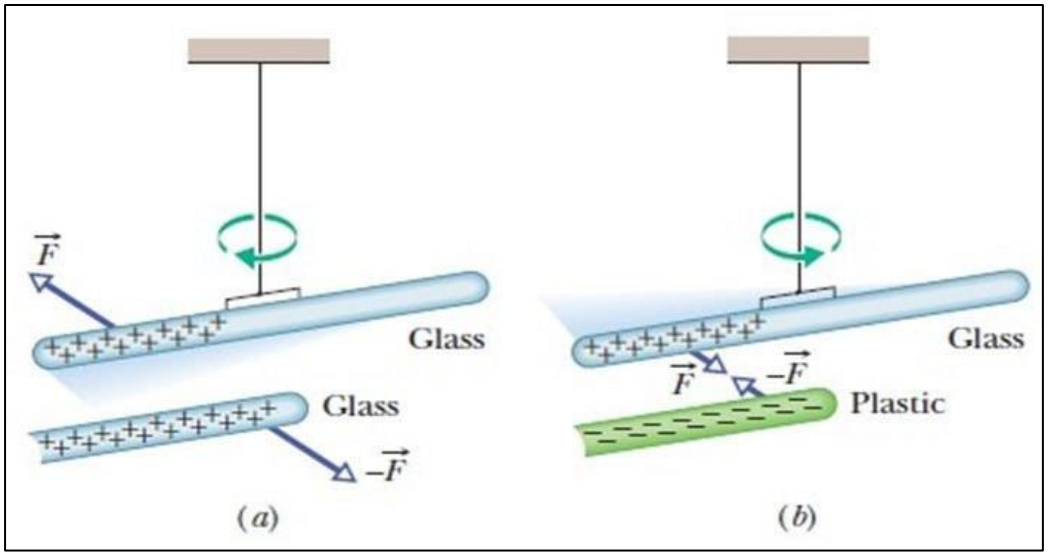
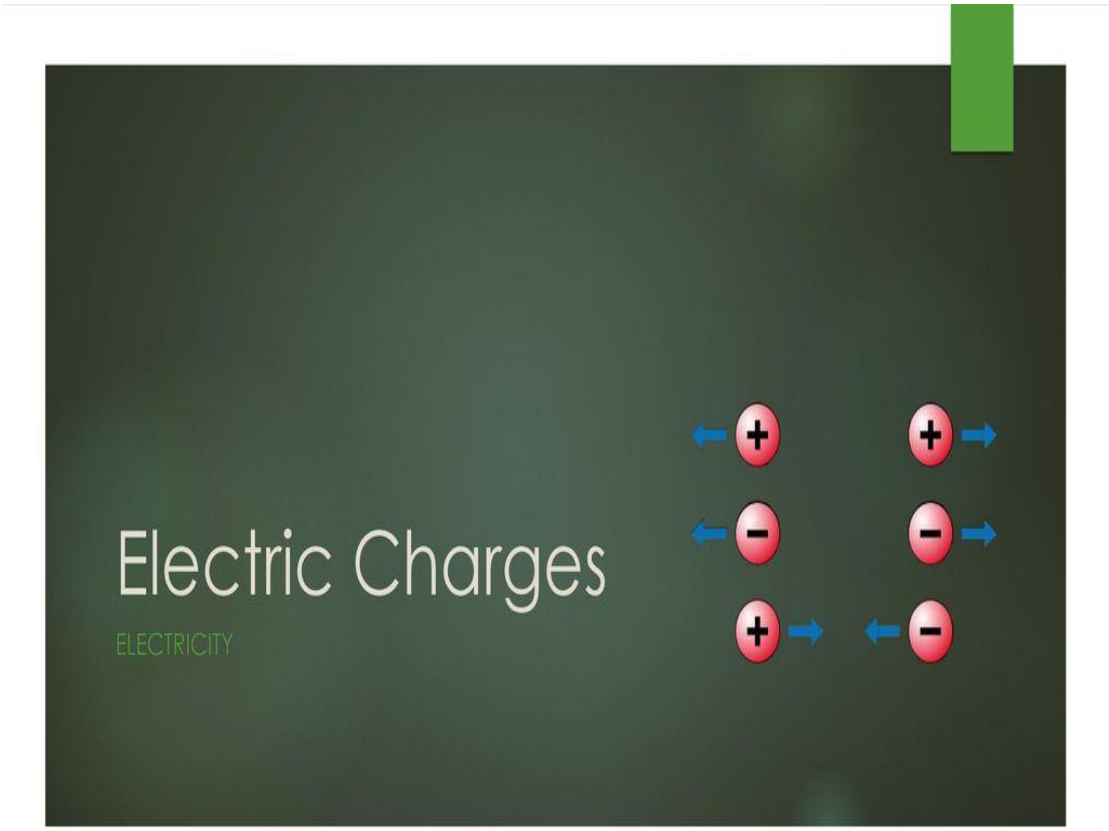


Figure. 1: (*a*) The two glass rods were each rubbed with a silk cloth and one was suspended by thread. When they are close to each other, they repel each other. (*b*) The plastic rod was rubbed with fur. When brought close to the glass rod, the rods attract each other.

1. **Repulsion:**
   When a second glass rod, also rubbed with the same silk cloth, is brought close to the hanging rod, the two rods repel each other. This repulsion indicates the presence of like charges on the two rods.
2. **Attraction:**
   When the second rod is replaced with a plastic rod that has been rubbed with fur, the hanging glass rod moves toward the plastic rod. This attraction demonstrates the presence of opposite charges between the glass rod and the plastic rod.



In the first demonstration, the force on the hanging rod was ***repulsive***, and in the second, ***attractive***. After a great many investigations, scientists figured out that the forces in these types of demonstrations are due to the **electric charge** that we set up on the rods when they are in contact with silk or fur.

3. Two Types of Charge

There are two types of electric charge, as named by the American scientist and statesman Benjamin Franklin: **positive charge** and **negative charge**.

In most everyday objects, such as a mug, the number of positively charged particles is approximately equal to the number of negatively charged particles. As a result, the net charge is zero, meaning the object is **electrically neutral**.

- **Key principle:**
  Particles with the same type of electric charge **repel** each other, while particles with opposite charges **attract** each other.

4. Charge is Conserved

When a glass rod is rubbed with silk, a **positive charge** appears on the rod. Careful measurement reveals that an **equal negative charge** appears on the silk. This observation demonstrates that rubbing does not create new charge; instead, it **transfers charge** from one object to another.

This principle is known as the **conservation of charge**, first proposed by Benjamin Franklin. The concept has been rigorously tested and holds true for both large objects and tiny particles like atoms and nuclei.

5. Charge is Quantized

Electric charge is a fundamental property of matter that exists in discrete and indivisible units. This means any observable charge(q) can be expressed as:

$$q=n\cdot e$$

Where:

e is the **elementary charge**, approximately valued at:
$e\approx 1.6\times 10^{-19}$ C (Coulombs)

- n is an integer (positive or negative), representing the number of elementary charges.

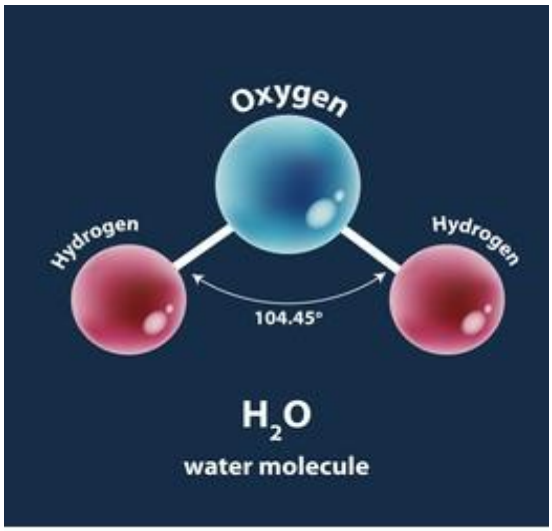
Examples of Elementary Charges

1. Electrons and Protons:
    - Electrons have a negative charge of −e.
      Example: An electron carries a charge of -1.6×10^{-19} C.
    - Protons have a positive charge of +e.
      Example: A proton carries a charge of $+1.6\times10^{-19}$ C.

6.Examples of matter and charge and their relationship to life sciences:

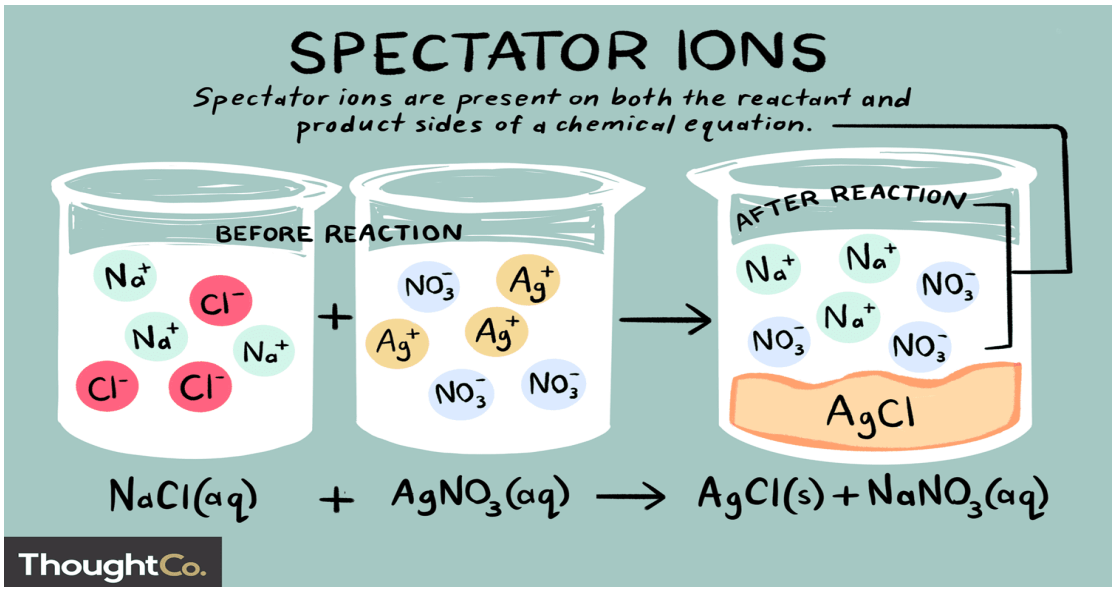
1. Water (H_2O) as a substance of life:

It consists of two positively charged hydrogen (H) atoms and a negatively charged oxygen (O) atom.



2. Ions in biological processes:

Potassium ions (Na+) and potassium (K+) play an essential role in blood circulation. The difference in the concentration of these ions across the cell output produces a difference in electrical potential, which is the basis of nerve activity.



3. Biomolecules and charge:

Species: Some species of birds carry positive or negative charges on their surface and include their clear structure. This affects their interaction with other organic molecules.Contains (DNA and RNA): a negative charge due to the phosphate group. This allows them to interact with birds (such as histones) and express that.

4. Bioelectricity in the living body:

Electricity such as electric sea fish: Electric generation responsible for itself or hunting prey fish, and it depends on the transfer of charges between its cells.

Heart: It works with electrical impulses and is regulated by human charges through the heart muscle cells.

5. The ratios between matter and charge and life sciences:

Matter (such as molecules and atoms) that contain electrical charges to interact with targeted programs.

Here are five questions based on the lecture:

1. **What are the primary components of an atom?**
   a) Protons, neutrons, and photons
   b) Electrons, protons, and neutrons
   c) Neutrons, quarks, and photons
   d) Protons, electrons, and ions
   Answer:
2. **What did Hans Christian Oersted discover about electricity and magnetism?**
   a) Electric charges exist in discrete units.
   b) An electric current can deflect a magnetic compass needle.
   c) Opposite charges attract.
   d) Charge is conserved.
   Answer:
3. **Which property of electric charge is demonstrated when a glass rod rubbed with silk acquires a positive charge and the silk gains an equal negative charge?**
   a) Quantization of charge
   b) Conservation of charge
   c) Attraction and repulsion
   d) Coulomb's law
   Answer:
4. **The electric charge of a single proton is approximately:**
   a) +1.6×10−19 C+1.6 \times 10^{-19} \, C
   b) −1.6×10−19 C-1.6 \times 10^{-19} \, C
   c) +3.2×10−19 C+3.2 \times 10^{-19} \, C
   d) Neutral
   Answer:
5. **Which phenomenon explains why rubbing two objects together can transfer charge?**
   a) Electrostatic induction
   b) Friction
   c) Polarization
   d) Conservation of charge
   Answer:

6. **Which biological process relies on the movement of ions across cell membranes?**
   a) Photosynthesis
   b) Nerve signal transmission
   c) Protein synthesis
   d) DNA replication
   Answer:
7. **What is the charge of an electron compared to that of a proton?**
   a) Equal in magnitude and sign
   b) Equal in magnitude but opposite in sign
   c) Unequal in both magnitude and sign
   d) Neutral
   Answer:
8. **Which biomolecules are negatively charged due to the presence of phosphate groups?**
   a) Lipids and carbohydrates
   b) DNA and RNA
   c) Proteins and enzymes
   d) Amino acids and vitamins
   Answer:
9. **Electricity generated by electric sea fish is primarily used for:**
   a) Digesting food
   b) Reproduction
   c) Hunting prey or self-defense
   d) Attracting mates
   Answer:
10. **What principle is demonstrated when the electrical neutrality of matter is maintained under normal conditions?**
    a) Coulomb's law
    b) Conservation of charge
    c) Attraction and repulsion
    d) Quantization of charge
    Answer: