Department of biology

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((Biophysics))

Stage 1

LEC (Lec 1)

Material and charge

By

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1. Material and Charge

1.1 Matter : is anything that has mass and occupies space.

It is composed of very small particles called atoms, and each atom consists of a central nucleus surrounded by electrons.

The nucleus is made up of protons and neutrons, and matter can exist in different physical states such as solid, liquid, and gas.

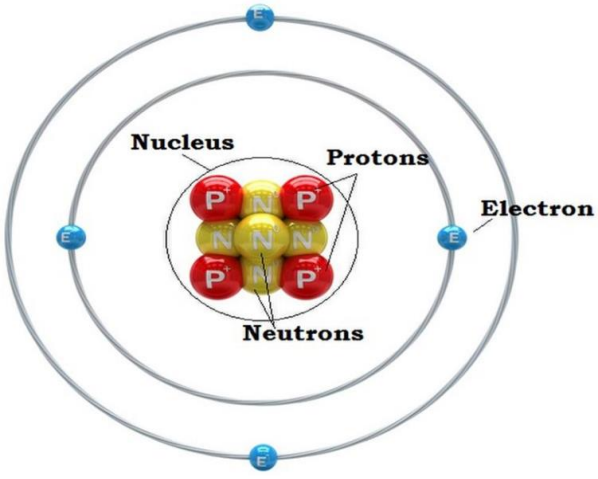
1.1.1 Basic Properties of Matter:

- **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.

1.2 Electric Charge

The concept of electric charge can be understood through a very simple experiment based on friction. When a glass rod is rubbed with a piece of silk, some electrons move from the glass to the silk. As a result, the glass becomes positively charged, while the silk gains a negative charge. If two glass rods charged in the same way are brought close to each other, they will repel because they carry the same type of charge. However, if a charged glass rod is brought near a plastic rod that has been rubbed with fur, the two rods will attract each other because their charges are different. This simple experiment shows that like charges repel, opposite charges attract, and that friction causes electric charge to be transferred from one object to another.

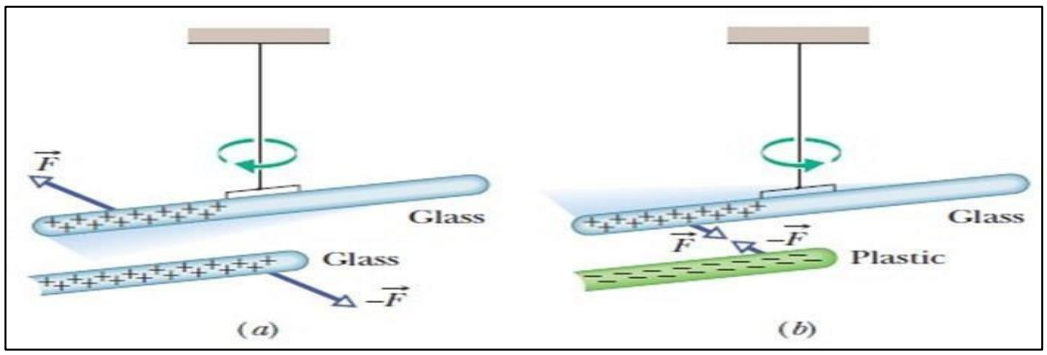


Figure 1 a) The two glass rods were each rubbed with a silk cloth and one was suspended by thread. When they are close to each other, they repel each other. (b) The plastic rod was rubbed with fur. When brought close to the glass rod, the rods attract each other

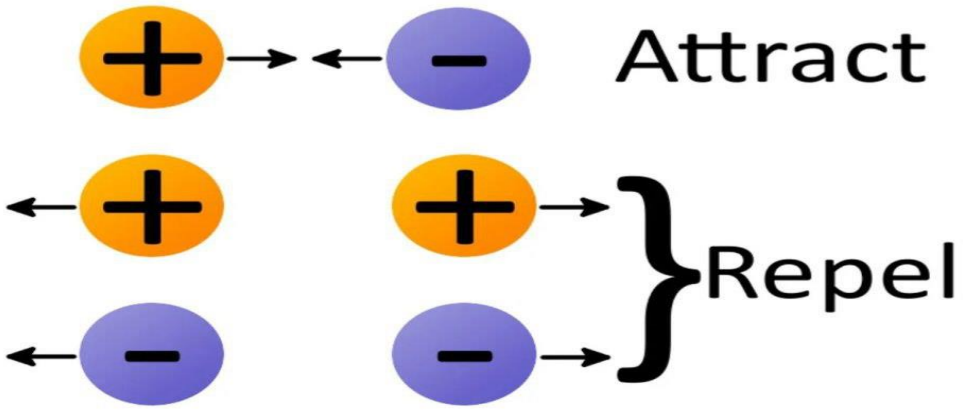
1. Repulsion:

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.

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**.

1.3 Charge is Conserved:

When a glass rod is rubbed with a piece of silk, some electrons transfer from the glass to the silk. As a result, the glass becomes positively charged, while the silk gains an equal amount of negative charge. This shows that friction does not create new charge; it simply transfers charge from one object to another.

This principle is known as the law of conservation of charge, a concept introduced by Benjamin Franklin. Its validity has been confirmed for both large objects and microscopic particles such as atoms and nuclei.

1.4 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: $e\approx1.6\times10-19$ C (Coulombs)

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

Examples of Elementary Charges

Electrons and Protons

- Electrons have a negative charge of $-e$.

Example: An electron carries a charge of -1.6×10^{-19} C.

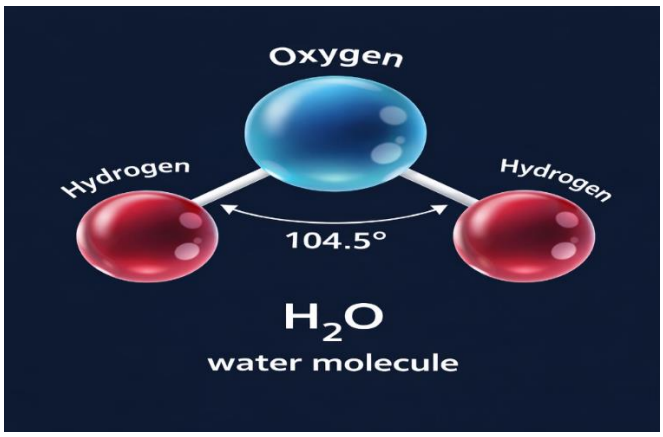
- Protons have a positive charge of $+e$.

Example: A proton carries a charge of $+1.6\times10^{-19}$ C.

1.5 Examples of matter and charge and their relationship to life sciences:

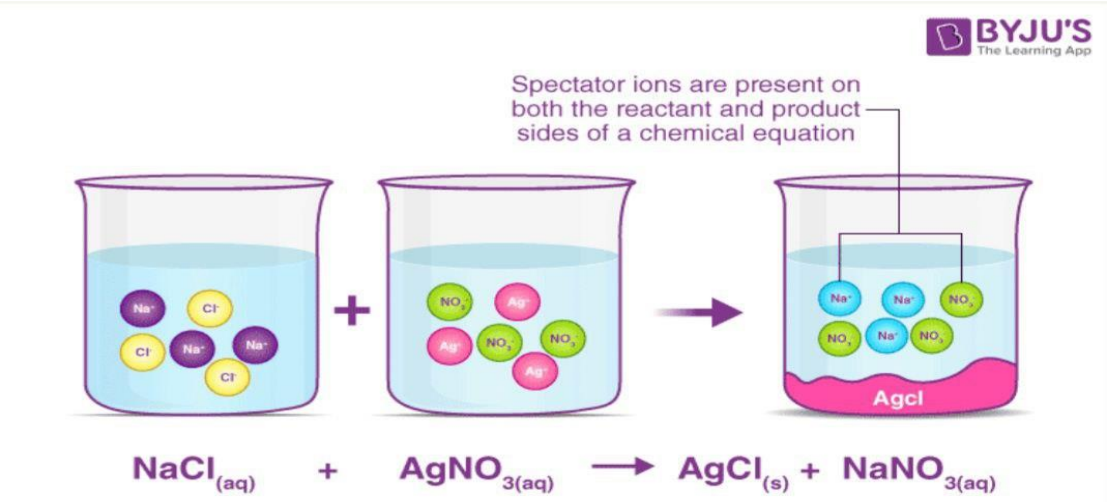
1. Water (H_2O) as a substance of life:

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



2. Ions in biological processes:

Sodium 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 ten questions based on the lecture:

1- What is the correct definition of matter?
A. Anything that has energy only.
B. Anything that has mass and occupies space.
C. Anything that carries charge only.
D. Anything visible to the eye.
2- An atom is mainly composed of:
A. Electrons and neutrons only.
B. Protons and photons.
C. A nucleus and electrons.
D. Positive ions only
3- The atomic nucleus. contains:
A. Electrons only.
B. Protons and neutrons.
C. Protons and electrons.
D. Neutrons only.

4- Under normal conditions, most matter is:
A. Positively charged.
B. Negatively charged.

C. Electrically neutral.
D. Always partially charged.

5- When a glass rod is rubbed with silk, it becomes:
A. Negatively charged.
B. Positively charged.
C. Neutrally charged.
D. Magnetic.

6- The force bet.ween two like charges is:
A. Attraction.
B. Repulsion.
C. Zero.
D. Variable.

7- Which phenomenon explains why rubbing two objects together can transfer charge?
A. Electrostatic induction.
B. Friction.
C. Polarization.
D. Conservation of charge.

8- The principle of conservation of charge means that charge:
A. Is created from nothing.
B. Disappears with time.
C. Is transferred but neither created nor destroyed.
D. Increases by friction.

9- The approximate value of the elementary charge (e) is:
A. 1.6×10^{-19} C.
B. 9.8×10^{-6} C.
C. 3.2×10^{-19} C.
D. 1.6×10^{19} C.

10-DNA and RNA molecules carry a:
A. Positive charge.
B. Neutral charge.
C. Negative charge.
D. Variable charge.