Department of biology

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((Biophysics))

Stage (1)

LEC ((Two))

Electric Charge

By

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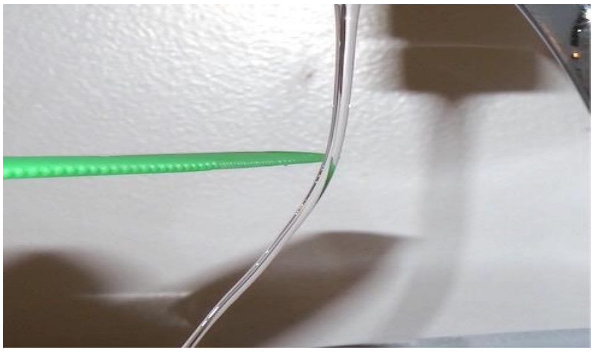
Electric Charge

Electric charge is one of the fundamental concepts in physics, serving as the cornerstone for understanding many natural phenomena and modern applications in medicine, biology, and electronics. This lecture aims to trace the historical sequence of the discovery of electric charge and explain its development from simple observation to the modern atomic interpretation.

First: The earliest natural observations of electrical phenomena

Before physics emerged as a science, humans noticed strange phenomena without scientific explanation, such as:

- Static in Clothing: Clothes stick together after being removed from a dryer, especially fabrics like wool or synthetics, due to the transfer of electric charges.
- Combing Hair: On dry days, hair sticks to the comb or is attracted to it. A charged comb can also bend a thin stream of water without contact.
- Cling Wrap and Balloons: Plastic wrap clings to surfaces due to charge



  buildup, and balloons rubbed against walls adhere because of static charge interaction.
- Shocks from Conductors: Walking on a carpet and then touching a metal doorknob can cause a mild shock due to discharge of accumulated static charge.

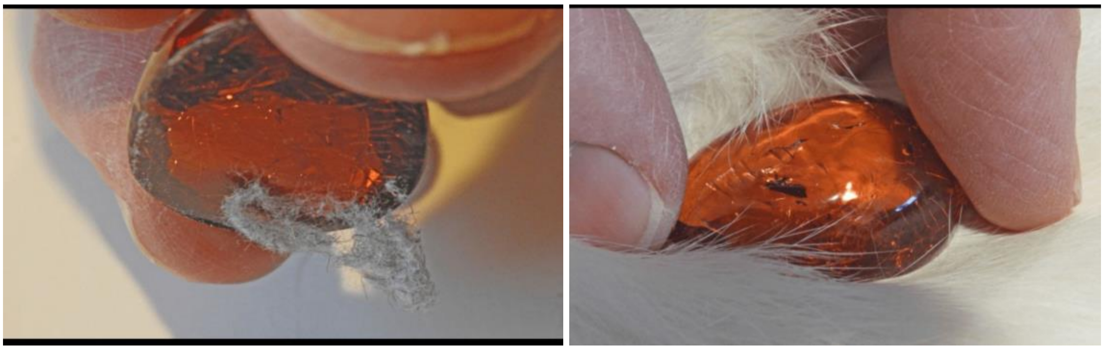
Modern explanation:

These phenomena occur as a result of the transfer of electrons between materials, leading to an imbalance in electric charge.

Second: The discovery of Thales of Miletus (around 600 B.C.)

Thales is considered the first to record a scientific observation related to electricity. He noticed that amber, a fossilized resin from trees, when rubbed with animal fur, became capable of attracting light objects such as feathers or bits of straw. This phenomenon was the first evidence of an invisible force generated by friction, which we now know as static electricity.

- He used a piece of amber.
- He rubbed it with animal fur.
- He observed that after rubbing, the amber was able to attract light objects such as feathers or straw.



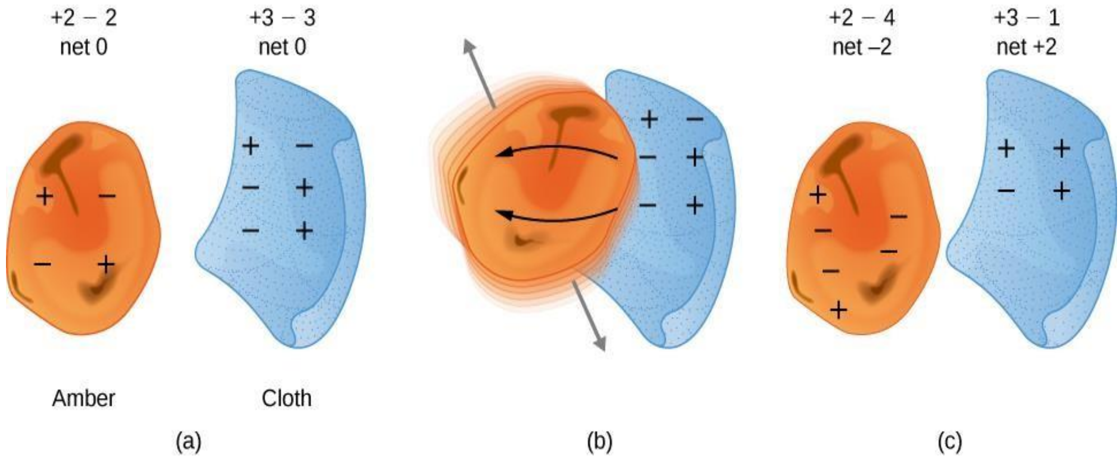


Figure1: When materials are rubbed together, charges can be separated, particularly if one material has a greater affinity for electrons than another. (a) Both the amber and cloth are originally neutral, with equal positive and negative charges. Only a tiny fraction of the charges are involved, and only a few of them are shown here. (b) When rubbed together, some negative charge is transferred to the amber, leaving the cloth with a net positive charge. (c) When separated, the amber and cloth now have net charges, but the absolute value of the net positive and negative charges will be equal

Modern explanation:

The rubbing process transfers electrons between the fur and the amber, creating an imbalance in electric charge that results in a force of attraction between the charged amber and the light objects.

Third: Distinguishing between electricity and magnetism (16th century)

At first, electricity and magnetism were thought to be the same phenomenon. However, experiments showed the difference:

- Magnetism attracts only specific materials such as iron.

- Static electricity (charges) attracts many light objects such as feathers or pieces of paper.

Importance of this stage: It allowed electricity to be studied as an independent

Aspect of Comparison	Magnetism	Static Electricity
What it attracts?	Specific materials such as iron	Light objects such as paper and feathers
How it is generated?	Naturally present in certain metals	Produced by friction between different materials
Type of force	Attracts or repels depending on poles	Only attracts due to charge imbalance
Dependence on motion	Does not require movement of charges	Caused by transfer of electrons
Applications	Motors, compass, magnetic cranes	Printers, copiers, physics demonstrations

Table 1(Comparison between Magnetism and Static Electricity)

Key Concept:

Static electricity arises from the **transfer of electrons** between materials, creating an imbalance of electric charges. This imbalance results in attraction, repulsion, or discharge, depending on the materials and conditions.

The discovery of static electricity led to the identification of two types of electric charge: positive and negative. The electric force between these charges behaves in a very specific way:

1. **Attraction and Repulsion**: The force between two charges depends on their type. If the charges are of the same type (both positive or both negative), the force is **repulsive**. If the charges are

of opposite types (one positive and one negative), the force is **attractive**. This is the basis for electrostatic attraction and repulsion.

2. **Coulomb's Law**: The force between two charges also depends on the distance between them. Specifically, the magnitude of the electric force decreases as the **square of the distance** between the two charges increases. This is a very rapid decrease—doubling the distance reduces the force to one-fourth of its original value.

Here are some key observations about electric forces:

1. The force can act **without physical contact** between objects.
2. It can be **attractive** or **repulsive** based on the types of charges.
3. Not all objects experience this force—only those with charge are affected.
4. The force decreases as the **inverse square** of the distance between the objects increases.
5. The surrounding environment of the charged objects can also affect the force, though this will be explored in more detail later.

2) properties of electric charge

The **properties of electric charge** reveal several fundamental principles that govern the behavior of charge in our universe. Here are the key properties:

1. **Quantization of Charge**: Electric charge comes in discrete amounts. The smallest possible unit of charge is represented by the **elementary charge** ee, which is 1.602×10^{-19} . This is the charge of a single electron (negative) or proton (positive). No object can have a charge smaller than this, and the charge on any object must be an integer multiple of this value. The charge on macroscopic objects arises from the addition or removal of electrons, resulting in a net charge that is a multiple of the elementary charge.
2. **Magnitude Independence**: The magnitude of the elementary charge is the same for both positive and negative charges. The smallest possible **positive charge** is $+1.602\times10^{-19}$, and the smallest possible **negative charge** is -1.602×10^{-19} . These values

are exactly equal, which reflects the symmetry in nature's treatment of positive and negative charges.

3. **Conservation of Charge**: Charge is **conserved**, meaning it cannot be created or destroyed. It can only be transferred between objects. When we say charges "cancel," we mean that the forces from equal and opposite charges can balance out in a way that the net force on another object is zero. However, the charges themselves do not disappear. The total amount of charge in the universe remains constant.

Charge conservation is true even in a **closed system**. For example, if negative charge were to disappear from one place (like your lab bench) and appear somewhere else (like the Moon), the total charge in the universe would still remain unchanged. In practice, charge flow into or out of a system will be measurable if there is a change in the system's total charge.

3) sources of charges

The sources of charges in bodies are rooted in the **atomic structure of matter**. Here's how charges arise in bodies:

1. Electrons and Protons:

- **Electrons**: Negatively charged particles that orbit the nucleus of an atom.
- **Protons**: Positively charged particles located in the nucleus.
- The charges of electrons and protons are equal in magnitude but opposite in sign. In a **neutral atom**, the number of electrons equals the number of protons, resulting in no net charg.

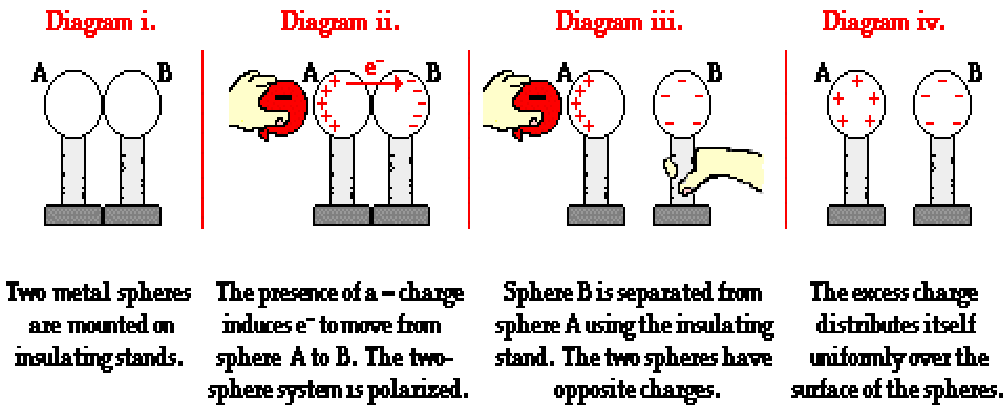
2. Ionization:

Atoms or molecules can gain or lose electrons:

- **Loss of Electrons**: Results in a **positive ion** (cation) because the atom has more protons than electrons.
- **Gain of Electrons**: Results in a **negative ion** (anion) because the atom has more electrons than protons.

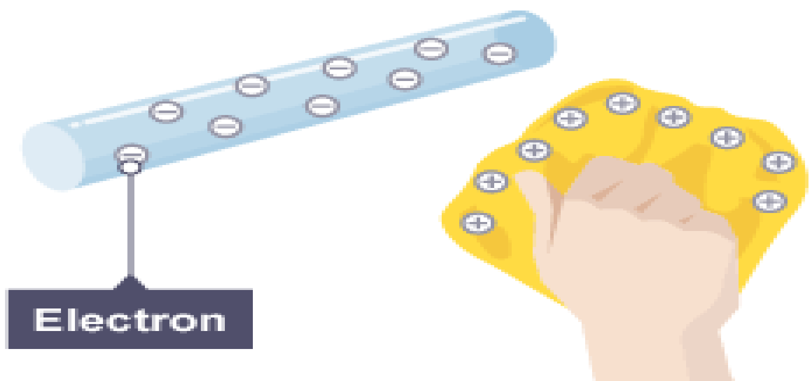
3. Charge Separation:

- When two materials come into contact and are then separated, electrons may transfer from one material to another due to differences in **electron affinity**.
    - The material gaining electrons becomes negatively charged.
    - The material losing electrons becomes positively charged.



4. Friction:

- Friction between two surfaces can cause the transfer of electrons:
    - For example, rubbing fur on amber (as observed by the Greeks) results in the amber becoming negatively charged and the fur positively charged.
- This is due to the **triboelectric effect**, where certain materials are
- more likely to gain or lose electrons when in contact

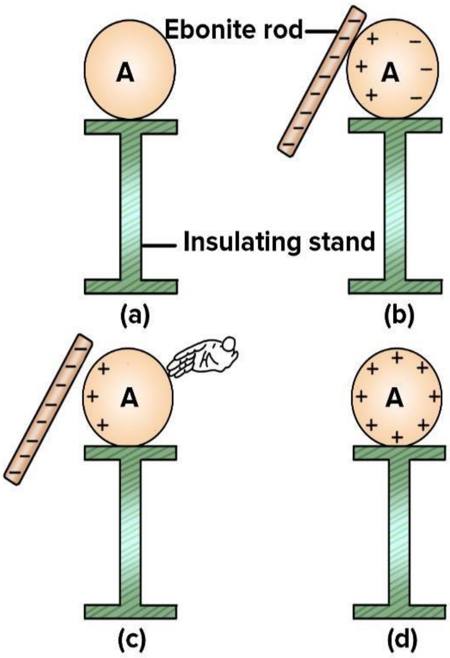


5. Chemical Reactions:

- In chemical reactions, atoms rearrange, often resulting in the transfer of electrons.
- For example, in a **battery**, chemical reactions create a flow of electrons, generating a charge difference between the terminals

6. Induction:

- A charge can be induced in a body without direct contact:
  - If a charged object is brought near a neutral conductor, the charges in the conductor rearrange. This separation creates areas of positive and negative charge within the conductor.



Multiple Choice Questions – Electric Charge

1. Who was the first to observe static electricity by rubbing amber with fur?

A. Coulomb

B. Faraday

C. Thales of Miletus

D. Ampère

2. The type of force between two like charges is:

A) Attraction

B) Repulsion

C) No force

D) Depends on the material

3. The smallest unit of electric charge is:

A. The charge of a neutron

B. 1.602×10^{-19} J

C. The charge of an electron

D. The charge of a neutral atom

4. When a balloon is rubbed with hair, the balloon usually becomes:

A. Positively charged

B. Negatively charged

C. Neutral

D. Charged with both positive and negative charges

5. The electric force between two charges:

A. Is constant

B. Increases with distance

C. Decreases as the distance increases

D. Decreases when the amount of charge increases

6. Electric charge is mainly produced due to the movement of:

A. Protons

B. Photons

C. Electrons

D. Neutrons

7. The process in which charges are rearranged in a neutral object without direct contact is called:

A. Ionization

B. Induction

C. Discharge

D. Conduction

8. A material that loses electrons during friction becomes:

A. Negatively charged

B. Neutral

C. Positively charged

D. A superconductor

9. The relationship between electric force and distance between two charges is:

A. Direct

B. Inverse

C. No relationship

D. Stops if both charges are negative

10 .Conservation of charge means:

A. Charge can be created from nothing

B. Charge can be destroyed completely

C. Charge can only be transferred, not destroyed

D. Charge appears only in magnetic materials