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WORKSHEET 21

SUBJECT: PHYSICS **YEAR 11**

Strand	P11.7 Electrostatics
Sub Strand	P11.7.1 Charge
Content Learning Outcome	P11.7.1 Learn and apply the concepts of electrostatic charge

Atom

- An atom is the smallest particle of matter and consist nucleus that is surrounded by one or more lightweight electrons.
- An atom is held in place by electrical attraction between electrons.
- **Electrons** are electrically negative.
- **Protons** that are electrically positive reside within the nucleus of an atom. Also present in an atom is neutron.
- **Neutron** is electrically neutral and it holds protons together. Electrons are always free to move in an atom. Only the electrons move inside the atom and they can transfer from one atom to the other. The movement of electron from one body to the other transfers the charge to the body the electrons are transferred.
- Materials that allow good electron flow are called conductors. Conductors are materials in which electrons can move freely. Metals are good conductors. Materials that do not allow electrons to flow are called insulators. Rubber is a good insulator because it does not allow the movement of electrons. An uncharged body is one that has equal number of electrons and protons. A positively charged body has more protons than electrons. A negatively charged body has more electrons than protons. Movement of electrons produces electricity.

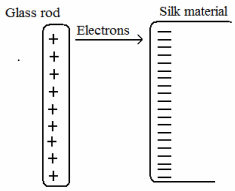
Conservation of Charge

- States that charge is conserved. Electrical charge cannot be created nor destroyed. Charges can only be transferred from one body to another.

Note: Transferring of charge means transfer of electrons. Protons do not move, only electrons can move. If a glass rod is rubbed with a piece of silk, electrons from the glass will move to the silk. Since the glass rod has lost electrons, it will now have more protons than electrons. We conclude that the glass rod is now positively charged because protons [positive] dominate the charge in this case. Since the piece of silk has gained more electrons [negative], we conclude that the silk is negatively charged because it has more electrons than protons. If you rub hard rubber rod with fur, electrons transfer from the fur to the rubber rod. Since the rubber rod gains electrons, it becomes negatively charged. To transfer charges, energy is needed to do this work. The energy to transfer charge in the above cases came from rubbing two bodies together. Whenever you hear a body being either positively or negatively charged, it means that electrons are transferred.

Example 1

The diagram given below shows the transfer of charges and charging a body by friction when a piece of glass rod is rubbed together with a piece of silk.



Conductors

- If you add electrons to one end of a metal, the electrons would move to all parts of the metal.
- Any amount of electrons added to one end of a metal would quickly spread to the rest of the part of the metal.
- Materials that allow free movement of electrons are called electrical conductors. Metals are good conductors of electricity.
- Copper and aluminium are good conductors of electricity and in Fiji they are used commercially to provide electricity. Also a good conductor of electricity is the graphite a form of carbon used in pencils.

Insulators

- A material in which electrons cannot move or their movement is insignificant is called insulators.
- Glass, dry wood, dry cloth, dry hair and tyre are good electrical insulators. It is important to not that dry air is a good insulator but strong charges can produce forces that can rip electrons off atoms in air producing plasma.
- Plasmas are good electrical conductors. The lightening that you see in space are plasmas created by electrical forces.

Semiconductors

- Semiconductors are materials with conductivity between that of conductors and insulators. A semiconductor allows only few electrons to move freely.
- Silicon is a good semiconductor. Semiconductors such as silicon are used in computers as transistor and integrated circuits.

Laws of Charges

The two types of charges that can be present in some materials are

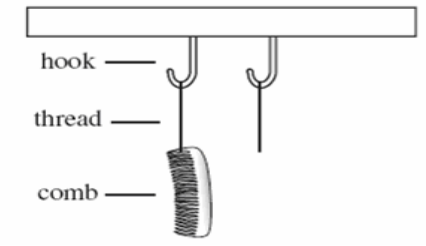
- Positive Charge: A body becomes positively charged when it loses electrons.
- Negative Charge: A body becomes negatively charged when it gains electrons.

When two bodies are brought close to each other, if they have different charges, they will attract. If they have the same charge, they would repel.

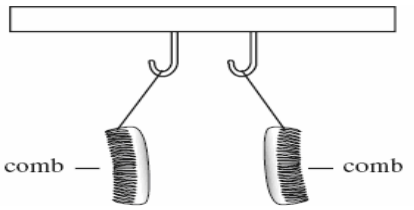
- Like charges repel
- Unlike charges attract.

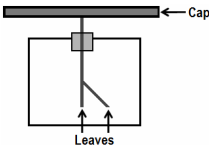
Example 2

A student combs her hair with a hard rubber comb and then hangs the comb on a loop of light thread that is suspended from a hook as shown below.



She immediately combs her hair with a second identical comb and hangs it on the second suspended loop of light thread. If the combing has caused a charge to accumulate on the combs, both combs would repel each other as show in the diagram given below. Both combs repel each other because both carry same charges. Like charges repel.





Electroscope

An electroscope is an instrument that can be used to

- Detect the presence of charge
- Detect the type of charge
- Measure the amount of charge
- Just remember that all charged electroscope have few opposite charges as well.
- A negatively charged electroscope has more electrons than protons.
- A positively charged electroscope has fewer electrons than protons.
- Also take not that in electroscopes, only electrons move.
- Protons do not move in electroscope.

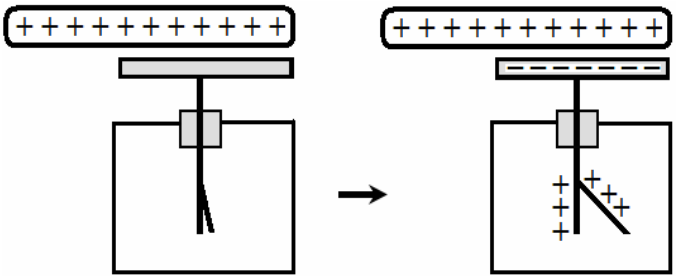
Detecting the Presence of Charge

If you bring a neutrally charged metal close to the cap of an electroscope you would not notice any change in behavior of the leaf. When the diverged leaf remains diverge or the collapsed leaf remains collapsed, we can conclude the rod or material that is brought close to the cap of the electroscope is neutral. Neutral means equal number of protons and electrons are present in the material. However, if a charged rod is brought close to the cap of an electroscope

- the leaf would diverge [repel]
- the charge on the leaf would be same as the charge on the rod

Example 3

- A positively charged rod is brought close to the cap of a neutral electroscope as shown in the diagram below.
- The electrons from the leaf are attracted to the cap of the electroscope because of the positively charged rod.
- Unlike charges attract each other.
- Since the electrons leaves the leaf, the leaf ends up with more proton and hence the leaf becomes positively charged.
- In the end, both the leaf and rod has same charge.



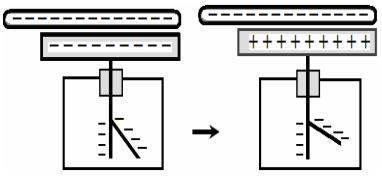
Detect the Type of Charge

If an electroscope of known charge is used, we can detect the charge on the rod. When a charged rod is brought to a charged electroscope, two possible outcomes are possible.

- If the leaves diverge more we can conclude that both the rod and the electroscope have the same charge.
- If the leaves collapse we can conclude that the rod has the opposite charge than the electroscope.

Negatively Charged Rod brought near a Negatively Charged Electroscope

Example 4



- As shown in the diagram above when a negatively charged rod is brought close to a negatively charged electroscope, the electrons. From the cap is repelled by the negatively charged rod.
- As a result, electrons from the cap move down to the leaves and hence, the number of electrons in the leaves increases.
- This causes the leave to further repel. Hence, if the leaves diverge more we can conclude that both the rod and the electroscope have the same charge.

ACTIVITY QUESTIONS (8 MARKS)

1. Explain how an object becomes electrically charged.

(2 marks)

2. If you scuff electrons onto your feet as you walk across a rug, state whether you become positively or negatively charged.

(2 marks)

3. State the meaning of “charge is conserved”.

(2 marks)

4. State the difference between a good conductor and a good insulator.

(2marks)

THE END