A Guide to Electrostatics and Charges

Teaching Approach

The study of electrostatics has a clear connection to many everyday experiences and is foundational for understanding circuit electricity. The lessons are best presented within the sequence suggested here, since each lesson builds on the previous one. In Lesson 1 learners are introduced to the concept of charge, then to the forces that exist between charged (Lesson 2) and uncharged (Lesson 3) objects. The measurement and quantisation of charge is covered in Lesson 4. The context of discharge is used in Lesson 5 to introduce the concept of potential difference, to apply the principle of conservation of charge, and to provide practice for simple calculations involving discharge between two identical insulated, charged, spheres. The task video can be used for formative or summative assessment.

Video Summaries

Some videos have a 'PAUSE' moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next days lesson; if desired, learners can be given specific questions to answer in preparation for the next day's lesson

1. Charge

Learners are given a brief history of the development of the concept of charge, introduced to the various scientific meanings of charge, and shown how insulators can be charged.

2. Electrostatic Force

The hypothesis that like charges repel and opposite charges attract is confirmed in this lesson.

3. Polarisation

Polarisation is demonstrated and explained with the aid of practical examples.

4. Charge Quantisation

The principle of quantisation of charge is explained and the coulomb is introduced as the unit for measuring charge.

5. Charge Conservation

The principle of conservation of charge is stated. Electrical discharge is explained and demonstrated. The learners are also led through worked examples of calculations of the charge on two insulated metal spheres.

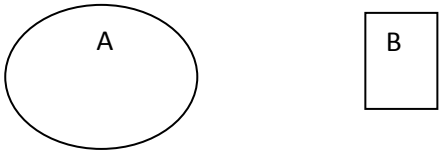
Resource Material

1. Charge	http://www.slideshare.net/AngelaStott/charge-29575756	A Slideshare presentation with most of the visuals used in this lesson.
	http://phet.colorado.edu/en/simulation/travoltage	A PhET simulation: John Travoltage. Charge John by rubbing his foot against the carpet. Discharge him by moving his hand towards the doorknob.
	http://www.physicsclassroom.com/Class/estatics/	The Physics Classroom contents page for electrostatics. Contains many links to very useful resources for the entire section.
2. Electrostatic Forces	http://www.slideshare.net/AngelaStott/electrostatic-forces-29591362	A Slideshare presentation containing some of the visuals used in this lesson.
	http://phet.colorado.edu/en/simulation/electric-hockey	A PhET simulation: Electric Field Hockey.
	http://www.angelastott.net/physical-science/grade-10/electrostatics	Interactive quizzes for the entire electrostatics section.
3. Polarisation	http://phet.colorado.edu/en/simulation/balloons	A PhET simulation: Balloons and static electricity.
	http://www.slideshare.net/AngelaStott/polarisation-29597252	A Slideshare presentation containing some of the visuals used in this lesson.
4. Charge Quantisation	http://www.slideshare.net/AngelaStott/discharge-29612377	A Slideshare presentation containing most of the visuals used in this lesson.
	http://everythingscience.co.za/grade-10/16-electrostatics/16-electrostatics-04.cnxmlplus	Siyavula Grade 10 textbook: Quantisation of charge and Polarisation
5. Charge Conservation	http://m.everythingscience.co.za/grade-10/16-electrostatics/16-electrostatics-03.cnxmlplus	Siyavula Grade 10 textbook: Conservation of charge
	http://socratic.org/physics/electric-forces-and-fields/electric-charge	Videos about charge and charge calculations: From Socratic Physics.

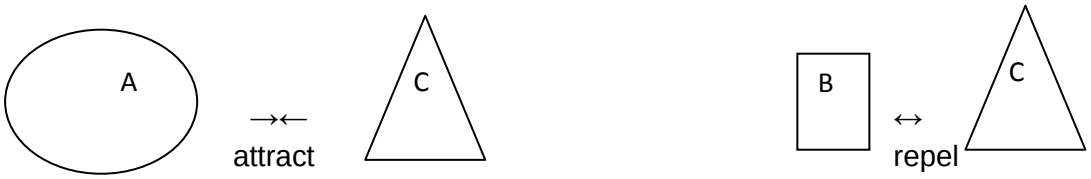
Task

Question 1

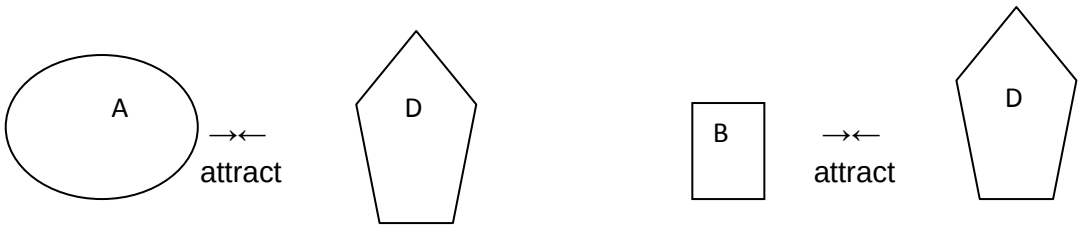
Object A is positively charged and object B is negatively charged.



1.1 True or false. Correct if false.
   a) Object A must contain more positive charges than object B.
   b) Object B must contain more electrons than protons.
1.2 Would A and B: [attract / repel / neither attract nor repel] one another?
1.3 Explain how B may have become negatively charged.
1.4 Explain what happens when a spark forms between A and B.
1.5 Object A attracts object C. Object B repels object C. What is the charge on object C?



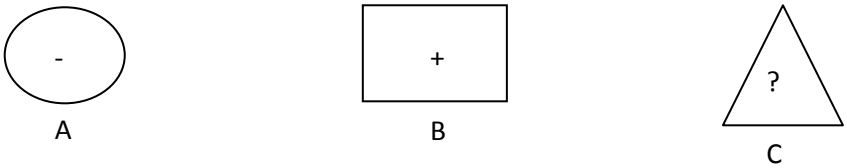
1.6 Object A attracts object D. Object B attracts object D. Explain why this can be so.



1.7 Object A repels object E. Would Object B attract E or repel it?

Question 2

Object A is negatively charged. Object B is positively charged. Object C's charge is unknown.



Object A attracts object C. This means that either object C is charged or that it can be polarized. Explain a further test that could be done to find out whether C is charged or neutral.

Give your answer in this form:
[*Give instructions on what to do*]. If [*describe what might be observed*], then you know that C is charged. If [*describe what might be observed*], then you know that C is neutral.

Question 3

Two identical spheres are on insulated stands. One has a charge of +3 C and the other of +2 C. The two spheres are moved close enough together so that discharge can occur.

3.1 Which way will electrons move (from +3 C to +2C or from +2 C to +3C or neither)
3.2 Explain your answer to 3.1.
3.3 Will the sphere which loses electrons in discharge become more, or less, positive?
3.4 Will discharge neutralise the two spheres? (yes/no)
3.5 What will the final charge on each sphere be?

Question 4

The charge on one electron is $-1{,}6 \times 10^{-19}$ C.

4.1 State the principle of quantisation of charge.
4.2 What is the charge of an object which has 1 million (1×10^{6}) fewer electrons than protons?
4.3 Are these charges possible?
  a) $155 \times (-1{,}6 \times 10^{-19}$ C)
  b) $15{,}5 \times (-1{,}6 \times 10^{-19}$ C)
  c) $6 \times 10^{19} \times (+1{,}6 \times 10^{-19}$ C)
  d) +15,5 C

Question 5

Read the description for the following investigation. Then answer the questions related to it:
Two pieces of Sellotape are placed next to one another. They neither attract nor repel.

  a) They are stuck onto a desk and pulled off. Now they repel one another.
  b) One is stuck onto a desk and the other stuck on top of this one. They are pulled off the desk and apart. Now they attract one another.

What observation suggests that:

5.1 Pulling the Sellotape strips off surfaces charged them.
5.2 There are two types of charge.
5.3 Like charges repel.
5.4 In b) the pieces of Sellotape must have become charged oppositely to one another.

Task Answers

Question 1

1.1
   a) False. A has more positive charges than A has negative charges, but not necessarily more positive charges than B.
   b) True

1.2 Attract

1.3 Electrons were transferred to B, e.g when B is rubbed.

1.4 Electrons move from B to A in a discharge which removes the potential difference and difference in charged state between A and B.

1.5 Negative

1.6 Object D is polarised by the presence of either charged object. This means that the charge distribution in D is distorted by the presence of the charged object, such that charges opposite to the charged object are attracted to the side closest to that object, causing attraction. [Since the attractive force between the charged object and the nearer opposite charge is greater than the repulsive force between the charged object and the further like charge, the two attract one another].

1.7 attract

Question 2

Bring a positively charged object closer to C, if it is repelled, you know that C is charged. If it is attracted, you know C is neutral.

Question 3

3.1 From +2 C to +3C

3.2 The +2 C object is less positive, and therefore more negative, than the +3 C object and electrons will move from the more negatively charged object.

3.3 More positive.

3.4 No

3.5 Final charge = $\frac{Q_1+Q_2}{2} = \frac{+2C+(+3C)}{2} = \frac{+5C}{2}$ = +2,5 C

Question 4

4.1 It is not possible for an object to have a charge which is not a whole number of the electron's charge

4.2 $1 \times 10^{6} \times (+1,6 \times 10^{-19})$ C = + $1,6 \times 10^{-13}$ C

4.3
   a) Yes
   b) Yes
   c) No
   d) Yes

Question 5

5.1 Before they didn't apply a force on one another. Afterwards they did.

5.2 There are two types of interaction (attraction and repulsion) so there must be two types of charge.

5.3 The pieces that were treated identically must be like charged, and they repelled.

5.4 These pieces behaved differently to those which were known to be of like charge, they must be charged unlike to one another.

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