B1 · Charge and charging

Student notes - follow the slides, fill the blanks, work the questions

Explain charge, draw charge separation, and predict the result of contact or grounding.

Name: _____ Date: _____

Slide 1 of 8 · Charge is carried by electrons

A rubbed balloon sticks to a wall. Unit B explains why. We start with what carries charge.

Atoms have _____ (+) in the nucleus and _____ (−) around it. One electron has charge size e = _____. C is the _____, the unit of charge.

Neutral: _____ protons and electrons, so the charges cancel. Only _____ move; protons stay in the nucleus.

Gain electrons: _____. Lose electrons: _____. Charge is _____: it moves, and is never made or lost.

Charge comes in whole electrons: Q = _____. n is a count, with no sign. Find the size, then add the _____.

Example. A neutral plastic rod is rubbed with wool and gains 2.5×10^{13} electrons from the cloth. What is the charge on the rod, with its sign? Use $e = 1.60 \times 10^{-19}$ C.

Work:

Answer: _____

Try it. A glass rod is rubbed with silk and ends with a charge of +3.2 μC. How many electrons did the glass rod lose, and where did they go?

Work:

Answer: _____

Slide 2 of 8 · Conductors, insulators and rubbing

On slide 1, only electrons moved. Where they can move depends on the material.

In a metal, some outer electrons are _____ and roam the whole object. Metals are _____. In plastic, glass, rubber and wool, electrons stay with their atoms. These are _____.

Extra electrons repel each other. On a metal they _____. On plastic they stay _____.

Rubbing moves electrons, because materials hold electrons with different strengths. The weaker holder loses electrons and turns _____. The other turns _____ by the _____.

On the diploma, explain a result by saying which way the _____ moved.

Example. A plastic ruler is rubbed with a wool cloth and the ruler becomes negative. No protons moved. What is the sign of the charge on the wool, how do the two sizes compare, and which material holds electrons more strongly?

Work:

Answer: _____

Try it. A student rubs a metal rod with a cloth while holding the rod in a bare hand. Brought near bits of paper, it does nothing. Explain why, and say what could be changed so the rod keeps its charge.

Work:

Answer: _____

Slide 3 of 8 · Why a neutral object is attracted

A charged rod also pulls on objects that have no charge. Slide 2 helps explain why.

A negative rod near a neutral metal sphere: like charges repel, so free electrons move to the _____ side. The near side is short of electrons, so it is _____.

This shift is charge _____. It ends when the rod leaves. The sphere is still _____. No electrons left it.

Unlike charges attract, and the near side is _____, so attraction is _____. The sphere is pulled toward the rod.

Attraction alone _____ prove an object is charged. Only _____ proves it.

Example. A negative rod is held near, but not touching, a neutral metal sphere on an insulating stand. What is the sign of the charge on the side nearest the rod, what is the total charge of the sphere, and does the sphere move toward or away from the rod?

Work:

Answer: _____

Try it. A charged rod attracts a small object hanging from a thread. Which statement must be true? A. The object has a charge opposite to the rod. B. The object is neutral. C. The object may be neutral or have a charge opposite to the rod. D. The object has the same charge as the rod.

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 4 of 8 · Charging by contact and sharing

So far the rod only came near an object. Now two metal spheres touch.

Touching conductors share charge. If the stands are _____, no charge can enter or leave, so the _____ stays the same.

Identical spheres (same size and shape) end with _____ charge: q = _____.

Add the charges _____ first, then divide by two. The final sign is the sign of _____.

Sketch the problem three times: _____, _____ and _____, with each charge written beside its sphere. Check that the total after equals the total _____.

Example. Two identical metal spheres carry +7.0 µC and −3.0 µC. They touch and are then separated. What is the charge on each sphere after the separation?

Work:

Answer: _____

Try it. Three identical spheres A, B and C carry +9.0 µC, 0 and −3.0 µC. A touches B and they separate. Then B touches C and they separate. What is the final charge on each of A, B and C?

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 5 of 8 · Method: how to find the charge after spheres touch

These are the steps you used on slide 4.

Step 1: write each charge _____. Step 2: _____ the signed charges. Step 3: divide by the _____.

Step 4: give _____ that charge, with its sign. Step 5: check that the total after is _____ the total before.

Example. Two identical metal spheres carry +7.0 µC and −3.0 µC. They touch and are then separated. Use the five steps to find the charge on each sphere.

Work:

Answer: _____

Try it. NEW, for teacher review: Two identical spheres carry +5.0 µC and −9.0 µC. They touch and are separated. What is the charge on each sphere?

Work:

Answer: _____

Slide 6 of 8 · Grounding and induction

On slide 3 the shift ended when the rod left. A path to the Earth lets the sphere keep a charge.

The Earth is so large that it can give or take any number of electrons and stay neutral. A wire or conducting path to the Earth is called a _____.

Induction means charging an object _____ with the charged object. Steps in order: 1. bring the rod _____; 2. connect the _____; 3. remove the _____ wire; 4. remove the _____.

A negative rod pushes electrons away, so they leave through the ground and the sphere ends _____. A positive rod pulls electrons up from the ground and the sphere ends _____.

Contact gives the _____ sign as the rod. Induction gives the _____ sign. The shift while the rod is near is charge _____; the charge left is _____ charge. Remove the ground wire first so the charge is trapped; if the rod leaves first, electrons _____.

Example. A positive rod is brought near, but never touches, a neutral metal sphere on an insulating stand. The sphere is grounded with a wire. The ground wire is removed first, and then the rod. What is the sign of the charge left on the sphere, and where did the charge come from?

Work:

Answer: _____

Try it. A neutral metal sphere on an insulating stand is to be given a positive charge using a negative rod. Which option does this? A. Touch the rod to the sphere, then remove the rod. B. Rod near, connect ground, remove rod, remove ground. C. Rod near, connect ground, remove ground, remove rod. D. Rod near, remove rod, connect ground.

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 7 of 8 · The electroscope

We cannot see electrons shift inside a metal. This tool shows it.

An electroscope is a metal _____ joined by a metal rod to two thin metal _____. Electrons can move between the knob and the leaves. When it is neutral the leaves hang _____.

A negative rod near the knob pushes electrons _____ to the leaves. Both leaves are _____, so they _____ and spread apart. A positive rod pulls electrons _____, so both leaves are _____ and they spread apart too.

A neutral electroscope shows that a charge is _____. It cannot show the _____. Touch the knob with a charged rod and the leaves _____: charging by contact. Touch the knob with a finger and the leaves _____: it is grounded.

On a charged electroscope, an object with the _____ sign makes the leaves spread more. An object with the _____ sign makes them move closer together.

Example. An electroscope has been charged negative by contact, so its leaves stand apart. Charged object X is held near the knob, without touching it, and the leaves move farther apart. X is taken away. Charged object Y is held near the knob, without touching it, and the leaves move closer together. What is the sign of the charge on X, and on Y? Explain each answer with the movement of electrons.

Work:

Answer: _____

Try it. NEW, for teacher review: An electroscope has been charged positive by contact, so its leaves stand apart. Charged object Z is held near the knob, without touching it, and the leaves move farther apart. What is the sign of the charge on Z? Explain with the movement of electrons.

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 8 of 8 · Method: how to explain a charging result in words

Use these steps for any “explain the charge” question in this lesson.

Step 1: name the object and say whether it is a _____. Step 2: say which way the _____ move. Step 3: say what each object _____.

Step 4: state the final sign. Gaining electrons gives _____; losing electrons gives _____. Step 5: say the total charge _____.

Example. A positive rod is brought near a neutral metal sphere on an insulating stand. The sphere is grounded, the ground is removed, and then the rod is removed. Explain the final charge on the sphere.

Work:

Answer: _____

Try it. NEW, for teacher review: A neutral metal sphere on an insulating stand touches a negative rod. Explain the sign of the charge on the sphere.

Work:

Answer: _____

B1 · Practice

Charge and charging | Questions 1-2 of 12

Use $k = 8.99 \times 10^9$ N·m²/C² and $g = 9.81$ m/s² where needed. These values are from the Alberta Physics 30 data sheets, Constants section. All point-charge calculations approximate air as vacuum.

Easy · B1-P01. An object has 8 protons and 10 electrons, each with a charge of the same size. What is the object's total charge in units of e, and what electron change would make it neutral?

Work:

Final answer (with unit and sign): _____

Easy · B1-P02. A neutral metal sphere loses electrons to another object. What is its final sign? Describe the change in the total charge of the two objects together.

Work:

Final answer (with unit and sign): _____

B1 · Practice

Charge and charging | Questions 3-4 of 12

Easy · B1-P03. Extra charge spreads across a metal object but stays near the rubbed spot on a plastic object. Which is the conductor and which is the insulator? Explain using charge motion.

Work:

Final answer (with unit and sign): _____

Easy · B1-P04. A known negative object repels a small charged object. What is the sign of the small object? If the observation were attraction instead, could you be certain it was positive? Explain.

Work:

Final answer (with unit and sign): _____

B1 · Practice

Charge and charging | Questions 5-6 of 12

Medium · B1-P05. A positive rod approaches the left side of a neutral metal sphere on an insulating stand without contact. Draw the sphere’s near-side and far-side charge signs, the electron-motion arrow, and its total charge. Explain the attraction.

Optional start: Track electrons first. Did any enter or leave the sphere?

Work:

Final answer (with unit and sign): _____

Medium · B1-P06. Two identical metal spheres on insulating supports have +8.0 µC and −2.0 µC. They touch and are separated far apart. No charge escapes. What is each final charge, and which way did electrons move?

Optional start: Add signed charges before dividing.

Work:

Final answer (with unit and sign): _____

B1 · Practice

Charge and charging | Questions 7-8 of 12

Medium · B1-P07. A negative rod is held near a neutral metal sphere. The sphere is grounded, the ground is disconnected, and then the rod is removed. What is the final sign? Draw the electron path during grounding and explain the order.

Work:

Final answer (with unit and sign): _____

Medium · B1-P08. A positive rod is brought near a neutral metal sphere on an insulating stand, then removed. There is no contact or grounding. What are the sphere’s total charge while the rod is near and after it leaves? Explain where the charges sit at both times.

Work:

Final answer (with unit and sign): _____

B1 · Practice

Charge and charging | Questions 9-10 of 12

Challenging · B1-P09. Sphere A starts at +10.0 μC, sphere B at −4.0 μC and sphere C at 0 μC. All are identical metal spheres on insulating supports. A touches B, then they separate far apart. B then touches C and they separate far apart. No charge escapes. What is each final charge? Check the total.

Work:

Final answer (with unit and sign): _____

Challenging · B1-P10. A student charges a sphere using a negative rod and ground, but removes the rod while the ground wire is still attached. The rod is moved far away before the ground is disconnected. What is the final charge? Explain why this differs from the correct induction sequence.

Work:

Final answer (with unit and sign): _____

B1 · Practice

Charge and charging | Questions 11-12 of 12

Challenging · B1-P11. A student says, “A neutral plastic comb cannot be attracted to a charged rod because electrons cannot move freely through plastic.” Identify the error. Draw or describe what the charges inside the comb do to explain the attraction without giving the comb a total charge.

Work:

Final answer (with unit and sign): _____

Challenging · B1-P12. Two metal objects of different sizes with charges +8.0 µC and −2.0 µC touch, and no charge can enter or leave. A student predicts +3.0 µC on each. Which part of the prediction is guaranteed, which is not, and what extra condition would justify equal sharing?

Work:

Final answer (with unit and sign): _____