**ANSWER KEY.**

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# Electric Charge

Physics | Answer Key

## Part A: Charge and Charging

Use the ideas from the lesson notes. Explain your reasoning in complete sentences.

**1.** The table shows the number of protons and electrons in three objects. For each one, decide whether it is neutral, positive, or negative, and give its net charge in units of $e$ (for example, $+2e$).

| Object | Protons | Electrons |
|---|---|---|
| X | 8 | 8 |
| Y | 8 | 10 |
| Z | 11 | 10 |

**X:** 8 protons and 8 electrons, so it is **neutral**, net charge **0**.

**Y:** 2 extra electrons, so it is **negative**, net charge **$-2e$**.

**Z:** 1 missing electron, so it is **positive**, net charge **$+1e$**.

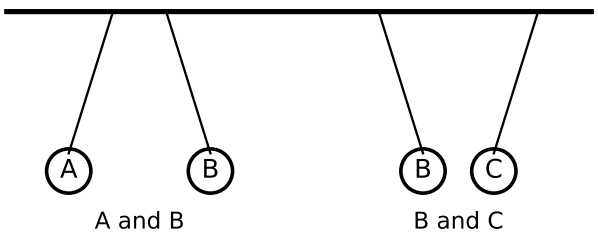
**2.** Marisol rubs a glass rod with a silk cloth, and the rod becomes positively charged. Which way did electrons move? What is the charge on the silk afterward, compared to the rod? Why can't protons be what moved?

**Electrons moved from the rod to the silk.** The rod lost electrons, so it is positive.

The silk gained exactly the electrons the rod lost, so it is **negative by the same amount**. No charge was created or destroyed (conservation of charge).

Protons are locked in the nucleus of each atom, so charging an object always means moving electrons.

**3.** Three small charged balls hang from threads. Ball C is known to be negative. Balls A and B push apart, and balls B and C pull together. What is the sign of the charge on A and on B? Explain.




B and C **attract**, and opposite charges attract. C is negative, so **B is positive**.

A and B **repel**, and like charges repel. B is positive, so **A is positive**.

This push in one case and pull in the other is the evidence that there are two types of charge.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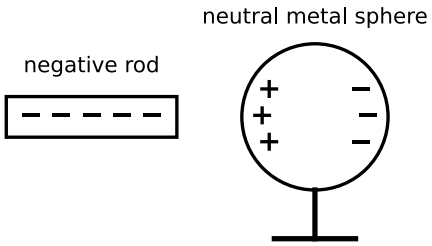
**4.** A negative rod is held near a neutral metal sphere, but it does not touch.




a. On the diagram, draw + and − signs to show where charge collects on the sphere. Explain why.
b. With the rod still nearby, the far side of the sphere is touched to the ground for a moment. Then the ground and the rod are taken away. What charge does the sphere keep?
c. Suppose instead the rod had touched the sphere. What sign of charge would the sphere get, and what is this method called?

**a. + signs on the side near the rod, − signs on the far side.** The rod's negative charge pushes the sphere's electrons away. The total charge of the sphere is still zero.

**b.** Electrons pushed to the far side flow into the ground. The sphere is left missing electrons, so it keeps a **positive** charge, opposite to the rod. This is **induction**.

**c.** Some of the rod's electrons flow onto the sphere, so it becomes **negative** (the same sign as the rod). This is **conduction**.

## Part B: Counting Charge

Use $q = ne$ with $e = 1.6 \times 10^{-19}$ C. Show the knowns, equation, substitution, and answer with units.

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**5.** Dev runs a plastic comb through his hair, and the comb picks up $3.0 \times 10^{11}$ extra electrons.

a. What is the charge on the comb, including its sign?
b. Could any object have a charge of $1.0 \times 10^{-19}$ C? Explain using the idea that charge is quantized.

**a. Knowns:** $n = 3.0 \times 10^{11}$ electrons, $e = 1.6 \times 10^{-19}$ C

**Equation:** $q = ne$

**Substitute:** $q = (3.0 \times 10^{11})(1.6 \times 10^{-19}\text{ C})$. $3.0 \times 1.6 = 4.8$, and $10^{11} \times 10^{-19} = 10^{-8}$

**Answer: $q = -4.8 \times 10^{-8}$ C**. It is negative because the comb gained electrons.

**b. No.** Charge comes only in whole numbers of electrons, so it must be a multiple of $1.6 \times 10^{-19}$ C. $1.0 \times 10^{-19}$ C would be less than one electron's charge (about 0.6 $e$), which is impossible.


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**6.** Two identical metal spheres have the charges shown. They touch, then separate.

a. What is the total charge of the two spheres?

b. What is the charge on each sphere after they separate?

c. How many electrons moved onto sphere B?

**a.** $q_{\text{total}} = (-7.0 \times 10^{-9}\ \text{C}) + (+1.0 \times 10^{-9}\ \text{C}) =$ **$-6.0 \times 10^{-9}$ C**. Charge is conserved, so this stays the same after they touch.

**b.** Identical spheres share equally: $(-6.0 \times 10^{-9}\ \text{C}) \div 2 =$ **$-3.0 \times 10^{-9}$ C on each sphere**.

**c.** Change for B: $(-3.0 \times 10^{-9}\ \text{C}) - (+1.0 \times 10^{-9}\ \text{C}) = -4.0 \times 10^{-9}$ C. $n = q/e = (4.0 \times 10^{-9}\ \text{C}) / (1.6 \times 10^{-19}\ \text{C}) =$ **$2.5 \times 10^{10}$ electrons** moved from A to B.


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