You run your finger along the slick side of a positively charged tape, and then observe that the tape is no longer attracted to your hand. Which of the following are plausible explanation(s) for this observation? Check all that apply.

- [ ] Protons are pulled out of the nuclei of atoms in the tape, and move onto your finger.
- [ ] Electrons from the mobile electron sea in your hand move onto the tape, leaving the tape with a zero (or very small) net charge.
- [ ] Sodium ions (Na^+) from the salt water on your skin move onto the tape, leaving the tape with a zero (or very small) net charge.
- [x] Chloride ions (Cl^-) from the salt water on your skin move onto the tape, leaving the tape with a zero (or very small) net charge.

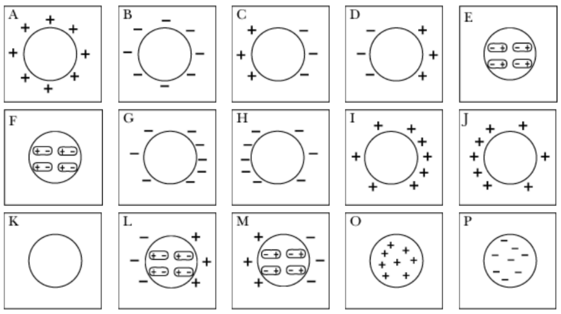
✔

You observe that a negatively charged plastic pen repels a charged piece of magic tape. You then observe that the same piece of tape is repelled when brought near a metal sphere. You are wearing rubber soled shoes, and you touch the metal sphere with your hand. After you touch the metal sphere, you observe that the tape is attracted to the metal sphere. Which of the following statements could be true? Check all that apply.

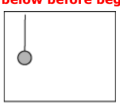
- [ ] Electrons from your hand moved onto the sphere.
- [x] The excess negative charge from the sphere spread out all over your body.
- [ ] Electrons from the sphere traveled through your body into the Earth.
- [x] Electrons from the sphere moved into the salt water on your skin, where they reacted with sodium ions.
- [x] Sodium ions from the salt water on your hand moved onto the sphere.
- [x] After you touched it, the metal sphere was very nearly neutral.
- [ ] Chloride ions from the salt water on your hand moved onto the sphere.

✔

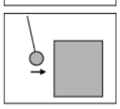
The figures below represent various possible charge distributions.



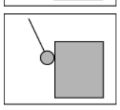
The diagrams below show a sequence of events involving a small lightweight aluminum ball which is suspended from a cotton thread. **In order to get enough information, you will need to read through the entire sequence of events described below before beginning to answer the questions.** Before trying to select answers, you will need to draw your own diagrams showing the charge state of each object in each situation.



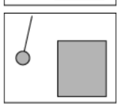
A small, lightweight, hollow aluminum ball hangs from a cotton thread. You touch the ball briefly with your fingers, then release it. Which of the diagrams above best shows the distribution of charge in and/or on the ball at this moment, using the diagrammatic conventions discussed in the textbook? K ✔



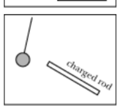
A block of metal which is known to be charged is now moved near the ball. The ball starts to swing toward the block of metal. Remember to read through the whole sequence before answering this question: Which of the diagrams above best shows the distribution of charge in and/or on the ball at this moment? C ✔



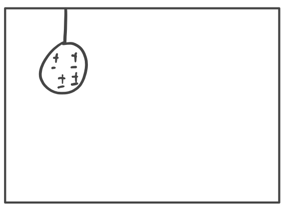
The ball briefly touches the charged metal block.

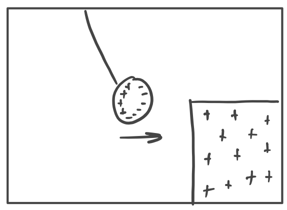


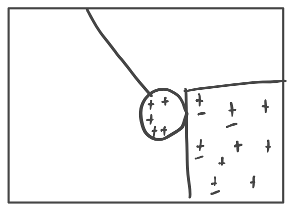
Then the ball swings away from the block, and hangs motionless at an angle, as shown. Which of the diagrams above best shows the distribution of charge in and/or on the ball at this moment? J ✔

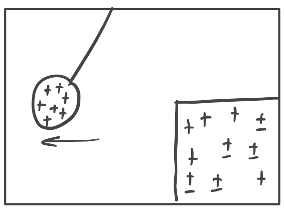


Finally, the block is moved far away. A positively charged rod is brought near the ball. The ball is repelled by the charged rod. Which of the diagrams above best shows the distribution of charge in and/or on the ball at this moment? J ✔



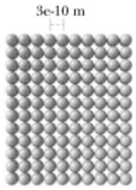






A group of students floated a charged invisible tape above another charged tape. They determined that the approximate charge on the floating tape was about 1.1e-08 C. The floating tape was 15 cm long and 1.875 cm wide.

The ratio of the number of excess electronic charges to the number of molecules on the surface of the tape is the fraction of the molecules on the surface of the tape that have gained (or lost) an extra electronic charge e = 1.6e-19 C. What is this fraction? To estimate this, assume that molecules in the tape are arranged in a cubic lattice, as indicated in the accompanying figure, and that the diameter of a molecule in the tape is about 3e-10 m.

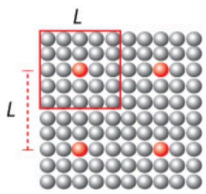


fraction of molecules with an extra charge = [ ] (# excess charges per molecule)

The inverse of your previous answer has units of (molecules/excess charge). This can be interpreted as the ratio of (uncharged molecules) to (charged molecules). What is this number?

1/fraction = [ ] (uncharged molecules per charged molecule)

Make the assumption that the excess charges are distributed uniformly over the surface, so each excess charge is at the center of an area containing the number of surface molecules you just calculated. For example, if there were one charged molecule per 25 molecules, each charged molecule would be in the center of a square of 25 molecules,as shown in the diagram below.



According to your calculations above, how far apart are the excess charges on these students' tape, measured in atomic diameters?
[ ] molecular diameters apart

Do your answers suggest that it is a common event or a rare event for a molecule to gain (or lose) an electron?
- ○ Common
- ○ Rare

If the electric field at a location in air exceeds about 3e6 N/C, the air will become ionized and a spark will be triggered. In Chapter 16 we will see that the electric field in a region very close to a uniformly charged disk or plate depends approximately only on the charge per square meter (total charge Q divided by total surface area A):

$$E = \frac{1}{2\epsilon_0}\frac{Q}{A}$$

Use this model to calculate the magnitude of the electric field at a location in the air very close to your tape (less than 1 mm from the surface of the tape), and note how it compares to the electric field needed to trigger a spark in the air.

E = [ ] N/C

This is a significant fraction of the breakdown field for air (3e6 N/C). If there were enough charge on a tape to make a field strong enough to trigger a spark, the air would become a conductor, and charge would leak off the tape. So the amount of excess charge you can put on a tape is limited by the breakdown strength of air.

Part A

$L = 0.15\ m$

$W = 0.01875\ m$

$Q = 1.1e-8\ C$

$d_{molecule} = 3e-10\ m$

$$\text{molecules in tape} = \frac{L}{d_{molecule}} \cdot \frac{W}{d_{molecule}}$$

$$= 3.125e16$$

$$\text{extra charges} = \frac{Q}{1.6e\text{-}19}$$

$$= 6.875e10$$

$$\text{fraction of molecules with extra charge} = \frac{3.125\,e16}{6.875\,e10}$$

$$= 2.2e\text{-}6$$

Part B

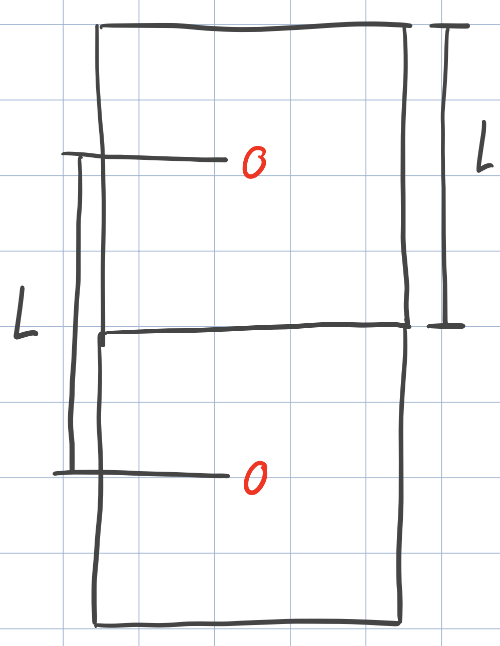
$$\text{non-charged molecules} = \frac{1}{2.2\,e\text{-}16}$$

$$= 454545$$

Part C

$$\sqrt{A} = L$$

$$= 674.200 \text{ molecules}$$



Part D

Rare

Part E

$$E = \frac{1}{2\varepsilon_0} \frac{Q}{A}$$

$$= \frac{1}{2\varepsilon_0} \frac{Q}{LW}$$

$$= 221168 \ N/C$$