# CH 16-1 – Charge

## Important Ideas

- Solids are made of atoms in a lattice. Protons are bound in the nucleus. Electrons orbit the nucleus. The charge of an electron is $q_{electron} = -e = -1.6 \times 10^{-19}$ C. The charge of a proton is $q_{proton} = e = 1.6 \times 10^{-19}$ C. The variable $e$ is the magnitude of the charge of an electron and proton.
- Neutral matter has equal numbers of protons and electrons. A negatively charged object has more electrons than protons. A positively charged object has more protons than electrons.
- Protons are fixed in the nucleus, and the nuclei are fixed in the lattice. Protons are not individually transferred from one object to another unless entire atoms are transferred. Electrons are (sometimes) loosely bonded to the atom. They can be individually transferred from one object to another. Also, when bonds between atoms are broken and entire atoms or molecules are transferred from one object to another, generally extra electrons are either transferred or left behind. This is how objects become charged by rubbing them together.
- The net charge of an object is

$$\begin{aligned} q &= n_{protons}e + n_{electrons}(-e) \\ q &= e(n_{protons} - n_{electrons}) \end{aligned}$$

  where $n$ is the number of protons or electrons.
- For a conductor, some electrons (called *conduction* electrons, and it's approximately 1 per atom at room temperature) can move freely throughout the conductor. As a result, excess charge on a conductor spreads evenly across the surface of the conductor if there are no external forces. If there is an external force, charge will "pile up" on the surface of the conductor in the direction of the force on the charge. Charge on a conductor moves until it reaches equilibrium (net force = 0). In an external force, a metal object becomes polarized due to the separation of charge on its surface.
- For an insulator, electrons are bound to the atoms. Excess charge remains localized and does NOT distribute itself around the object. If there is an external force, the electron cloud around an atom shifts and the atom is polarized. But electrons are NOT transferred to other atoms and do NOT move through the material. Electrons remain bound to atoms and merely shift relative to the atom.

## Examples

1. If you rub a balloon on your head, some electrons in the atoms of your hair move to the atoms of the latex balloon. Is the charge of the balloon, positive, negative, or zero?

   (a) positive
   (b) negative
   (c) zero

2. Is the charge of your hair positive, negative, or zero?

   (a) positive
   (b) negative
   (c) zero

3. Given an object that is composed of $3.0 \times 10^{11}$ protons and $4.0 \times 10^{11}$ electrons, what is the object's net charge?

4. Rubbing a neutral plastic rod against a piece of neutral wool transfers $6.0 \times 10^{10}$ electrons from the wool to the rod. What is the net charge of the rod? What is the net charge of the piece of wool?

5. You have a neutral aluminum cube 1 cm x 1 cm x 1 cm?

   (a) How many protons are in the cube?

   (b) How many electrons are in the cube?

   (c) If the cube gains a charge of +1 nC, did it lose or gain protons or lose or gain electrons?

   (d) How many protons or electrons did it gain or lose?

6. Will a charged particle and neutral atom attract, repel, or not interact?

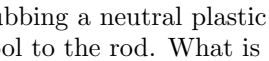
   (a) attract

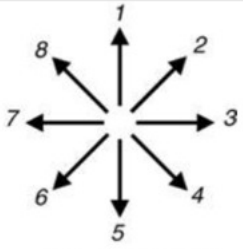
   (b) repel

   (c) not interact

7.

A negative point charge causes a neutral molecule to polarize, as shown below. What is the direction of the *electric force on the point charge,* due to the induced dipole?






*9* zero magnitude

8. A negatively charged ion is located to above of a neutral atom. Sketch a diagram showing the polarization of the atom. Sketch force vectors showing the force on the ion and the force on the neutral atom.