Source of Charge

- An atom
  - Protons – ___________ charge
  - Neutrons – ___________ charge, but same ___________ as proton
- Electron cloud
  - Electron – ___________ charge, ___________ mass
  - \( q_e = -1.60 \times 10^{-19} \text{ C} \)

- Unit of charge: ___________ (C)
- \( q_e \) is the ___________ charge discovered
- Electricity is ___________ \( \rightarrow \) comes in ___________ numbers
- \(|q_e|\) is the ___________ unit of charge
- In nature atoms have ___________ net charge
  - \# ___________ = \# ___________ 

How many electrons does it take to make a charge of \(-4 \times 10^{-6} \text{ C}\)? What is their mass \( m_e = 9.11 \times 10^{-31} \text{ kg} \)?

Law of Conservation of Charge

During any process, the net ___________ ___________ of a ___________ system remains ___________

- Like charges ___________
- Unlike charges ___________
  - The attraction and repulsion are ___________ and can be used with ___________ Laws and other dynamics problems

Conductors and Insulators

- Electricity can flow ___________ objects
- Conductors let electrons flow ___________
  - Most ___________ conductors are also ___________ conductors
  - ___________
- Insulators are very poor conductors
  - ___________ ___________ ___________ ___________

Charging by contact

- Negative charged rod gives some ___________ to sphere
- Sphere becomes ___________ charged until charges are ___________

Charging by Induction

- Charge without ___________
- Charged rod comes near ___________ sphere
- The like charges are ___________ to ___________ side of sphere
- A ___________ wire lets the charges ___________ from the sphere
- The ___________ wire is ___________, then the charged rod
- Sphere is ___________
If the sphere was ________ instead of metal
  o  Electrons ________ flow
  o  The surface would become ________ charged as the electrons in each individual atom rearrange, but no ________ effect
  o  ________ cling is made by this ________

**Homework**

1. There are very large numbers of charged particles in most objects. Why, then, don’t most objects exhibit static electricity?

2. An eccentric inventor attempts to levitate by first placing a large negative charge on himself and then putting a large positive charge on the ceiling of his workshop. Instead, while attempting to place a large negative charge on himself, his clothes fly off. Explain.

3. When a glass rod is rubbed with silk, it becomes positive and the silk becomes negative—yet both attract dust. Does the dust have a third type of charge that is attracted to both positive and negative? Explain.

4. Describe how a positively charged object can be used to give another object a negative charge. What is the name of this process?

5. What is grounding? What effect does it have on a charged conductor? On a charged insulator?

6. A metallic object is given a positive charge by induction. (a) Does the mass of the object increase, decrease, or remain the same? Why? (b) What happens to the mass of the object if it is given a negative charge by induction?

7. Common static electricity involves charges ranging from nanocoulombs to microcoulombs. (a) How many electrons are needed to form a charge of $-2.00 \text{ nC}$? (b) How many electrons must be removed from a neutral object to leave a net charge of $0.500 \text{ \mu C}$? (OpenStax 18.1) **1.25 \times 10^{10} \text{ electrons, 3.13 \times 10^{12} \text{ electrons}}**

8. If $1.80 \times 10^{20} \text{ electrons}$ move through a pocket calculator during a full day’s operation, how many coulombs of charge moved through it? (OpenStax 18.2) **-28.8 \text{ C}}

9. To start a car engine, the car battery moves $3.75 \times 10^{21} \text{ electrons}$ through the starter motor. How many coulombs of charge were moved? (OpenStax 18.3) **-600 \text{ C}}

10. A certain lightning bolt moves $40.0 \text{ C}$ of charge. How many fundamental units of charge $|q_e|$ is this? (OpenStax 18.4) **2.50 \times 10^{20} \text{ electrons}}

11. Suppose a speck of dust in an electrostatic precipitator has $1.0000 \times 10^{12} \text{ protons}$ in it and has a net charge of $-5.00 \text{ nC}$ (a very large charge for a small speck). How many electrons does it have? (OpenStax 18.5) **1.03 \times 10^{12} \text{ electrons}}

12. An amoeba has $1.00 \times 10^{16} \text{ protons}$ and a net charge of $0.300 \text{ pC}$. (a) How many fewer electrons are there than protons? (b) If you paired them up, what fraction of the protons would have no electrons? (OpenStax 18.6) **1.88 \times 10^{6}, 1.88 \times 10^{-10} \text{ electrons}}

13. Consider three identical metal spheres, A, B, and C. Sphere A carries a charge of $+5q$. Sphere B carries a charge of $-q$. Sphere C carries no net charge. Spheres A and B are touched together and then separated. Sphere C is then touched to sphere A and separated from it. Last, sphere C is touched to sphere B and separated from it. (a) How much charge ends up on sphere C? What is the total charge on the three spheres (b) before they are allowed to touch each other and (c) after they have touched? (Cutnell 18.5) **1.5q, 4q, 4q**