

Northeast Community College  
Diversified Manufacturing Technology

Conductors, Semi-Conductors, Insulators

PURPOSE:

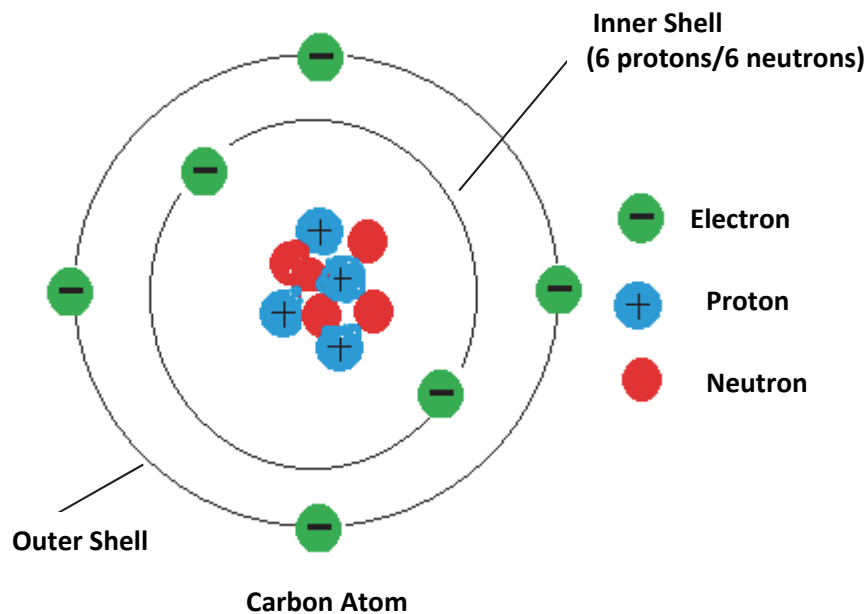
In the following experiment, you will determine which materials are conductors and which are not.

DISCUSSION:

The basic makeup of all materials consists of **atoms** that combine to form various elements and compound substances. These atoms are so tiny that they are invisible. Atoms are composed of even smaller particles called **protons** and **electrons** which are arranged in a systematic way.

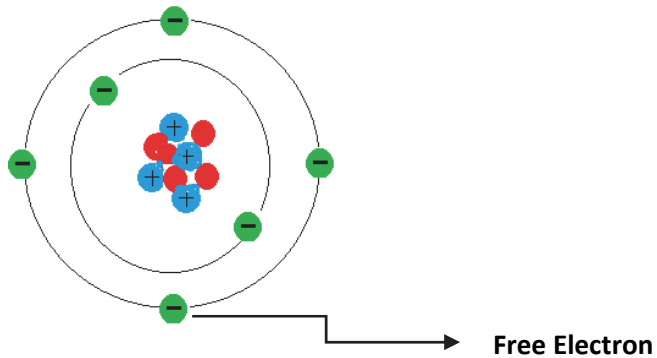
The following illustrates an atom. In the center of an atom is the nucleus containing the protons and **neutrons**. The nucleus is orbited by one or more electrons which are arranged in layers with each layer being further away from the nucleus.

The protons have a positive charge, while the neutrons are neutral. Electrons, on the other hand are negatively charged. Within an atom the protons (+) and the electrons (-) balance out so that the atom is neutral.

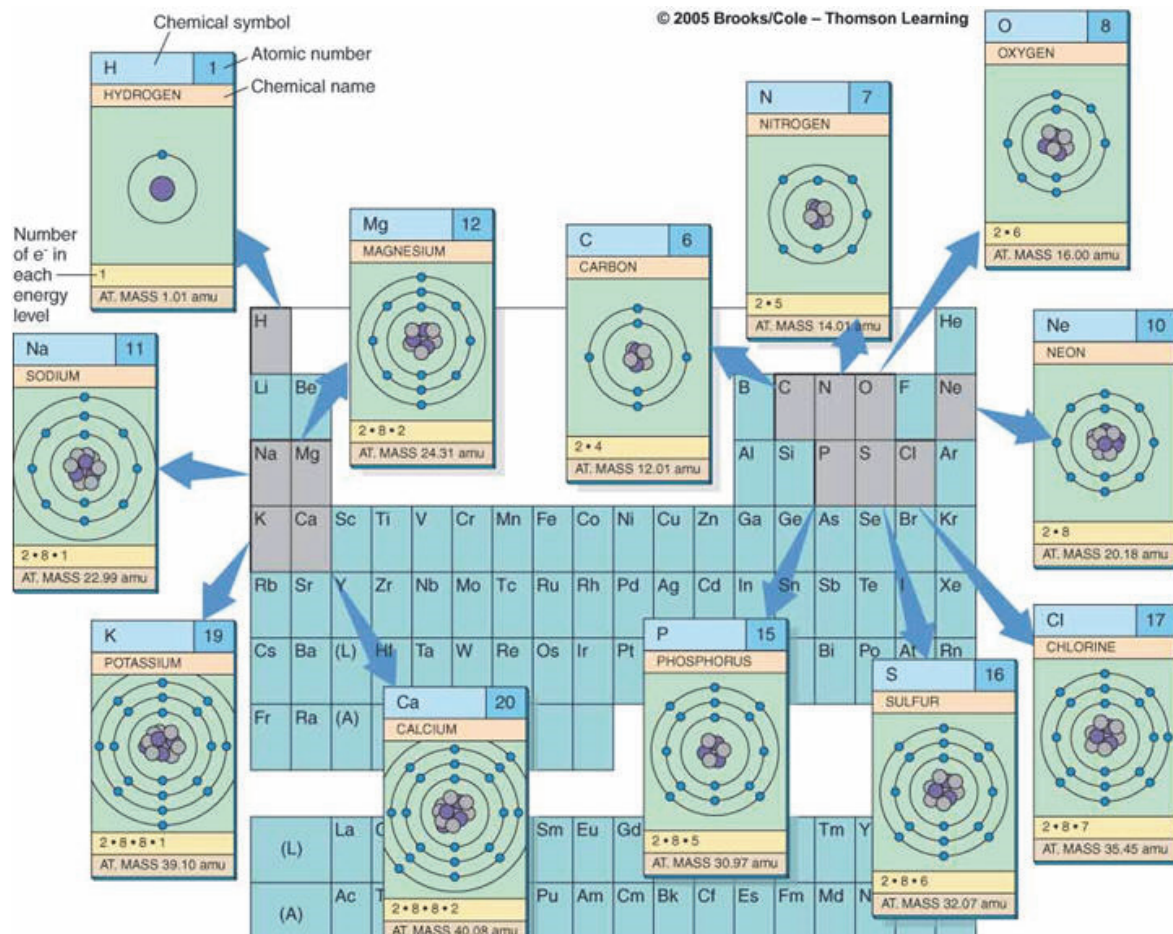


You may have heard the saying opposites attract. (Like charges repel.) There is an attraction, called a **charge**, between the positively charged protons and the negatively charged electrons. It is this attraction that prevents the electrons from flying into space. It is this attraction that is also the basis for electricity.

Electricity involves separating some of the electrons from the atom. Those electrons that are furthest from the nucleus (called **valence electrons**) are involved in the movement of electricity. Valence or **free electrons** are not strongly attracted to the nucleus and thus can be moved between atoms.



The basic difference between a **conductor** and an **insulator** is the number of electrons in the outermost shell (ring) of the element. The closer the outer shell is to being full (eight electrons) the harder it is to develop free electrons for current to flow. Inert gases such as Neon (Ne) and Argon (Ar) have eight electrons in their outer shell and are classified as insulators. Compounds such as glass, wood, and stone are also good insulators.



Source: Solomon, Berg, Et. Al. (n.d). *Biology*, 6<sup>th</sup> Ed. Cengage Learning. Used with permission.

A general rule of thumb is that if four or more electrons are in the outer ring of an element, they are held to that atom with a relatively strong force, and cannot be moved about very easily. Such materials are called insulators. Insulators do not conduct electricity very well.

If the outer ring of the element has less than four electrons, that element is known as a conductor. Elements with less than four electrons in their outer shell are held to the nucleus with relatively weak forces and are therefore easily moved from atom to atom.

If four electrons are present in an elements outer shell (rings) the materials is said to be a **semiconductor**. Semiconductors are materials that somewhat conduct electrons by not very well.

PROCEDURE:

1. Using [Circuit Construction kit](#), connect a 9-volt battery, a lamp, and wires as shown in Diagram 2-1 using the simulation.

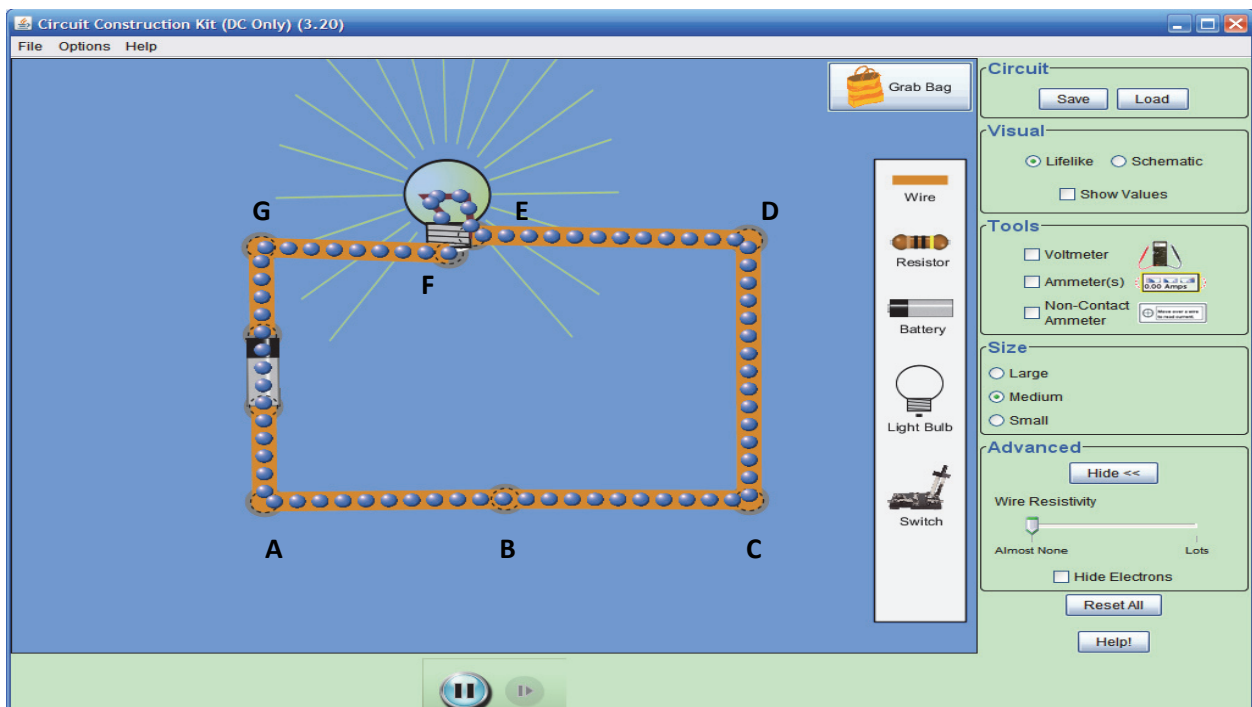


Diagram 2-1

2. Verify the voltmeter is working properly by placing the two leads together.



Record the value: \_\_\_\_\_ Diagram 2-2

If the reading was not zero, you need to check your voltmeter to determine why it is not working properly.

- Verify the voltage across the battery by placing the positive lead (red) on the positive terminal of the battery and the negative lead (black) on the negative terminal of the battery. The battery should be set at 9 volts. If it is not, right click on the battery and select “change voltage” to set the battery voltage at the proper setting.

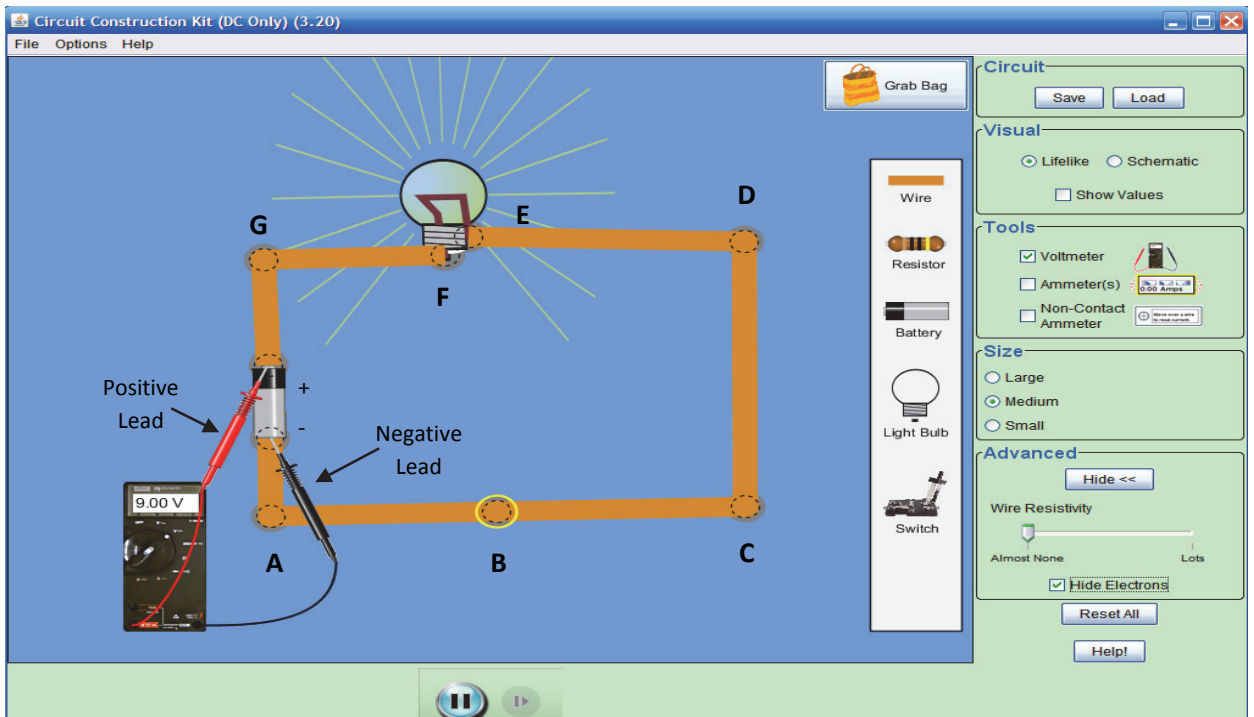


Diagram 2-3 – Shown without electrons

- With the positive lead on the positive terminal of the battery verify the voltage at points A, B, C, D, E, F, G using the negative lead on the voltmeter. Record your readings in TABLE 1 below.
- With the negative lead on the negative terminal of the battery verify the voltage at points A, B, C, D, E, F, G using the positive lead of the voltmeter. Record your readings in TABLE 1 below.
- With the non-contact ammeter record the current (Amps) in TABLE 1 as points A, B, C, D, E, F, G.



Diagram 2-4

TABLE 1  
Instrument Readings

Instrument	A	B	C	D	E	F	G
Negative Lead (Voltmeter)							
Positive Lead (Voltmeter)							
Ammeter							

7. Discuss why you think that after the lamp the voltages of F and G read zero when testing with the positive lead, or why the voltages of A, B, C, D, E read zero when tested using the positive lead of the voltmeter.
  
8. Discuss your results using the ammeter and why there is a difference between the readings of the ammeter and the voltmeter throughout the circuit.
  
9. Now reverse the battery by right clicking on the battery and selecting *Reverse*. Complete steps 4-5 recording your data in TABLE 2.

TABLE 2  
Instrument Readings

Instrument	A	B	C	D	E	F	G
Negative Lead (Voltmeter)							
Positive Lead (Voltmeter)							
Ammeter							

10. When comparing your results in TABLE 1 and TABLE 2, what conclusions can you draw about the flow of electrons from the battery and how can you tell.
11. With the battery remaining in reverse, record the results in Table 2 obtained using the non-contact ammeter.
12. Would an ammeter be a valuable tool in determining the direction of current flow? Why or Why Not.
13. Reverse your battery so that the positive terminal is closest to the lamp. Also select *hide electrons* under the “Advanced” column on the far right hand side of the page.

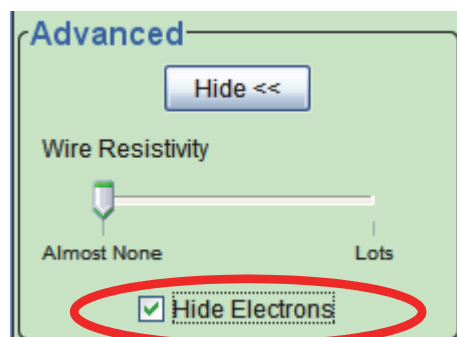


Diagram 2-5

14. By right clicking on the “B” wire junction, select *split junction* to separate the wires. Insert the dollar bill from the grab bag at point “B” being sure to connect the wires to the object. With the positive lead on the positive terminal of the battery verify the voltage passing through the grab bag material using the negative lead on the voltmeter. Record your readings in Table 3 below and indicate whether the materials is a conductor, semiconductor, or insulator. Prior to removing an

item from the grab bag, be sure to use the Non-Contact Ammeter to verify the current of each point. Complete the table using the remainder of the items in the grab bag.

TABLE 3

Data	Grab Bag Material						
	Paper (Dollar Bill)	Aluminum (Paper Clip)	Copper (Penny)	Rubber (Eraser)	Lead (Pencil)	Hand	Dog
Voltmeter							
Ammeter							
Conductor (C), Semi-Conductor (S), Insulator (R)							

15. In order for an ammeter to properly measure a value, what can you determine about current?

16. What types of materials in which you tested make the best insulators and best conductors?

## Conductors, Semi-Conductors, Insulators Vocabulary

Atoms – The smallest part of an element which contains all the unique characteristics of the element.

Protons - An atomic particle that is positively charged

Electrons – An atomic particle that is negatively charged.

Neutron – An atomic particle that has not charge

Charge – The process of accumulating an electric field.

Valence Electron – Refers to the electron in the outer ring of an atom.

Free Electron – A valence electron which has broken away from its original atom, and is free to move from atom to atom within the atomic structure.

Insulator – A material that resists the flow of free electrons and current.

Conductor – Materials which easily allow the flow of current.

Semi-Conductor – Materials that will allow some current to flow but not well.



Resources:

1. Solomon, Eldra, Linda Berg, Diana W. Martin (2002). *Biology*, 6<sup>th</sup> Ed. Cengage Learning.
2. University of Colorado Boulder (n.d.). PhET - [Circuit Construction Kit](#).

Founded in 2002 by Nobel Laureate Carl Wieman, the PhET Interactive Simulations project at the University of Colorado Boulder creates free interactive math and science simulations. PhET sims are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery.

3. Grant Statement

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