Name _____ Date _____ Period _____

Lab: Electricity and Circuits

CHAPTER 34: CURRENT ELECTRICITY

BACKGROUND: Just as water is the flow of H_2O molecules, electric current is the flow of charged particles. In circuits of metal wires, **electrons** are the flowing charged particles. This is because one or more electrons from each metal atom are free to move throughout the atomic lattice. These charge carriers are called ***conduction electrons***. Protons, on the other hand, do not move because they are bound inside the nuclei of atoms that are more or less locked in fixed positions.

Any path along which electrons can flow is a ***circuit***. For a continuous flow of electrons, there must be a complete circuit with no gaps. A gap is usually provided by an electric switch that can be opened or closed to either cut off or allow energy flow.

MATERIALS:

- Light bulb
- Battery
- Wires (2)
- Light socket
- Switch
- Penny
- Glass rod
- Pencil "lead"
- Aluminum foil
- Metal rod
- Poker chip (plastic)
- Cardboard

PROCEDURE:

1. Form groups of 3 to 4 students each.

2. Obtain a bag containing the required materials (see above). Make sure you return all the materials to the bag when you are finished with the lab.

3. Complete each of the Experiments below and record your results. Answer question in each section before you more on.

EXPERIMENT 1:

- Obtain one battery, one light bulb, and one wire. Connect these in as many ways as you can. **Sketch** each arrangement below. On the left side of the page, list arrangements in which the bulb lights. On the right side of the page, sketch arrangements in which the bulb does *not* light.

Question 1: You should have sketches of at least four different arrangements that light the bulb. How are they similar? How are they different from arrangements in which the bulb fails to light?

Question 2: What requirements must be met in order for a bulb to light?

*An arrangement of a bulb, a battery and a wire that allows the bulb to light is said to be a **closed electric circuit**. The terms **complete circuit**, or just **circuit** are also used. The word "**circuit**" was originally used to mean "a circular route or course."*

Question 3: Why is a circuit an especially suitable name for an arrangement of bulb, battery, and wire in which the bulb is lit?

Question 4: Write an operational definition of **an electric circuit**. (An operational definition is a list of steps to follow to determine if you have what is being defined.)

EXPERIMENT 2:

- Using a bulb, a battery, and two wires, set up an electric circuit in which the bulb is lit. Does it matter which part of the bulb is connected to the end of the battery with the plus sign on it?

Conductors and insulators: Substances can be divided into categories based on their effect on an electric circuit. In the following experiment we classify some common substances.

EXPERIMENT 3:

- Use a battery, a bulb, and two wires to make a circuit in which the bulb lights. Insert at least a half-dozen various objects (a penny, a glass rod, pencil lead, cardboard, etc.) into the circuit, one at a time.

Question 5: Does the bulb continue to glow brightly or does it dim or go out? Classify your materials into different categories according to their effect on the bulb. Complete the table below describing the results.

Material	Glow brightly/ Dims / Goes out	Conductor / Insulator

NOTE: An object that allows the bulb to glow brightly is called a conductor. An object that makes the bulb go out is called an insulator. Some objects, like pencil lead, fall between the two categories

Question 6: What do most objects that let the bulb light have in common?

Questions 7: What is the definition of a ***conductor***?

Question 8: What is the definition of an ***insulator***?

EXPERIMENT 4:

- Suppose you have a closed box from which two wires protrude.

Question 9: Explain how to use a battery and a bulb to find out whether there is an electrical connection between the two wires inside the box.

EXPERIMENT 5:

- Carefully examine a bulb. Make a careful sketch the entire bulb, including the inside of the bulb.

Use your test circuit from Experiment 3 to determine whether each part of the bulb is a conductor or an insulator and label it on your **sketch**. **Describe** what you believe is the purpose of each part.

Note the two wires coming up from inside the base of the bulb. Use your test circuit to determine where in the base each of these wires originates. Draw a label.

EXPERIMENT 6:

- For convenience, light bulbs are usually placed in sockets. Carefully examine a socket. Identify the conducting and insulating parts, and **label** these on a careful **sketch** of the socket. Use the method you invented in Exercise 5 to determine which of the conducting parts are connected to one another and show the connections in your sketch.

- If there is more than one type of socket available, repeat this experiment for each type. Identify which parts of one type of socket correspond with which parts of other types.

- Repeat the experiment for **a battery holder** and **switch**. Try the switch both open and closed.

Question 10: What do you think is the function of a switch?

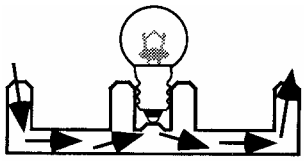
- Using a **battery**, a **holder**, a **bulb**, a **socket**, and **two wires**, set up a circuit that lights the bulb. Trace the path of conductors around the circuit. Draw a **sketch** of the circuit in which you show in detail the conducting path through the socket.

EXPERIMENT 7:

Consider the following dispute between two students:

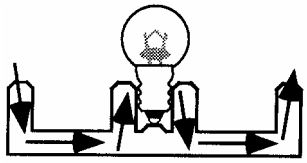
Student 1:

"Here is how a socket works. When the bulb is screwed in, it makes contact with the conductors in the socket as shown in the diagram. The socket thus provides access to the electricity in a safe manner without exposing the user to the electricity."



Student 2:

"No that's not how a socket works. My diagram shows how the socket really works. The screw threads on the bulb serve a dual purpose-to hold the bulb in place and to make a connection with the wires. The rivet at the bottom just holds the socket together."



Question 10: Do you agree with student 1, student 2, or neither? Why?

EXPERIMENT 8:

- Connect a battery, a bulb, and a switch so that they form a single closed loop.

  Observe the appearance of the bulb as you open and close the switch. Under which circumstances is the circuit not complete? A circuit that is not complete is called an ***open circuit***.

- Connect a switch and a bulb together so that they form a closed loop. With the switch in the open position and still connected to the bulb, connect the ends of the switch to the ends of the battery.

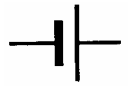
- Observe the appearance of the bulb as you close and open the switch quickly. *Do not leave the switch closed.*

- You have just seen that even when a bulb is in a ***complete circuit***, it will not light if there is a wire, or switch, connected across it. In such cases, the wire, or switch, is called a ***short*** or a ***short circuit***, and the bulb is said to be "***shorted out***."

Question 11: Summarize the conditions under which closing a switch turns a bulb on and the conditions under which closing a switch turns a bulb off.

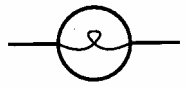
Circuit Diagrams:

Circuit diagrams let us represent a circuit on paper by using symbols for the batteries and bulbs instead of drawing pictures. The symbol for a ***battery*** is:



The ends of a battery are called ***terminals***. The long line represents the positive terminal of the battery (knob end), the short line represents the negative terminal (flat end).

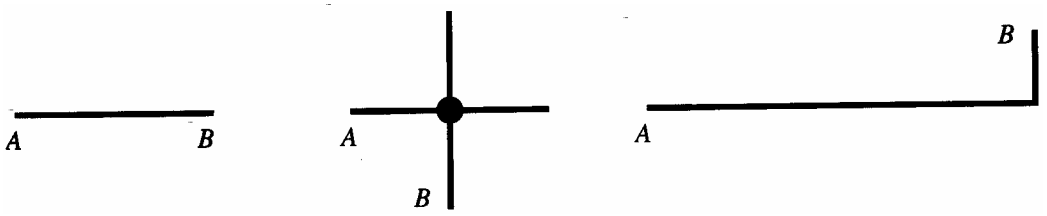
The knob and screw base of a bulb are also called terminals. The symbol for a ***bulb*** is:



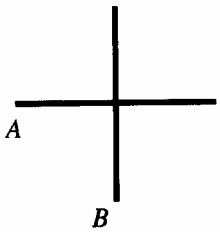
Note that although the symbol for a battery shows it has two different terminals, the symbol for a bulb shows no difference between the two terminals.

The symbol for a ***switch*** is:

The representation used for wires is more complicated that the simple symbols for batteries, bulbs, or switches. As we have seen, contact through a conductor is just the same electrically as direct contact. Direct contact and connection by a wire are therefore represented by the same symbol: a line or a group of connected lines. In each case below, the diagrams show that points *A* and *B* are electrically connected.



Sometimes it is necessary to draw a circuit in which a wire crosses over another wire, but no electrical connection is made. The symbol used for this is show at right. In this case the diagram shows that points *A* and *B* are *not* electrically connected.



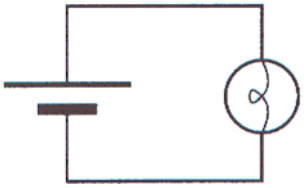
Individual parts of a circuit, such as batteries, bulbs, and switches, are often called *circuit elements.* From a circuit diagram, we cannot tell whether two elements of a circuit are far apart and connected by a wire or whether the elements are actually touching. This

ambiguity is often confusing because it means that the diagram for a circuit may look quite different from its actual physical appearance. On the other hand, this kind of diagram is particularly useful in analyzing circuits because it focuses on electrical connections rather than the physical arrangement of the circuit.

This last fact is worth emphasizing:

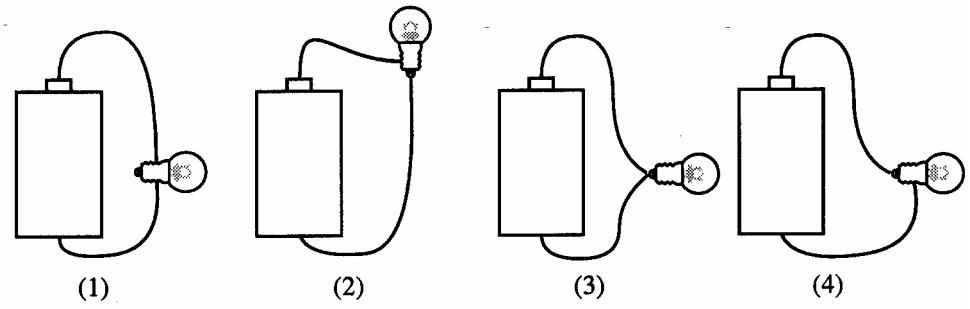
Circuit diagrams show electrical connections,
<u>not</u> physical layout.

We have found that a bulb will light only if there is a complete circuit: a closed loop from one end of the battery, through the bulb, and back to the other end of the battery. A circuit diagram that shows a bulb connected to a battery to form a complete circuit is shown in the accompanying diagram. The wires from the battery are often referred to as positive and negative *leads*.



<u>EXPERIMENT 9:</u>

Questions 12: In which of the circuits below will the bulb light?

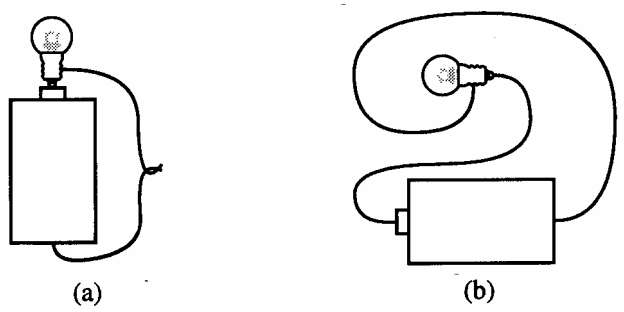


- Draw standard circuit diagrams for the four arrangements of battery, bulb and wires shown above.

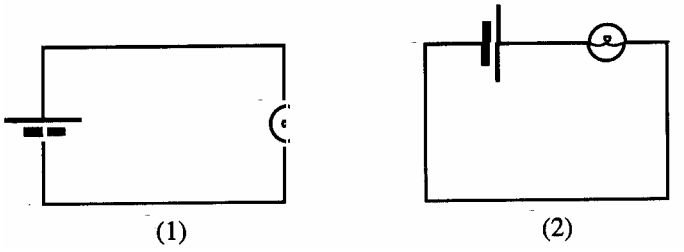
Question 13: Which of the circuits above have identical circuit diagrams?

EXPERIMENT 10:

- Draw the circuit diagram for each of the following circuits:



Question 14. In which of the following circuits are two wires *required*: only circuit 1, only circuit 2, both circuits, or neither circuit?



Question 15: Can circuit diagram 1 above represent circuit (a) above? Can it represent circuit (b)?

Question 16: Can circuit diagram 2 above represent circuit a in part A? Can it represent circuit b?

Question 17: Discuss the ways in which this exercise illustrates that a circuit diagram does not indicate the physical layout of a circuit.

EXPERIMENT 11:

- In Experiment 1 you found four arrangements of a battery, a bulb, and a single wire that light the bulb. **Sketch** a **circuit diagram** for each of the four arrangements.

Question 18: Which of the four arrangements can be represented by the same circuit diagram? Explain.