Period 11 Activity Sheet: Electric Current

Activity 11.1: What is an Electric Circuit?

a) Lighting a bulb  Arrange one small light bulb (not in a tray), one connecting wire, and one battery so that the bulb lights. You may need to try several different arrangements.

1) Draw a diagram showing how you arranged the bulb, wire and bulb.

This arrangement makes a complete circuit from the battery through the bulb and back to the battery. The bulb has connecting pathways through the side and bottom of its base. Arrangements, which do not connect the side and bottom of the bulb base, do not form a closed circuit and will not light the bulb.

b) Plumbing Analogies  Your instructor will demonstrate plumbing analogies for circuits. Fill in the electrical concepts represented by the plumbing display.

1) Water  __ electric charge__
2) Water (flowing)  __ electric current__
3) Water pressure  __ voltage__
4) Plastic tubes  __ connecting wires__
5) Narrow plastic tubes  __ resistors__
6) Pump  __ battery or other current source__

An open circuit in a flashlight could be caused by:

- a burned out bulb (the bulb filament is broken),
- the long copper switch not touching metal at its bottom or at its top,
- the batteries not touching one another, or
- dead batteries, which send no charge through the circuit.
d) Group Discussion Question: Are charges “used up” to make a bulb light? If not, what happens to make it light?

**Current is not used up.** The same amount of charge that leaves the battery flows through the circuit and returns to the battery. As charge flows through a resistor, the moving charges collide with atoms in the resistor, transferring some of their kinetic energy to the atoms. The kinetic energy of the atoms increases, raising their thermal energy and the temperature of the resistor. In a light bulb, the resistor (filament) is heated until it glows.

**Activity 11.2: What is Electric Current?**

a) **Electric current is a flow of charge**

Connect a D cell battery and a one-bulb tray with connecting wires so that the bulb lights.

1) Using a multimeter, measure the current that flows through the circuit. _____________

2) If this current flows for 10 seconds, calculate how many coulombs of charge have moved through the circuit.

\[
\text{Solve } I = \frac{Q}{t} \text{ for } Q: \quad Q = I \times t
\]

b) **Electric current and power**

1) Select appliances from your table and measure their current, voltage, and power with a wattmeter. Record your data in the table below.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power ( P ) (watts)</th>
<th>Voltage ( V ) (volts)</th>
<th>Current ( I ) (amps)</th>
<th>Calculate ( I \times V )</th>
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2) Do you see a relationship among these three variables? Write an equation that describes the relationship among current, voltage, and power.

The values for current times voltage are approximately equal to the measurement of the power.

\[
P = I \times V
\]

**Activity 11.3: What Voltage Boosts and Drops Occur in a Circuit?**

a) **Batteries in series** In this activity, use loose batteries on your table. Please do NOT take batteries out of the battery trays!

1) Using a multimeter, measure the voltage across one D cell battery. _____________

Measure the voltage across a second D cell. _____________
2) Hold the two batteries together in series as they would be in a flashlight. What is the voltage across BOTH of the batteries? First, think about what might happen, and then measure the voltage.

   Prediction: _______________  
   Measurement: _______________  
   The voltage across the two batteries is the sum of the voltage across each battery.

3) What will happen to the voltage if you reverse the direction of one of the batteries?

   Prediction: _______________  
   Measurement: _______________  
   The voltages of the batteries cancel each other, so the voltage across both batteries is zero.

4) Hold four batteries together in series and measure the voltage across them. _______________

5) Reverse the direction of one of the four batteries. Predict and then measure the voltage across the four batteries.

   Prediction: _______________  
   Measurement: _______________  
   The voltages of the two reversed batteries cancel each other.

b) Voltage boosts and drops in a circuit: Connect a 3-battery tray and two 1-bulb trays with connecting wires so that the bulbs light. Using a multimeter, measure the voltage boosts and drops across the batteries, the bulb trays, and the connecting wires. (When measuring the connecting wires, place the end of the multimeter lead at the tip of the connecting wire clamp.)

   ![Diagram of battery and bulb setup]

   Voltage Boosts                  Voltage Drops
   Points A to B                   Points D to E
   Points B to C                   Points E to F
   Points C to D                   Points F to G
   Points G to H
   Points H to A

1) What is the total voltage boost across the batteries? _______________
2) What is the total voltage drop across the bulbs and wires? _______________
3) How do the total voltage boosts and total voltage drops in the circuit compare?

   The total voltage boosts and total voltage drops are equal.
Activity 11.4: What Does the Electrical Resistance of a Wire Depend Upon?

a) **Resistor length, \( L \)** Use a **multimeter** to measure the resistance of the wires on the green board.
   1) Measure the resistance of the thin 30 cm nichrome wire. __________
   2) Measure the resistance of the 15 cm nichrome wire. ______________
   3) Does resistance, \( R \), increase or decrease with increasing length, \( L \)? _The resistance increases with increased length._

b) **Resistor thickness, \( A \)**
   1) Using a multimeter, measure the resistance of the thick 30 cm wire. _____________
   2) Does resistance, \( R \) increase or decrease with increasing cross sectional area, \( A \)? _The resistance decreases with increased cross sectional area (thickness) of the wire._

c) **Resistivity:** The resistance of wires also depends upon their resistivity (\( \rho \)). Resistivity is affected by the type of wire material and the temperature of the wire.

   1) **Resistor material:** Connect a 3-battery tray, a one-bulb tray, and a piece of copper with connecting wires. Note the brightness of the bulb. Then replace the copper with other materials and note the brightness of the bulb. Indicate which materials have the most resistance, intermediate resistance, and least resistance.

<table>
<thead>
<tr>
<th>Material</th>
<th>Bulb brightness</th>
<th>Resistance</th>
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</thead>
<tbody>
<tr>
<td>a) Copper</td>
<td>brightest</td>
<td>least</td>
</tr>
<tr>
<td>b) Plastic</td>
<td>not lit</td>
<td>high</td>
</tr>
<tr>
<td>c) Graphite</td>
<td>barely lit</td>
<td>intermediate</td>
</tr>
<tr>
<td>d) Glass</td>
<td>not lit</td>
<td>high</td>
</tr>
<tr>
<td>e) Iron</td>
<td>bright</td>
<td>low</td>
</tr>
</tbody>
</table>

   2) **Resistor temperature:** Connect 3 D cell batteries, a one-bulb tray, and a resistor with connecting wires. Note the brightness of the bulb.

   Your instructor will give you liquid nitrogen. (**Caution:** liquid nitrogen quickly freezes skin. Avoid getting liquid nitrogen on your skin.) Carefully put the resistor into the liquid nitrogen and note the bulb’s brightness.

   a) What happens to the brightness of the bulb? __________________________

   b) Does resistance increase or decrease as the temperature decreases?

   _Resistance decreases as the temperature decreases._

   c) We have found that the resistance of a wire, \( R \), is directly proportional to length, \( L \), and inversely proportional of cross sectional area, \( A \). Resistivity, \( \rho \), combines resistor material and temperature. For a given type material, \( \rho \) is directly proportional to resistance. Using these variables, write an equation for the resistance of a wire.

   \[ R = \rho \frac{L}{A} \]