Name _____ **Section** _____

Period 13 Activity Sheet: Electrical Resistance and Joule Heating

Activity 13.1: 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 of the same thickness. _____
3) Does resistance ***R*** increase or decrease with increasing length ***L*** ? _____

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*** ? _____

c) **Resistivity:** The resistance of wires also depends upon the resistivity (ρ), of the wire material.

Use connecting wires to connect a 3-battery tray, a one-bulb tray, and a piece of copper in series. Note the brightness of the bulb. Then replace the copper with other materials and note the brightness of the bulb. Indicate which materials have high resistance, intermediate resistance, and low resistance.

	Material	**Bulb brightness**	**Resistance**
a)	Copper		
b)	Plastic		
c)	Graphite		
d)	Glass		
e)	Iron		

d) **Relationship between *R, L, A*, and** r: We have found that the resistance of a wire, ***R***, is directly proportional to length, ***L***, and inversely proportional to the cross-sectional area, ***A.*** For a given type material, the resistivity, ρ, is directly proportional to the resistance. Using these variables, write an equation for the resistance of a wire.

e) The resistivity of copper at room temperature (20^o C) is 1.7×10^{-8} Ω-m. What is the resistance of a piece of copper wire 0.10 meters long with a cross-sectional area of 0.01 meters^2 ?

_____

Activity 13.2: How Do High Resistance Wires Affect Current Flow?

a) Use a **digital multimeter** to measure resistance. Note: Do **NOT** connect the wires to a battery when measuring their resistance.

1) Measure the resistance of one of the nichrome wires on the red board _____

2) Measure the resistance of the other nichrome wire on the board. _____

b) Connect a 4 bulb tray to a 3 battery tray using connecting wires. Note the brightness of the 4 bulbs. How will the brightness of the bulbs change if one of the nichrome wires on the red board is added to the circuit in series with the 4-bulb tray and the batteries?

Prediction: _____ **Answer:** _____

Your instructor will show you how to connect a nichrome wire to the circuit. Explain what happens when the nichrome wire is added to the circuit.

c) How much joule heating occurs in the high resistance wires?

1) Using the **digital multimeter,** measure the voltage across the high resistance wire. _____

2) Using your measurement of the resistance of the wire from part a.1), calculate the amount of current through the high resistance wire when it is connected in series to the battery and the bulb tray.

_____

3) Calculate the amount of joule heating in the high resistance wires.

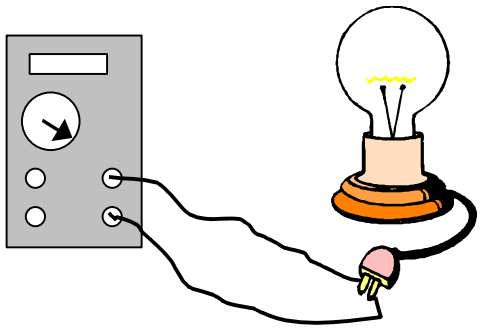
_____

d) Group Discussion Question: Do you think joule heating in a wire is an advantage or a disadvantage?

Name _____ **Section** _____

Activity 13.3: How Does Temperature Affect Resistance?

a) **A heated resistor:** Your instructor will show you how to measure the resistance of a light bulb. We first measure the resistance of the bulb at room temperature **before** it is plugged in. As shown in the diagram, use a **digital multimeter** on the ohms setting to measure the resistance of the **UNPLUGGED** bulb. _____



Caution: Do NOT plug the bulb into an outlet.

b) Next, we will calculate the resistance of the light bulb when it is hot. Plug the bulb into a wattmeter and plug the wattmeter into a power strip. Use the wattmeter to measure the bulb's voltage and current while it is operating.

1) Voltage across the bulb _____

   current through the bulb _____

2) Calculate the resistance of the light bulb when it is operating.

   _____

3) How does the calculated resistance when the bulb is hot compare to the measured resistance when the bulb is at room temperature?

c) Group Discussion Question: A light bulb filament usually burns out when the light is first turned on. Why is the bulb more likely to burn out when it is first turned and is still cool than when the filament is hot?

d) **A cooled resistor:** Use connecting wire to connect in series a 3 battery tray, a single bulb tray, and a resistor. Note the brightness of the bulb. (**Caution:** the resistor will quickly become very hot.)

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.

1) What happens to the brightness of the bulb? _____

2) Does resistance increase or decrease as the temperature decreases? _____

e) Group Discussion Question: How could you reduce the joule heating of a wire? Could your ideas be used to reduce the energy wasted as joule heating in long distance power transmission lines?