

**Subject Area:** Physics

**Title:** Electric Energy from Heat

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**Objectives:** This activity is for 8-12 grade students to investigate conservation of energy, thermoelectricity, Seebeck effect, Peltier effect, thermocouple, thermopile, and calibration.

**Material Needed:**

PASCO or Lab pro	Ice
Temperature probes	Hot Plate
Glass Beakers (2)	Glass beakers (2)
Heat source (matches, Bunsen burner)	Copper Wire
Iron Wire	
Galvanometer, milliammeter or similar current detector	

**Strategy:**

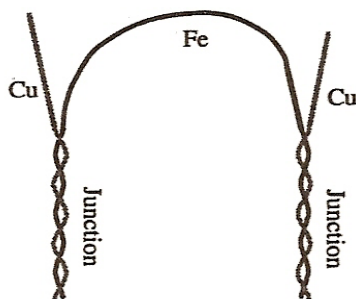
*The principle of conservation of energy states we can neither create nor destroy energy, but simply convert it from one form to another.* Other forms of energy are converted to electric energy by means of electromagnetic (generators), photoelectric (photocells), piezoelectric (microphones), chemical (batteries), or thermoelectric (thermocouples) processes. In this activity you will investigate thermoelectric conversion, which is the transformation of heat energy directly into electric energy.

**Thermocouple (Seebeck effect):**

On March 9, 1979, the *Voyager 2* spacecraft was launched from Cape Kennedy, Florida, on the grandest space exploration mission ever attempted. *Voyager 2*, designed by NASA's Jet Propulsion Laboratory traveled for ten years before leaving the solar system. During this time, *Voyager 2* sent back a wealth of images and data on the planets Jupiter, Saturn, Uranus, and Neptune. Previous spacecraft relied heavily upon solar panels to convert sunlight into the electricity needed to run the spacecraft's instrumentation, but scientists realized that the intensity of solar radiation would be far too weak to power the spacecraft by the time it reached Jupiter. Consequently, NASA engineers designed a supplemental system that generated electricity from the heat produced by the decay of radioactive elements. Their thermoelectric generator relied upon a principle discovered by the German physicist Thomas Seebeck in 1821. *The Seebeck effect refers to the generation of electricity in a circuit composed of two wires whose junctions are at different temperatures.* In this activity you will have the opportunity to make your own thermoelectric generator.

**Procedure:**

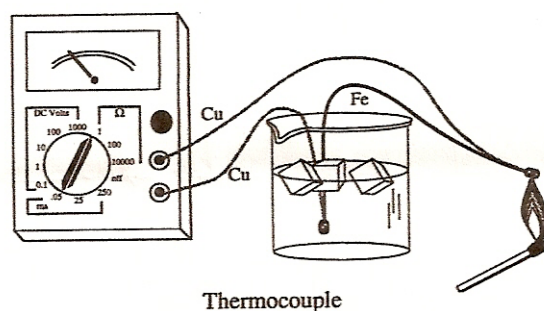
1. Create thermocouple junctions at both ends of a section of iron wire by twisting the ends together with copper wire, as shown below (figure 1).



Thermocouple

Figure 1

2. Place one copper/iron junction in a beaker filled with ice water while leaving the other junction outside (figure 2).



Thermocouple

Figure 2

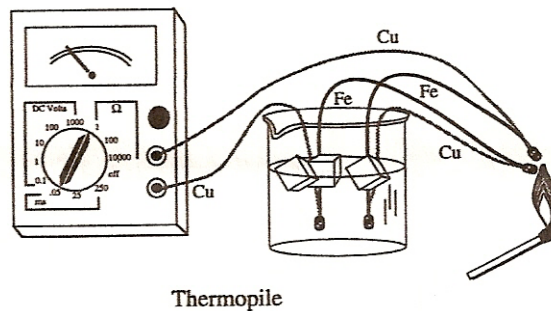
3. Connect the two remaining ends of the copper wires to the galvanometer, milliammeter, or similar current detector.

4. Heat the exposed junction with a Bunsen burner or match and record the current. Does the current increase or decrease if the heat source is removed? Is the change in current immediate? Why or why not?

**Thermopile:**

When two or more batteries are placed in series a higher voltage is generated and more current is produced. Can the voltage and current of a thermoelectric system be increased by adding two or more thermocouples in series? Try it.

5. Connect an additional thermocouple in series with the first, as illustrated in Figure 3. Be sure one junction of this new thermocouple is in the water while the other is in the flame.



Thermopile

Figure 3

6. Repeat with three and four thermocouples in series. Describe the relationship between the number of thermocouples in series and the current generated. You may want to bundle the thermocouple wires together with string so the resulting thermopile is easier to manage.

The current produced by a thermocouple or thermopile is directly related to the temperature difference between the two junctions. Calibrate a thermopile or thermocouple by plotting the amperage measured on a galvanometer as a function of the temperature registered on the PASCO or Lab pro temperature probe.

7. Place a reference junction in a beaker filled with ice water and the thermocouple in a second beaker. When the second beaker is filled with ice water there should be no flow of electricity since both junctions are at the same temperature.

8. Gradually warm the second beaker until it boils, plotting the amperage of the circuit as a function of temperature (Figures 4 and 5). Once you have completed the calibration curve, measure the temperature of various things using your new thermoelectric

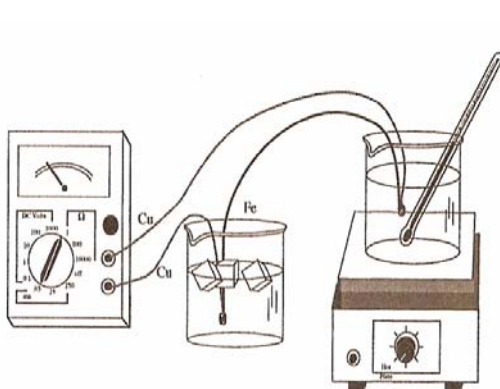


Figure 4

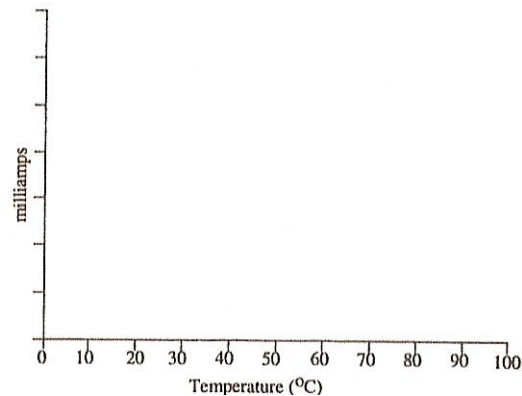


Figure 5

### **Questions:**

1. What is the relationship between the temperature difference of the two junctions of a thermocouple and the resulting current?
2. Explain why the current generated by the thermocouple does not change instantly when the heat source is removed.
3. A thermopile is a group of thermocouples placed in series. Based upon your measurements, describe the relationship between the number of thermocouples and the resulting current.
4. Settlers in remote regions of Siberia use thermoelectric generators to produce electricity from burning wood or kerosene. How might you design such a device to produce a current large enough to meet household needs?
5. What advantages are there to a thermoelectric thermometer compared with an alcohol thermometer?
6. The Seebeck effect describes the generation of an electric current when a temperature differential exists between two junctions of a thermocouple. The reverse situation is known as the Peltier effect, in which an electric current generates a temperature difference between the junctions of a thermocouple. Describe possible uses of the Peltier effect.

### **References:**

Cunningham, James & Herr, James; *Hands-On Physics Activities with Real Life Applications*: Center for Applied Research in Education: 1994