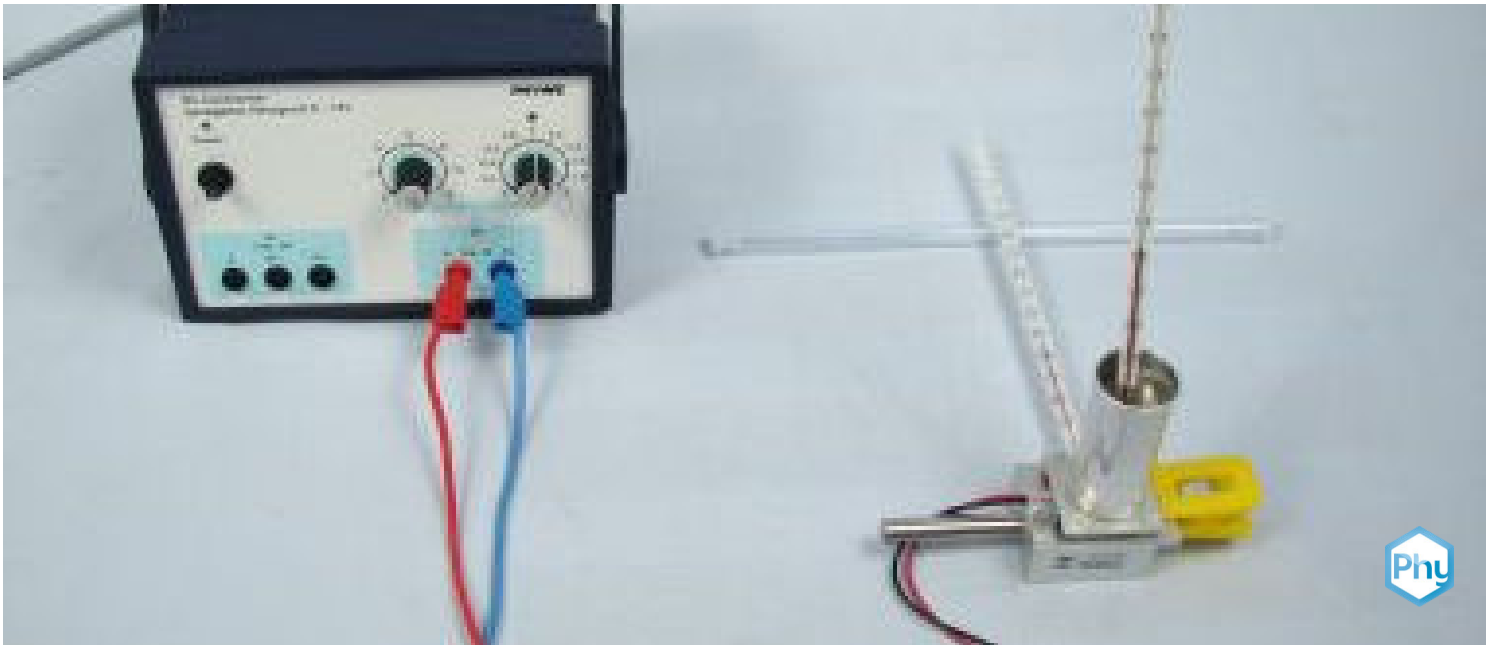
Peltier effect: cooling engine



Physics	Thermodynamics	Conversion of heat, entropy	
Physics	Energy	Renewable energies: Earth	

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/62e814ea99933e00032706bb

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Teacher information

Application

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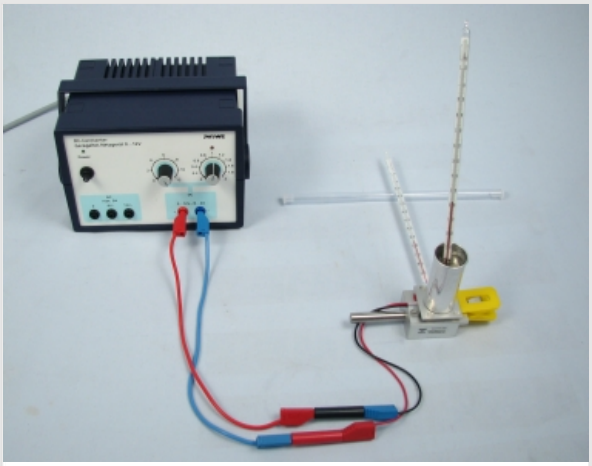

Experimental setup

The Peltier element (the thermogenerator) consists of many thermocouples. These are connected electrically in series and thermally in parallel so that their thermoelectric voltages add up.

Instead of using the thermogenerator to convert heat into electrical energy, we demonstrate the Peltier effect here. This consists of the fact that a current flowing through the Peltier element causes one of the Peltier element plates to heat up and the other to cool down.

The higher the current strength, the faster the two plates heat up or cool down.

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Other teacher information (1/3)

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Prior knowledge

Students should be familiar with the basic concepts of thermodynamics.

Principle

In this experiment, a Peltier element is put into operation and it is investigated how a temperature difference can be generated with an electric current flow.

Other teacher information (2/3)

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Learning objective

The students learn how a Peltier element can be used to create cooling.

Tasks

A beaker with water stands on the Peltier element of the thermogenerator. If a current is allowed to flow through this Peltier element with the correct polarity, the upper plate of the Peltier element cools the water.

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Other teacher information (3/3)

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Notes on set-up and procedure

Care should be taken to ensure that the Peltier element does not have electricity flowing through it for too long when it is unattended, as it would continue to heat up permanently and become damaged.

Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

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Student information

Motivation

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Car air conditioning system

Air conditioning systems are standard equipment in motor vehicles and can also be found in various buildings.

The technology to generate cold in a targeted manner is also of great importance in refrigerators, freezers and quite a few industrial processes and there are many different ways to achieve this.

One of them is the current-carrying Peltier element, which can be used to create a temperature difference.

This experiment takes a closer look at this physical phenomenon.

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Tasks

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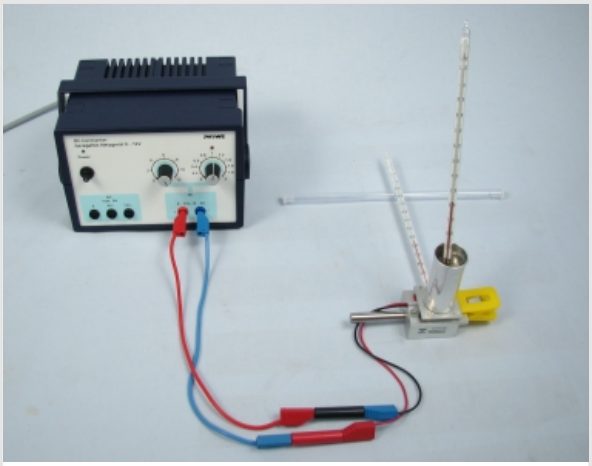

The experimental setup

A beaker with water stands on the Peltier element of the thermogenerator. If a current is allowed to flow through this Peltier element with the correct polarity, the upper plate of the Peltier element cools the water.

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Equipment

Position	Material	Item No.	Quantity
1	Thermal generator for student experiments	05770-00	1
2	Beaker, aluminum, polished	05903-00	1
3	Lab thermometer,-10..+110 °C	38056-00	2
4	Beaker, 100 ml, plastic (PP)	36011-01	1
5	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
6	Double sockets,1 pair,red a.black	07264-00	1
7	Connecting cord, 32 A, 250 mm, red	07360-01	1
8	Connecting cord, 32 A, 250 mm, blue	07360-04	1
9	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Set-up (1/2)

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1. Attach the Peltier element to the aluminium block using the yellow clamp (Fig. 1). Note that the smaller side of the Peltier element is on top.

2. Now connect the thermogenerator to the power supply unit using the two double sockets and the cables (Fig. 2). The power supply unit is switched off. Make sure that the red cable of the thermogenerator is connected to the negative pole of the power supply unit (blue socket) and the black cable to the positive pole (red socket).

3. Turn the current regulator up to 1 A and the voltage regulator all the way up (Fig. 3).

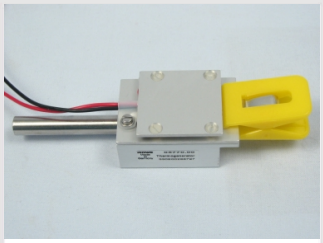

Figure 1

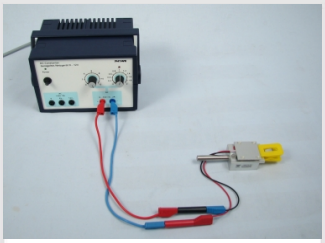

Figure 2

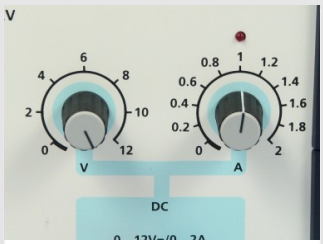

Figure 3

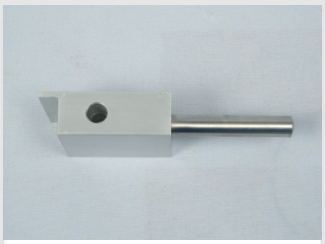

Figure 4

Set-up (2/2)

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4. On one side of the aluminium block there is an opening for temperature measurement (Fig. 4).

5. Insert one of the two thermometers into this opening. Make sure that the tip of the thermometer touches the aluminium block (Fig. 5).

6. It might be helpful to place the other end of the thermometer, for example, on the sheath in which it is kept in the box (Fig. 6).

7. Control measurements with an infrared thermometer are useful (Fig. 7).

8. Now dip the second thermometer into the water (Fig. 8).

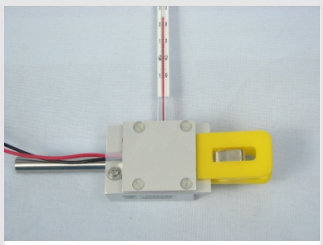

Figure 5

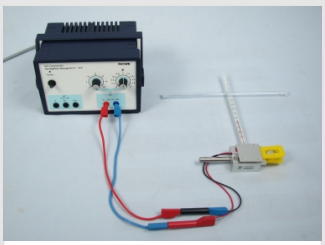

Figure 6

Figure 7

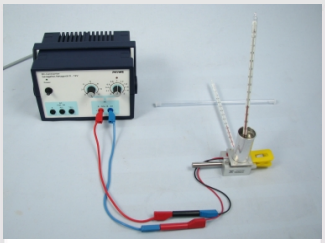

Figure 8

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Procedure (1/2)

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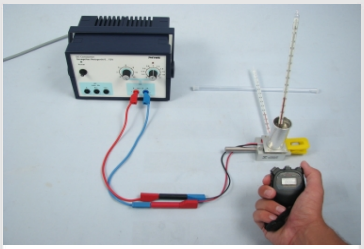

Figure 9

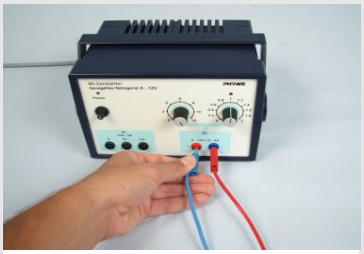

Figure 10

1. Measure the temperature ϑ_1 of the water and the temperature ϑ_2 of the aluminium block (currently t= 0) and note them down. Now switch on the power supply unit and note down the temperatures. ϑ_1 and ϑ_2 at the times t= 1,2,3,4,5 in your report (Fig. 9).

2. Switch off the power supply unit, pour the water out of the beaker and place the Peltier element on the table. Wait until the aluminium block has cooled down again. Then repeat the measurement with a current of 0.5 A and note the measured values.

3. Switch off the power supply unit, pour the water out of the beaker and place the Peltier element on the table. Swap the connection cables on the power supply unit (Fig. 10).

Procedure (2/2)

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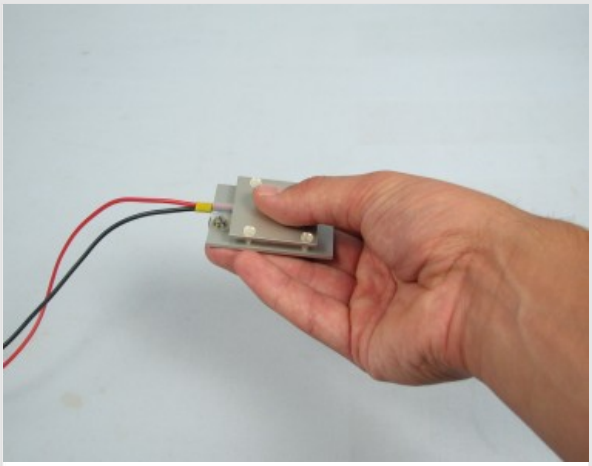

Figure 11

4. Take the Peltier element in your hand. Switch on the power supply unit and observe the temperatures at the Peltier element (Fig. 11). Make a note of your observations.

5. Switch the power supply unit off again.

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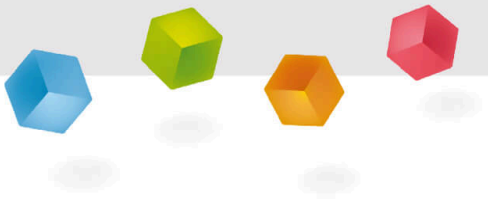

Report

Task 1

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Choose the correct word in the bracket

The heat separation takes place due to the (*Peltier effect* / "Seebeck effect"). When current flows between two (semiconductors / consumers) with different energy levels, the free electron encounters a potential barrier at the contact point between the two semiconductors, which it overcomes by absorbing (light / heat) energy from the material.

This causes cooling in the first semiconductor. The high-energy (electron / proton) releases the heat behind the potential barrier and thus heats up the second semi-conductor.

Check

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Task 2

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Which material properties influence the Peltier effect?

- [ ] Specific heat capacity
- [ ] Resistivity
- [ ] Seebeck coefficient
- [ ] Electrical conductivity
- [ ] Thermal conductivity

Check

Task 3

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Which of these statements is true?

- The heat flow generated is directly proportional to the electric current.
- The generated heat flow increases cubically to the electrical power.
- Due to saturation, the heat flow generated falls exponentially as the electric current increases.
- Due to saturation, the generated heat flow falls linearly with the increase of the electric current.

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Slide	Score / Total
Slide 16: Peltier effect	0/3
Slide 17: Material property Peltier effect	0/2
Slide 18: Heat flow	0/1

Total 0 / 6

Solutions Repeat

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