Using ambient heat with the aid of a Peltier heat pump

Physics | Thermodynamics | Conversion of heat, entropy

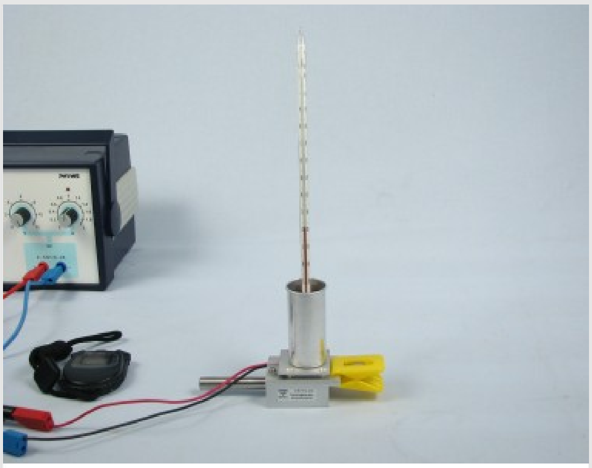
Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/62e8150c99933e00032706c5

Teacher information

Application



Experimental setup

If an electric current flows through the Peltier element, one side heats up and the other cools down. The temperature of the warm side has an influence on the temperature of the cold side.

This can be used for cooling with ambient heat, for example: If the warm side is kept at a constant temperature by air, water or earth (geothermal heat), the cold side cools down more than without storage. The aluminium block of the thermogenerator is used as a storage tank in this experiment.

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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 the heat separation is observed with different substrates.

Other teacher information (2/3)

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Learning objective

The students learn how the ambient temperature influences the heat separation of a Peltier element.

Tasks

Change the ambient temperature when heating the Peltier element

a) with an aluminium block as a base

b) with a felt plate as a base

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Other teacher information (3/3)

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Notes on set-up and procedure

The experiment consists of two partial experiments. Make sure to leave enough time between these partial experiments for both sides of the thermogenerator to adjust to room temperature again. The heated side of the thermogenerator can be placed on the table to cool down, for example.

The water in the beaker should have the same temperature at the beginning of both experiments.

The results depend on the ambient temperature, so the readings may differ from a previous measurement.

In addition, make sure that the power supply unit is always switched off after 5 minutes to protect the thermogenerator. Especially without the aluminium block as cooling, the thermogenerator may otherwise overheat.

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

A room heater to regulate the ambient temperature

Peltier elements can use available energy from their environment to perform heat transport.

This is particularly useful because this energy did not have to be converted beforehand in an elaborate way to build physical work useful for people. The useful line is therefore higher than the invested line.

In order to better exploit this principle, understanding exactly how the ambient temperature now influences the physical processes is of great importance.

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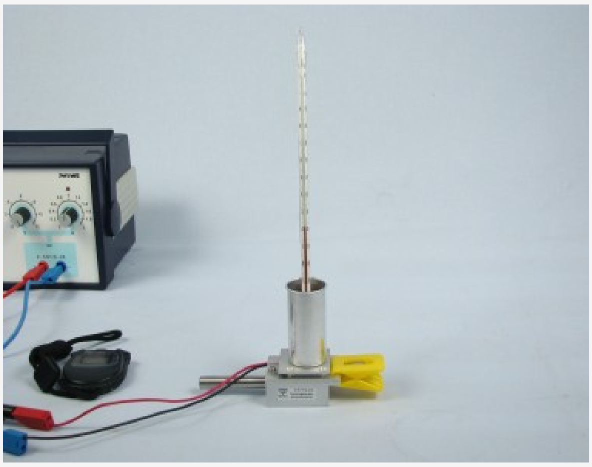
Tasks



The experimental setup

Change the ambient temperature when heating the Peltier element

a) with an aluminium block as a base

b) with a felt plate as a base

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Equipment

Position	Material	Item No.	Quantity
1	Thermal generator for student experiments	05770-00	1
2	Felt sheet, 100 x 100 mm	04404-20	1
3	Lab thermometer,-10..+110 °C	38056-00	1
4	Beaker, aluminum, polished	05903-00	1
5	Beaker, 100 ml, plastic (PP)	36011-01	1
6	Double sockets,1 pair,red a.black	07264-00	1
7	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
8	Connecting cord, 32 A, 250 mm, red	07360-01	1
9	Connecting cord, 32 A, 250 mm, blue	07360-04	1
10	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

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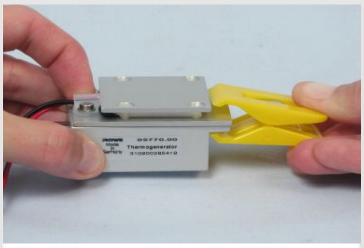

Figure 1

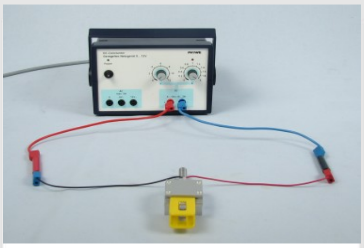

Figure 2

1. Place the aluminium block on the table with the small side down.

Attach the Peltier module to the aluminium block with the clamp so that its larger side is facing downwards (Fig. 1).

2. Connect the thermocouple to the power supply unit via the double sockets (Fig. 2).

Make sure that the blue cable of the power supply unit is connected to the red cable of the thermocouple and vice versa.

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Procedure (1/4)

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Figure 3

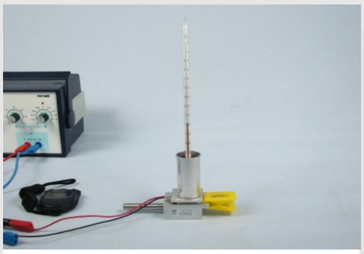
Figure 4

Experiment 1

1. Fill the blank beaker with 30 ml of water and place it on the thermogenerator (fig. 3).

2. Place the thermometer in the blank beaker (Fig. 4).

Wait briefly until the temperature of the water has adjusted to the room temperature.

Procedure (2/4)

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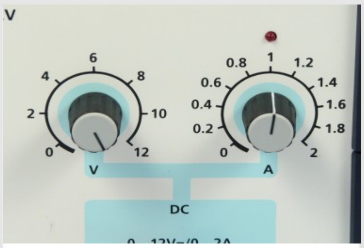

Figure 5

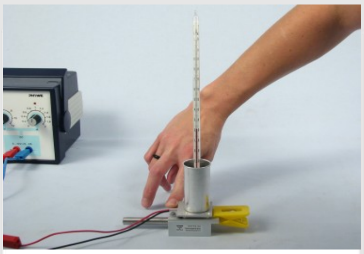
Figure 6

3. Turn the control knob for the current to 1 A. Turn the voltage to 12 V (Fig. 5).

4. Measure the initial temperature of the water and note it under ϑ_1 at t = 0 in your report.

5. Switch on the power supply. At the same time, take the time with the stopwatch. Measure the temperature every 30 seconds and record it as ϑ_1.

Stop the measurement after 4 minutes (240 seconds) and switch off the power supply.

6. Touch the lower plate of the thermogenerator (Fig. 7). How does the temperature feel?

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Procedure (3/4)

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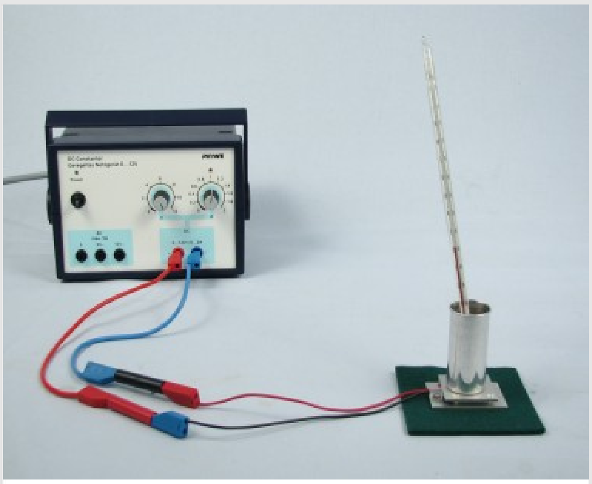

Figure 7

Experiment 2

1. Fill fresh water into the blank beaker.

Take the thermogenerator from the aluminium block and place it with the warm side on the table.

2. Wait until both sides of the thermogenerator have adjusted to room temperature again.

Place the thermogenerator on the felt plate (Fig. 7).

Procedure (4/4)

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3. Wait until the temperature of the water has adjusted to the same initial temperature as in the first partial experiment and note it under ϑ_2 at t=0.

Repeat the experiment as in the 1st part of the experiment.

Record your readings as ϑ_2.

4. Now touch the lower plate of the thermogenerator. How does the temperature feel?

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Report

Task 1

What factor can be used to determine how much energy comes from the environment compared to the energy expended by a Peltier element?

- The performance figure ϵ
- The thermal conductivity κ
- The efficiency η
- The Seebeck coefficient $S_m(T)$

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Task 2

Drag the words into the correct gaps

In this experiment, the ________ serves as a substitute for the environment. Heat is extracted from it by the ________ to bring about ________. The heat extracted Q_{Al} from the aluminium block is calculated from the ________ of its mass m the specific ________ c_{Al} and the temperature difference ΔT.

- aluminium block
- Peltier effect
- heat capacity
- heat separation
- product

Check

Task 3

Insert the indices to find the correct formula for efficiency η in an experiment to set up

$$\eta = \frac{Q_{\square}}{Q_{\square} + Q_{\square}}$$

- el
- Al
- W

el = electric, Al = Aluminium, W = transported heat

Check

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