

Investigation of the efficiency of energy transfer in electrical contexts

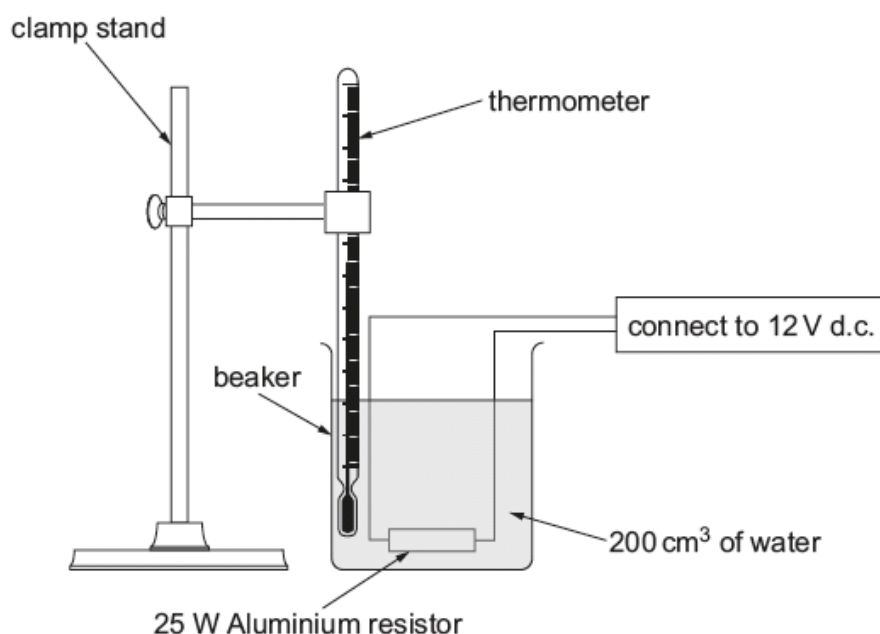
Introduction

A resistor can be used as a simple electrical immersion heater and the efficiency of the heat energy transferred to the water calculated.

Apparatus

25 W aluminium resistor for heating water
 250 cm³ beaker
 clamp stand, boss and clamp
 thermometer
 connecting wires
 12V d.c. power supply
 200 cm³ water
 stopwatch

Diagram of Apparatus



Method

1. Connect the circuit as shown. Ensure that the thermometer does not touch the resistor. Do not switch on the power supply until the resistor is fully immersed in the water.
2. Ensure that the power supply is set at 12V.
3. Switch on the power supply and record the temperature of the water every 60 seconds for 600 seconds.

Analysis

1. Draw a graph of time (*x*-axis) vs temperature of the water (*y*-axis).
2. Calculate the efficiency of this method of heating water by using the following equations.

A) The useful energy output of the resistor can be calculated by:

$$\text{Energy (J)} = \text{Power (W)} \times \text{Time (seconds)}$$

B) The energy gained by the water can be calculated by:

$$\text{Energy (J)} = \text{Temperature rise (}^{\circ}\text{C)} \times 840 \text{ (if } 200\text{cm}^3 \text{ of water is used)}$$

The efficiency is then calculated from:

$$\% \text{ efficiency} = \frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$$

Where:

- energy usefully transferred = answer to **B** (energy gained by the water)
- total energy supplied = answer to **A** (useful energy output of the resistor)

Risk Assessment

Hazard	Risk	Control measure
Resistor will be very hot if not submerged and can burn	Burning skin on the hot resistor	Allow apparatus to cool before touching Do not switch on the power supply until the resistor is fully submerged

Teacher / Technician notes

Suitable 25 W, 10 Ω aluminium resistors (it is easier to pre-solder leads to the resistors).

Power supplies should be set, fixed, at 12V.

The calculations in this experiment will be made easier if students tabulate time in seconds not minutes.

Note: the temperature of the water will, probably, only increase by a few degrees during this experiment. Therefore it will be impractical to ask students to draw 'lines of best fit' on their plotted graphs.

More able students could suggest how the efficiency could be improved.

Working scientifically skills covered

2. Experimental skills and strategies

Evaluate methods and suggest possible improvements and further investigations.

3. Analysis and Evaluation

Carry out and representing mathematical analysis.

4. Scientific vocabulary, quantities, units, symbols and nomenclature

Recognise the importance of scientific quantities and understand how they are determined.

Use SI units and IUPAC chemical nomenclature unless inappropriate.