

4.1.2.1 Thermal insulation

Energy will always be transferred from warmer places to cooler ones. Sometimes this is useful, as in a domestic heating system. However, on other occasions we need to stop that transfer, or at least slow it down. In this investigation you will study the rate of cooling of a beaker of hot water when insulated with different thicknesses of insulating materials. You will plot cooling curves to determine if there is any benefit in using additional layers for thermal insulation.

Learning outcomes	Maths skills required
- Identify variables that need to be kept constant in order to ensure validity of results. - Plot a graph of the results and use it to compare the rates of cooling.	- Translate information between graphical and numeric form. - Plot two variables from experimental data.

Apparatus list	
- beaker (for example, 250 cm³) - thermometer - electric kettle (and water) - piece of cardboard - scissors	- stopwatch - insulating material of different thicknesses or enough to have numbers of layers - rubber bands

Safety notes
- Do not handle the electric kettle, plug or socket with wet hands. - If you scald yourself with hot water, cool the burn under cold running water immediately and ask your teacher for assistance.

Common mistakes
- Make sure the thermometer is actually in the water. - Make sure you use the same volume of water each time.

Method

Read these instructions carefully before you start work.

- Set up 6 beakers, with 0, 1, 2, 3, 4 and 5 layers of insulating material around each beaker. Each group will use a different beaker.
- Pour 200 cm³ of hot water into your beaker.
- Use a piece of cardboard, with a hole for the thermometer, as a lid for the beaker.
- Push the thermometer through the hole in the cardboard lid so that its bulb is in the hot water.
- Measure the temperature of the hot water and record this in **Table 1** in the correct row for your number of layers. **Start the stopwatch.**
- Every 5 minutes measure the temperature of the water and record it in **Table 1**.
- Continue for 20 minutes.
- Record the class results in **Table 1**.
- Draw cooling curve graphs by plotting **temperature (°C)** against **time (s)** for each number of different layers of insulation on **Graph 1**. Draw the curves for each number of layers on the same graph.

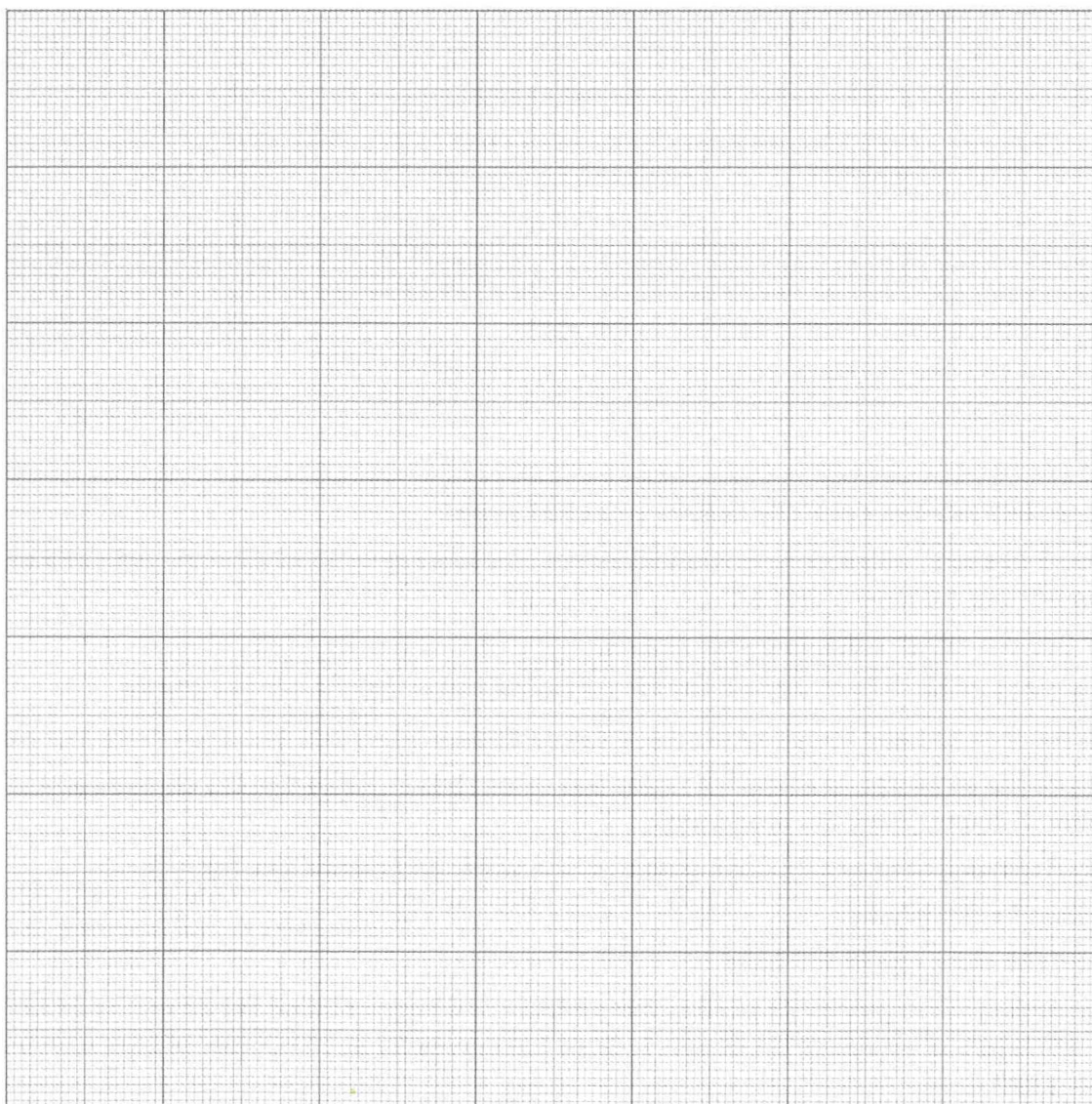
10. From your graph, write a conclusion about the effect of changing the number of layers of insulation.
11. To compare the insulating material with other materials, repeat your experiment with a different material or compare your results with your peers if they have used a different material. Record your results in a copy of **Table 1** and stick it into your book.

Record your results

Table 1 – Number of layers and temperature

Number of layers	Temperature (°C)				
	0 mins	5 mins	10 mins	15 mins	20 mins
0					
1					
2					
3					
4					
5					

Graph 1



Conclusion

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Check your understanding

1. The graph you have drawn should have six curves on it.

a. Describe the general trend of all the curves on your graph.

[2 marks]

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b. How many layers would be the most appropriate to keep a beaker of water warm for longest?

Use data from your results to support your answer.

[3 marks]

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2. Explain why the same volume of water was used each time.

[2 marks]

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3. A student wants to keep ice cream frozen when the ice cream is outside the freezer.

How many layers of insulation you would advise the student to use?

Explain why you would advise this many layers.

[3 marks]

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Exam-style questions

1. **Table 2** shows a student's results after an experiment investigating the insulating properties of different materials.

Table 2

Thermal insulator	Temperature of the pot (°C)					
	Start	1 hour	2 hours	3 hours	4 hours	5 hours
Cling film	90.0	38.0	26.5	25.5	25.0	25.0
Bubble wrap	90.0	43.5	28.0	25.5	25.5	25.0
Polystyrene	90.0	55.0	43.5	37.5	30.0	26.5
Wood shavings	90.0	52.5	40.0	32.5	28.0	25.5

- a. Describe a method the student could have used to collect this data.

You should include the safety precautions the student should take.

[6 marks]

[illegible]

- b.** Explain why the lowest temperature reached is 25 °C.

[1 mark]