Transfer of Thermal Energy

Question Paper

Course	CIE IGCSE Physics
Section	2. Thermal Physics
Topic	Transfer of Thermal Energy
Difficulty	Medium

Time Allowed 70

Score /57

Percentage /100

Question 1a

A student is investigating the rate of cooling of water under different conditions. A greater rate of cooling occurs if there is a greater change in the temperature during the same period of time.

Fig. 3.1 shows some of the apparatus.

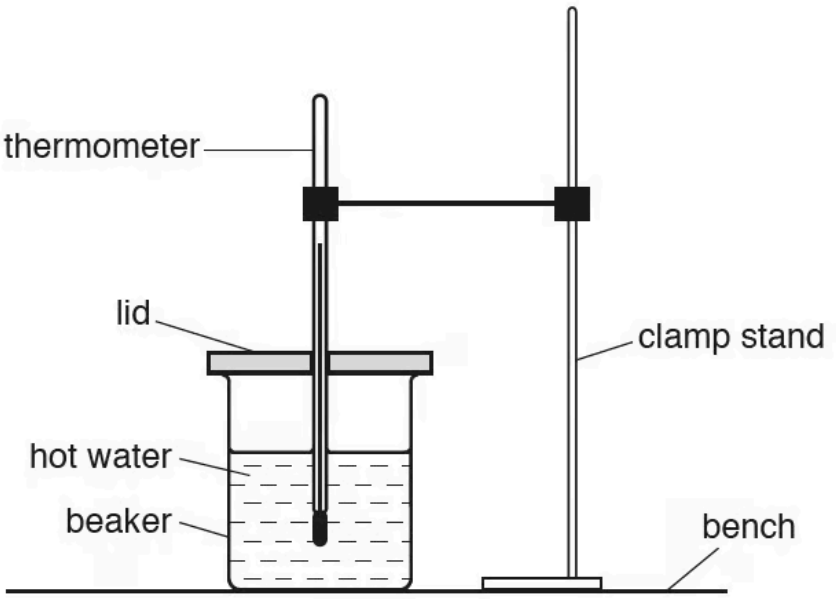

Fig. 3.1

The thermometer in Fig.3.2 shows the room temperature θ_R at the beginning of the experiment. Record θ_R.

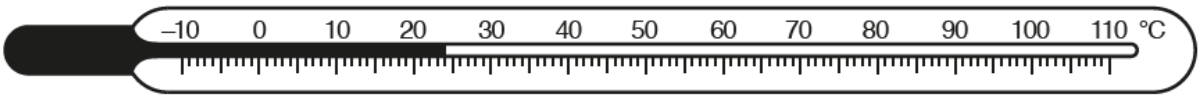

Fig. 3.2

θ_R = ...

[1 mark]

Question 1b

The student pours 200 cm^3 of hot water into the beaker.

She records the temperature θ of the hot water at time $t = 0$. She immediately starts a stopclock.

She continues recording the time and the temperature readings every 30 s. The readings are shown in Table 3.1.

Table 3.1

Beaker

t /	θ /
0	94
30	93
60	92
90	91
120	90
150	89

Table 3.2

Can

t /	θ /
0	93
30	91
60	90
90	89
120	88
150	87

The student repeats the procedure using a metal can, painted matt black, in place of the beaker.

The readings are shown in Table 3.2.

(i) Complete the column headings in Table 3.1 and in Table 3.2.

[1]

(ii) Look carefully at the readings in Table 3.1 and in Table 3.2.

Tick the box to show your conclusion from the readings.

- ☐ The water in the beaker has a greater rate of cooling than the water in the can.
- ☐ The water in the beaker has a smaller rate of cooling than the water in the can.
- ☐ There is no significant difference between the rates of cooling of the water in the beaker and the can.

[1]

(iii) Justify your conclusion by reference to the readings.

[2]

[4 marks]

Question 1c

A student in another school carries out the experiment and reports that the rate of cooling of the water in the can is different from the rate of cooling of the water in the beaker. He plans a change to the experiment to find out whether this difference in the rates of cooling is caused by

- the matt black surface of the can being a better radiator of thermal energy than the shiny surface of the beaker
- the metal of the can being a better conductor of thermal energy than the material of the beaker.

(i) Suggest two suitable changes to the apparatus that the student could make.

[2]

(ii) Suggest two variables that should be controlled in order to make the experiment a fair test.

[2]

[4 marks]

Question 1d

State **one** precaution that you would take in order to record accurate temperature readings.

[1 mark]

Question 2

A student is investigating ways of slowing the rate of cooling of hot liquids in a container.
The student knows that a lid will reduce the rate of cooling. He wants to find out if the thickness of the lid makes any difference to the rate of cooling.

Plan an experiment which will enable him to compare the effects of lids of different thicknesses.

In your plan, you should:

- list the apparatus needed
- explain briefly how you would carry out the investigation, including the measurements to be taken
- state any key variables that would need to be kept the same
- draw a suitable table or tables, with column headings, to show how the readings would be displayed (you are not required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

You may draw a diagram if it helps to explain your plan.

[7 marks]

Question 3a

Students are investigating the cooling of hot water in a beaker.

They are using the apparatus shown in Fig. 2.1.

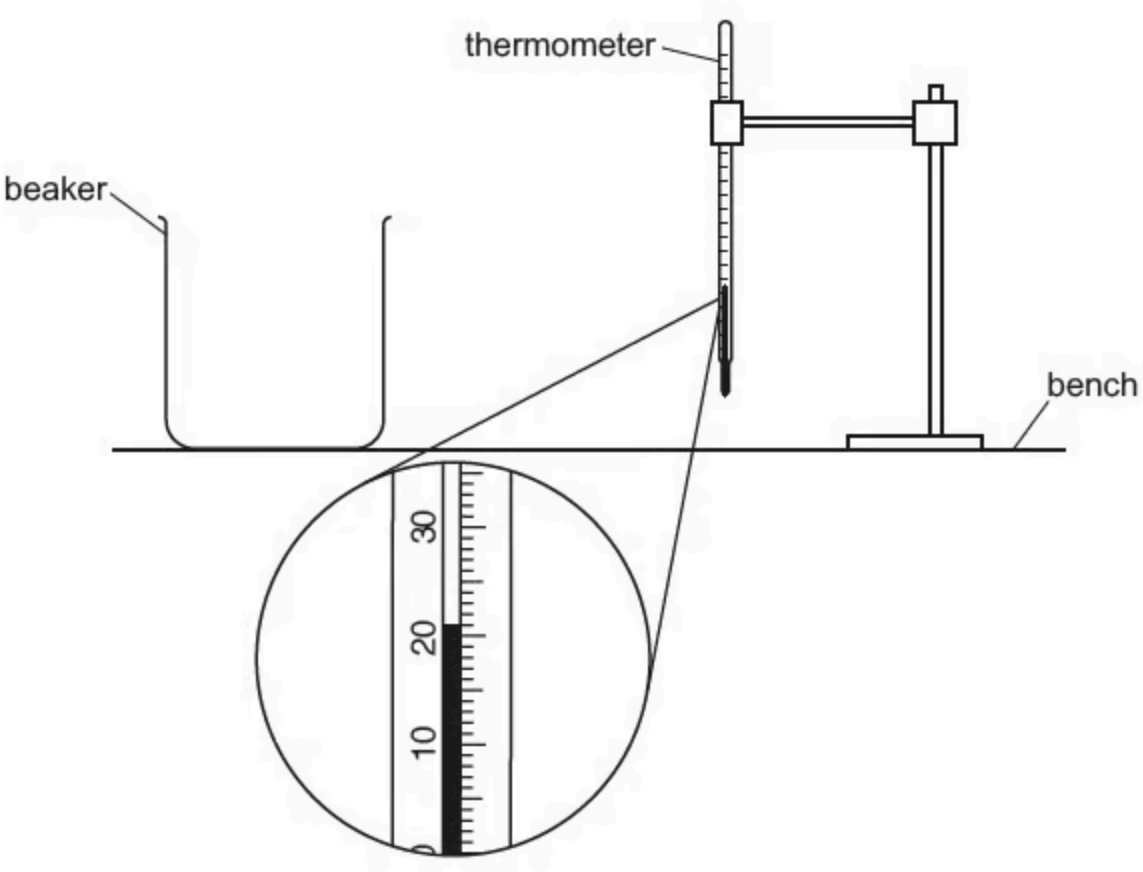

Fig. 2.1

Record room temperature θ_R shown on the thermometer in Fig. 2.1.

θ_R = ...

[1 mark]

Question 3b

A volume of 150 cm^3 of hot water is poured into the beaker and the initial temperature θ is recorded in Table 2.1.

The temperature of the water is recorded every 30 s. The values are shown in Table 2.1.

(i) Complete the headings in Table 2.1.

[1]

Table 2.1

t/	θ/
0	95.0
30	89.0
60	83.5
90	79.0
120	75.0
150	71.5
180	68.5
210	66.0
240	64.0
270	62.5

(i) Describe one precaution that you would take to ensure that the temperature readings in the experiment are as accurate as possible.

[1]

[2 marks]

Question 3c

(i) Calculate the average cooling rate x_1 during the first 90s of the experiment. Use the readings from Table 2.1 and the equation

$$x_1 = \frac{\theta_0 - \theta_{90}}{T}$$

where T = 90 s and θ_0 and θ_{90} are the temperatures at t = 0 and t = 90 s.

Include the unit for the cooling rate.

x_1 = ... [1]

(ii) Calculate the average cooling rate x_2 during the middle 90 s of the experiment. Use the readings from Table 2.1 and the equation

$$x_2 = \frac{\theta_{90} - \theta_{180}}{T}$$

where T = 90 s and θ_{90} and θ_{180} are the temperatures at t = 90 and t = 180 s.

x_2 = ... [1]

(iii) Calculate the average cooling rate x_3 during the last 90 s of the experiment. Use the readings from Table 2.1 and the equation

$$x_3 = \frac{\theta_{180} - \theta_{270}}{T}$$

where $T = 90$ s and θ_{180} and θ_{270} are the temperatures at $t = 180$ and $t = 270$ s.

x_3 = ... [1]

[3 marks]

Question 3d

(i) The temperature of the water falls as time passes. Use the results from **(c)** to describe the pattern of the rate of cooling of the water during the experiment.

Justify your answer by reference to the results.

[1]

(ii) Give an estimate of the probable final temperature θ_F of the water if left to cool for many hours.

θ_F = ... [1]

[2 marks]

Question 3e

(i) A student in another school carries out a similar experiment.
She starts with the hot water at a lower initial temperature.
Suggest how her cooling rates are likely to compare with those calculated in **(c)**.
Use the results to explain your answer.

[2]

(ii) State one variable, other than the initial temperature, which the student should control.

[1]

[3 marks]

Question 4a

Students are investigating how the use of a lid or insulation affects the rate of cooling of hot water in a beaker. They use the apparatus shown in Fig. 2.1.

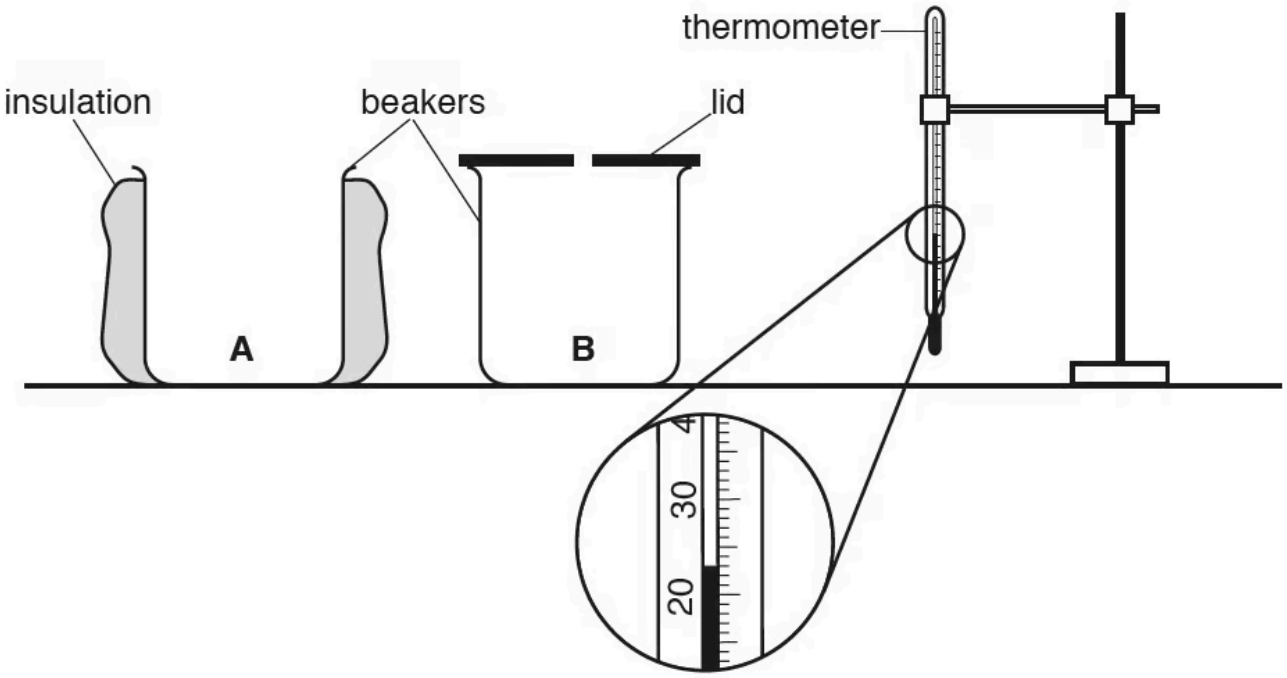

Fig. 2.1

Record the room temperature θ_R shown on the thermometer in Fig. 2.1.

θ_R = ...

[1 mark]

Question 4b

- 100 cm^3 of hot water is poured into beaker **A** and the initial temperature θ is recorded in Table 2.1.
- The temperature θ of the water at times t = 30 s, 60 s, 90 s, 120 s, 150 s and 180 s are shown in Table 2.1.
- This process is repeated for beaker **B**.

Complete the headings and the time column in Table 2.1.

Table 2.1

	beaker **A** with insulation	beaker **B** with a lid
t/	θ/	θ/
0	83.0	86.0
	79.0	84.0
	75.5	82.5
	73.0	81.0
	71.0	80.0
	69.5	79.0
	68.5	78.5

[2 marks]

Question 4c

Write a conclusion stating whether the insulation or the lid is more effective in reducing the cooling rate of the water in the beakers in this experiment.

Justify your answer by reference to the results.

[2 marks]

Question 4d

One student thinks that the experiment does not show how effective insulation is on its own or how effective a lid is on its own.

Suggest an additional experiment which could be used to show how effective a lid or insulation is.

Explain how the additional results could be used.

[2 marks]

Question 4e

(i) Calculate x_A, the average cooling rate for beaker **A** over the whole experiment. Use the readings for beaker **A** from Table 2.1 and the equation

$$x_A = \frac{\theta_0 - \theta_{180}}{T}$$

where T = 180 s and θ_0 and θ_{180} are the temperatures at time t = 0 and time t = 180 s.
Include the unit for the cooling rate.

x_A = ... [2]

(ii) Students in another school are carrying out this experiment using identical equipment.

State why they should make the initial temperature of the water the same as in this experiment if they are to obtain average cooling rates that are the same as in Table 2.1.
Assume that the room temperature is the same in each case.

Use the results from beaker **A** to explain why this factor should be controlled.

[2]

[4 marks]

Question 5

A student investigates the effect of the colour of the surface of a metal container on the rate of loss of heat from the container. She knows that black surfaces are better radiators of thermal energy than white surfaces and wants to investigate the effect of other colours.

The following apparatus is available:

metal containers each with the outer surface painted a different colour

a thermometer

a stop-watch

a supply of hot water.

She can also use other apparatus and materials that are usually available in a school laboratory.

Plan an experiment to investigate the effect of the colour of the surface of a metal container on the rate of loss of heat from the container.

You should:

- draw a diagram of the apparatus used
- explain briefly how you would carry out the investigation
- state the key variables to be kept constant
- draw a table, or tables, with column headings, to show how you would display your readings (you are not required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

[7 marks]

Question 6a

Some students are investigating how the volume of water affects the rate at which water in a beaker cools.

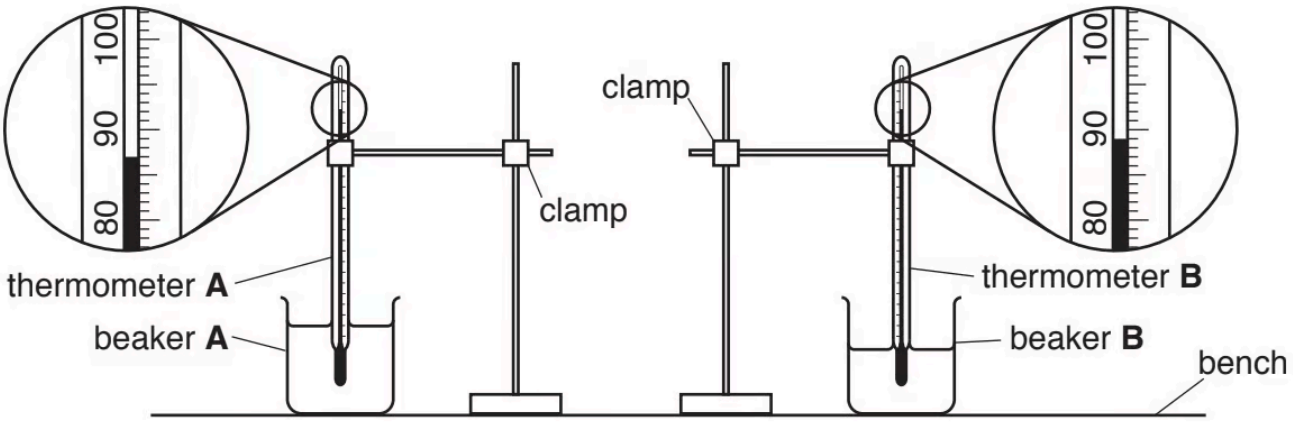

Fig. 2.1

They are using the apparatus shown in Fig. 2.1.

(i) 200 cm^3 of hot water is poured into beaker **A** and the initial temperature rises to the value shown on thermometer **A** in Fig. 2.1.

In the first row of Table 2.1, record this temperature θ_A for time $t = 0$.

100 cm^3 of hot water is poured into beaker **B**. The temperature rises to the value shown on thermometer **B** in Fig. 2.1.

In the first row of the table, record this temperature θ_B for time $t = 0$.

[1]

(ii) The temperatures θ_A and θ_B of the water in each experiment at times t = 30 s, 60 s, 90 s, 120 s, 150 s and 180 s are shown in the table.

Complete the headings and the time column in the table.

[2]

Table 2.1

	beaker **A** with 200 cm^3 of water	beaker **B** with 100 cm^3 of water
t/	θ_A/	θ_B/
0		
	85.0	86.0
	83.0	83.0
	81.5	80.5
	80.0	78.0
	78.5	76.0
	77.5	74.5

[3 marks]

Question 6b

Describe one precaution which should be taken to ensure that the temperature readings in the experiment are as accurate as possible.

[1 mark]

Question 6c

Write a conclusion stating how the volume of water in the beaker affects the rate of cooling of the water. Justify your answer by reference to the results.

[2 marks]

Question 6d

(i) Using the results for 100 cm^3 of water, calculate the average rate of cooling x_1 for the **first** 90 s of the experiment. Use the readings from the table and the equation

$$x_1 = \frac{\theta_0 - \theta_{90}}{t}$$

where t = 90 s and θ_0 and θ_{90} are the temperatures at time 0 and at time 90 s. Include the unit for the rate of cooling.

x_1 = ...[1]

(ii) Using the results for 100 cm^3 of water, calculate the average rate of cooling x_2 in the **last** 90 s of the experiment. Use the readings from the table and the equation

$$x_2 = \frac{\theta_{90} - \theta_{180}}{t}$$

where t = 90 s and θ_{90} and θ_{180} are the temperatures at time 90 s and at time 180 s. Include the unit for the rate of cooling.

x_2 = ...[1]

[2 marks]

Question 6e

A student suggests that it is important that the experiments with the two volumes of water should have the same starting temperatures.

State whether your values for x_1 and x_2 support this suggestion. Justify your statement with reference to your results.

[1 mark]

Question 6f

Another student plans to investigate whether more thermal energy is lost from the water surface than from the sides of the beakers.

Describe an experiment that could be done to investigate this.

You may draw a diagram to help your description.

[2 marks]