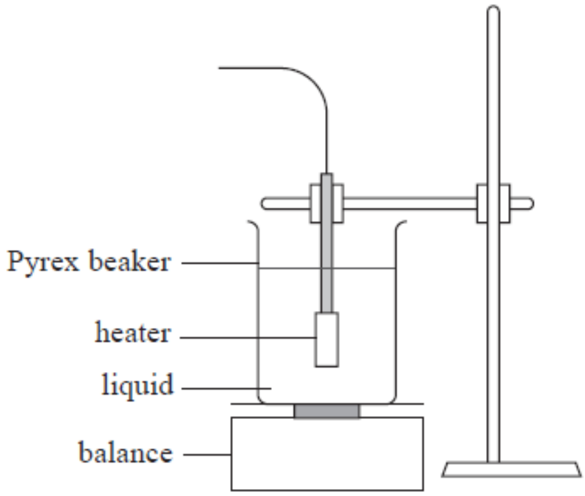
Questions

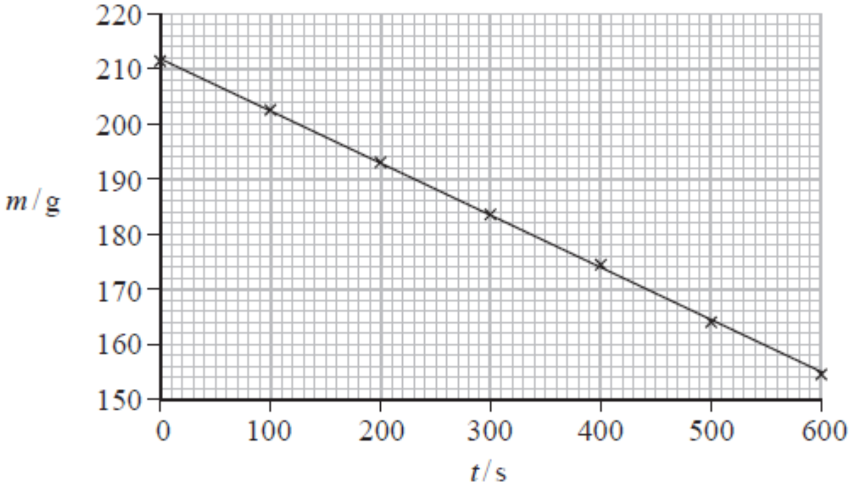
Q1.

A student determined the latent heat of vaporisation of a liquid using an electrical heater to boil the liquid in a Pyrex beaker.

The apparatus used is shown below.



The student monitored the mass of the beaker and the liquid *m* over the time *t* for which the liquid was boiling. Her results are plotted on the graph.



The student used her graph to determine a value for the latent heat of the liquid in the beaker. She concluded that the liquid was pure water.

Liquid	Latent heat of vaporisation / MJ kg^{-1}
Pure water	2.26
Weak salt water solution	2.10
Strong salt water solution	2.00

Comment on the validity of the student's conclusion.

V = 20.5 V

I = 10.5 A

(7)

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(Total for question = 7 marks)

(b) Describe an electrical experiment to determine the specific heat capacity *c* of a liquid.

Include in your answer:

- a labelled diagram of the arrangement
- a list of the measurements to be taken
- an explanation of how the value of *c* would be determined from your results
- possible sources of uncertainty in your measurements and how these could be reduced.

3 A beaker contains water and some metal blocks as shown in Fig. 3.1.

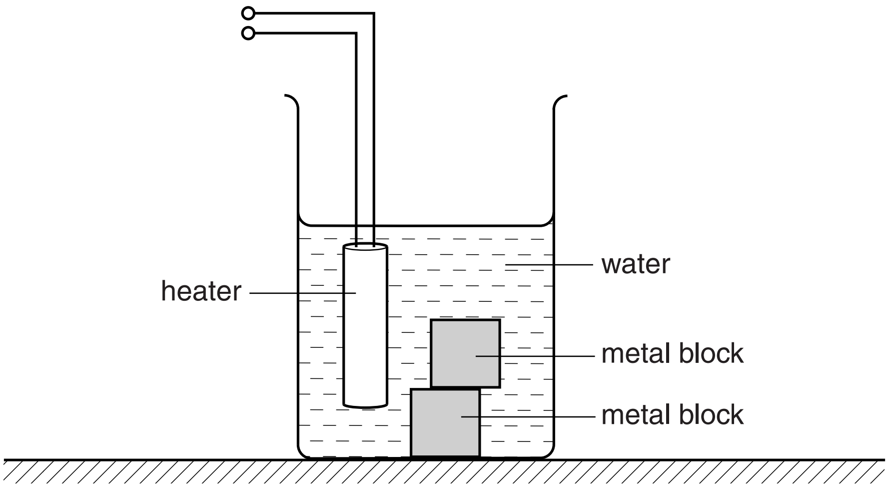

Fig. 3.1

A student uses an electrical heater to produce a particular temperature increase in the water.

It is suggested that the electrical energy E supplied to the heater is related to the mass m of metal blocks by the relationship

$$E = am + b$$

where a and b are constants.

Design a laboratory experiment to test the relationship between E and m. Explain how your results could be used to determine values for a and b. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

4 A student is investigating how the boiling point of a salt solution varies with pressure.

It is suggested that the relationship between the Celsius temperature θ at which the water of the solution starts to boil and the air pressure P is

$$\theta = k\sigma P^q$$

where σ is the density of the solution and k and q are constants.

Design a laboratory experiment to test the relationship between θ and P.
Explain how your results could be used to determine values for k and q.

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

Diagram

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[15]

5 A student is investigating how the resistance of a thermistor varies with temperature. The thermistor is placed in water, as shown in Fig. 5.1.

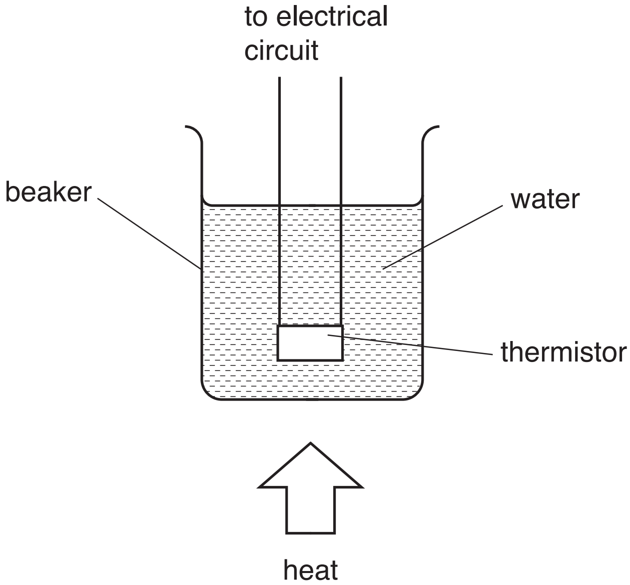


Fig. 5.1

The thermistor is connected to a battery with electromotive force (e.m.f.) E and negligible internal resistance. The current I in the thermistor is measured. The resistance R of the thermistor is then determined using the expression

$$R = \frac{E}{I}.$$

The experiment is repeated for different temperatures of the water.

It is suggested that the resistance R of the thermistor and the thermodynamic temperature T are related by the equation

$$R = pT^q$$

where p and q are constants.

(a) A graph is plotted of lg R on the y-axis against lg T on the x-axis.

Determine expressions for the gradient and the y-intercept.

gradient = ...

y-intercept = ...
[1]

(b) The value of E is 9.4 ± 0.1 V.

Values of T, I and lg T are given in Fig. 5.2.

T/K	I/mA	$R/10^3\,\Omega$	lg (T/K)	lg ($R/10^3\,\Omega$)
303	1.0 ± 0.1		2.481	
313	1.6 ± 0.1		2.496	
323	2.4 ± 0.1		2.509	
333	3.7 ± 0.1		2.522	
343	5.5 ± 0.1		2.535	
353	8.7 ± 0.1		2.548	

Fig. 5.2

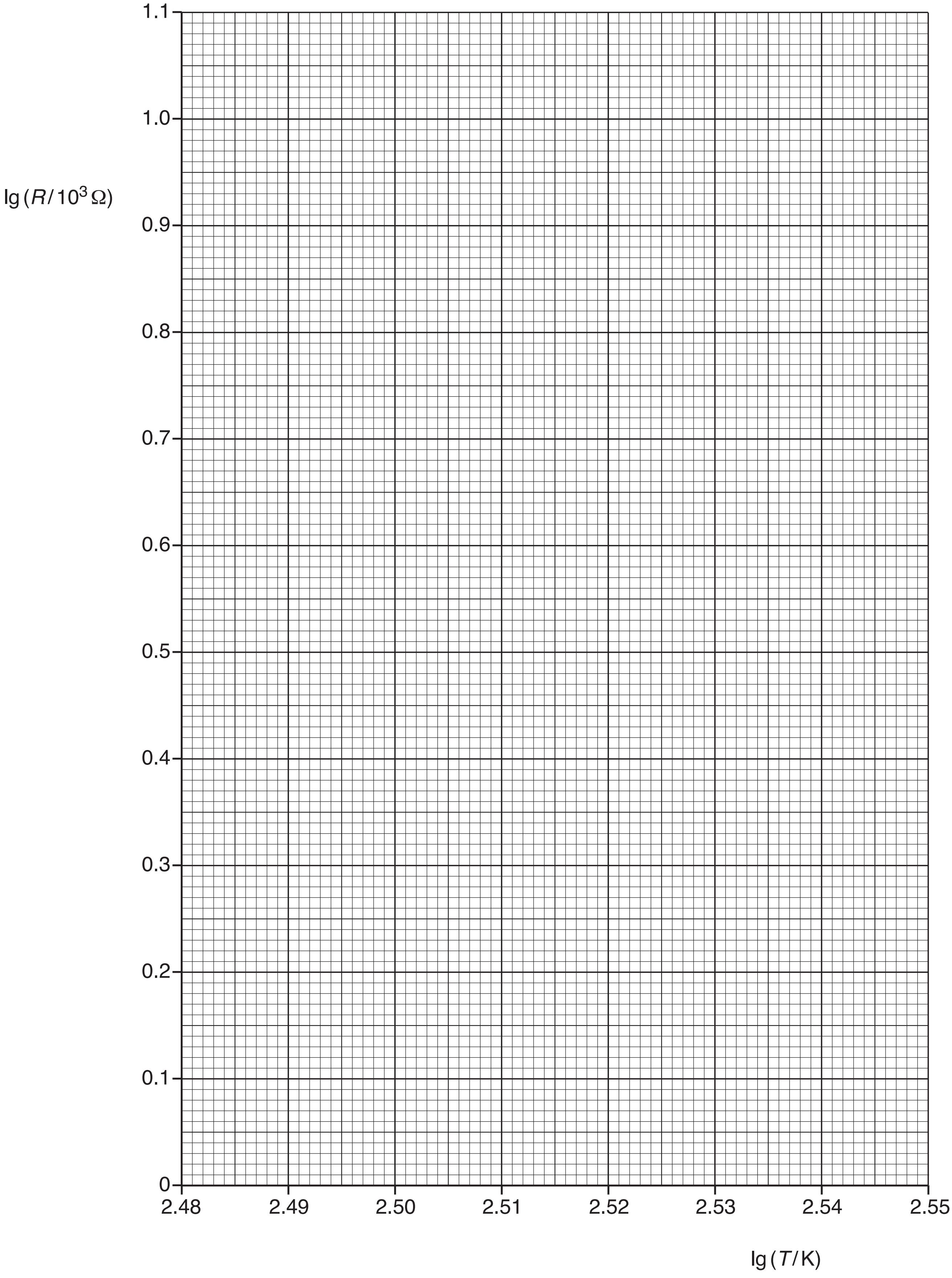
Calculate and record values of $R/10^3\,\Omega$ and lg ($R/10^3\,\Omega$) in Fig. 2.2.
Include the absolute uncertainties in $R/10^3\,\Omega$ and lg ($R/10^3\,\Omega$). [4]

(c) **(i)** Plot a graph of lg ($R/10^3\,\Omega$) against lg (T/K).
Include error bars for lg ($R/10^3\,\Omega$). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ... [2]


lg (R / 10^3 Ω)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2.48
2.49
2.50
2.51
2.52
2.53
2.54
2.55
lg (T / K)

(iv) Determine the y-intercept of the line of best fit. Do **not** determine the absolute uncertainty.

y-intercept = ... [1]

(d) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of p and q. You need not be concerned with units. Do **not** include the absolute uncertainties.

p = ...

q = ...
[2]

(e) Using your answers to **(d)**, determine the thermodynamic temperature T when the resistance of the thermistor is 15 kΩ.

T = ... K [1]

[Total: 15]