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9702/52

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [].

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[Turn over

- 1 A student investigates stationary waves with an elastic cord of circular cross-section attached to a load, as shown in Fig. 1.1.

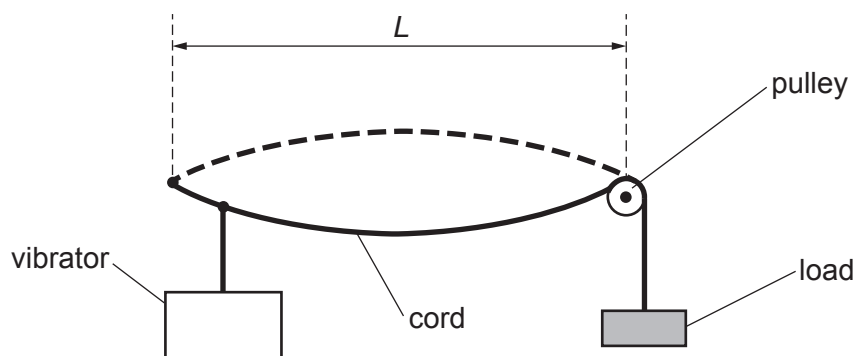


Fig. 1.1

When the frequency of the vibrator is f , the cord vibrates with the stationary wave pattern shown. The student investigates how f varies with the cross-sectional area A of the cord.

It is suggested that the relationship between f and A is

$$f = \frac{1}{2L} \sqrt{\frac{M}{kA}}$$

where L is the distance between the two nodes, M is the mass of the load and k is a constant.

Design a laboratory experiment to test the relationship between f and A . Explain how your results could be used to determine a value for k .

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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- 2 A student investigates how the viscous force in a liquid varies with temperature.

The student releases a ball from the surface of the liquid in a container. The ball falls as shown in Fig. 2.1.

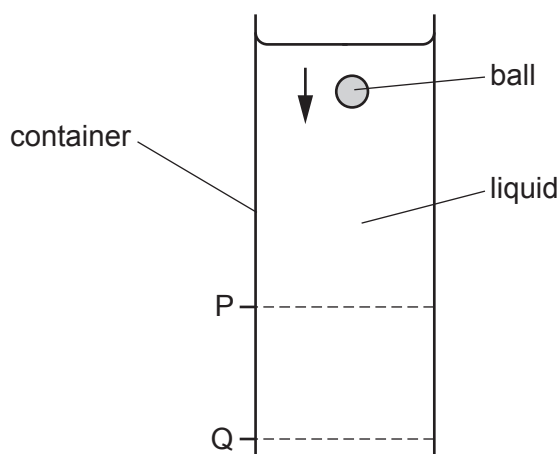


Fig. 2.1

The student determines the speed of the ball between P and Q and measures the thermodynamic temperature T of the liquid.

Viscosity is a term used to describe the viscous forces acting in a liquid. Viscosity has the unit pascal second (Pa s). The viscosity η of the liquid is calculated from the speed of the ball.

The experiment is repeated for the same liquid at different temperatures.

It is suggested that η and T are related by the equation

$$\eta = He^{\left(\frac{E}{kT}\right)}$$

where E and H are constants and k is the Boltzmann constant.

- (a) A graph is plotted of $\ln \eta$ on the y -axis against $\frac{1}{T}$ on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of T and η are given in Table 2.1.

Table 2.1

T/K	$\eta/10^{-4}\text{Pa s}$	$\frac{1}{T}/10^{-3}\text{K}^{-1}$	$\ln (\eta/10^{-4}\text{Pa s})$
292	12.3 ± 0.2	3.42	
303	9.8 ± 0.2	3.30	
311	8.4 ± 0.2	3.22	
323	6.8 ± 0.2	3.10	
335	5.6 ± 0.2	2.99	
346	4.8 ± 0.2	2.89	

Calculate and record values of $\ln (\eta/10^{-4}\text{Pa s})$ in Table 2.1.

Include the absolute uncertainties in $\ln (\eta/10^{-4}\text{Pa s})$.

[2]

- (c) (i) Plot a graph of $\ln (\eta/10^{-4}\text{Pa s})$ against $\frac{1}{T}/10^{-3}\text{K}^{-1}$.
Include error bars for $\ln \eta$.

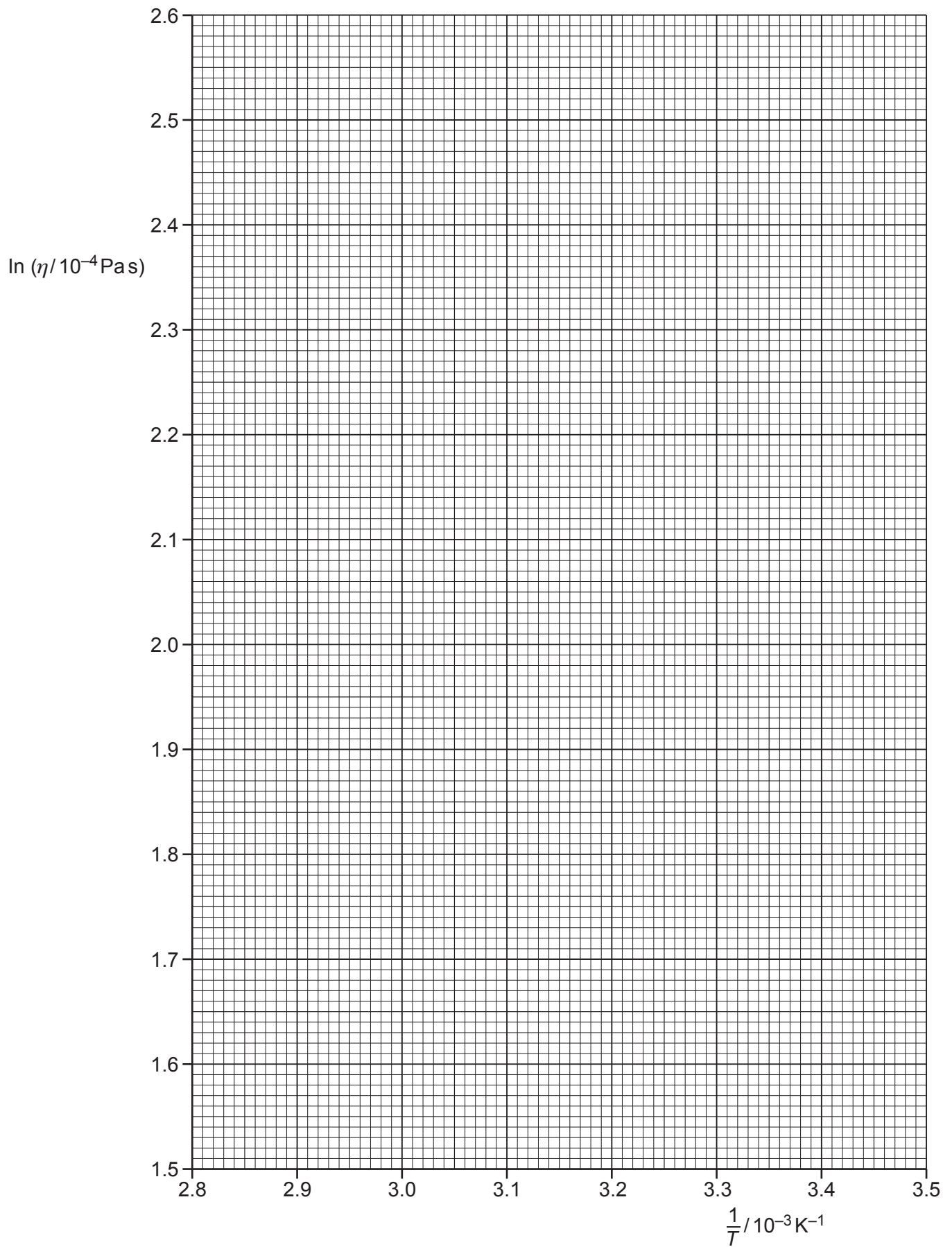
[2]

- (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]



- (iv) Determine the y -intercept of the line of best fit. Do **not** include the absolute uncertainty in your answer.

y -intercept = [1]

- (d) (i) Using your answers to (a), (c)(iii) and (c)(iv), determine values of E and H . Include appropriate units.

Data: $k = 1.38 \times 10^{-23} \text{ J K}^{-1}$

$E = \dots\dots\dots$

$H = \dots\dots\dots$ [3]

- (ii) Determine the absolute uncertainty in E .

absolute uncertainty in $E = \dots\dots\dots$ [1]

- (e) Determine the value of η for a temperature of 273 K.

$\eta = \dots\dots\dots \text{ Pas}$ [1]

[Total: 15]