6 Viscosity is a measure of the resistance to flow of a liquid. Apparatus that can be used to measure the viscosity is shown in Fig. 6.1.

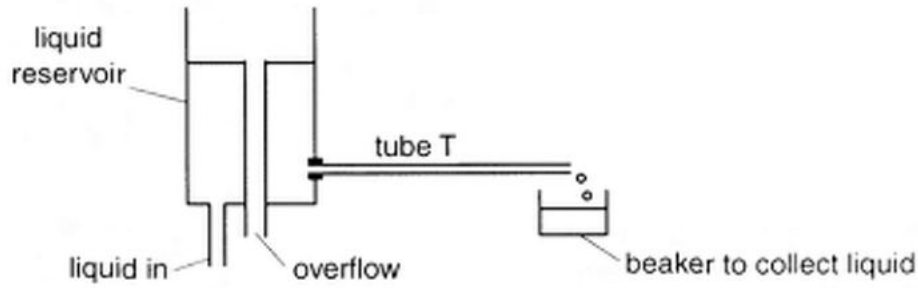

Fig. 6.1

Liquid flows through the horizontal tube T. By maintaining a constant liquid level in the reservoir, liquid flows through T at a constant rate.

The rate of flow of the liquid is measured for different tubes T with the same length but of different radii *r*. The same liquid level is used in each experiment.

The volume of liquid collected per second is *Q*. The variation with *r* of *Q* is shown in Fig. 6.2.

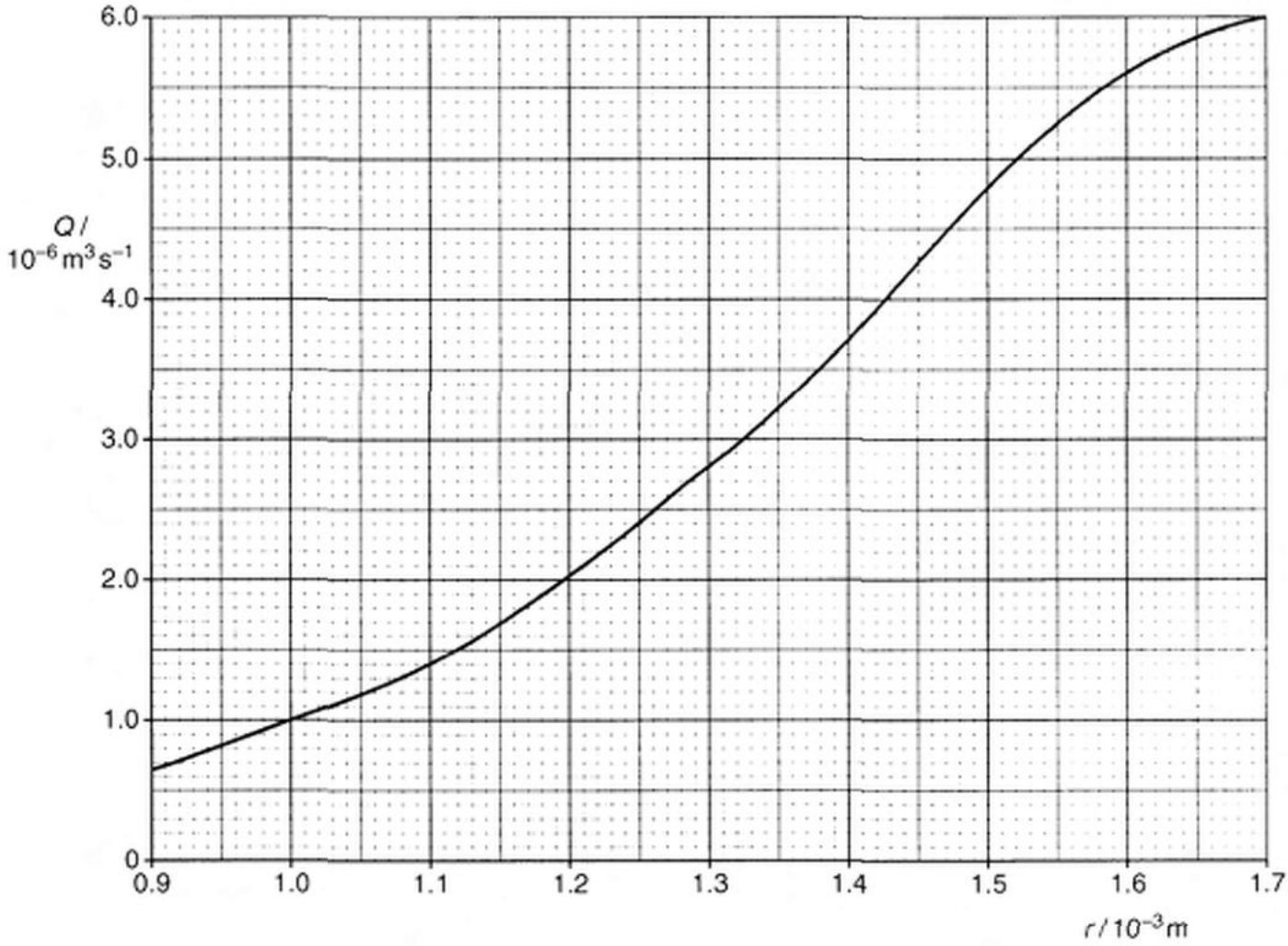

Fig. 6.2

(a) Describe, without calculation, the variation with r of Q.

.....

.....

.....[2]

(b) The relation between Q and r is thought to follow the expression

$$Q = kr^n$$

where k is a constant and n is an integer.

Data from Fig. 6.2 are used to obtain values of lg Q and lg r. These are plotted on the graph of Fig. 6.3.

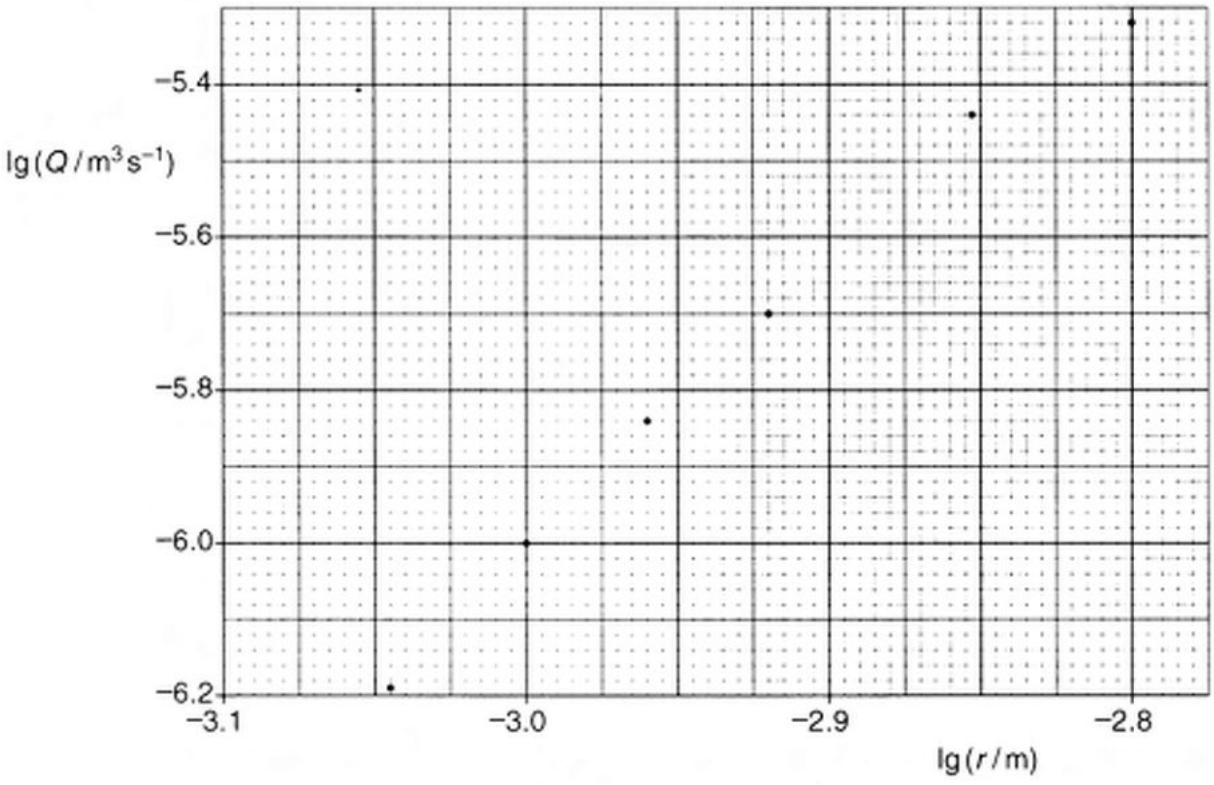

Fig. 6.3

(i) On Fig. 6.3,

1 plot the point corresponding to $r = 1.3 \times 10^{-3}$ m,

2 draw the line of best fit for all the points. [2]

(ii) Determine the gradient of the line drawn in **(i)**.

gradient = ... [2]

(iii) Using your answer in **(ii)**, determine the magnitude of k.

For Examiner Use

magnitude of k = ... [2]

(c) Theory suggests that k is given by the expression

$$k = \frac{\pi \Delta P}{8 \eta L}$$

where ΔP is the pressure difference between the two ends of the tube T of length L and η is the viscosity of the liquid. For this experiment, $\Delta P = 500\,\text{Pa}$ and $L = 0.20\,\text{m}$.

(i) Calculate the magnitude of the viscosity η.

magnitude of η = ... [2]

(ii) Determine the SI base units for viscosity.

SI base units = ... [3]

(d) The radius of tube T is reduced from R to $\frac{R}{2}$. Use your answer in **(b)** to determine the ratio

$$\frac{\text{pressure difference for } \frac{R}{2}}{\text{pressure difference for radius R}}$$

to maintain the same volume of liquid collected per second.

For Examiner Use

ratio = ... [2]

(e) The graph of Fig. 6.2 was obtained for water. Suggest what change to Fig. 6.2 would occur if the experiment were repeated with cooking oil.

.....

.....

.....

.....[1]