7 This question is about the conduction properties of semiconductors.

For Examiner's Use

The variation with temperature θ of the resistance R of a sample of an intrinsic semiconducting material is shown in Fig. 7.1.

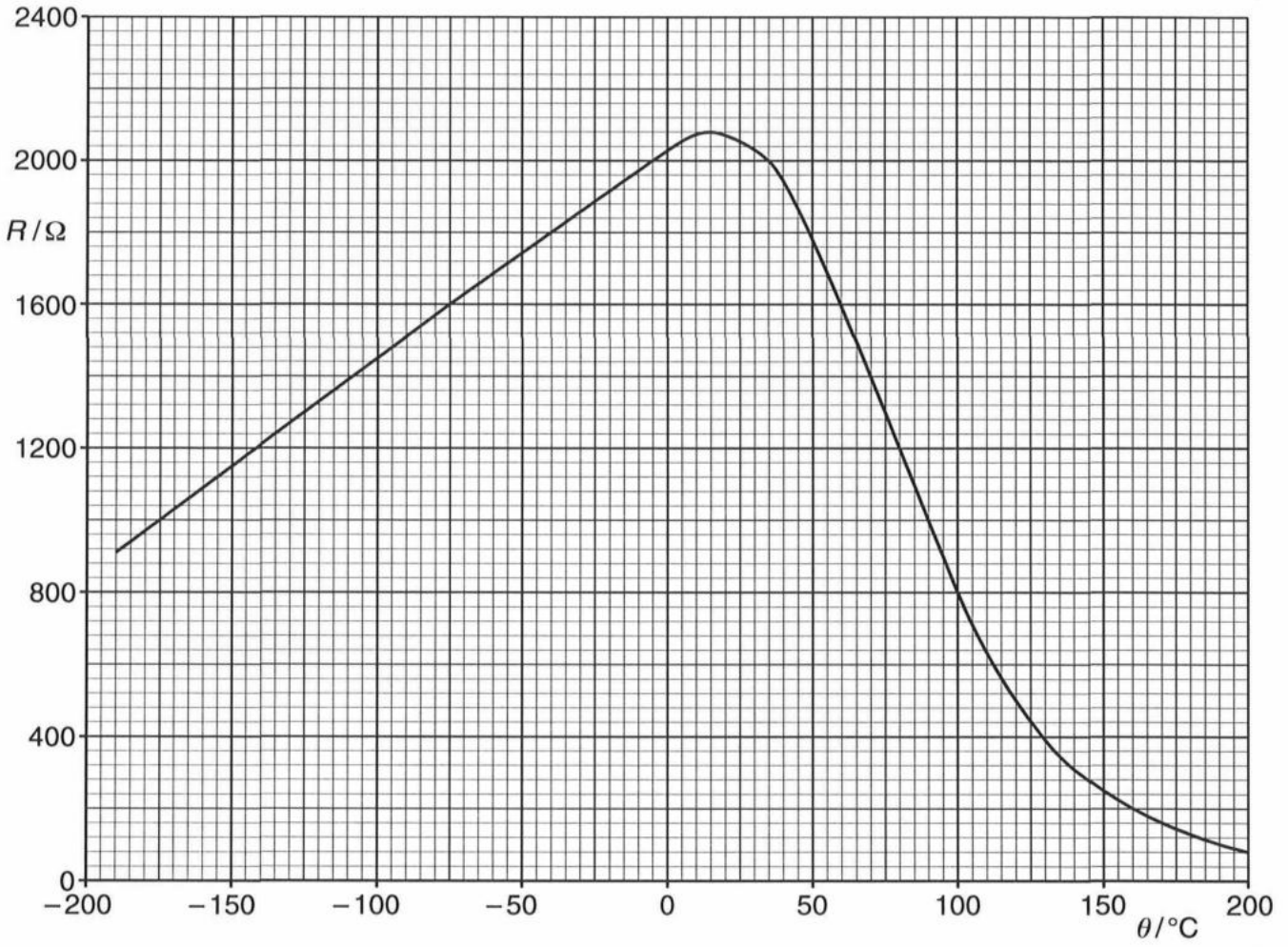

Fig. 7.1

(a) Use Fig. 7.1 to describe the variation of the resistance of the sample with temperature.

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.....[2]

(b) A student proposes that R may be inversely proportional to θ over the range of temperature from 50 °C to 150 °C. Show, without drawing a graph, that this proposal is **not** correct.

[2]

(c) A second student proposes that R decreases exponentially with thermodynamic temperature T for temperatures above about 100 °C. Fig. 7.2 shows some of the data for R, θ, T^{-1}, and $\ln(R/\Omega)$.

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R/Ω	θ/°C	$T^{-1}/10^{-3}K^{-1}$	$\ln(R/\Omega)$
500	120	2.54	6.21
400	130	2.48	5.99
310	140	2.42	5.74
250	150	2.36	5.52
	160		
158	170	2.26	5.06
120	180	2.21	4.79

Fig. 7.2

(i) Complete Fig. 7.2 for the temperature of 160 °C. [1]

(ii) Fig. 7.3 is a graph of some of the data of Fig. 7.2.

For Examiner's Use

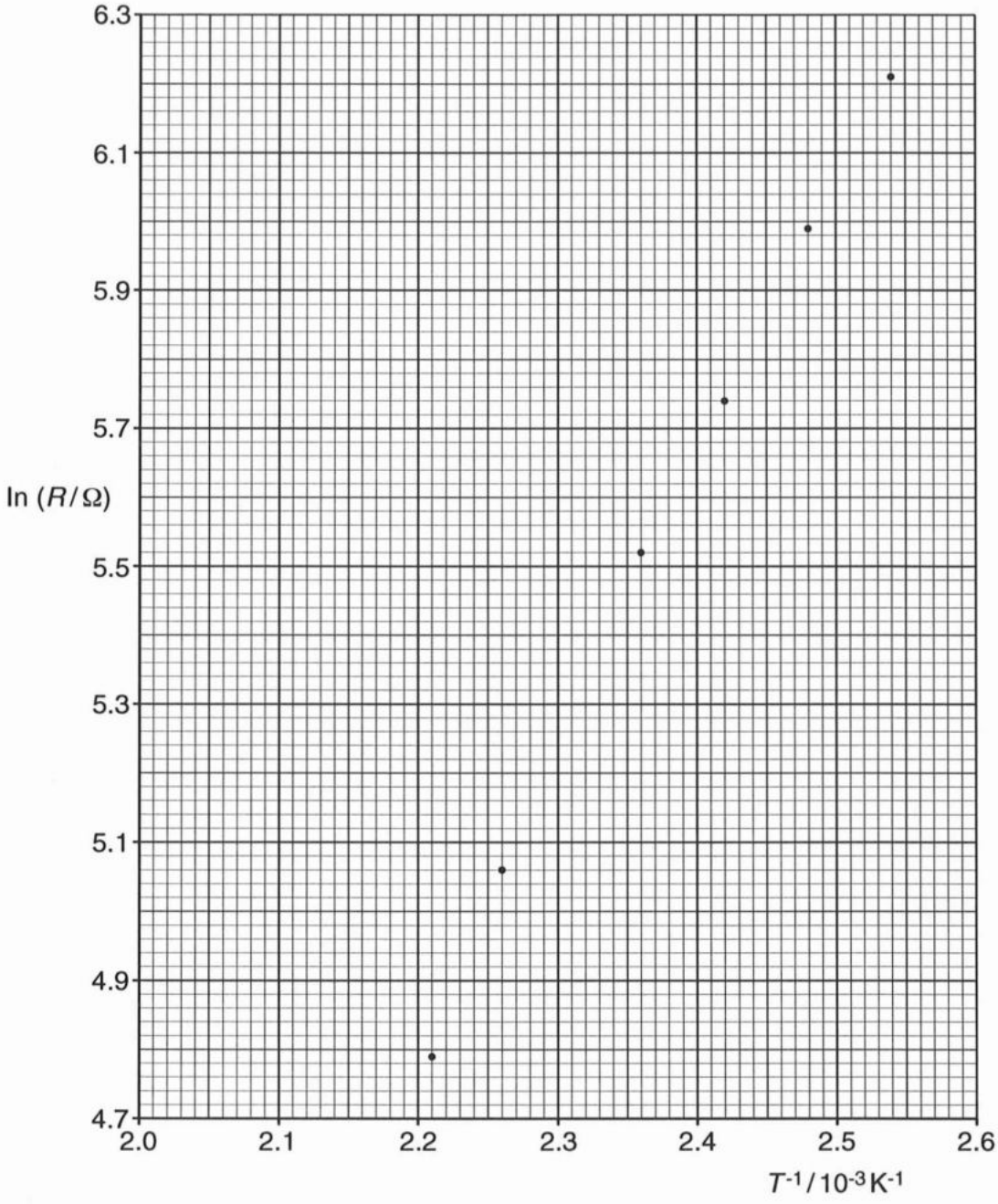

Fig. 7.3

Complete Fig. 7.3 using your data for the temperature of 160 °C. [1]

(d) The proposal for the variation with T of R for temperatures above about 100 °C is the expression

$$R = Ae^{E_g/2kT}$$

where A is a constant, E_g is the energy band gap for the semiconducting material and k is the Boltzmann constant.

(i) Explain why the graph of Fig. 7.3 supports this proposal.

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.....[2]

(ii) Use Fig. 7.3 to determine

1. the energy band gap E_g in eV,

E_g = ... eV [3]

2. the constant A.

A = ... Ω [1]

(e) Suggest and explain a difference in the resistance of an n-type semiconducting material compared to an intrinsic semiconducting material.

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.....[2]

(f) Suggest why the resistance variation with temperature of a metal is different to that shown for the semiconducting material.

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.....[1]