Q1. The critical temperature of tin is −269 °C. The resistivity of tin increases as its temperature rises from −269 °C.

(a) (i) Define resistivity.

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(2)

(ii) State the significance of the critical temperature of a material.

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(2)

(b) A sample of tin in the form of a cylinder of diameter 1.0 mm and length 4.8 m has a resistance of 0.70 Ω.

Use these data to calculate a value of the resistivity of tin.
State an appropriate unit for your answer.

resistivity .... unit ....

(4)
(Total 8 marks)

Q2. (a) State what is meant by a superconducting material.

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(2)

(b) State an application of a superconductor and explain why it is useful in this application.

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(2)
(Total 4 marks)

Q3. (a) A sample of conducting putty is rolled into a cylinder which is 6.0×10^{-2} m long and has a radius of 1.2×10^{-2} m.

resistivity of the putty = 4.0×10^{-3} Ωm.

Calculate the resistance between the ends of the cylinder of conducting putty.
Your answer should be given to an appropriate number of significant figures.

answer = ... Ω

(4)

(b) Given the original cylinder of the conducting putty described in part (a), describe how you would use a voltmeter, ammeter and other standard laboratory equipment to determine a value for the resistivity of the putty.

Your description should include

- a labelled circuit diagram,
- details of the measurements you would make,
- an account of how you would use your measurements to determine the result,
- details of how to improve the precision of your measurements.

The quality of your written communication will be assessed in this question.

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(8)
(Total 12 marks)

M1. (a) (i) resistivity is defined as

$$\rho = \frac{RA}{l}$$

where *R* is the resistance of the material of length *l* ✓
and cross-sectional area *A* ✓

2

(ii) below the critical temperature / maximum temperature which resistivity / resistance ✓
is zero / becomes superconductor ✓

Any reference to negligible / small / very low resistance loses second mark

2

(b) (*use of* $\rho = \frac{RA}{l}$)

$\rho = 0.70 \times \pi \times 0.0005^2 / 4.8$ ✓ $= 1.1(5) \times 10^{-7}$ (1.1 – 1.2) ✓ ✓ Ω m ✓

First mark for substitution R and l
Lose 1 mark if diameter used as radius and answer is 4 times too big (4.4 – 4.8) OR if power of ten error

4

[8]

M2. (a) no resistance

M1

(at or) below critical temperature

A1

alternative:

allow a labelled diagram which indicates features, allow T_c for transition temp in diagram

2

(b) **Use**

eg mri scanner, transformer, generator, maglev train, particle accelerators, microchips, computers, energy storage with detail

B1

Reason

eg **strong** magnetic field, no energy dissipation (mri scanner / maglev / particle accelerator)
higher (processing) speeds, smaller, no energy dissipation

(microchip / computer)

B1

smaller, no energy dissipation, no fire risk (transformer / generator)
no energy dissipation (power transmission / energy storage with detail)

2

[4]

M3. (a) (use of $R = \rho l/A$)

$R = 4.0 \times 10^{-3} \times 0.060$ **(1)**/($\pi \times 0.012^2$) **(1)**

$R = 0.53$ (Ω) **(1)**

2 significant figures **(1)**

4

(b) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

circuit must include:

voltmeter and ammeter connected correctly **(1)**

power supply with means of varying current **(1)**

2

QWC	descriptor	mark range
good-excellent	(i) Uses accurately appropriate grammar, spelling, punctuation and legibility. (ii) Uses the most appropriate form and style of writing to give an explanation or to present an argument in a well structured piece of extended writing. [may include bullet points and/or formulae or equations] An excellent candidate will have a working circuit diagram with correct description of measurements (including range of results) and processing. An excellent candidate uses a range of results and finds a mean value or uses a graphical method, eg *I-V* characteristics. They also mention precision eg use of vernier callipers.	**5-6**
modest-adequate	(i) Only a few errors. (ii) Some structure to answer, style acceptable, arguments or explanations partially supported by evidence or examples. An adequate candidate will have a working circuit and a description with only a few errors, eg do not consider precision. They have not taken a range of results and fail to realise that the diameter needs to be measured in several places.	**3-4**
poor-limited	(i) Several significant errors. (ii) Answer lacking structure, arguments not supported by evidence and contains limited information. Several significant errors, eg important measurement missed, incorrect circuit, no awareness of how to calculate resistivity.	**1-2**
incorrect, inappropriate or no response		**0**

The explanation expected in a good answer should include a coherent account of the procedure and include most of the following points.

- length with a ruler
- thickness/diameter with vernier callipers/micrometer
- measure voltage
- measure current
- calculate resistance
- use of graph, eg *I*-*V* or resistance against length
- use of diameter to calculate cross-sectional area
- mention of precision, eg vernier callipers or full scale readings for V and I
- flat metal electrodes at each end to improve connection

6

[12]