1 The black core of a pencil is referred to as pencil lead.

Pencil lead is a non-metallic material which has a resistivity of 5.4×10^{3} Ω m at room temperature.

(a) A piece of pencil lead has a length of 15 cm and a cross-sectional area of 1.5×10^{6} m^2.

Show that its resistance is approximately 500 Ω.

(3)

(b) (i) Pencil lead has a negative temperature coefficient of resistance.

Explain what this means.

(2)

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*(ii) A piece of pencil lead is connected in series with an ammeter and a power supply.
The power supply is turned on. After a few minutes, although the potential difference across the pencil lead does not change, the current in the circuit increases significantly.

Explain why the current increases.

(3)

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(Total for Question 8 marks)

2 An integrated circuit uses strips of gold as connectors and strips of silicon as resistors.

A strip of gold of cross-sectional area 3.0×10^{-6} m^2 carries a current of 8.0 mA. The charge carrier density n is 6.0×10^{28} m^{-3}.

(a) Show that the carrier drift velocity v for gold is approximately 3×10^{-7} m s^{-1}.

(2)

(b) An approximate value of v for a sample of silicon of the same dimensions, carrying the same current, would be 0.2 m s^{-1}.

Compare this value with the one for gold and account for the difference in the values.

(2)

(c) State and explain what happens to the resistance of a sample of silicon as its temperature increases.

(2)

(Total for Question = 6 marks)

3 The current I in a length of aluminium of cross-sectional area A is given by the formula

$$I = nevA$$

where e is the charge on an electron.

(a) State the meanings of n and v.

(2)

n: .....

v: .....

(b) Show that the units on the left hand side of the equation are consistent with those on the right hand side.

(3)

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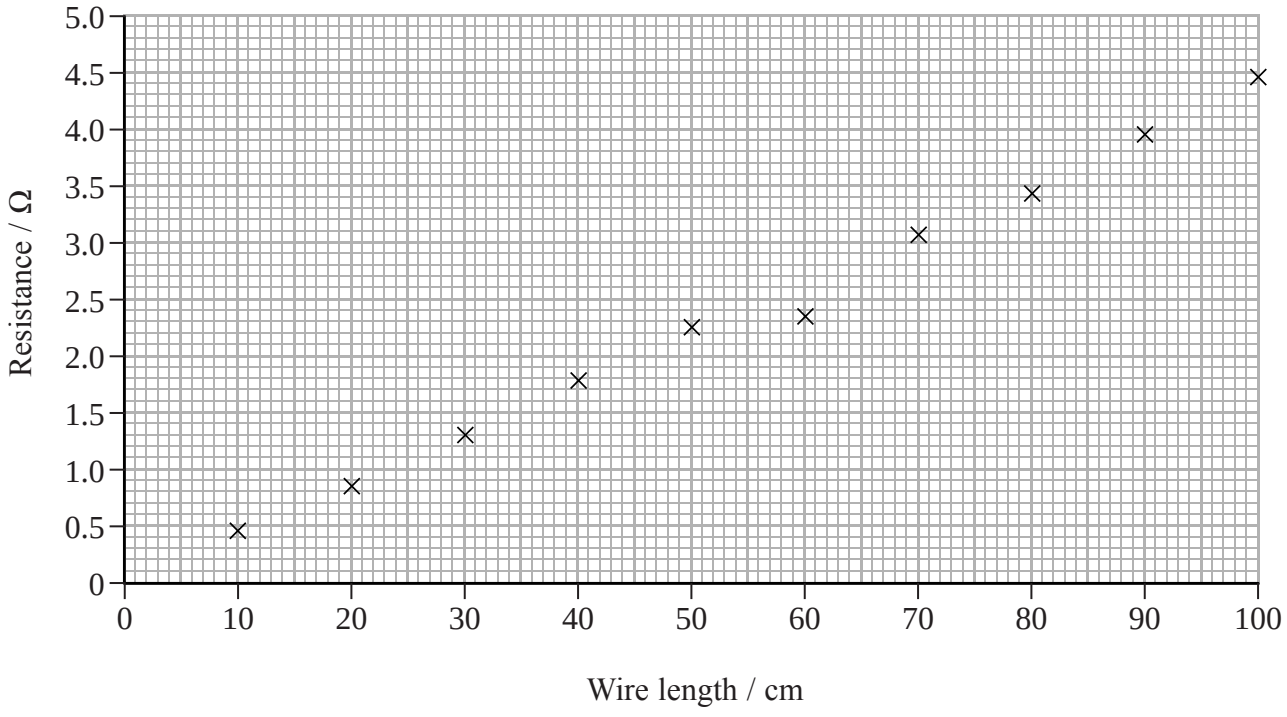
(Total for Question = 5 marks)

4 A student carried out a series of measurements to determine how the resistance of a wire varies with its length.

The student obtained the following results.

Wire length / cm	Current / A	Potential difference / V	Resistance / Ω
100	0.15	0.67	4.47
90	0.16	0.63	3.94
80	0.17	0.58	3.41
70	0.17	0.52	3.06
60	0.18	0.42	2.33
50	0.18	0.40	2.22
40	0.19	0.34	1.79
30	0.20	0.26	1.30
20	0.22	0.18	0.82
10	0.22	0.10	0.45

The student plotted the results on a graph.



(a) Calculate the resistivity of the wire used.

cross-sectional area of wire = 1.06×10^{-7} m^2

(4)

Resistivity =

(b) One precaution taken by the student was to keep the current small.

Explain why this precaution was necessary.

(2)

(c) Explain **one** other precaution which should be taken by the student to ensure the accuracy of the results in the table.

(2)

(Total for Question = 8 marks)

5 The instruction booklet for an electric garden shredder includes the following advice.

When using an extension cable, the following dimensions should be observed:

Cross-sectional area of conductor / mm^2	Maximum cable length / m
1.00	40
1.50	60
2.50	100

(a) Describe the relationship between area and length in the table.

(1)

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(b) The cable for the shredder contains two conductors in series, the live wire and the neutral wire. A cable of length 40 m has a total conductor length of 80 m.

(i) Show that the resistance of a copper conductor of length 80 m and cross-sectional area 1.00 mm^2 is about 1.3 Ω.

resistivity of copper 1.68×10^{-8} Ω m

(2)

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(ii) When in use the current for the shredder is 11 A.
Calculate the rate of energy dissipation by the 40 m, 1.00 mm^2 cable when it is used with the shredder.

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Rate of energy dissipation .....

(iii) Calculate the total potential difference across the conductors in the 40 m cable when it is used with the shredder.

(2)

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Potential difference .....

(c) Suggest why the advice in the instruction booklet is included.

(2)

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(Total for Question 9 marks)

6 A car battery has an e.m.f. of 12 V and an internal resistance of $3.0 \times 10^{3}\ \Omega$. For the starter motor to turn the engine, the battery must provide a current of 400 A.

(a) Calculate the terminal potential difference across the terminals of the battery when the current through the battery is 400 A.

(3)

Terminal potential difference .....

(b) The copper wires between the battery and the motor have a diameter of 1 cm.

Explain why such a thick wire is needed.

(3)

(Total for Question 6 marks)

7 When food is cooked in a microwave oven, microwave radiation is absorbed by water molecules, increasing the internal energy of the food.

(a) A student heats water in a microwave oven for 1 minute to determine the efficiency of the oven at transferring energy to the water. The current in the microwave oven is 5.0 A and the potential difference is 230 V. The increase in internal energy of the water is 29 000 J.

Calculate the efficiency of the microwave oven at heating the water.

(4)

Efficiency .....

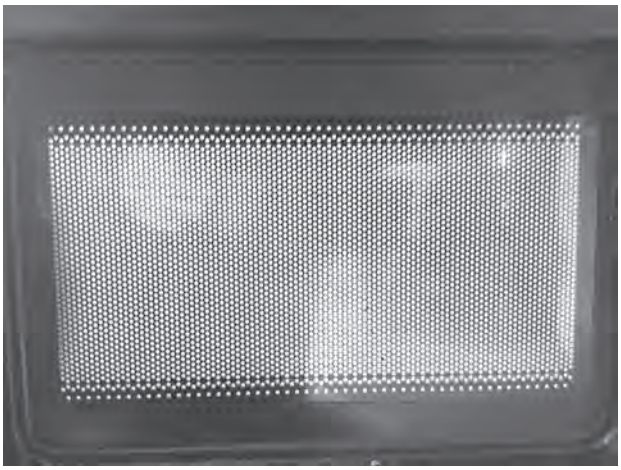
(b) The photograph shows a microwave leakage detector.

The detector is held next to the microwave oven to see if any microwave radiation is leaking to the surroundings.

Suggest why microwave radiation leaking to the surroundings could be dangerous to people.

(2)

(c) The internal walls of the microwave oven are solid metal. The photograph shows the door of a microwave oven.



The door consists of two sheets of glass with a layer of metal between. The layer of metal has many small holes in it, so that food inside the microwave oven may be seen while it is being heated without exposing the user to dangerous levels of microwave radiation. It has been suggested that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(i) Explain what is meant by diffraction.

(2)

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(ii) Calculate the wavelength of the microwave radiation used in the oven.

microwave frequency 2.5 GHz.

(2)

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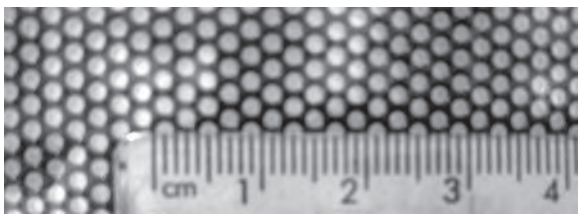
Wavelength .....

(iii) The photograph shows a section of the microwave oven door. Use the photograph to determine the diameter of the holes.



(1)

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Diameter .....

*(iv) Discuss the suggestion that, due to diffraction effects, light can pass through the holes but microwaves cannot.

(3)

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(Total for Question 14 marks)