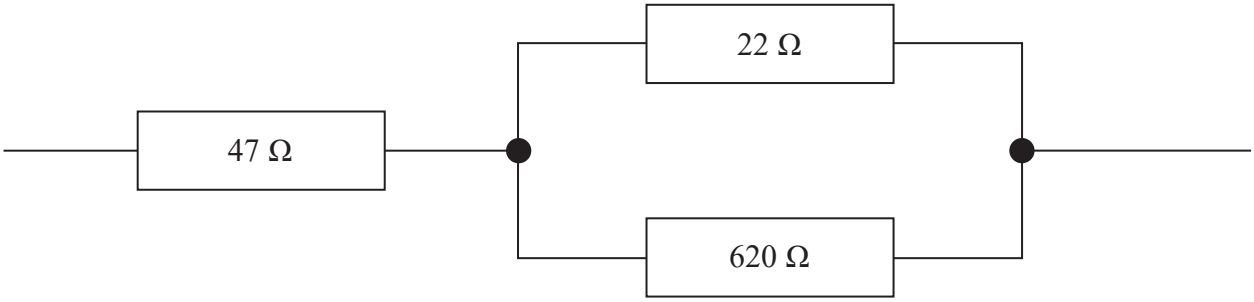
1 The circuit shows a combination of three resistors.



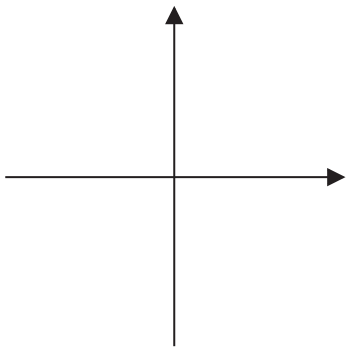
Calculate the total resistance of this combination.

(3)

Total resistance =

(Total for Question = 3 marks)

2 (a) Sketch a graph to show how current varies with potential difference for a filament lamp.



(2)

(b) The temperature of a filament lamp increases as the current through it increases.

Explain this in terms of the structure of a metal.

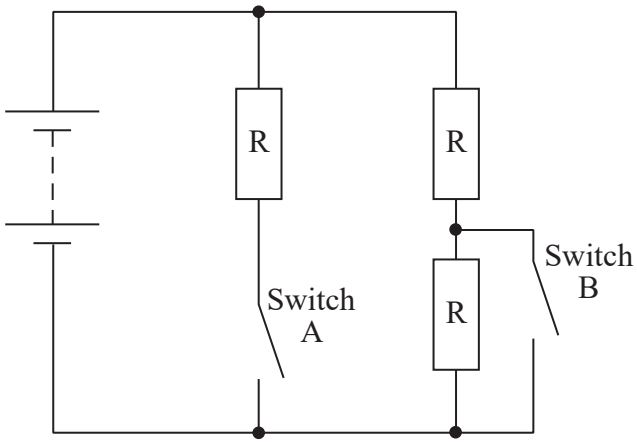
(3)

(Total for Question = 5 marks)

3 The photograph shows a convector heater designed for use in a home. It operates by air flowing through the heater and passing over its heating elements.

The heater contains three identical heating elements and two switches.

(a) A student models the heater using the circuit below. The power supply has a negligible internal resistance.



The table gives the four possible combinations of the two switches.
Complete the table to show the total circuit resistance for each switch combination.

(3)

Switch combinations	Total circuit resistance
A open. B closed	R
A open. B open	
A closed. B closed	
A closed. B open	

(b) Explain which switch combination dissipates the most energy in a given time.

(2)

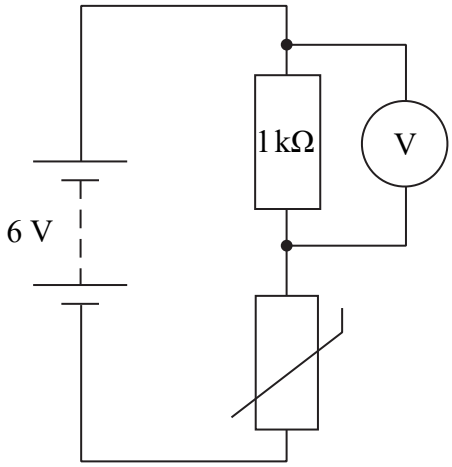
(c) The power supply is replaced by one with an internal resistance.

Explain what effect this change will have on the thermal energy output of the heater.

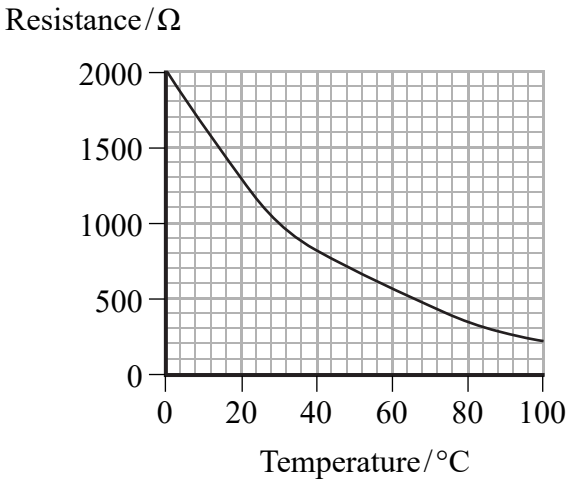
(2)

(Total for Question 7 marks)

4 The following circuit is used to monitor the temperature in a greenhouse. The battery has no internal resistance.



(a) The graph shows how the resistance of the thermistor varies with temperature.



(i) Use the graph to find the resistance of the thermistor at 20 °C.

(1)

Resistance =

(ii) Calculate the reading on the voltmeter when the thermistor is at 20 °C.

(3)

Reading on the voltmeter =

(b) Explain what will happen to the reading on the voltmeter as the temperature of the greenhouse decreases.

(2)

(Total for Question = 6 marks)

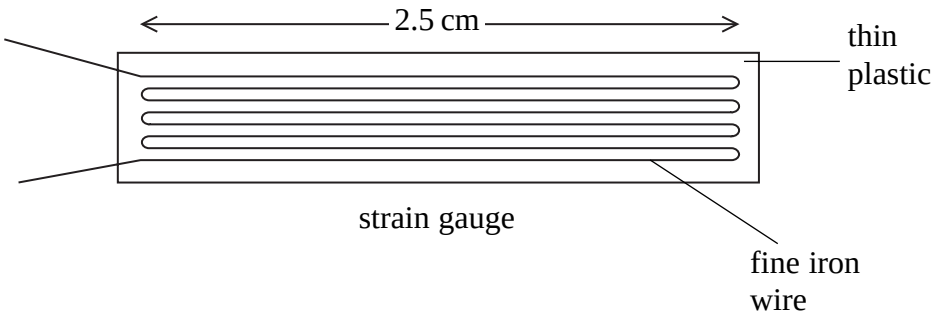
5 The aircraft industry uses an instrument called a resistance strain gauge to determine the strain in propellers.

The resistance strain gauge is based on the principle that the electrical resistance of a wire changes when it is stretched.

(a) A stretched wire becomes longer and thinner. Using an equation to justify your answer, explain what effect stretching a length of wire would have on its resistance.

(3)

(b) The diagram shows a typical resistance strain gauge. The wire in the gauge is arranged in a zigzag pattern.



The length of the zigzag pattern is 2.50 cm and the cross-sectional area of the iron wire is $9.0 \times 10^{-8}\,m^2$. The resistivity of iron is $9.9 \times 10^{-8}\,\Omega\,m$.

Show that the total resistance of the strain gauge is about $0.2\,\Omega$.

(3)

(c) (i) A wire of length l and cross-sectional area A is stretched. Assuming the volume V of the wire remains constant

$$V = lA = \text{constant}$$

Show that the resistance of the wire is directly proportional to l^2.

(2)

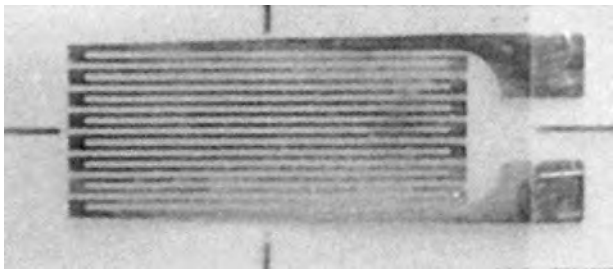
(ii) The length of the zigzag pattern, when under strain, increases to 2.51 cm.

Calculate the increase in resistance of the wire in the gauge.

(3)

Increase in resistance =

(d) In practice, very small changes in length are to be determined and the gauge itself has to be reasonably small. Consequently, the gauge is made of a length of very fine iron wire which is arranged in a zigzag pattern between two thin sheets of plastic.

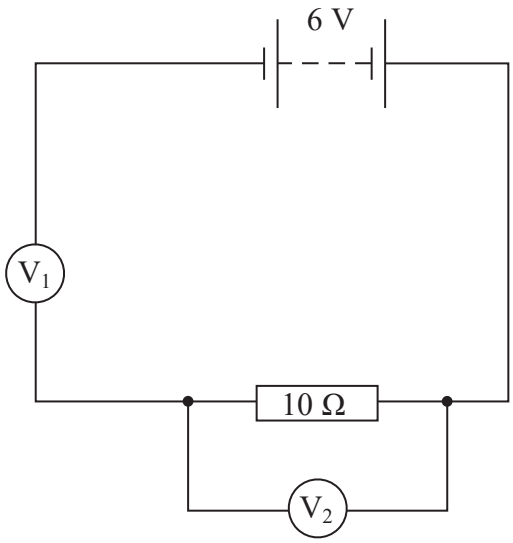


What is the benefit of the iron wire being in this pattern?

(2)

(Total for Question = 13 marks)

6 The diagram shows a circuit set up by a student.



(a) Both voltmeters have a resistance of 10 MΩ. The reading on V_1 is 6 V and the reading on V_2 is zero.

Explain these readings.

(2)

(b) The student replaces the 10 Ω resistor with a resistor of unknown resistance *R*. The reading on V_1 is now 4 V.

Calculate the value of *R*.

(3)

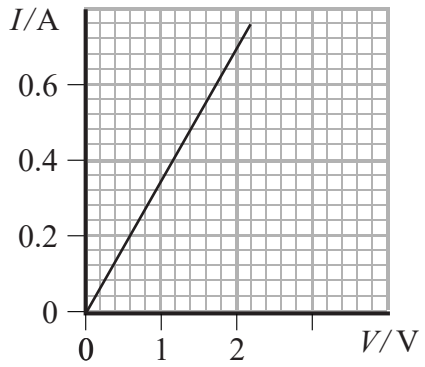
R =

(Total for Question 5 marks)

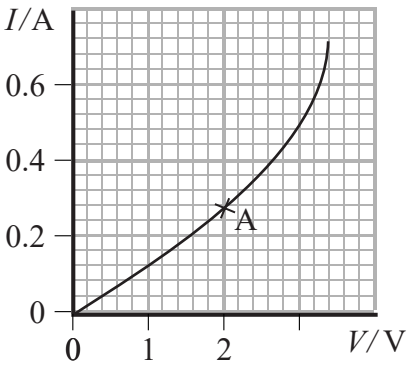
7 (a) Show how the ohm is derived.

(1)

(b) The graphs show the current-potential difference (*I*-*V*) characteristics for a metal conductor and for a thermistor.



Metal conductor



Thermistor

(i) Calculate the resistance of the thermistor at point A.

(2)

Resistance =

(ii) Use the graphs to describe how the resistance varies with potential difference for each component.

(2)

(iii) Explain, in terms of electrons, why the thermistor behaves in this way.

(2)

(Total for Question 7 marks)

8 (a) A kettle is rated at 1 kW, 220 V.

Calculate the working resistance of the kettle.

(2)

Resistance =

(b) When connected to a 220 V supply, it takes 3 minutes for the water in the kettle to reach boiling point.

Calculate how much energy has been supplied.

(2)

Energy =

(c) Different countries supply mains electricity at different voltages. Many hotels now offer a choice of voltage supplies as shown in the photograph.

(i) By mistake, the kettle is connected to the 110 V supply. Assuming that the working resistance of the kettle does not change, calculate the time it would take for the same amount of water to reach boiling point.

(3)

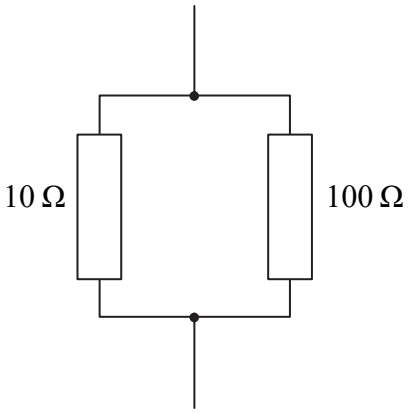
Time =

(ii) Explain what might happen if a kettle designed to operate at 110 V is connected to a 220 V supply.

(2)

(Total for Question 9 marks)

9 Two resistors are connected in parallel.



(a) Calculate the resistance of the combination.

(2)

Resistance =

(b) This resistance combination is used in an electrical circuit. A student measures the potential difference across the combination with a high resistance voltmeter. Explain why the resistance of the combination is hardly changed by the addition of the voltmeter.

(3)

(Total for Question = 5 marks)