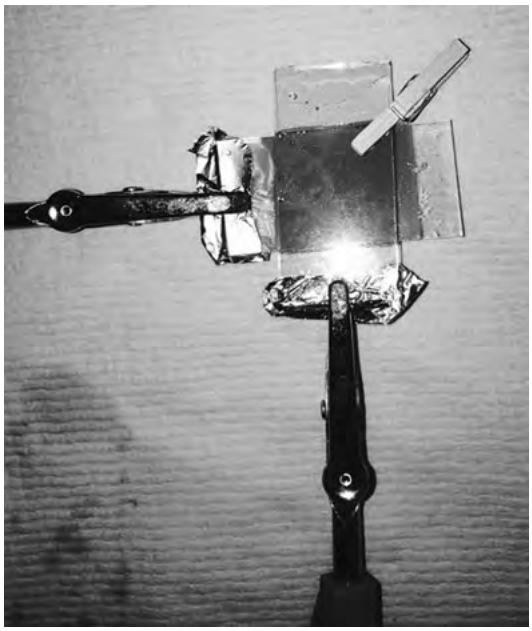
1 Many plants obtain energy from sunlight using a green pigment called chlorophyll. Other plant pigments can also absorb sunlight, for example the red pigment in raspberries. The photograph shows a solar cell that uses a pigment from raspberries to absorb light in order to generate an e.m.f.



When measured with a high resistance voltmeter, the e.m.f. is found to be 400 mV. When the solar cell is connected across a 4700 Ω resistor, the potential difference across the resistor is 18 mV.

(a) Calculate the internal resistance of the solar cell.

(3)

Internal resistance =

(b) The absorbing area of the solar cell is 3.9×10^{-4} m^2 and the radiation flux is 1.5 mW m^{-2}. Calculate the efficiency of the solar cell in transferring energy from sunlight to the resistor.

(4)

Efficiency =

(Total for Question = 7 marks)

2 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.

(2)

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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)

3 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 .....

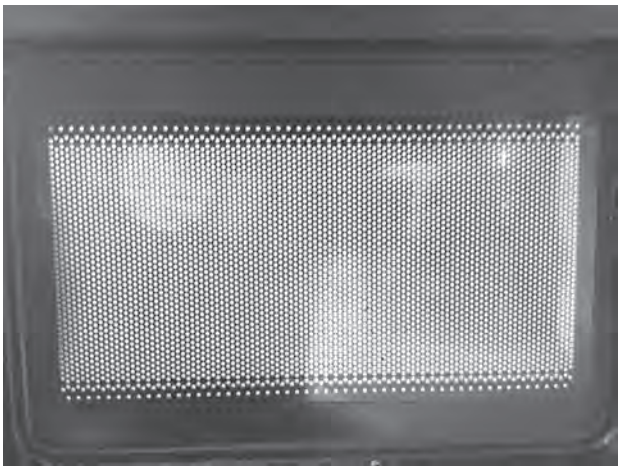
(b) The photograph shows a microwave leakage detector.

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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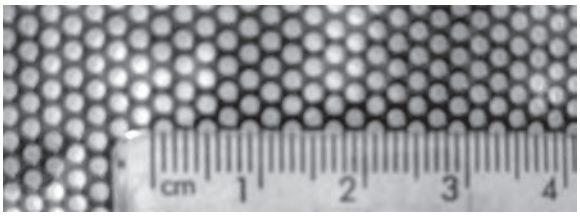
Wavelength .....

(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)

4 A student is taking measurements in order to determine the resistance of a component in a circuit. He connects a voltmeter in parallel with the component and an ammeter in series with the component.

Explain why the voltmeter should have a very high resistance.

(2)

(Total for Question = 2 marks)

5 An electric kettle is used to heat water from room temperature to boiling point.

(a) (i) Calculate the electrical power used by the kettle.

potential difference = 230 V

current = 12.5 A

(2)

Electrical power =

(ii) The kettle is switched on for 140 s.

Calculate the total energy supplied to the kettle.

(2)

Total energy supplied =

(iii) The amount of thermal energy transferred to the water is calculated to be 351 000 J.

Calculate the efficiency of the kettle at heating the water.

(2)

Efficiency =

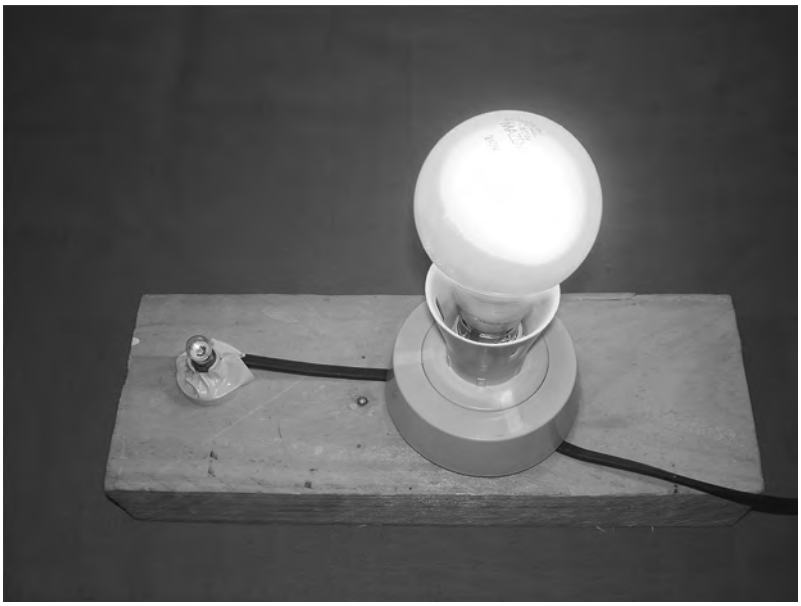
(b) A student suggests that the useful energy required is thermal and the kettle only produces thermal energy, so it should be 100 % efficient.

Discuss this suggestion.

(2)

(Total for Question = 8 marks)

6 The photograph shows a piece of apparatus in which a mains light bulb and a torch bulb are both connected to the mains.



Students were surprised to see both bulbs shining normally when the apparatus was switched on.

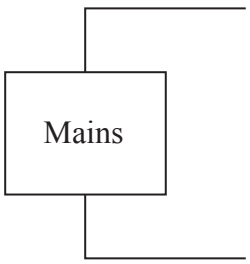
It is impossible to tell from looking at the apparatus whether the bulbs are connected in series or in parallel.

To test this, the apparatus was switched off and the mains bulb was removed. When it was switched on again the torch bulb did not light up. When this was repeated, removing the torch bulb, the mains bulb did not light up.

When the circuit was tried again with both bulbs, they still operated normally.

(a) Complete the circuit diagram to show how the bulbs are connected and explain why they must be connected in this way and not the alternative.

(3)



(b) The mains bulb is marked 40 W, 230 V.

(i) Show that the current in the mains bulb is about 0.2 A when it is operating normally.

(2)

(ii) Calculate the resistance of the mains bulb when it is operating normally.

(2)

Resistance =

(iii) The torch bulb is marked 2.5 V, 0.20 A.

Calculate the resistance of the torch bulb when it is operating normally.

(2)

Resistance =

(c) Explain, with reference to both current and potential difference, why it is possible to operate both bulbs at the same time from the same power supply.

(2)

(d) Earlier in the question you were asked to calculate the resistances of the bulbs when operating normally.

Explain the effect on the resistances of the bulbs if they are operated at a much smaller current so that neither bulb lights up.

(4)

(Total for Question = 15 marks)

7 Mobile phones have a rechargeable battery which is recharged by means of a mains adaptor. One such adaptor has an input power of 4.8 W at a voltage of 230 V.

(a) Calculate the input current to the adaptor when it is in use.

(2)

Input current =

(b) The adaptor's output is labelled as 5 V 0.1 A 0.5 V A

(i) Show that the unit V A is equivalent to the watt.

(1)

(ii) Calculate the efficiency of the adaptor.

(2)

Efficiency =

(iii) Suggest a reason why the efficiency is less than 100%.

(1)

(Total for Question = 6 marks)