Mains electricity A.C.

Domestic uses and safety

Name: _____

Class: _____

Date: _____

Time: **69 minutes**

Marks: **68 marks**

Comments: **Questions**

1 (a) Describe the difference between an alternating current (a.c.) and a direct current (d.c.).

_____

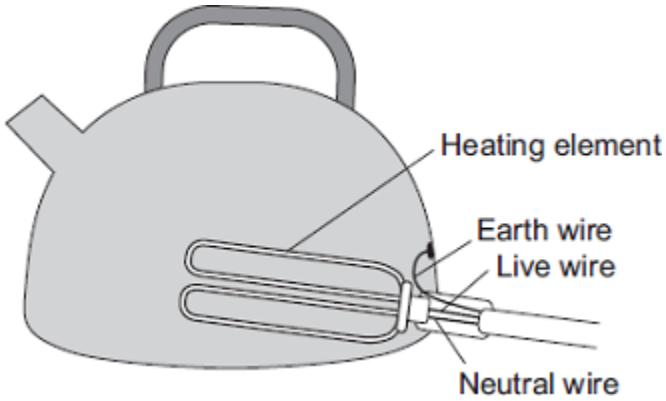
_____

_____

_____

(2)

(b) The diagram shows how the electric supply cable is connected to an electric kettle. The earth wire is connected to the metal case of the kettle.



If a fault makes the metal case live, the earth wire and the fuse inside the plug protect anyone using the kettle from an electric shock.

Explain how.

_____

_____

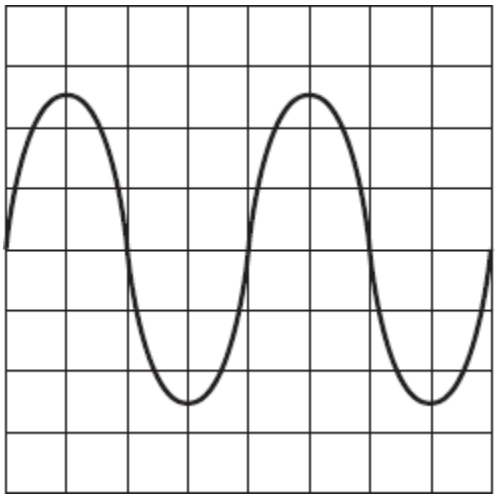
_____

_____

(2)

(Total 4 marks)

2 An oscilloscope is connected to an alternating current (a.c.) supply.
The diagram shows the trace produced on the oscilloscope screen.



Each horizontal division on the oscilloscope screen represents 0.002 s.

(a) Calculate the frequency of the alternating current supply.

Show clearly how you work out your answer and give the unit.

_____

_____

_____

Frequency = _____

(3)

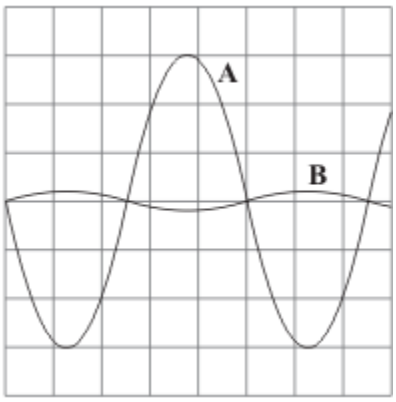
(b) What is the frequency of the a.c. mains electricity supply in the UK?

_____

(1)

(Total 4 marks)

3 The diagram shows two oscilloscope traces, **A** and **B**.



Trace **A** shows how the potential difference between the live and neutral terminals of an electricity supply changes with time.

(a) Describe how the potential of the live terminal varies with respect to the neutral terminal of the electricity supply.

_____

_____

(2)

(b) What does trace **B** show?

_____

_____

(1)

(c) Each horizontal division on the oscilloscope represents 0.005 s.

(i) What is the period of this electricity supply?

_____

Period = _____ seconds

(1)

(ii) Calculate the frequency of the supply.

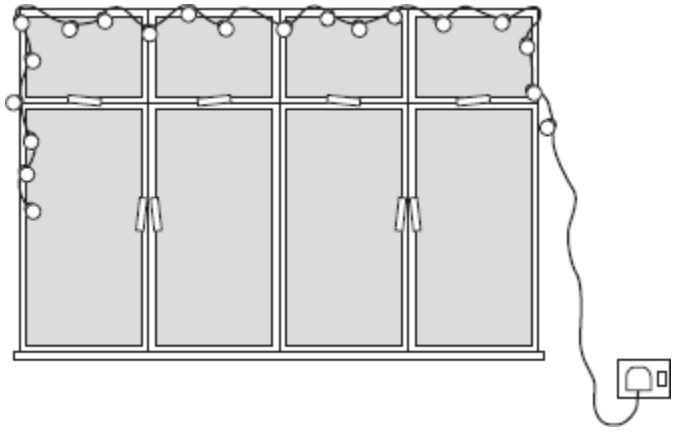
_____

Frequency = _____ hertz

(1)

(Total 5 marks)

4 A set of lights consists of 20 lamps connected in series to the 230 V mains electricity supply.



(a) When the lights are switched on and working correctly, the current through each lamp is 0.25 A.

(i) What is the total current drawn from the mains supply?

_____

(1)

(ii) Calculate the charge passing through **one** of the lamps in 5 minutes.

Show clearly how you work out your answer and give the unit.

_____

_____

_____

_____

Total charge = _____

(3)

(b) One of the lamps in the set is a fuse lamp. This contains a filament which melts if a fault occurs. A short time after the lights are switched on, a fault causes the filament inside the fuse lamp to melt and all the lamps go out.

The householder cannot find another fuse lamp so connects a piece of aluminium foil across the contacts inside the fuse lamp holder.
When switched on, the nineteen remaining lamps work.
What the householder has done is dangerous.

Explain why.

_____

_____

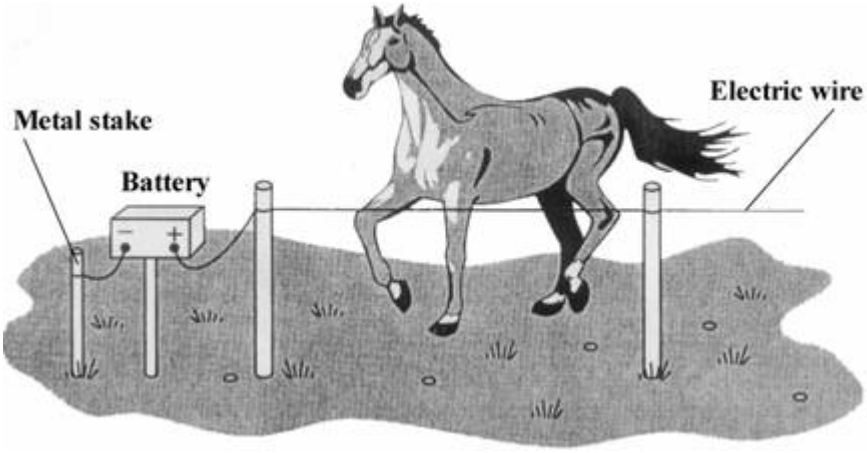
_____

_____

(2)

(Total 6 marks)

5 (a) The diagram shows an electric fence, designed to keep horses in a field.



When a horse touches the wire the horse receives a mild electric shock. Explain how.

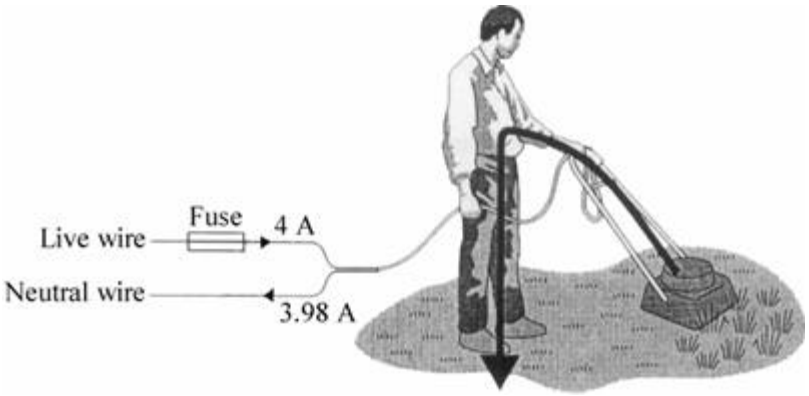
_____

_____

_____

(2)

(b) The diagram shows how a person could receive an electric shock from a faulty electrical appliance. Using a residual circuit breaker (RCB) can help to protect the person against receiving a serious shock.



(i) Compare the action of an RCB to that of a fuse.

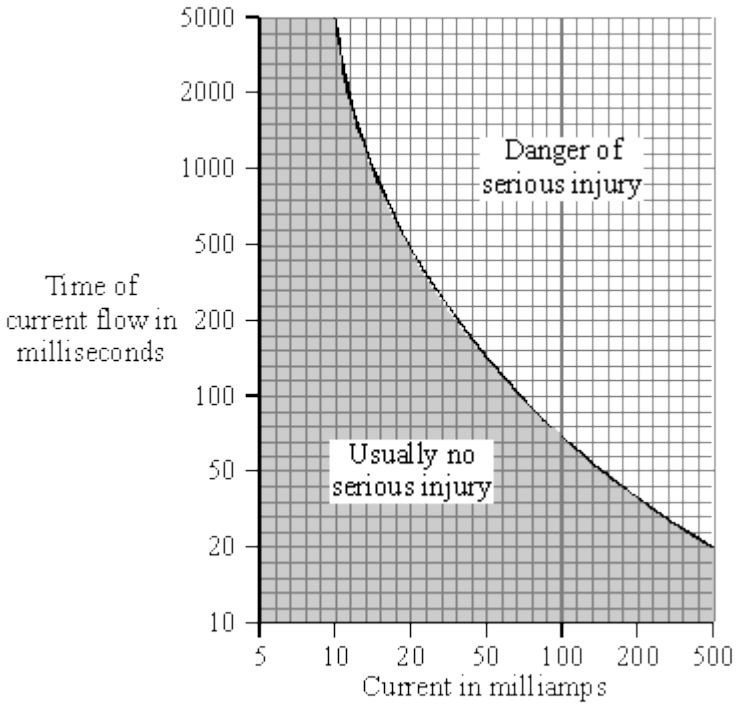
_____

_____

_____

(2)

(ii) The graph illustrates how the severity of an electric shock depends upon both the size of the current and the time for which the current flows through the body.



Within how long must the RCB cut off the current if the person using the lawnmower is to be in no danger of serious injury?

_____

_____

Time = _____ milliseconds

(2)

(Total 6 marks)

6 Carefully read the following extract from a safety leaflet. Then answer the questions.

> An RCD adaptor is an automatic safety switch. It should be used when there is a particular risk of electric shock. For example, it is recommended that it is used with an electric lawnmower.
>
> Inside one make of RCD is an electromagnet that holds the switch closed so that the RCD is switched on. An electronic circuit in the RCD monitors the difference between the current in the live wire and the current in the neutral wire.
>
> If something goes wrong and this difference is greater than 30 milliamps then the RCD will trip (= switch off) within 40 milliseconds.

(a) Suggest **two** reasons why there is a particular risk of an electric shock when using an electric lawnmower.

1. _____

_____

2. _____

_____

(2)

(b) Why will there be a difference between the current in the live wire and the current in the neutral wire if something goes wrong?

_____

_____

(1)

(c) (i) Use the words charge, current and time to write an equation which shows the relationship between them.

_____

(1)

(ii) Calculate how much charge flows when a current of 30 milliamps passes for 40 milliseconds.

Clearly show how you get to your answer and give the unit.

_____

_____

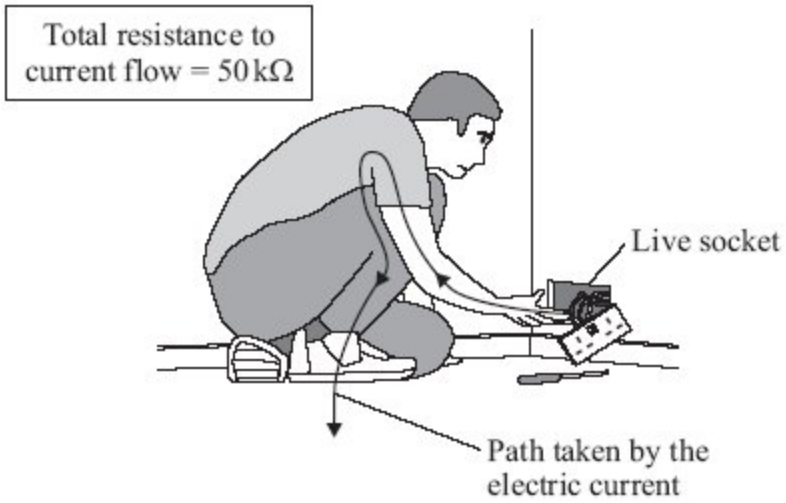
Charge = _____

(3)

(Total 7 marks)

7 The diagram shows someone accidentally touching the live wire inside a dismantled 230 volt mains electricity socket.

A current flows through the person giving him an electric shock.



(a) (i) Calculate the current that will flow through the person.

Show clearly how you work out your answer.

_____

_____

Current = _____ A

(2)

(ii) Rubber is a good insulator.

Explain why it is a good idea for electricians to wear rubber soled boots when working.

_____

_____

_____

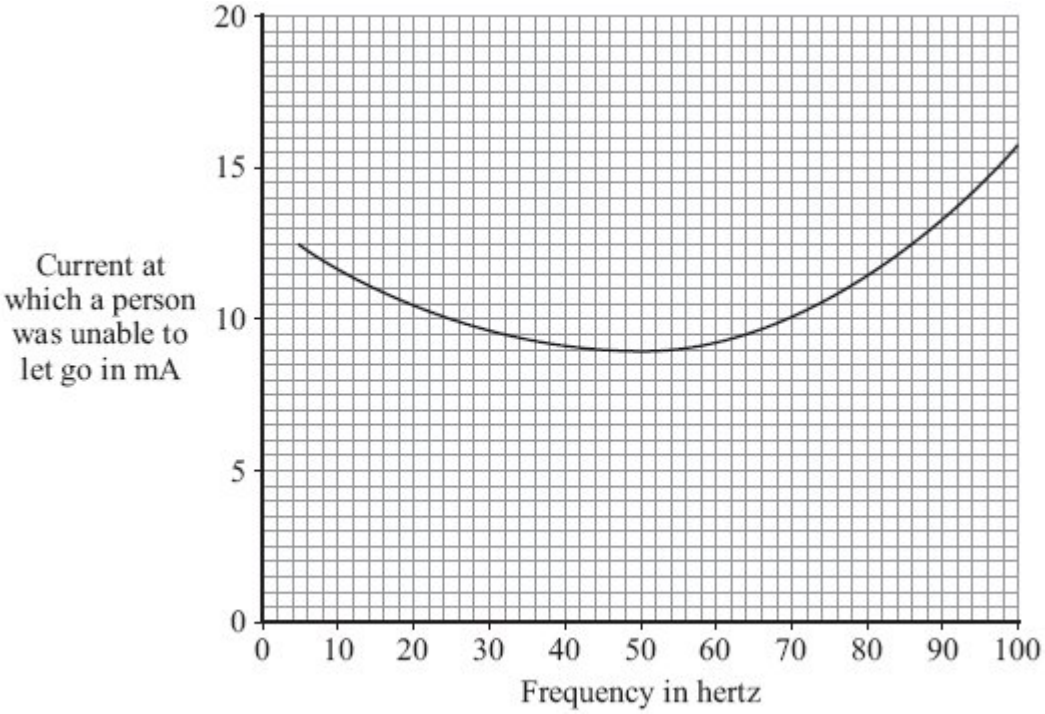
_____

(2)

(b) If the current flowing through a person is too high, the person cannot let go of the electrical source.

Different people were tested to see whether the ability to let go of an electrical source depended on the frequency of the current.

The results of the test are shown in the graph.



(i) What is the frequency of the mains electricity supply in the UK?

_____

(1)

(ii) From a safety point of view, is the frequency of the UK mains electricity supply suitable?

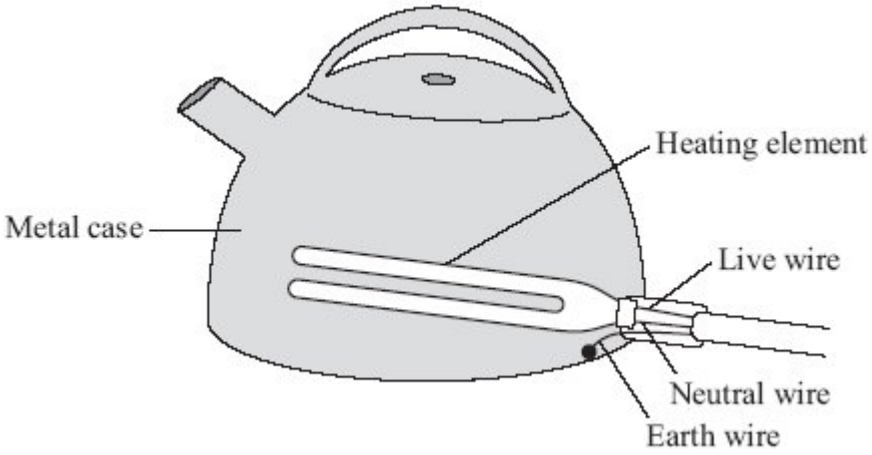
Give a reason for your answer.

_____

_____

(1)

(c) The diagram shows how the electric supply cable is connected to an electric kettle.
The earth wire is connected to the metal case of the kettle.



If a fault makes the metal case live, the earth wire and the fuse inside the plug protect anyone using the kettle from an electric shock.

Explain how.

_____

_____

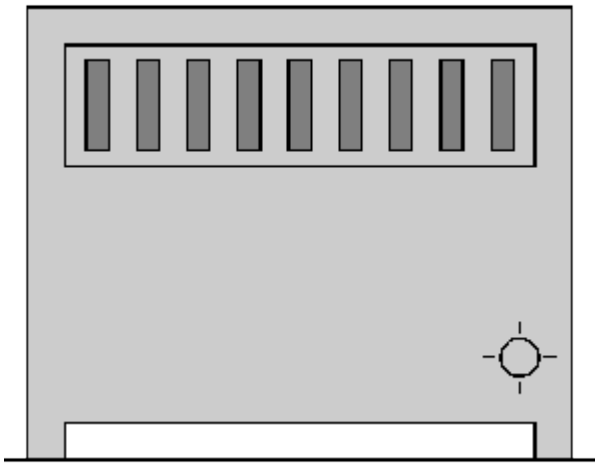
_____

_____

(2)

(Total 8 marks)

8 (a) The diagram shows a fan heater.



(i) A current of 11A flows when the fan heater is working normally.
Fuses of value 3A, 5A, 10A and 13A are available.
Which one should be used in the plug of the fan heater?

_____

(1)

(ii) A fault caused a much higher than normal current to flow in the heater.
Describe what happened to the wire in the fuse.

_____

_____

_____

_____

(2)

(b)

You may find this equation useful when answering this part of the question

energy transferred (kWh) = power (kilowatt, kW) × time (hour, h)

(i) The power of the fan heater is 2.75 kW.
Calculate how many kilowatt hours of energy are transferred when the fan heater is used for 6 hours.

_____

_____

_____

Number of kilowatt hours _____

(2)

(ii) How much will it cost to use the fan heater for 6 hours if one Unit of electricity costs 7p?

_____

_____

Cost _____ p

(2)

(Total 7 marks)

9 (a) The picture shows a person using a set of electronic 'Body Fat Scales'. When the person stands on the scales, a small, harmless, electric current passes through the person's body. The scales then calculate the resistance of the person's body and convert the resistance into a *prediction* of body fat content.

(i) The scales contain two 3 V cells joined in series.

Calculate the resistance of a person's body, if when he stands on the scales, a current of 0.12 mA passes through his body.

1000 mA = 1 A

Show clearly how you work out your answer and give the unit.

_____

_____

_____

Resistance = _____

(3)

(ii) The scales can only produce a *prediction* of body fat content and not an accurate measurement.

Suggest why.

_____

_____

_____

(1)

(iii) It is recommended that the scales are **not** used immediately after a person has drunk a large amount of water.

Suggest why.

_____

_____

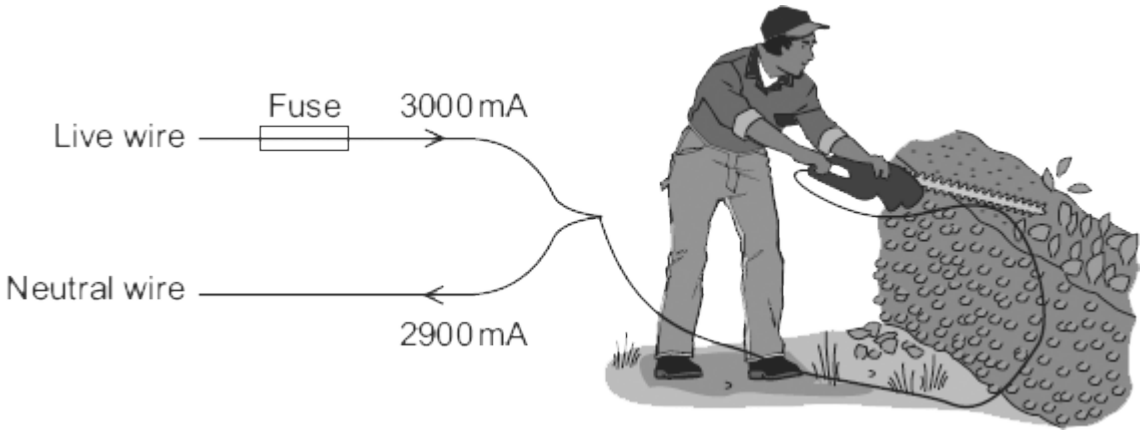
_____

_____

_____

(2)

(b) The diagram shows how someone could get an electric shock from accidentally cutting into an electric cable. If this happens, and a Residual Current Circuit Breaker (RCCB) is being used, the circuit will switch off automatically.



(i) A faulty appliance or circuit can be switched off by a RCCB or a fuse.

Compare the action of a RCCB with the action of a fuse.

_____

_____

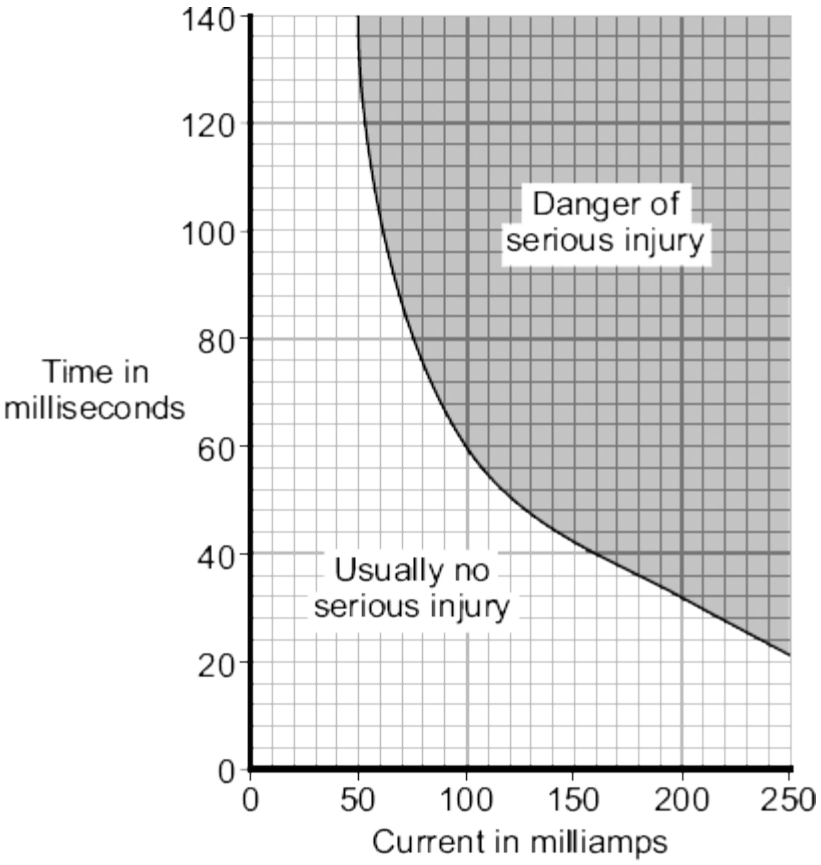
_____

_____

_____

(2)

(ii) The graph shows how the severity of an electric shock depends on the size of the current and the time that the current flows through the body.



Using the RCCB helps prevent an electric shock seriously injuring the person using the hedge trimmers.

Using information from both the diagram and the graph explain how.

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

10 An electrician is replacing an old electric shower with a new one.

The inside of the old shower is shown in **Figure 1**.

Figure 1

(a) If the electrician touches the live wire he will receive an electric shock.

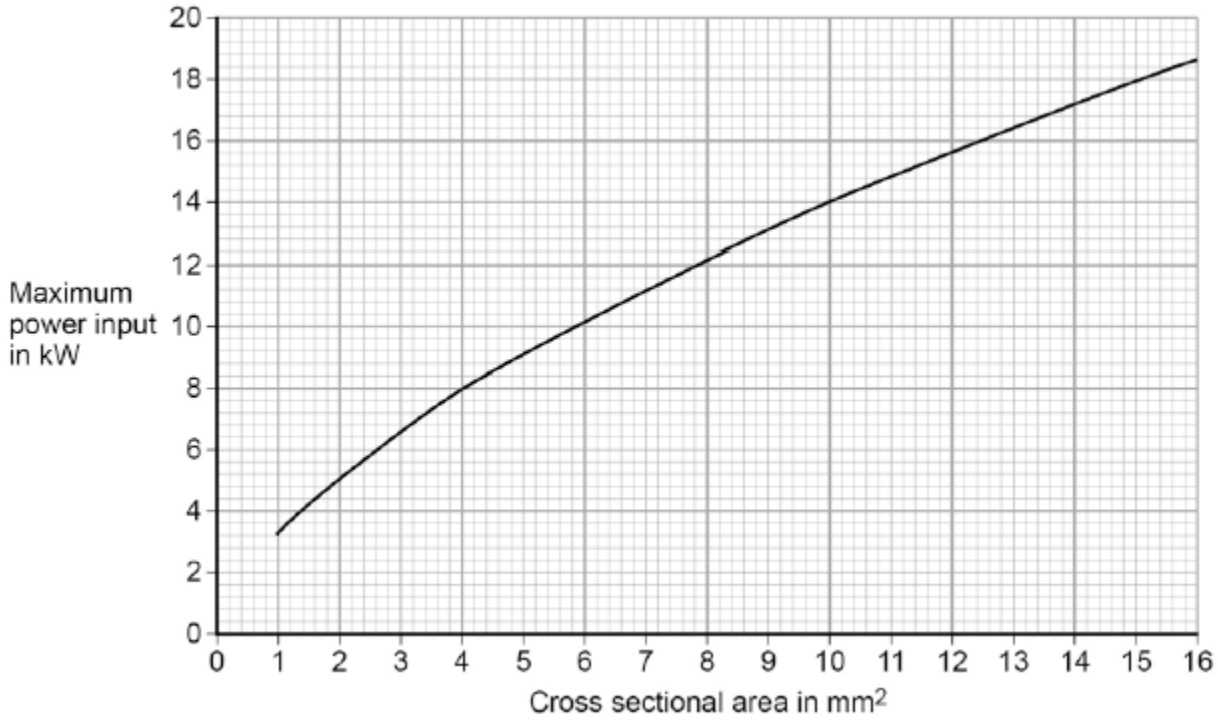
Explain why.

(4)

(b) Different electrical wires need to have a cross-sectional area that is suitable for the power output.

Figure 2 shows the recommended maximum power input to wires of different cross-sectional areas.

Figure 2



The new electric shower has a power input of 13.8 kW.

Determine the minimum **diameter** of wire that should be used for the new shower.

The diameter, d, can be calculated using the equation:

$$d = \sqrt{\frac{4A}{\pi}}$$

A is the cross-sectional area of the wire.

_____

_____

Minimum diameter = _____ mm

(2)

(c) The charge that flows through the new shower in 300 seconds is 18 000 C.
The new electric shower has a power of 13.8 kW.

Calculate the resistance of the heating element in the new shower.

Write down any equations you use.

Resistance = _____ Ω

(5)

(Total 11 marks)