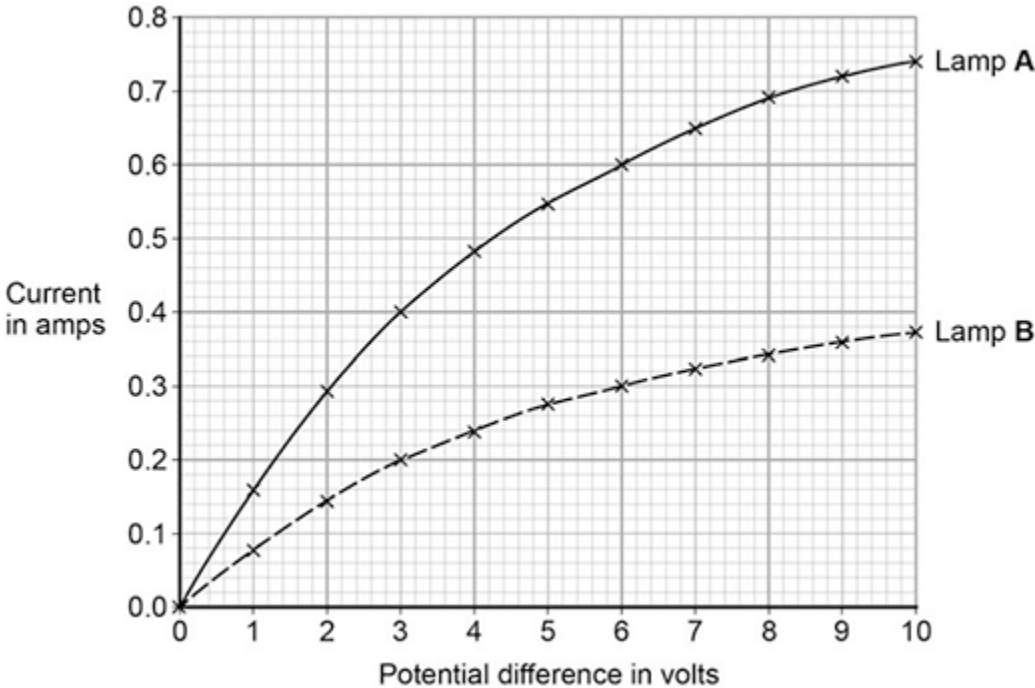


1

A student investigated how current varies with potential difference for two different lamps.

Her results are shown in the figure below.



- (a) Complete the circuit diagram for the circuit that the student could have used to obtain the results shown in the figure above.



(3)

- (b) Which lamp will be brighter at any potential difference?

Explain your answer.

Use the figure above to aid your explanation

.....

.....

.....

.....

(2)

(c) Lamp **B** has the higher resistance at any potential difference.

Explain how the figure above shows this.

.....  
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.....  
.....

**(2)**

(d) Both lamps behave like ohmic conductors through a range of values of potential difference.

Use the figure above to determine the range for these lamps.

Explain your answer.

.....  
.....  
.....  
.....  
.....  
.....

**(3)**  
**(Total 10 marks)**

2

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**



© Michael Priest

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

Explain why.

.....

.....

.....

.....

.....

.....

.....

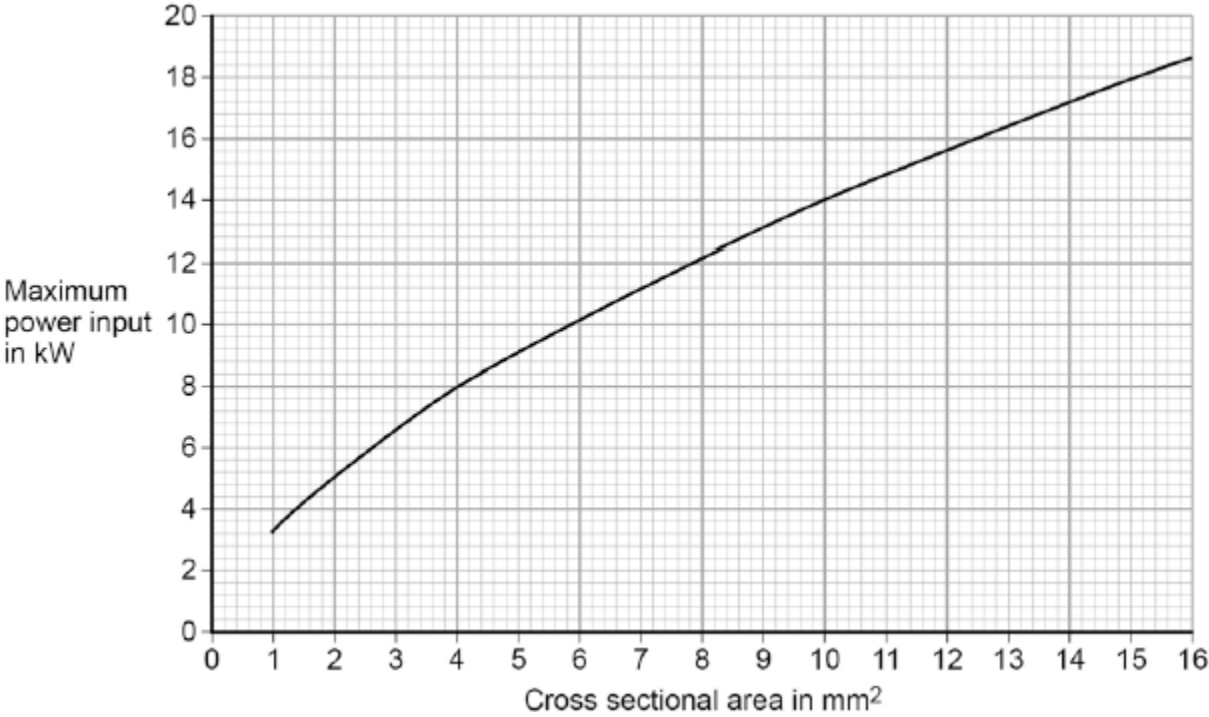
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(4)

- (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 = .....  $\Omega$

**(5)**  
**(Total 11 marks)**

**3**

The current in a circuit depends on the potential difference (p.d.) provided by the cells and the total resistance of the circuit.

- (a) Using the correct circuit symbols, draw a diagram to show how you would connect 1.5 V cells together to give a p.d. of 6 V.

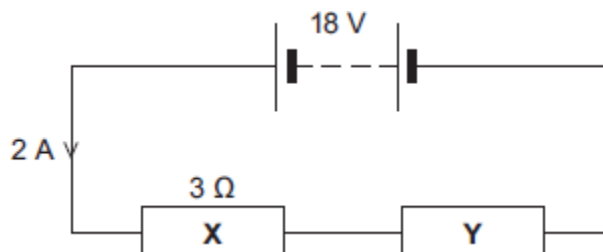
**(2)**

(b) **Figure 1** shows a circuit containing an 18 V battery.

Two resistors, **X** and **Y**, are connected in series.

- **X** has a resistance of 3  $\Omega$ .
- There is a current of 2 A in **X**.

**Figure 1**



(i) Calculate the p.d. across **X**.

.....  
.....

P.d. across **X** = ..... V

**(2)**

(ii) Calculate the p.d. across **Y**.

.....  
.....  
.....

P.d. across **Y** = ..... V

**(2)**

(iii) Calculate the total resistance of **X** and **Y**.

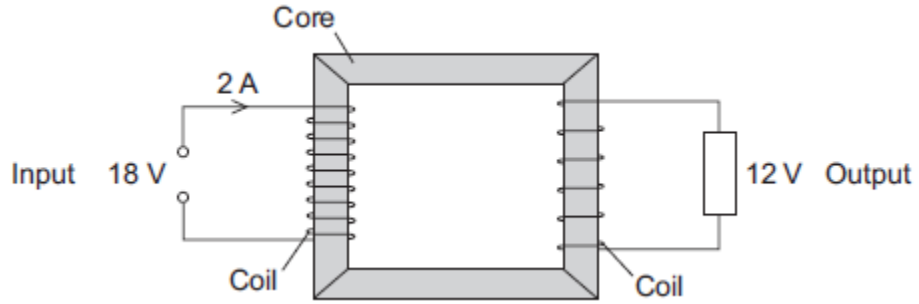
.....  
.....  
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Total resistance of **X** and **Y** = .....  $\Omega$

**(2)**

(c) **Figure 2** shows a transformer.

**Figure 2**



(i) An 18 V battery could **not** be used as the input of a transformer.

Explain why.

.....  
.....  
.....  
.....

(2)

(ii) The transformer is 100% efficient.

Calculate the output current for the transformer shown in **Figure 2**.

.....  
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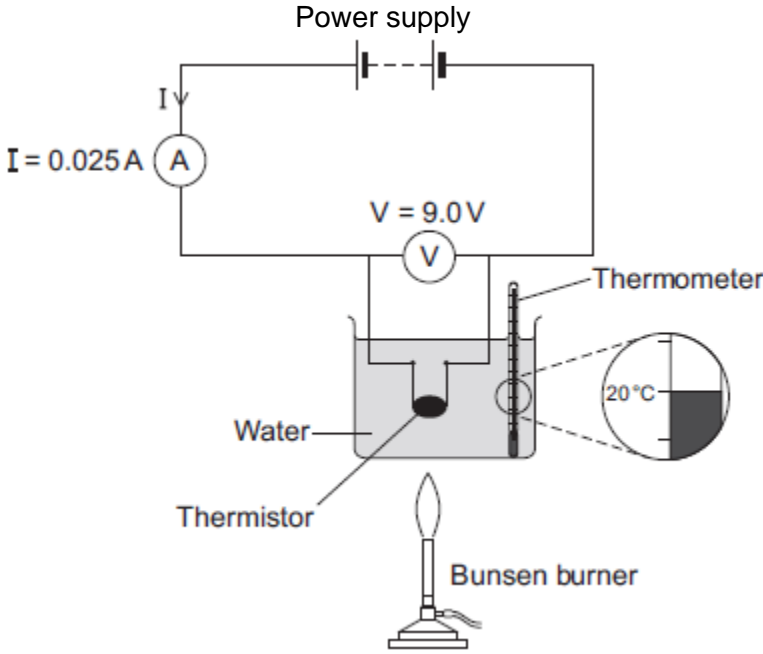
Output current = ..... A

(2)  
(Total 12 marks)

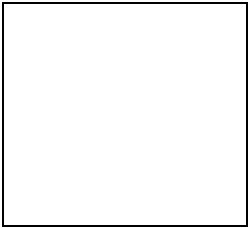
4

(a) **Figure 1** shows the apparatus used to obtain the data needed to calculate the resistance of a thermistor at different temperatures.

**Figure 1**



(i) In the box below, draw the circuit symbol for a thermistor.



(1)

(ii) Use the data given in **Figure 1** to calculate the resistance of the thermistor at  $20\text{ }^\circ\text{C}$ .

.....  
.....  
.....

Resistance = ..... ohms

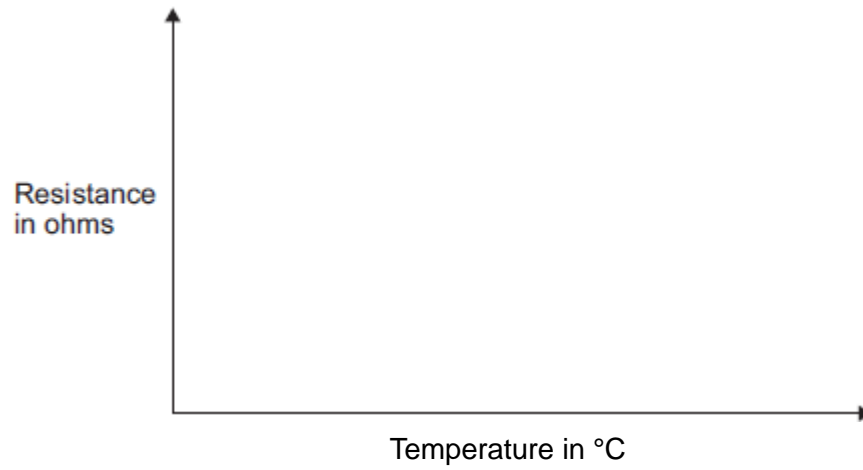
(2)



(iii) **Figure 2** shows the axes for a sketch graph.

Complete **Figure 2** to show how the resistance of the thermistor will change as the temperature of the thermistor increases from 20 °C to 100 °C.

**Figure 2**



(1)

(iv) Which **one** of the following is most likely to include a thermistor?

Tick (✓) **one** box.

An automatic circuit to switch a plant watering system on and off.

An automatic circuit to switch an outside light on when it gets dark.

An automatic circuit to switch a heating system on and off.

(1)

(b) The ammeter used in the circuit has a very low resistance.

Why is it important that ammeters have a very low resistance?

.....

.....

(1)

- (c) The table below gives the temperature of boiling water using three different temperature scales.

Temperature	Scale
100	Celsius ( $^{\circ}\text{C}$ )
212	Fahrenheit ( $^{\circ}\text{F}$ )
80	Réaumur ( $^{\circ}\text{Re}$ )

Scientists in different countries use the same temperature scale to measure temperature.

Suggest **one** advantage of doing this.

.....  
.....  
.....

(1)

- (d) A student plans to investigate how the resistance of a light-dependent resistor (LDR) changes with light intensity.

The student starts with the apparatus shown in **Figure 2** but makes three changes to the apparatus.

One of the changes the student makes is to replace the thermistor with an LDR.

Describe what other changes the student should make to the apparatus.

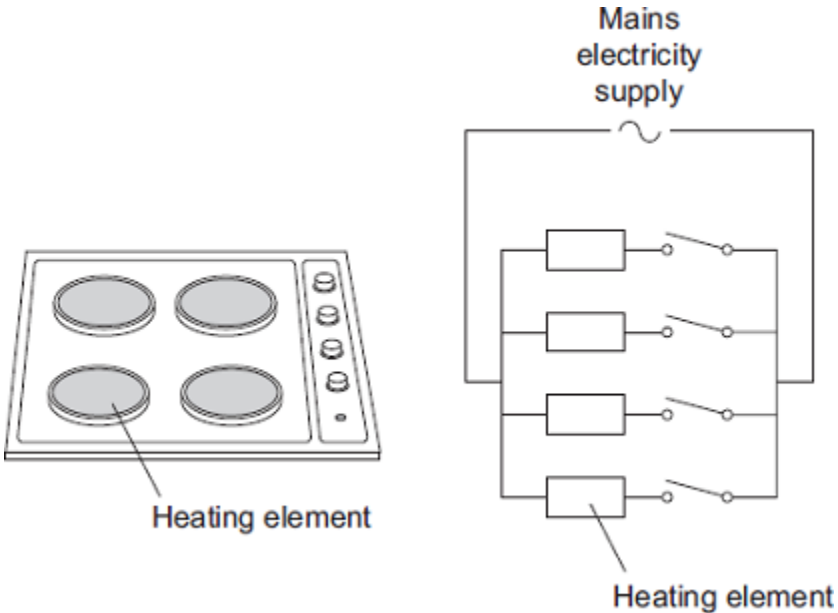
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(2)

(Total 9 marks)

5

The picture shows an electric cooker hob. The simplified circuit diagram shows how the four heating elements connect to the mains electricity supply. The heating elements are identical.



When all four heating elements are switched on at full power the hob draws a current of 26 A from the 230 V mains electricity supply.

(a) Calculate the resistance of one heating element when the hob is switched on at full power.

Give your answer to 2 significant figures.

.....  
.....  
.....

Resistance = .....  $\Omega$

(3)

(b) The table gives the maximum current that can safely pass through copper wires of different cross-sectional area.

Cross-sectional area in mm <sup>2</sup>	Maximum safe current in amps
1.0	11.5
2.5	20.0
4.0	27.0
6.0	34.0

The power sockets in a home are wired to the mains electricity supply using cables containing 2.5 mm<sup>2</sup> copper wires. Most electrical appliances are connected to the mains electricity supply by plugging them into a standard power socket.

It would **not** be safe to connect the electric cooker hob to the mains electricity supply by plugging it into a standard power socket.

Why?

.....  
.....  
.....  
.....

(2)

(c) Mains electricity is an alternating current supply. Batteries supply a direct current.

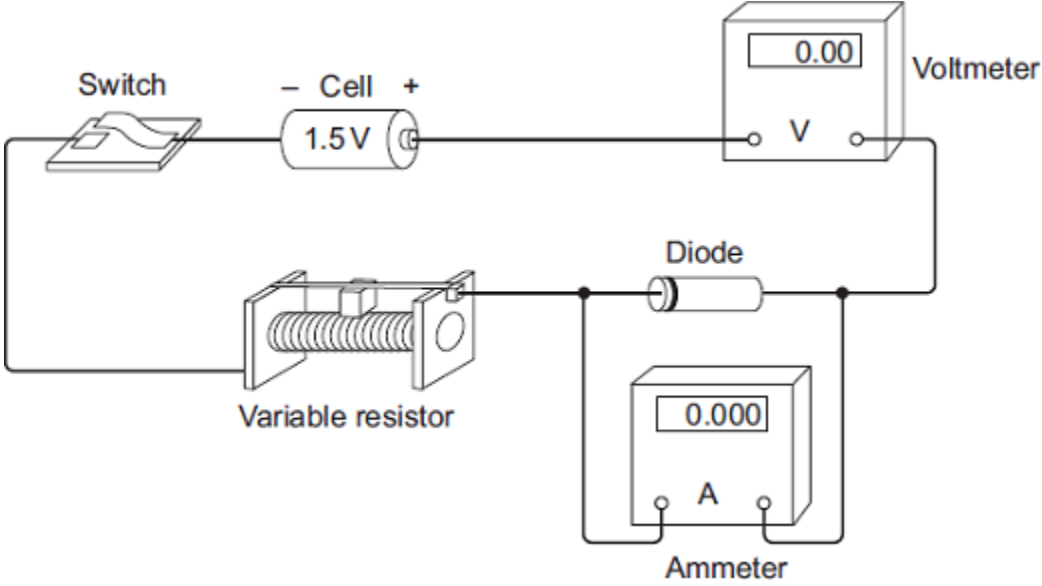
What is the difference between an alternating current and a direct current?

.....  
.....  
.....  
.....

(2)  
(Total 7 marks)

6

(a) A student set up the circuit shown in the diagram. The student uses the circuit to obtain the data needed to plot a current - potential difference graph for a diode.



(i) Draw, in the boxes, the circuit symbol for a diode and the circuit symbol for a variable resistor.

**Diode**

**Variable resistor**

(2)

(ii) The student made two mistakes when setting up the circuit.

What **two** mistakes did the student make?

1 .....

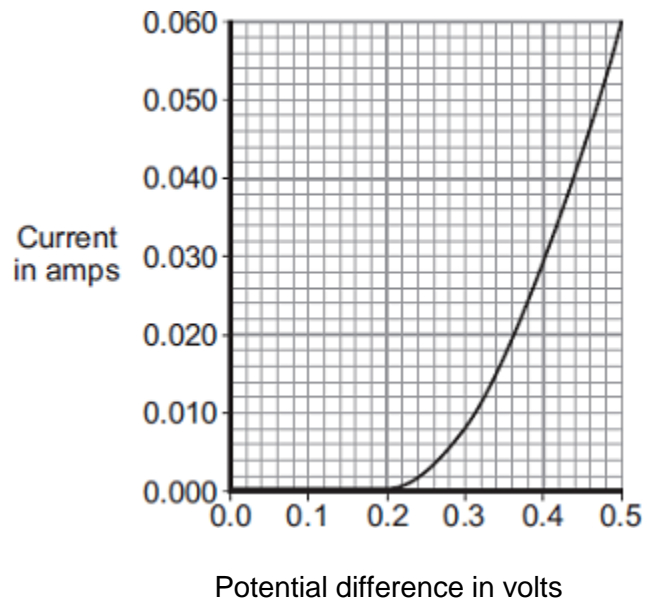
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2 .....

.....

(2)

(b) After correcting the circuit, the student obtained a set of data and plotted the graph below.



(i) At what potential difference did the diode start to conduct an electric current?

..... V

**(1)**

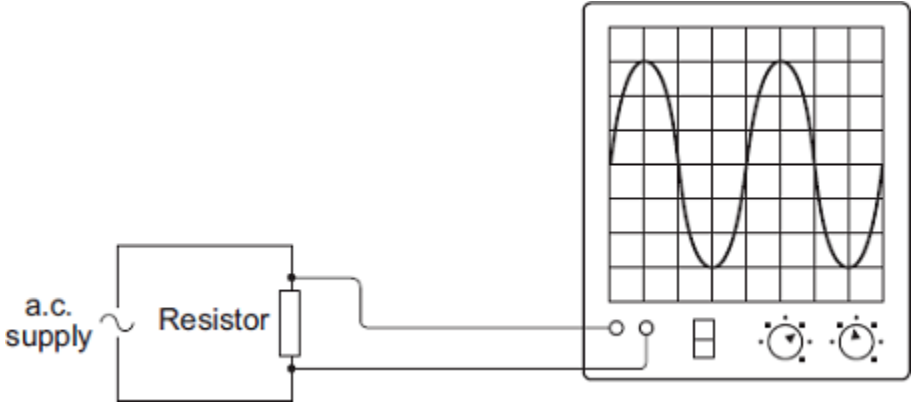
(ii) Use data from the graph to calculate the resistance of the diode when the potential difference across the diode is 0.3 V.

.....  
.....  
.....

Resistance = ..... ohms

**(3)**

(c) The diagram shows the trace produced by an alternating current (a.c.) supply on an oscilloscope.



Each horizontal division on the oscilloscope screen represents a time of 0.01s.

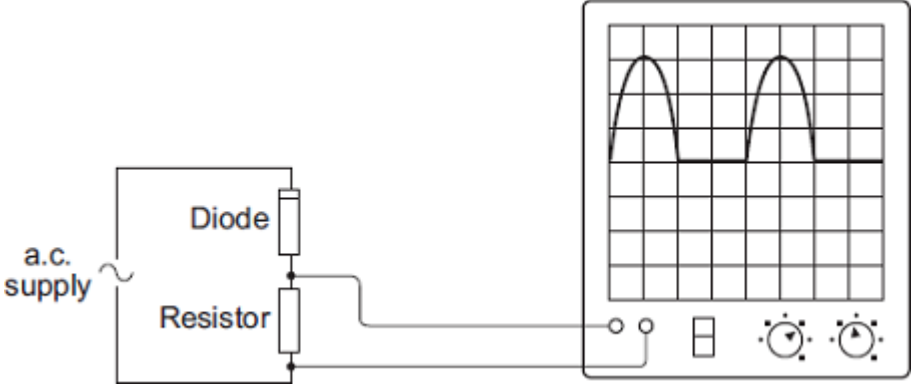
(i) Calculate the frequency of the a.c. supply.

.....  
 .....  
 .....

Frequency = ..... hertz

(2)

(ii) A diode is now connected in series with the a.c. power supply.



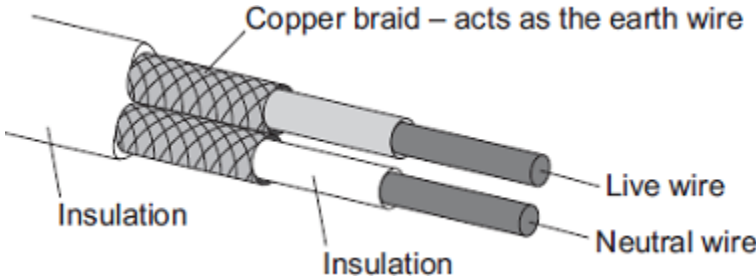
Why does the diode cause the trace on the oscilloscope screen to change?

.....  
 .....  
 .....  
 .....

(2)  
 (Total 12 marks)

7

The diagram shows the structure of a cable. The cable is part of an undersoil heating circuit inside a large greenhouse.



(a) The cable is connected to the mains electricity supply through a residual current circuit breaker. If the cable is accidentally cut the circuit breaker automatically switches the circuit off.

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

.....

(1)

(ii) What happens, as the cable is cut, to cause the circuit breaker to switch the circuit off?

.....  
.....  
.....  
.....

(2)

(iii) A circuit can also be switched off by the action of a fuse.

Give **one** advantage of using a circuit breaker to switch off a circuit rather than a fuse.

.....  
.....

(1)

(b) The 230 volt mains electricity supply causes a current of 11 amps to flow through the cable.

(i) Calculate the amount of charge that flows through the cable when the cable is switched on for 2 hours and give the unit.

.....  
.....  
.....

Charge = .....

(3)



(ii) Calculate the energy transferred from the cable to the soil in 2 hours.

.....  
.....

Energy transferred = ..... J

(2)

(c) The heating circuit includes a thermistor. The thermistor is buried in the soil and acts as a thermostat to control the increase in the temperature of the soil.

Describe how an **increase** in the temperature of the soil affects the thermistor.

.....  
.....  
.....  
.....

(2)  
(Total 11 marks)

8

(a) The resistance of a 24 W, 12 V filament lamp depends on the current flowing through the lamp. For currents up to 0.8 A, the resistance has a constant value of 2.5  $\Omega$ .

(i) Use the equation in the box to calculate the potential difference across the lamp when a current of 0.8 A flows through the lamp.

potential difference = current $\times$ resistance
--

Show clearly how you work out your answer.

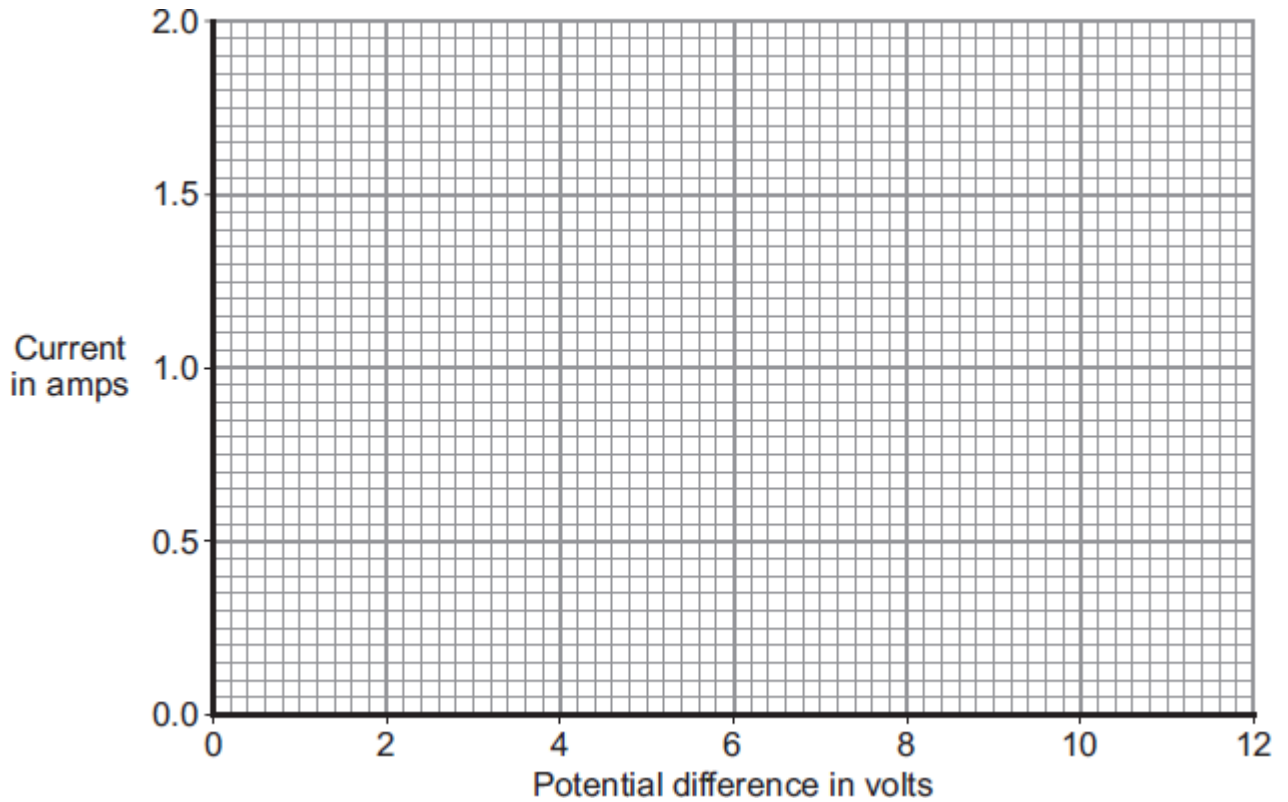
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Potential difference = ..... V

(2)

- (ii) When the potential difference across the lamp is 12 V, the current through the lamp is 2 A.

On the axes below, draw a current–potential difference graph for the filament lamp over the range of potential difference from 0 to 12 volts.



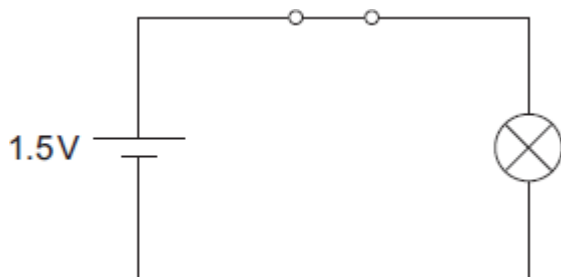
(2)

- (iii) Why does the resistance of the lamp change when the current through the lamp exceeds 0.8 A?

.....  
.....

(1)

- (b) The lamp is now included in a circuit. The circuit is switched on for 2 minutes. During this time, 72 coulombs of charge pass through the lamp.



Use the equation in the box to calculate the energy transformed by the lamp while the circuit is switched on.

energy transformed = potential difference × charge
--

Show clearly how you work out your answer.

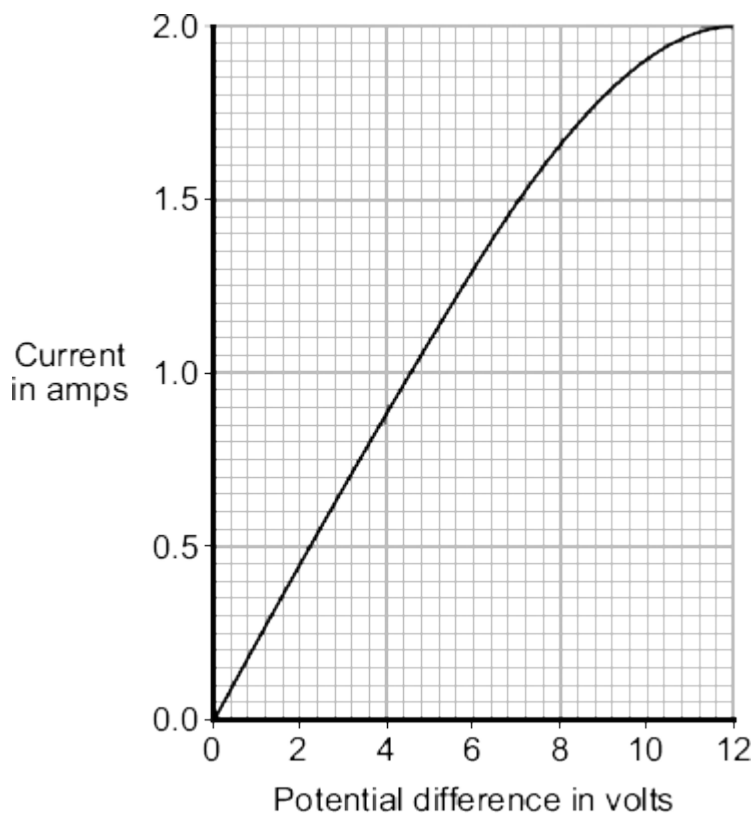
.....  
.....

Energy transformed = ..... J

**(2)**  
**(Total 7 marks)**

9

The graph shows how the electric current through a 12 V filament bulb varies with the potential difference across the bulb.



(a) What is the meaning of the following terms?

electric current

.....  
.....

potential difference

.....  
.....

(2)

- (b) The resistance of the metal filament inside the bulb increases as the potential difference across the bulb increases.

Explain why.

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**(3)**

- (c) Use data from the graph to calculate the rate at which the filament bulb transfers energy, when the potential difference across the bulb is 6 V.

Show clearly how you work out your answer.

.....

.....

Rate of energy transfer = ..... W

**(2)**  
**(Total 7 marks)**

10

(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.

$$1000 \text{ mA} = 1 \text{ A}$$

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.

.....

.....

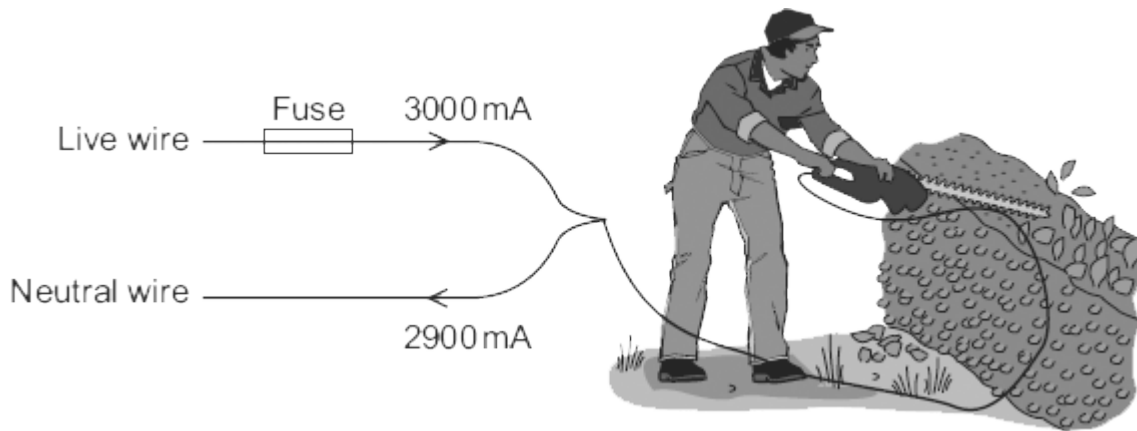
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(2)

- (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.

.....

.....

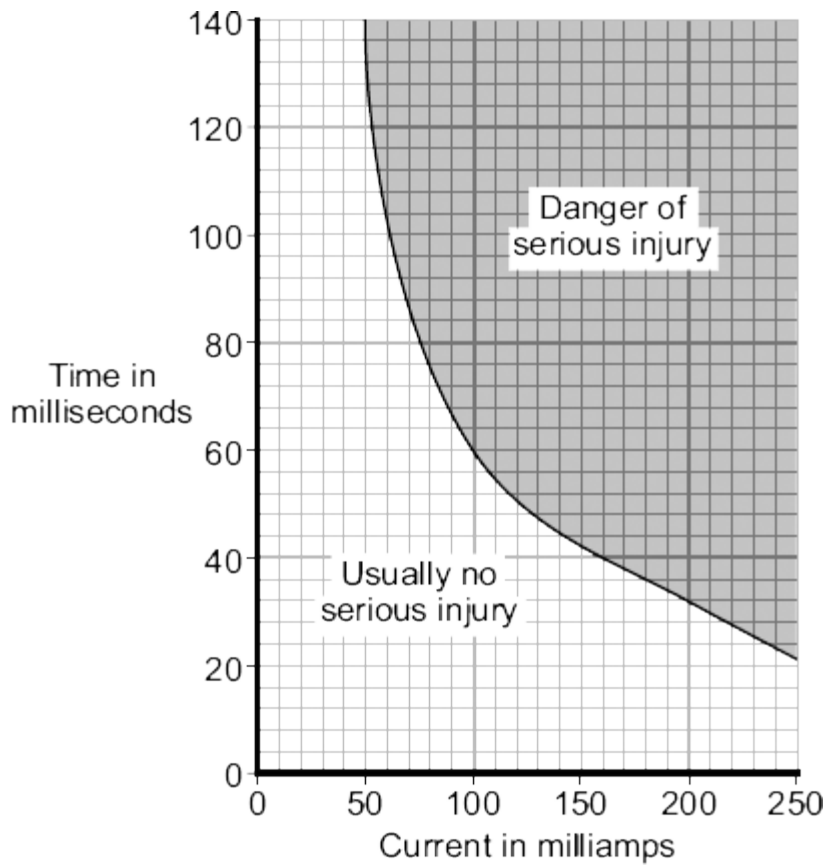
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(2)

- (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.

.....

.....

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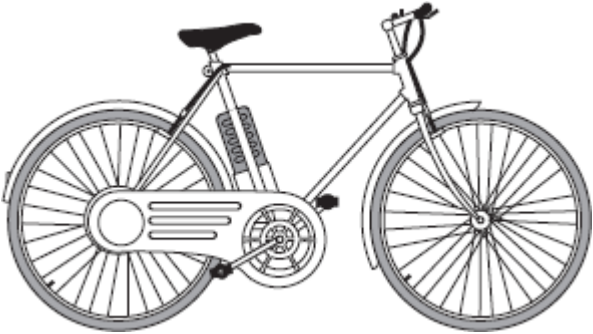
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(2)  
(Total 10 marks)



11

The picture shows an electric bicycle. The bicycle is usually powered using a combination of the rider pedalling and an electric motor.



(a) A 36 volt battery powers the electric motor. The battery is made using individual 1.2 volt cells.

(i) Explain how a 36 volt battery can be produced using individual 1.2 volt cells.

To gain full marks, you must include a calculation in your answer.

.....  
.....  
.....  
.....

(2)

(ii) The battery supplies a direct current (d.c.).

What is a *direct current* (d.c.)?

.....  
.....

(1)

(iii) When fully charged, the battery can deliver a current of 5 A for 2 hours. The battery is then fully discharged.

Calculate the maximum charge that the battery stores.

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

.....  
.....

Charge stored = .....

(3)

- (b) When powered only by the electric motor, the bicycle can carry a 90 kg rider at a maximum speed of 6 m/s. Under these conditions, the maximum distance that the bicycle can cover before the battery needs recharging is 32 km.

The bicycle has a mass of 30 kg.

- (i) Calculate the maximum kinetic energy of the bicycle **and** rider when the rider is not pedalling.

Show clearly how you work out your answer.

.....  
.....

Kinetic energy = ..... J

**(2)**

- (ii) The bicycle can be fitted with panniers (bags) to carry a small amount of luggage.

What effect would fitting panniers and carrying luggage have on the distance the bicycle can cover before the battery needs recharging?

.....

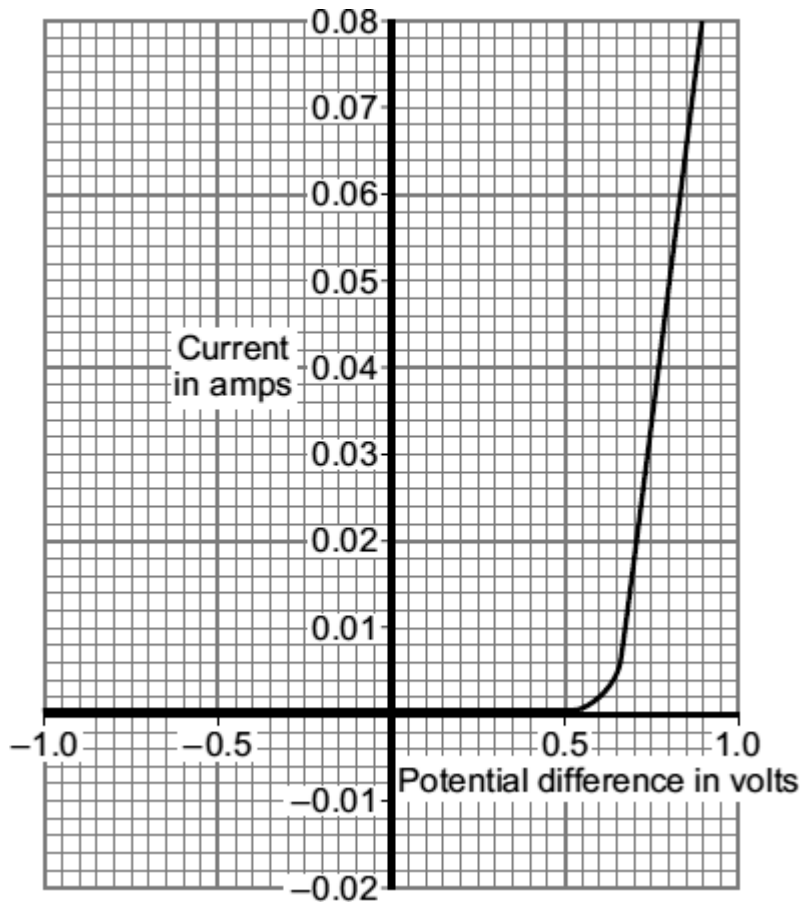
Give a reason for your answer.

.....  
.....

**(2)**  
**(Total 10 marks)**

12

The current–potential difference graph for one type of electrical component is drawn below.

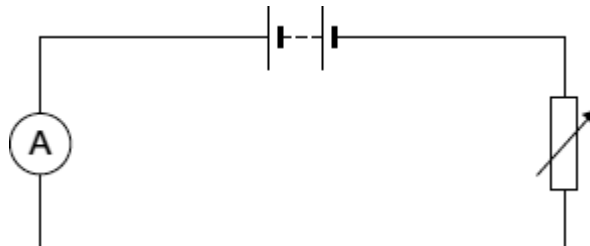


(a) What is the component?

.....

(1)

(b) Complete the diagram to show a circuit that can be used to obtain the data needed to plot the graph. Use the correct circuit symbol for each component that you add to the diagram.



(2)

(c) (i) What is the current through the component when the potential difference across the component is 0.8 volts?

Current ..... amps

(1)

- (ii) Calculate the resistance of the component when the potential difference across it is 0.8 volts.

Show clearly how you work out your answer.

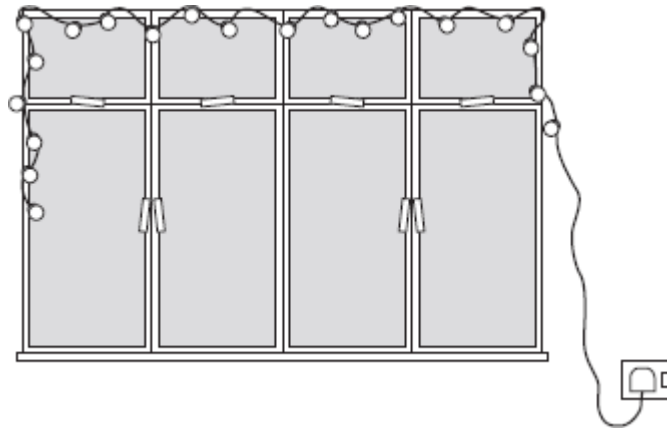
.....  
 .....

Resistance = .....  $\Omega$

(2)  
 (Total 6 marks)

13

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.

.....

.....

.....

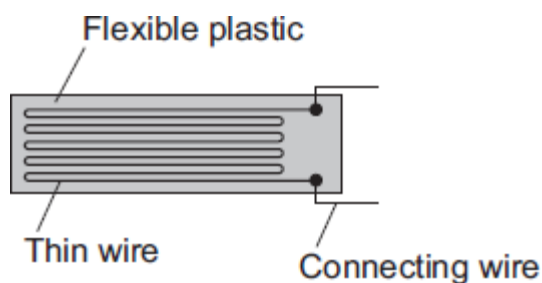
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(2)  
(Total 6 marks)

14

The diagram shows a strain gauge, which is an electrical device used to monitor a changing force.

Applying a force to the gauge causes it to stretch.  
This makes the electrical resistance of the wire change.



- (a) (i) Using the correct symbols, **add** to the diagram to show how a battery, an ammeter and a voltmeter can be used to find the resistance of the strain gauge drawn above.

(2)

- (ii) When in use, the strain gauge is always connected to a d.c. power supply, such as a battery.

How is a d.c. (direct current) power supply different from an a.c. (alternating current) power supply?

.....  
.....  
.....

(1)

- (b) Before any force is applied, the unstretched gauge, correctly connected to a 3.0 V battery, has a current of 0.040 A flowing through it.

- (i) Calculate the resistance of the unstretched gauge.

Show clearly how you work out your answer.

.....  
.....

Resistance = .....  $\Omega$

(2)

- (ii) Stretching the gauge causes the current flowing through the gauge to decrease.

What happens to the resistance of the gauge when it is stretched?

.....  
.....

(1)

- (iii) What form of energy is stored in the gauge when a force is applied and the gauge stretches?

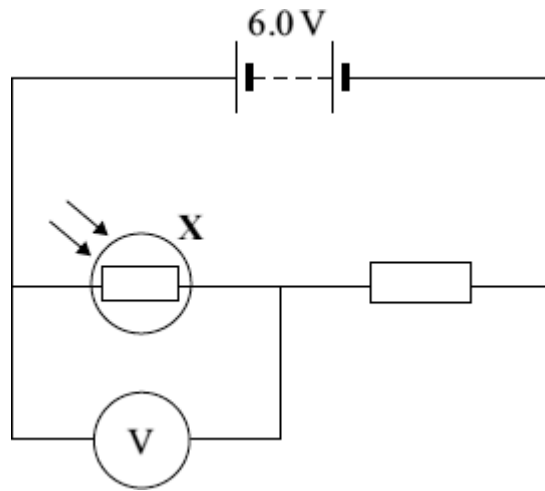
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(1)

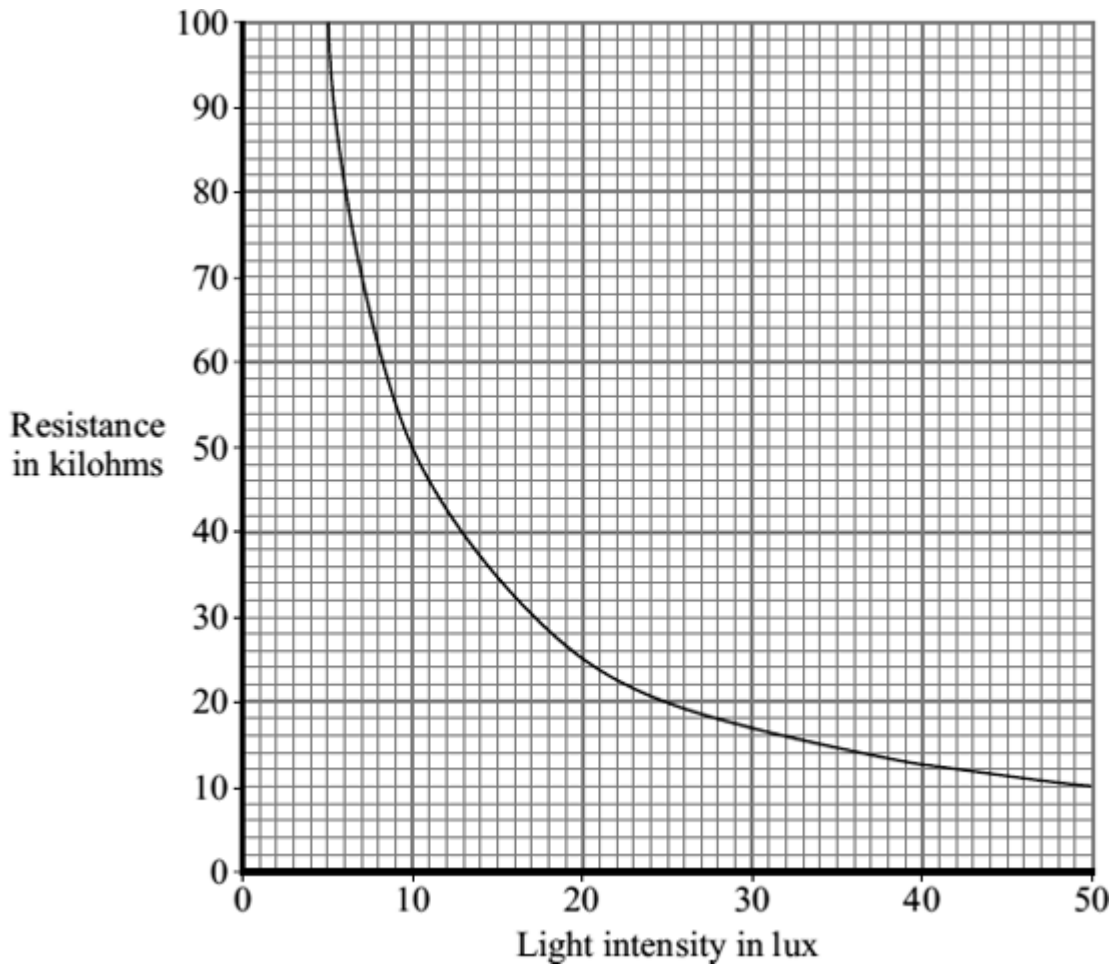
(Total 7 marks)

15

The diagram shows a simple light-sensing circuit.



- (a) The graph, supplied by the manufacturer, shows how the resistance of the component labelled **X** varies with light intensity.



- (i) What is component **X**?

.....

(1)

(ii) Use the graph to find the resistance of component X when the light intensity is 20 lux.

.....

(1)

(iii) When the light intensity is 20 lux, the current through the circuit is 0.0002 A.

Calculate the reading on the voltmeter when the light intensity is 20 lux.

Show clearly how you work out your answer.

.....

.....

Voltmeter reading =..... volts

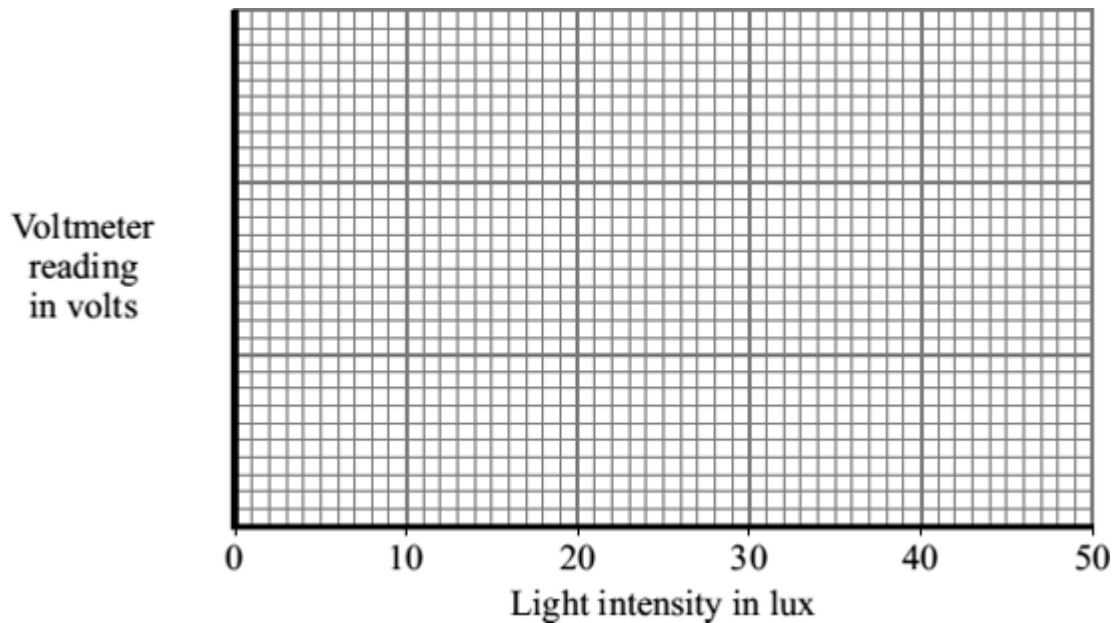
(2)

(b) Use the grid below to show how the voltmeter reading in the light-sensing circuit varies with light intensity.

(i) Add a suitable scale to the y-axis (vertical axis).

(1)

(ii) Complete the sketch graph by drawing a line on the grid to show how the voltmeter reading will vary with light intensity.



(2)



- (c) The following passage is taken from the technical data supplied for component **X** by the manufacturer.

For any given light intensity, the resistance of this component can vary by plus or minus 50% of the value shown on the **graph of light intensity and resistance**.

- (i) Calculate the maximum resistance that component **X** could have at 20 lux light intensity.

.....

Maximum resistance = ..... kilohms

(1)

- (ii) Explain why this light-sensing circuit would **not** be used to measure values of light intensity.

.....

.....

.....

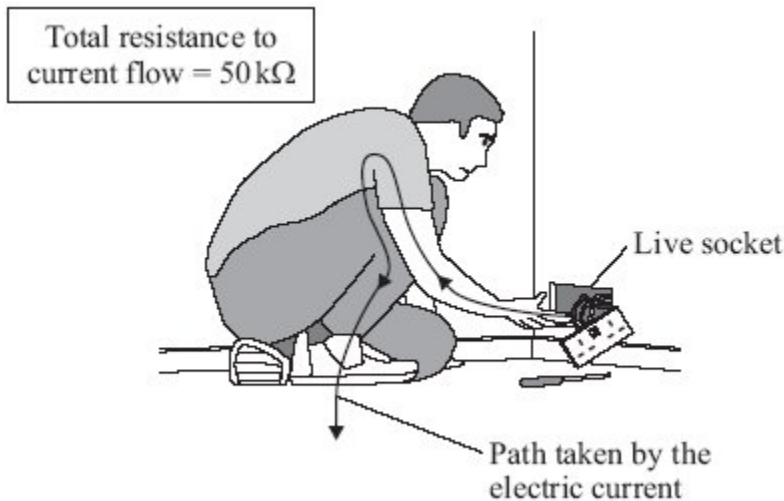
(2)

(Total 10 marks)

16

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.

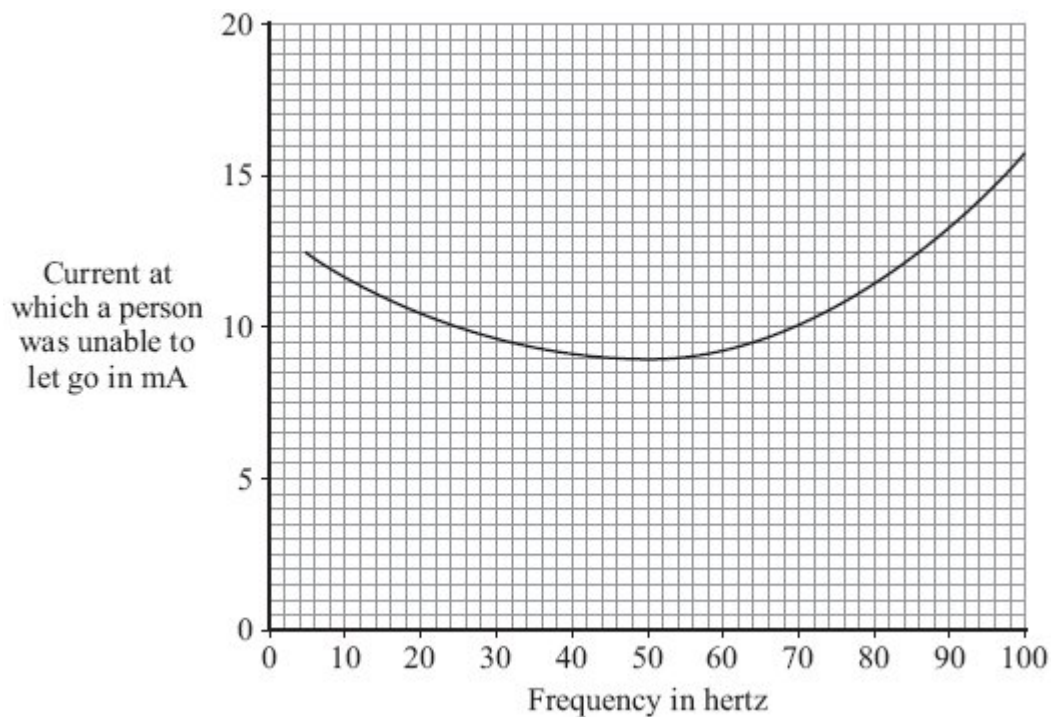
.....  
.....  
.....  
.....

(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)

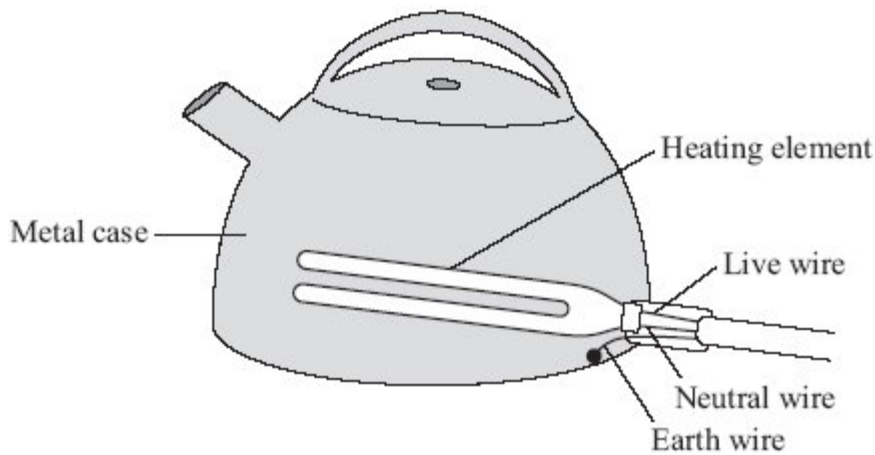
(ii) From a safety point of view, is the frequency of the UK mains electricity supply suitable?

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)

17

A set of Christmas tree lights is made from twenty identical lamps connected in series.



(a) Each lamp is designed to take a current of 0.25 A. The set plugs directly into the 230 V mains electricity supply.

(i) Write down the equation that links current, potential difference and resistance.

.....  
.....

(1)

(ii) Calculate the resistance of **one** of the lamps. Show clearly how you work out your final answer and give the unit.

.....  
.....  
.....  
.....

Resistance = .....

(4)

(iii) What is the total resistance of the set of lights?

.....  
.....

Total resistance = .....

(1)

- (b) How does the resistance of a filament lamp change as the temperature of the filament changes?

.....

.....

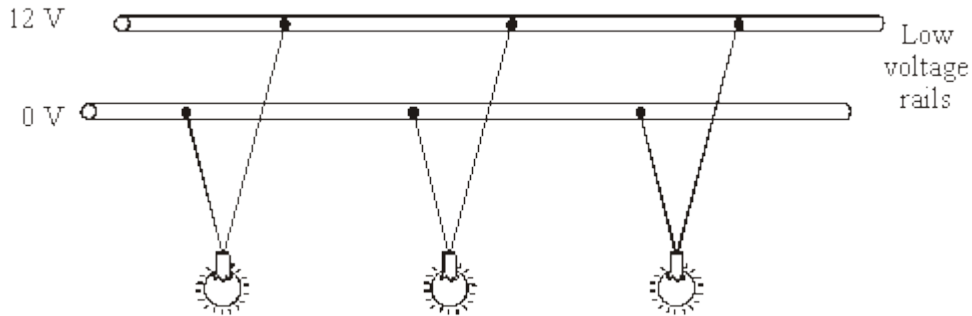
.....

.....

(1)  
(Total 7 marks)

18

The diagram shows a 12 volt lighting system. Each lamp has a power of 32 watts.



- (i) Write down the equation that links current, potential difference and power.

.....

(1)

- (ii) Calculate the input current to the lighting system. Show clearly how you work out your answer.

.....

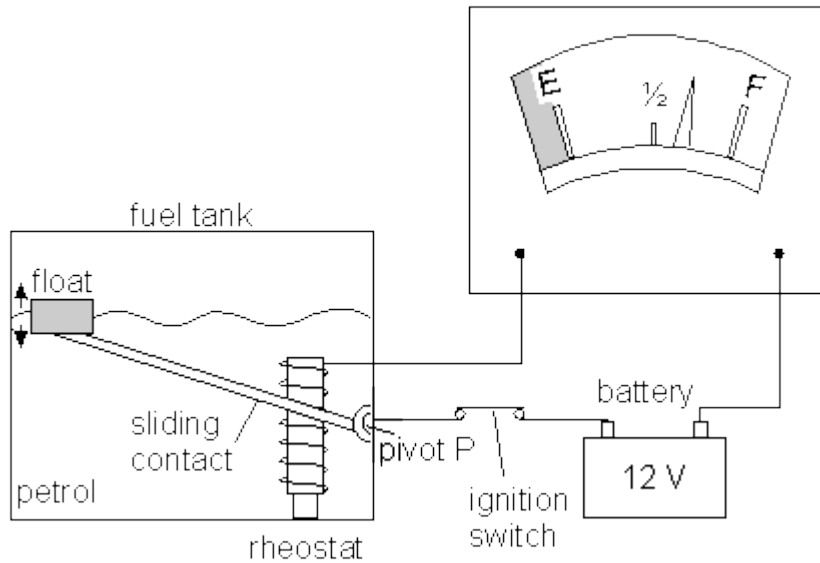
.....

current = ..... A

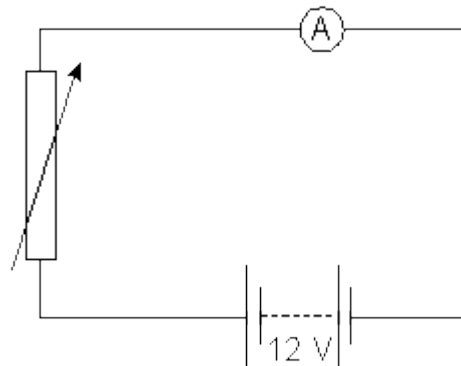
(2)  
(Total 3 marks)

19

The diagram below shows how one type of fuel gauge in a car works. A sliding contact makes contact with a resistance wire wound in a coil (rheostat). It is connected to a float via a pivot P. When the petrol level changes the circuit resistance changes. This causes the pointer in the fuel gauge to move and show how much petrol is in the petrol tank.



The circuit diagram is shown below.



The petrol gauge is an ammeter. Explain why the reading on the ammeter falls as the petrol is used.

.....

.....

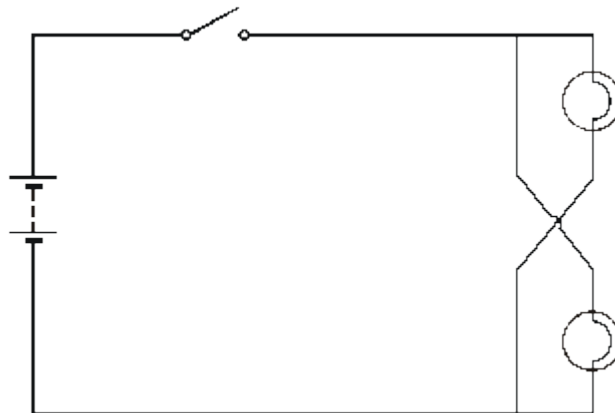
.....

.....

(Total 3 marks)

**20**

The circuit diagram below shows a circuit used to supply electrical energy to the two headlights of a car.



The current through the filament of one car headlight is 3.0 A. The potential difference across each of the two headlights is 12 V.

(a) Suggest a suitable fuse for the circuit. ....

**(1)**

(b) Calculate the resistance of the headlight filament when in use.

.....  
.....  
.....  
.....

Answer ..... W

**(2)**

(c) Calculate the power supplied to the two headlights of the car.

.....  
.....  
.....

Answer ..... W

**(2)**

(d) The fully charged car battery can deliver 72 kJ of energy at 12 V. How long can the battery keep the headlights fully on?

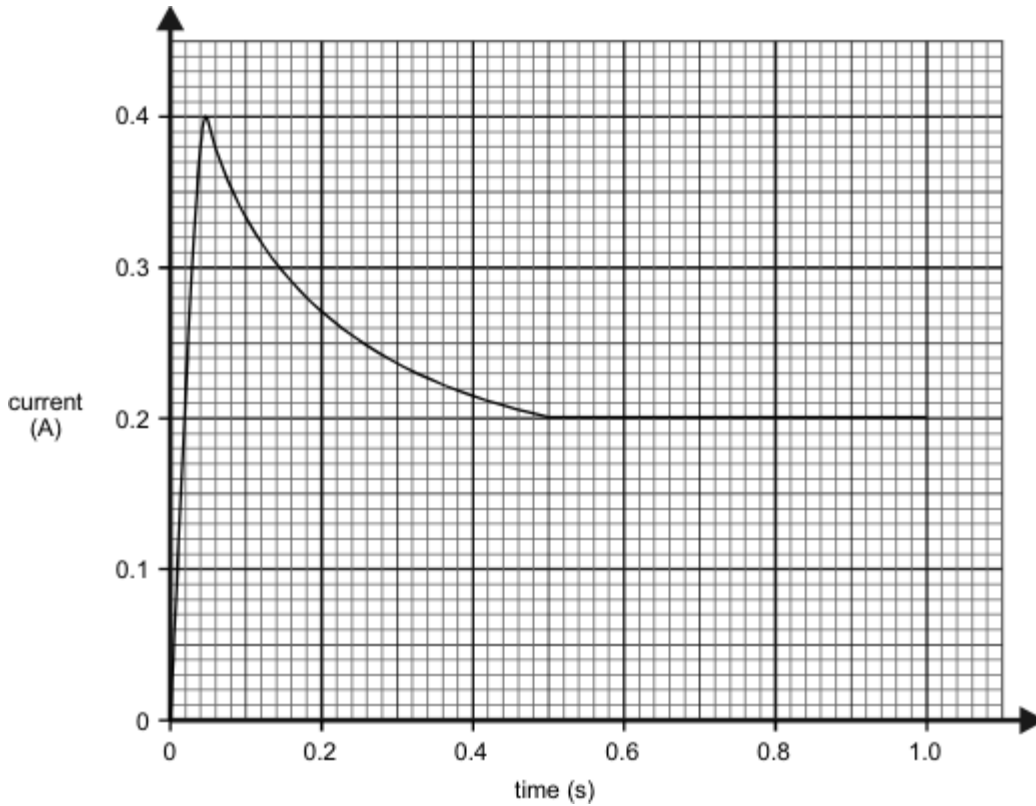
.....  
 .....  
 .....

Answer ..... s

(2)  
 (Total 7 marks)

21

When a mains lamp is switched on it takes 0.5 seconds for the filament to reach its normal operating temperature. The way in which the current changes during the first second after switching on is shown in the sketch graph below. Mains voltage is 240 V.



(a) Calculate the resistance of the filament whilst the lamp is drawing the **maximum** current.

.....  
 .....  
 .....

(3)



(b) Describe how the resistance of the lamp changes after the current has reached its maximum value.

.....  
.....

(2)

(c) Calculate the **maximum** power taken by the lamp.

.....  
.....  
.....

(2)

(d) Calculate the power of the lamp in normal use.

.....  
.....  
.....

(2)

(e) Calculate the energy used by the lamp in six hours of normal use.

.....  
.....  
.....

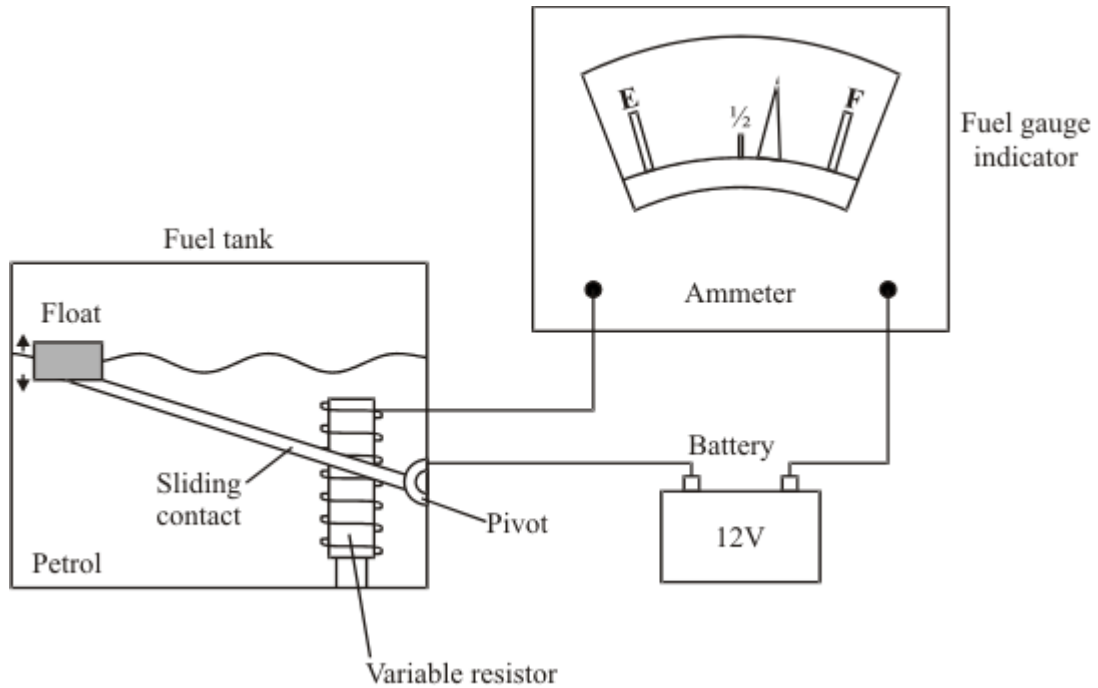
(3)

(Total 12 marks)

22

The diagram shows the fuel gauge assembly in a car.

- The sliding contact touches a coil of wire and moves over it.
- The sliding contact and the coil form a variable resistor.
- The sliding contact is connected to a float via a pivot.
- The fuel gauge indicator is an ammeter.
- When the petrol level changes, the resistance of the circuit changes.
- This causes the pointer in the fuel gauge indicator to move.



(a) Use standard symbols to draw a circuit diagram for the fuel gauge assembly.

**(3)**

(b) How will the current in the circuit change as the level of petrol in the tank falls?

.....

Explain the reason for your answer.

.....

.....

.....

**(2)**  
**(Total 5 marks)**

**23**

The following specification is taken from the instruction booklet of a combination microwave oven.

AC voltage	240 V 50 Hz
Power required	
Microwave	1.5 kW
Dual (Roast/Bake)	2.8 kW
Dual (Grill)	2.5 kW
Convection	1.35 kW
Grill	2.3 kW
Output power	
Microwave	850 W
Convection heater	1350 W
Grill heater	1000 W
Microwave frequency	2450 MHz

(a) (i) What is the current when the oven is being used to cook in the dual (roast/bake) mode? Show clearly how you work out your answer.

.....  
.....

Current = ..... A

**(2)**

(ii) Calculate the resistance of this combination microwave oven when it is being used in the dual (roast/bake) mode. Show clearly how you work out your answer and give the units.

.....  
.....  
.....

Resistance = .....

**(3)**

(b) What is the percentage efficiency of the oven when it is working in the microwave mode?

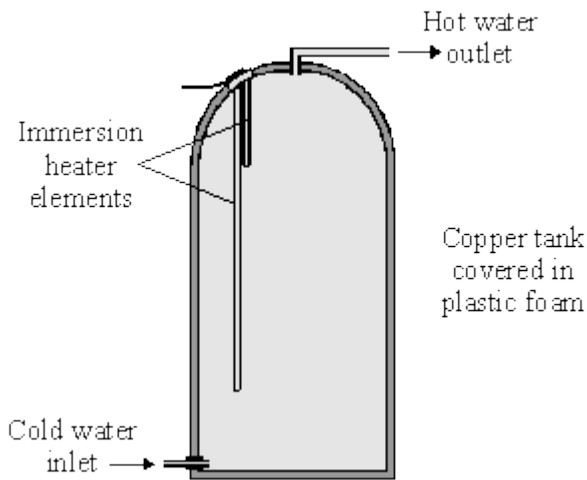
.....  
.....  
.....

Percentage efficiency = ..... %

(2)  
(Total 7 marks)

24

The diagram shows a type of electric immersion heater in a hot water tank. These hot water tanks are normally found in airing cupboards.



Information on the immersion heater states:

230 V  
10 A

(a) (i) What is the equation which shows the relationship between power, current and voltage?

.....

(1)

(ii) Calculate the power of the heater. Show clearly how you get to your answer and give the units.

.....

Power = .....

(2)

(b) (i) What rating of fuse should be in the immersion heater circuit?

.....

(1)

(ii) There are three wires in the cable to the immersion heater. Two of the wires are connected to the immersion heater. The third wire is connected to the copper tank.

Explain the function of this third wire and the fuse in the circuit.

.....  
.....  
.....  
.....

(3)

(c) (i) What is the equation which shows the relationship between resistance, current and voltage?

.....

(1)

(ii) Calculate the resistance of the heater. Show clearly how you get to your answer and give the units.

.....

Resistance = .....

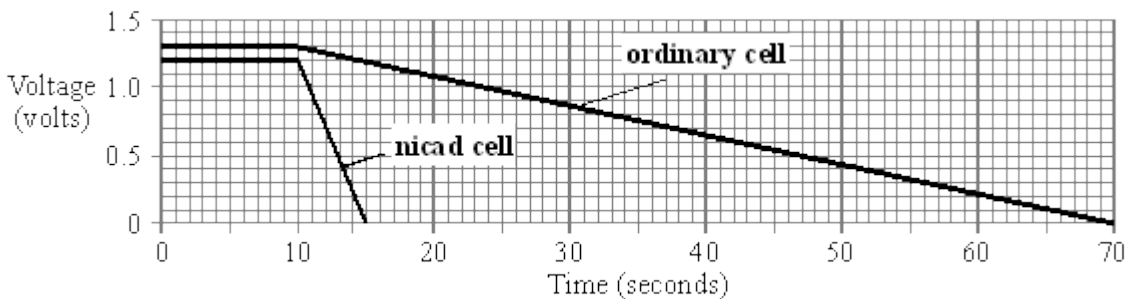
(2)

(Total 10 marks)

25

A small torch uses a single cell to make the bulb light up.

(a) The graphs show the voltage across two different types of cell as they transfer the last bit of their stored energy through the torch bulb.

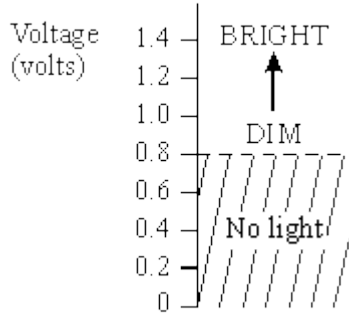


Describe the differences that the graphs show between the two types of cell.

.....  
.....

(3)

(b) The diagram shows how bright the torch bulb is for different voltages.



From the point when the voltage of each cell starts to fall, how long will the bulb stay lit:

(i) with the ordinary cell?

.....

(ii) with the nicad cell?

.....

(4)

(c) When the voltage across the bulb falls to half, the current through the bulb falls by **less than** half. Why is this?

.....  
.....  
.....  
.....

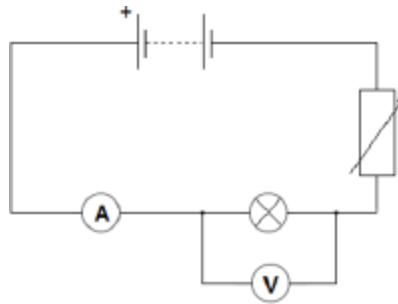
(3)

(Total 10 marks)

Mark schemes

**1**

(a)



*battery in series with bulb and ammeter*

1

*voltmeter in parallel with bulb*

1

*variable resistor*

**or**

*variable power pack*

**or**

*potentiometer*

1

(b) A is brighter because it has a higher current (than lamp B at any p.d.)

1

(therefore A has a) higher power output (than bulb B)

*accept higher energy output per second*

1

(c) lower current (than lamp A) for the same potential difference

*accept answer in terms of  $R = V / I$*

1

lower gradient (than lamp A)

1

(d) 0 – 2 Volts

*allow a range from 0 V up to any value between 1 and 2 V.*

1

(for an ohmic conductor) current is directly proportional to potential difference

*allow lines (of best fit) are straight and pass through the origin*

1

(so) resistance is constant

1

**[10]**

**2**

(a) (because the) potential of the live wire is 230 V

1



(and the) potential of the electrician is 0 V

1

(so there is a) large potential difference between live wire and electrician

1

charge / current passes through his body

*allow voltage for potential difference*

1

(b) diameter between 3.50 and 3.55 (mm)

*allow correct use of value of cross-sectional area of 9.5 to 9.9 (mm<sup>2</sup>) with no final answer given for 1 mark*

2

(c)  $18000 = I \times 300$

1

$$I = 18000 / 300 = 60$$

1

$$13\,800 = (60^2) \times R$$

1

$$R = 13\,800 / 60^2$$

1

$$3.83 \text{ (}\Omega\text{)}$$

1

*allow 3.83(Ω) with no working shown for 5 marks*

*answer may also be correctly calculated using  $P = IV$  and  $V = IR$  if 230 V is used.*

[11]

3

(a) *attempt to draw four cells in series*

1

*correct circuit symbols*

*circuit symbol should show a long line and a short line, correctly joined together*

*example of correct circuit symbol:*



1

(b) (i) 6 (V)

*allow 1 mark for correct substitution, ie*

$$V = 3 \times 2 \text{ scores 1 mark}$$

*provided no subsequent step*

2

(ii) 12 (V)

*ecf from part (b)(i)*

$$18 - 6$$

**or**

*18 – their part (b)(i) scores 1 mark*

2

(iii) 9 ( $\Omega$ )

*ecf from part (b)(ii) correctly calculated*

*3 + their part (b)(ii) / 2*

**or**

*18 / 2 scores 1 mark*

*provided no subsequent step*

2

(c) (i) need a.c.

1

battery is d.c.

1

(ii) 3 (A)

*allow 1 mark for correct substitution, ie*

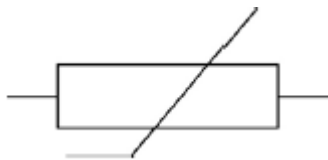
*$18 \times 2 = 12 \times I_s$  scores 1 mark*

2

[12]

4

(a) (i)



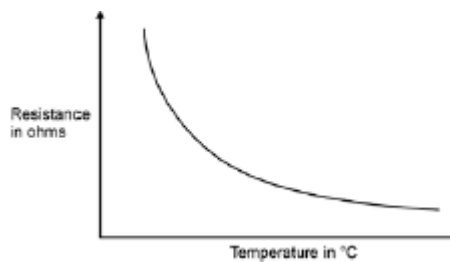
1

(ii) 360

*allow 1 mark for correct substitution, ie  $9 = 0.025 \times R$*

2

(iii) sketch graph of correct shape, ie



1

(iv) An automatic circuit to switch a heating system on and off.

1

(b) so ammeter reduces / affects current as little as possible  
*accept so does not reduce / change the current (it is measuring)*  
*accurate reading is insufficient*  
*not change the resistance is insufficient*

1

(c) gives a common understanding  
*accept is easier to share results*  
*accept can compare results*  
*do not need to be converted is insufficient*  
*prevent errors is insufficient*

1

(d) replace Bunsen (and water) with a lamp  
*accept any way of changing light level*

1

replace thermometer with light sensor  
*accept any way of measuring a change in light level*  
*datalogger alone is insufficient*

1

[9]

5

(a) 35

*an answer with more than 2 sig figs that rounds to 35 gains 2 marks*  
*allow 2 marks for correct method, ie  $\frac{230}{6.5}$*

*allow 1 mark for  $I = 6.5$  (A) or  $R = \frac{230}{26}$*

*an answer 8.8 gains 2 marks*

*an answer with more than 2 sig figs that rounds to 8.8 gains 1 mark*

3

(b) (maximum) current exceeds maximum safe current for a 2.5 mm<sup>2</sup> wire  
*accept power exceeds maximum safe power for a 2.5 mm<sup>2</sup> wire*

**or**

(maximum) current exceeds 20 (A)

*(maximum) current = 26 (A) is insufficient*

1

a 2.5 mm<sup>2</sup> wire would overheat / melt

*accept socket for wire*

*do **not** accept plug for wire*

1

- (c) a.c. is constantly changing direction  
*accept a.c. flows in two directions*  
*accept a.c. changes direction*  
*a.c. travels in different directions is insufficient*


1

d.c. flows in one direction only

1

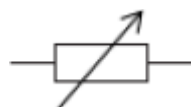
[7]

6

- (a) (i) symbol for a diode 

*accept* 

1

symbol for a variable resistor 

1

- (ii) voltmeter is in series **or** voltmeter is not in parallel

1

ammeter is in parallel **or** ammeter is not in series

*accept an answer in terms of how the circuit should be corrected*  
*voltmeter and ammeter are wrong way around is insufficient*

1

- (b) (i) 0.2 (V)  
*accept any value between 0.20 and 0.21 inclusive*

1

- (ii) 37.5  
*allow 1 mark for  $I = 0.008$*   
**or**  
*allow 2 marks for correct substitution, ie  $0.3 = 0.008 \times R$*   
**or**  
*allow 1 mark for a correct substitution using  $I = 0.8$  **or**  $I = 0.08$*   
**or**  $I = 0.009$   
**or**  
*allow 2 marks for answers of 0.375 **or** 3.75 **or** 33(.3)*

3

- (c) (i) 25  
*allow 1 mark for obtaining period = 0.04(s)*

2

- (ii) diode has large resistance in reverse / one direction

1

so stops current flow in that / one direction

*allow diodes only let current flow one way / direction*

*allow 1 mark for the diode has half-rectified the (a.c. power) supply*

1  
[12]

7

(a) (i) 50(Hz)

*ignore any unit given*

1

(ii) any **two** from:

- (some) current flows to Earth  
*accept ground for Earth*
- current flows through copper braid  
*accept current flows through the earth wire*  
*accept electricity for current in either the first or second marking point but not both*
- RCCB detects difference between current in live and neutral wire

2

(iii) can be reset

*accept does not need replacing*

**or**

faster acting

*accept switches circuit off faster*

1

(b) (i) 79 200

*allow 1 mark for correct substitution, ie  $11 = \frac{Q}{2 \times 3600}$*

*an answer 22 gains 1 mark*

2

coulombs / C

*do **not** accept c*

1

(ii) 18 216 000

*accept for 2 marks 18 216 kJ **or** 18.216 MJ*

**or**

230 × their (b)(i) correctly calculated

*allow 1 mark for correct substitution, ie 230 × their (b)(i) **or***

*allow 1 mark for power calculated as 2530(W)*

2

(c) increases temperature of thermistor

1

changes resistance (of thermistor)

*do not accept increases resistance (of thermistor)*

*an answer decreases resistance (of thermistor) gains 2 marks*

1

[11]

8

(a) (i) 2

*allow 1 mark for correct substitution i.e.  $0.8 \times 2.5$  provided no further step shown*

2

(ii) straight line drawn from origin to 2, 0.8

**or**

their (a)(i), 0.8

1

curve from 2, 0.8 to 12,2

**or**

their (a)(i) 0.8 to 12,2

*accept curve from 2, 0.9 to 12,2*

**or**

*their (a)(i) 0.9 to 12,2*

*'convex' curve required*

*accept a curve that flattens between 10 and 12V*

1

(iii) filament / lamp gets hot

*accept temperature increases*

1

(b) 108

*allow 1 mark for correct substitution i.e.  $1.5 \times 72$  provided no further step shown*

2

[7]

9

(a) electric current  
(rate of) flow of (electric) charge / electrons

*accept  $I = \frac{Q}{t}$*

*with Q and t correctly named*

1

potential difference

work done / energy transferred per coulomb of charge  
(that passes between two points in a circuit)

$$\text{accept } V = \frac{W}{Q}$$

*with W and Q correctly named*

1

(b) metals contain free electrons (and ions)

*accept mobile for free*

1

as temperature of filament increases ions vibrate faster /  
with a bigger amplitude

*accept atoms for ions*

*accept ions/atoms gain energy*

*accept vibrate more for vibrate faster*

*do not accept start to vibrate*

1

electrons collide more (frequently) with the ions

**or**

(drift) velocity of electrons decreases

*do not accept start to collide*

*accept increasing the p.d. increases the temperature (1 mark)*

**and**

*(and) resistance increases with temperature (1 mark) if no other  
marks scored*

1

(c) 7.8

*allow 1 mark for obtaining value 1.3 from graph*

**or** *allow 1 mark for a correct calculation using an incorrect current  
in the range 1.2-1.6 inclusive*

2

[7]

10

(a) (i) 50 000

*allow 1 mark for correct substitution, ie*

$$6 = 0.00012 \times R$$

$$\text{or } 6 = 0.12 \times R$$

**or** *answers of 25 000 or 50 gain 1 mark*

**or** *allow 1 mark for an incorrect answer caused by one error only ie  
using 3V or an incorrect conversion of current*

2

ohm /  $\Omega$

*an answer 50k $\Omega$  gains 3 marks*

1

(ii) (body) resistance changes

**or**

body fat/resistance affected by (many) factors

*accept named factor, eg age, gender, height, fitness, bone structure, muscle, drinking water related to body fat / resistance*

1

(iii) gives misleading / wrong/inaccurate value

*do not credit if specifically linked to a change in mass / weight*

1

(because) high water content changes body resistance

*accept a specific change to resistance*

*water changes body mass is insufficient*

1

(b) (i) RCCB – detects difference between current in live and neutral (wires)

*accept RCCB can be reset*

1

fuse – (overheats and) melts

*accept blows for melts*

1

(ii) switches the circuit / hedge trimmers off within 60 milliseconds

*allow for 1 mark the RCCB / it is (very) fast.*

*do not accept the bigger the current the faster the RCCB switches off*

2

**[10]**

**11**

(a) (i) (connect) 30 (cells)

1

in series

1

(ii) current always flows in the same direction

**or**

current only flows one way

1



(iii) 36 000

*allow 1 mark for correctly converting 2 hours to 7200 seconds  
answers 10 or 600 score 1 mark*

2

coulombs / C

*do **not** accept c*

1

(b) (i) 2160

*allow 1 mark for correct substitution, ie  $\frac{1}{2} \times 120 \times 6^2$   
answers of 1620 or 540 score 1 mark*

2

(ii) reduce it

1

any **one** from:

- draws a larger current (from battery)
- motor draws greater power (from battery)  
*accept energy per second for power  
accept more energy needed to move the bicycle*
- greater resistance force (to motion) / air resistance / drag / friction  
*accept less streamlined  
more mass to carry is insufficient*

1

**[10]**

**12**

(a) diode

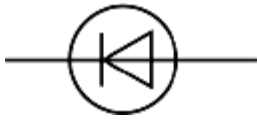
*accept LED*

1

(b) all symbols correct

*must include at least voltmeter and diode*

1



diode

*allow ecf from part (a) if the component is not identified as a diode*  
*allow symbol without the line through triangle*  
*ignore polarity of diode*

voltmeter in parallel with component added in series

*any additional components must not affect the ability to measure **V** and **I** for the diode / their (a)*

1

(c) (i) 0.05

*accept 50 mA*

*accept between 0.048 and 0.050 inclusive*

1

(ii) 16

$$\frac{0.8}{0.05}$$

*their (c)(i) correctly calculated gains both marks*

*allow 1 mark for correct transformation and substitution*

$$\frac{0.8}{0.05} \text{ or } \frac{0.8}{\text{their (c)(i)}}$$

*allow 17 if using 0.048*

2

[6]

13

(a) (i) 0.25 (A)

1

(ii) 75

*allow 1 mark for converting 5 minutes to 300 seconds*

*or allow 1 mark for correct substitution*

*ie  $0.25 \times 300$*

*allow 1 mark for an answer 1.25*

*allow 1 mark only for their (a)(i)  $\times 300$  correctly calculated*

2

coulombs or C

*do **not** accept c*

1

(b) any **two** from:

- fault not repaired  
*accept if a fault was to occur*
- larger current will (still) flow
- aluminium foil will not melt (if a fault)  
*accept aluminium foil needs a higher current / charge to melt*
- wiring will overheat / (may) cause a fire  
*accept idea of fire hazard*  
*do **not** accept explode etc*

2

[6]

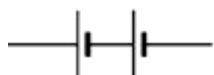
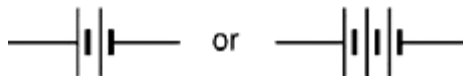
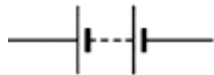
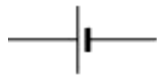
14

(a) (i) ammeter and battery **in series** with the **gauge**

*symbols must be correct*

*ignore a voltmeter drawn in series*

**accept**



**not**



*or cells reversed to cancel out*

1

voltmeter in parallel with the gauge

*symbol must be correct*

*accept a freestanding circuit*

*diagram provided strain gauge is labelled or a resistor symbol used for the strain gauge*

1

(ii) d.c. flows only in one direction  
*a.c. changes direction is insufficient*

1

(b) (i) 75

*this answer only*

*allow 1 mark for correct substitution **and** transformation,*

$$\text{ie resistance} = \frac{3.0}{0.040}$$

2

(ii) increases

1

(iii) elastic / strain potential

*do **not** accept potential*

1

[7]

15

(a) (i) light dependent resistor / LDR  
*accept ldr*

1

(ii) 25 (kilohms)  
*accept 24 - 26 inclusive*  
*accept 25 000  $\Omega$*

1

(iii) 5 (V) or their (a)(ii) correctly converted to ohms  $\times 0.0002$  correctly calculated  
*allow 1 mark for converting 25 k $\Omega$  /*  
*their (a)(ii) to ohms*

**or**

*allow 1 mark for correct substitution*

*ie 0.0002  $\times$  25(000)*

**or** 0.0002  $\times$  their (a)(ii)

*allow an incorrect conversion from kilohms providing this is clearly shown*

2

(b) (i) linear scale

*using all of the available axis*

*must cover the range 4 - 6 v*

**or** their (a)(iii) - 6 v and lie within the range 0 - 15 inc.

1

(ii) negative gradient line

*do **not** allow lines with both positive and negative gradients*

1

passing through 20 lux and their (a)(iii)  
*only scores if the first mark is awarded*  
*only scores if line does not go above 6 volts*

1

(c) (i) 37.5 (kΩ) or their (a)(ii) + 50 % (a)(ii) correctly calculated

1

(ii) light intensity value would be unreliable / not accurate

1

due to variation in resistance value

*accept because resistance varies by ± 50 %*

*accept tolerance of resistor is too great*

*do **not** accept results are not accurate*

1

[10]

16

(a) (i) 0.0046

*accept 4.6 mA*

*allow 1 mark for correct substitution and transformation*

$$\text{i.e. current} = \frac{230}{50000}$$

*an answer of 4.6 gains 1 mark*

2

(ii) • increases overall resistance

1

• (in event of a shock) gives a smaller current

*accept gives smaller shock*

*do **not** accept no shock/current*

1

(b) (i) 50 (hertz)

*ignore units*

1

(ii) NO has the lowest current at which people cannot let go

*answer and reason needed*

*accept a sensible reason in terms of their answer to (b) (i)*

**or** YES changing the frequency changes the current by only a small amount

1

- (c) a current flows through from the live wire/metal case to the earth wire

*accept a current flows from live to earth*

*do **not** accept on its own if the current is too high*

this current causes the fuse to melt

*accept blow for melt*

2

[8]

17

- (a) (i) potential difference = current  $\times$  resistance

*accept voltage **or** pd for potential difference*

*accept  $V = I \times R$*

*accept correct transformation*

*do **not** accept  $V = C \times R$*

*do **not** accept  $V = A \times R$*



*subsequent use of  $\Delta$  correct*

*do **not** accept an equation expressed in units*

1

- (ii) 46

*credit correct transformation for 1 mark*

*allow 1 mark for use of 11.5 V or division of final resistance by 20*

*a final answer of 920 gains 2 marks only*

3

ohm(s)

*accept symbol  $\Omega$*

*do **not** accept  $\Omega$  s*

*unit / symbol mark can be awarded in (iii) provided unit / symbol is omitted in (ii)*

1

- (iii) 920 (ohms) **or** their (a)(ii)  $\times$  20

1


- (b) as temperature increases, resistance increases  
*accept hotter for temperature increase*  
*do **not** accept a reference to resistance only i.e. it / resistance goes up*

1

[7]

18

- (i) power = potential difference  $\times$  current  
*accept voltage for potential difference*  
*accept  $P = V \times I$*   
*or correct transposition*

accept  *provided subsequent method correct*

1

- (ii) 8

*allow 1 mark for correct substitution or transformation or an answer 2.67 / 2.7*

2

[3]

19

level drops as petrol used;  
 causes circuit resistance to increase;  
 causes current to decrease

*for 1 mark each*

**or** if change not specified;  
*(one correct and two vague statements gains 2 marks,  
 three vague statements gains 1 mark)*  
 e.g. level changes;    )  
 so resistance changes; ) = 1 mark  
 so current changes    )

[3]

20

- (a) in range  $6 < I \leq 13$  A

*for 1 mark*

*(no unit no mark)*

1

- (b) 4  
*gains 2 marks*  
 (else working  
*gains 1 mark*  
 (resistance of circuit correctly worked ( $2\Omega$ ))
- 2
- (c)  $72 (I^2 R)$  ecf  
*gains 2 marks*  
 else working  
*gains 1 mark*  
 an answer of 36W (ie for one lamp) – (1)
- 2
- (d) 1000 or 16.7 min (ecf from (c))  
*gains 2 marks*  
 else working  
*gains 1 mark*  
*(formula with incorrect substitution – no mark (12V))*
- 2

[7]

21

- (a) Current = 0.4A (1)  
 $R = V/I$  or  $240/0.4$  (1)  
 $R = 600$  ohm (1)
- 3
- (b) Doubles  
*gets 2 marks*  
 OR gets bigger  
*gets 1 mark*
- 2
- (c)  $P = V.I$  or  $240 \times 0.4$   
 $P = 96W$   
*for 1 mark each*
- 2
- (d)  $I = 0.2A$   
 $P = 48W$   
*for 1 mark each*  
*BUT may get equation mark here if not in (c)*
- 2



(e)  $P = V.I.t$  (1)  
 $P = 240 \times 0.2 \times 6 \times 3600$   
**OR**  $P = 48 \times 6 \times 3600$   
*gets 1 mark*

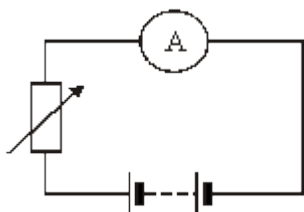
$P = 1036800 \text{ W}$   
*gets 1 mark*

3

[12]

22

(a)



3

one mark for each symbol  
 allow more than 2 cells joined

*max. 2 marks if symbols incorrectly allow rheostat arrow in either direction*

(b) current will decrease

1

since resistance greater

1

[5]

23

(a) (i) power  $\div$  voltage = current **or**  
 $2800 \div 240 = 11.6 - 11.7$  **or** 12

*2 marks for correct answer 1 mark for  $2.8 \div 240$*

2

(ii) resistance = voltage  $\div$  current

$$240 \div 11.7$$

*(efc here)*

1

20.5 **or** 20.57 **or** 20.6 **or** 21

*2 marks for correct answer*

1

ohms **or**  $\Omega$

*do not credit R*

1

(b)  $850 \div 1500 \times 100$

*marks only available for division of power*

1

$$= 56.7$$

*2 marks for correct answer*

*for 1 mark accept 5670*

1

[7]

24

(a) (i)  $P = V \times I$

**or** equivalent

*credit a triangle if part (ii) correctly uses the relationship*

*credit power = volts  $\times$  amps **or** watts  $V \times A$*

*do not accept C for current*

1

(ii) ( $P = 230 \times 10 =$ ) 2300

*credit 2.3*

1

W **or** J/s

*kW*

1

- (b) (i) 15 A  
*credit 13 A or amps* 1
- (ii) any **three** from  
earth  
any short (to the metal tank) causes fuse to blow  
fuse is in the live wire  
to prevent damage to the heater  
*credit to stop the current* 3
- (c) (i)  $V = I \times R$   
**or** equivalent  
*credit a triangle if part (ii) correctly uses the relationship* 1
- (ii)  $(230 = 10 \times R \Rightarrow) 23$   
ohms **or**  $\Omega$  2

[10]

25

- (a) ordinary cell has higher voltage (normally / at start)  
**or**  
ordinary cell 1.3V nicad 1.2V (normally / at start)  
*for 1 mark*
- voltage of ordinary cell falls more slowly  
*gains 1 mark*
- (*accept* ordinary cell lasts longer)  
**but**  
as above with relevant quantification e.g. falls to zero in 60 seconds  
compared to 6 seconds  
**or**  
nicad falls to zero 10 times as fast  
*gains 2 marks*

3

(b) (i) answer in range 32-34 (seconds) (inclusive)  
*gains 1 mark*

**but**  
answer in range 22-24 (seconds) (inclusive)  
*gains 2 marks*

(ii) 12 (seconds)  
*gains 1 mark*

**but**  
2 (seconds)  
*gains 2 marks*

4

(c) resistance of the lamp / filament changes / increases  
*gains 1 mark*

**but**  
resistance of the lamp / filament decreases  
*gains 2 marks*

because the temperature of the filament falls / filament cools  
*for 1 mark*

3

**[10]**