Section 2: Electricity 1

Answer Key

1.1	What is current?	The rate of flow of charge. I = Q/t where I is the current, measured in Amps Q is the charge, measured in coulombs t is time, measured in seconds
1.2	What is needed for current to flow?	A potential difference and a closed circuit.
1.3	**What is the unit of charge?**	**C (coulombs)**
1.4	**What is the unit of current**	**A (amps)**
1.5	What is resistance?	The opposition to the flow of current.
1.6	**What is the unit of resistance?**	**Ω (ohms)**
1.7	**What is the unit of potential difference?**	**V (volts)**
1.8	How do we measure current?	With an ammeter in series with the circuit
1.9	How do we measure potential difference?	With a voltmeter in parallel to the component of interest
1.10	**How do we find resistance of a component or circuit?**	**Find the current and potential difference, then use Ohms Law** **V = IR, where** **V is the voltage, measured in volts** **I is the current, measured in amps** **R is the resistance, measured in ohms**

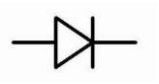
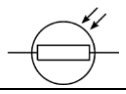
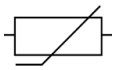
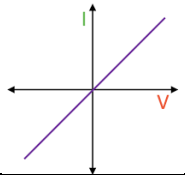
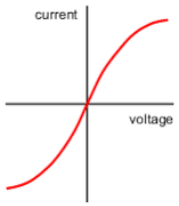
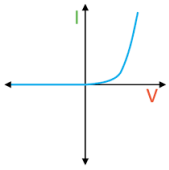
Section 2: Electricity 2

Answer Key

2.1	What is the difference between series and parallel circuits?	Components in series are on the same loop of the circuit; components in parallel are on separate loops
2.2	**What happens to current in series?**	**Stays the same**
2.3	**What happens to current in parallel?**	**Splits up then recombines.**
2.4	What happens to potential difference in series?	Total p.d. is split across the components.
2.5	What happens to potential difference in parallel?	Total p.d. stays the same across each branch.
2.6	What happens to resistance in series?	Total resistance is the sum of the resistances of all the components
2.7	What happens to resistance in parallel?	Total resistance is lower than the resistance of the component with the smallest resistance
2.8	What is the difference between direct current (DC) and alternating current (AC)?	In DC, the charges move continuously in one direction. In AC, charges continuously change direction (p.d. is continuously changed direction)
2.9	**Describe 3 features of UK mains electricity**	**230V, AC, 50Hz**
2.10	**In a 3-core cable, what are the features of the live wire?**	**Alternates to potential difference from maximum +325V to -325V, 50 times per second**
2.11	**In a 3-core cable, what are the features of the neutral wire?**	**Potential difference = 0V – completes the circuit between the appliance and the local substation**
2.12	**In a 3-core cable, what are the features of the earth wire?**	**Potential difference = 0V – only carries current in the event of a fault**

Section 2: Electricity 3

Answer Key

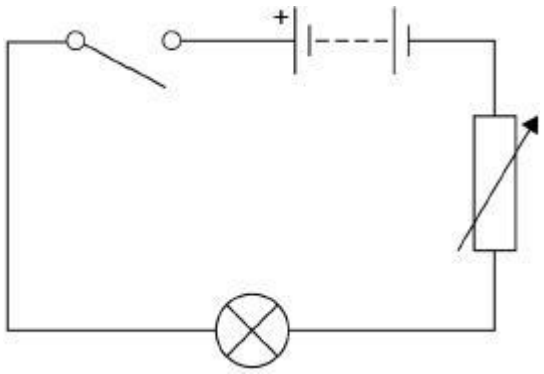
3.1	Why is the live wire dangerous even when the switch in a mains circuit is open?	Because it is at a very high p.d. Compared to earth, so that if a person touched it they would be electrocuted as current flowed through them to earth
3.2	How is electrical power transferred in the National Grid?	At a very high potential difference between power stations and consumers, then stepped down to 230V before use.
3.3	Why is transferring electrical power at a very high potential difference across long distances an efficient method?	Because power lost due to heating is proportional to I, a higher pd means a lower I and therefore less power lost.
3.4	**What is this component and what does it do?** 	**Diode only lets current flow through in one direction (the direction of the arrow)**
3.5	**What is this component and what does it do?** 	**Light Dependent Resistor Has a resistance that decreases as light intensity increases**
3.6	**What is this component and what does it do??** 	**Thermistor Has a resistance that decreases as temperature increases**
3.7	What component does this graph show? 	Ohmic conductor or Wire
3.8	What component does this graph show? 	Filament lamp
3.9	What component does this graph show? 	Diode

FOUNDATION

Q1.

A student investigated how the power output of a filament lamp varied with the current in the lamp.

The diagram below shows part of the circuit the student used.



(a) To calculate power output the student measured the current in the lamp and the potential difference across the lamp.

Complete the diagram above by adding an ammeter and a voltmeter to make the measurements.

Use the correct circuit symbols.

(3)

(b) Which energy store in the battery decreases when the lamp is switched on?

_____

(1)

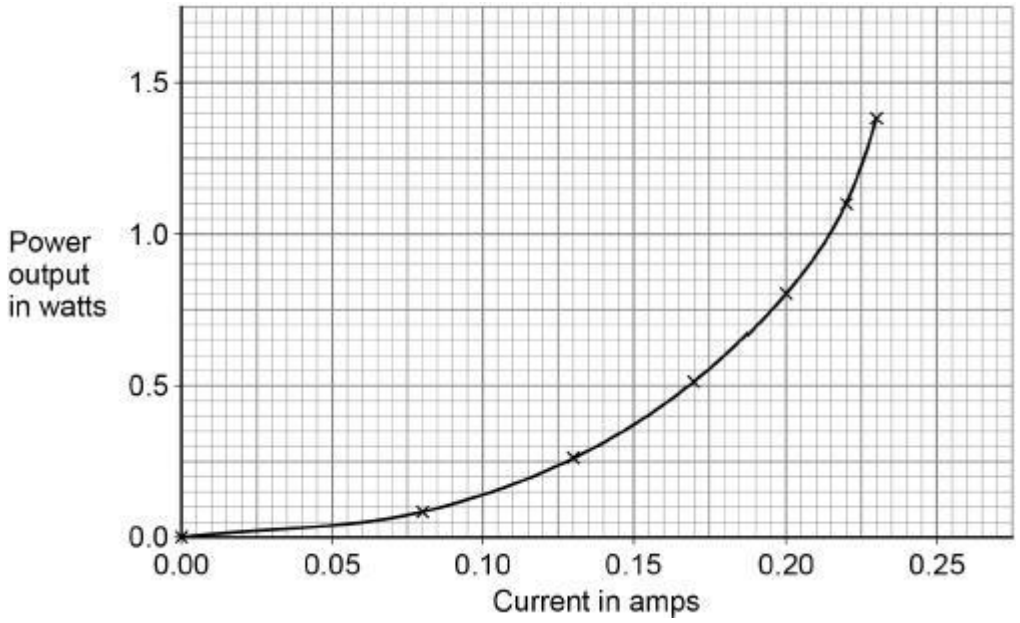
(c) What happens to the energy transferred by the lamp?

_____

_____

(1)

The graph below shows the results.



(d) Describe how varying the current affects the power output of the filament lamp.

_____

_____

_____

_____

(2)

(e) Write down the equation which links current (*I*), power (*P*) and resistance (*R*).

_____

(1)

(f) Determine the resistance of the lamp when the current in the lamp is 0.22 A

_____

_____

_____

_____

_____

_____

_____

Resistance = _____ Ω

(4)

(Total 12 marks)

Q2.

Electrical circuits have resistance.

(a) Draw a ring around the correct answer to complete the sentence.

When the resistance of a circuit increases, the current in the circuit

decreases.
increases.
stays the same.

(1)

(b) Use the correct answer from the box to complete each sentence.

a filament bulb	**an LED**	**an LDR**

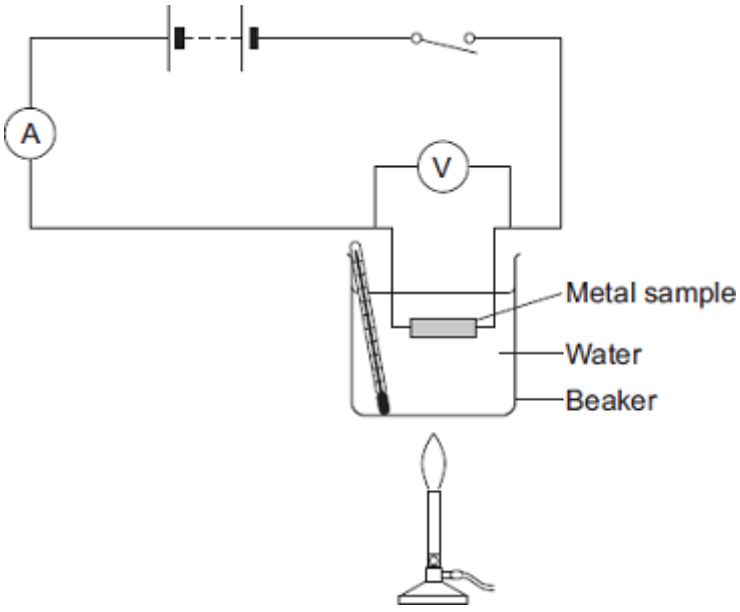
An electrical component which has a resistance that increases as the temperature increases is _____ .

An electrical component which emits light only when a current flows through it in the forward direction is _____ .

(2)

(c) When some metals are heated the resistance of the metal changes.

The equipment for investigating how the resistance of a metal changes when it is heated is shown in the diagram.



In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Describe an investigation a student could do to find how the resistance of a metal sample varies with temperature. The student uses the equipment shown.

Include in your answer:

- how the student should use the equipment
- the measurements the student should make
- how the student should use these measurements to determine the resistance
- how to make sure the results are valid.

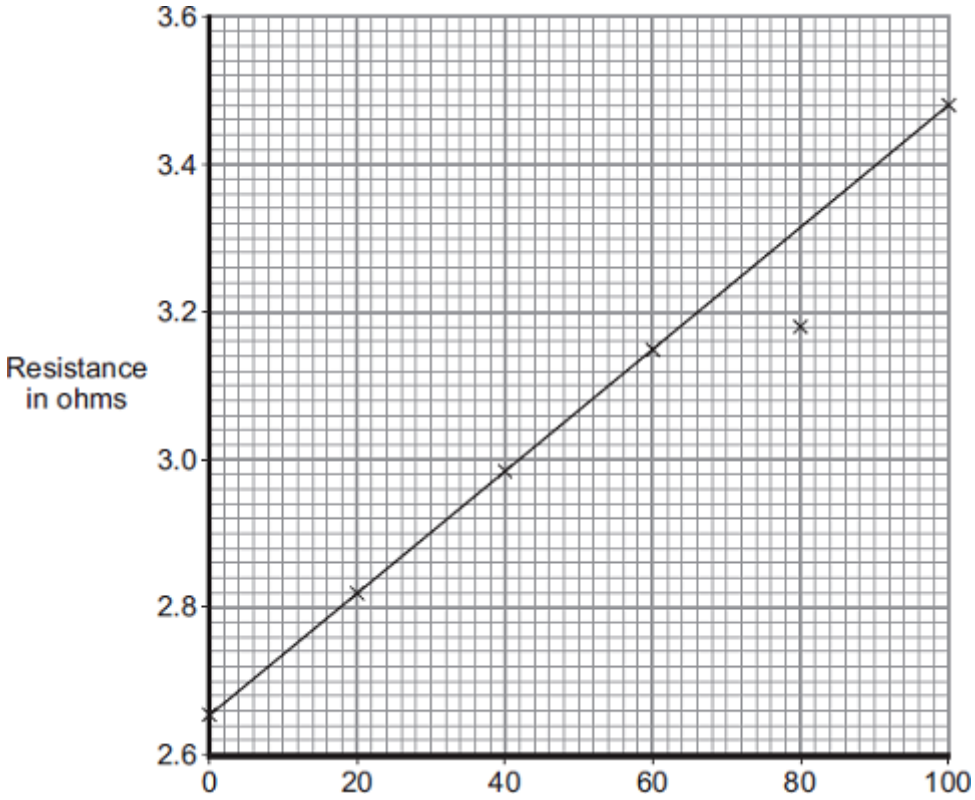
(6)

(d) The table shows some data for samples of four metals **P**, **Q**, **R** and **S**.

The metal samples all had the same cross-sectional area and were the same length.

Metal sample	Resistance at 0°C in ohms	Resistance at 100°C in ohms
P	4.05	5.67
Q	2.65	3.48
R	6.0	9.17
S	1.70	2.23

A graph of the results for one of the metal samples is shown.



(i) Which metal sample, **P**, **Q**, **R** or **S**, has the data shown in the graph?

(1)

(ii) One of the results is anomalous. Circle this result on the graph.

(1)

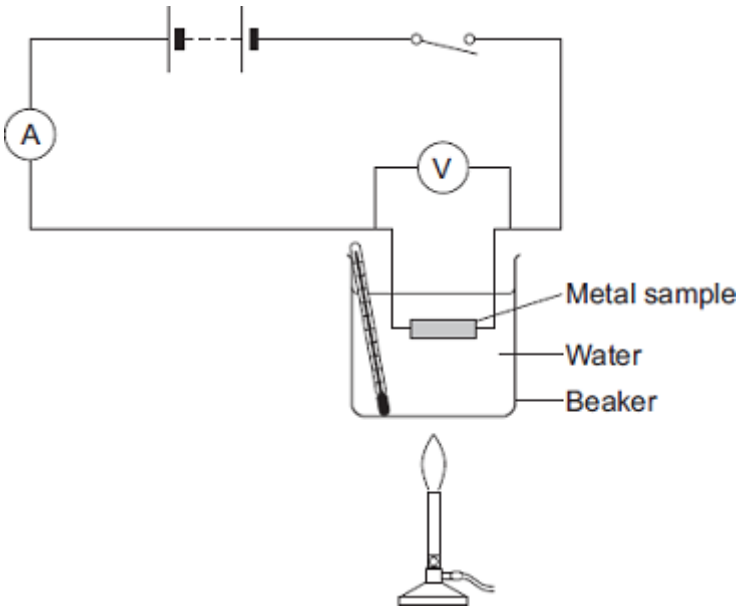
(iii) Suggest a reason for the anomalous result.

_____

_____

(1)

(iv) The same equipment used in the investigation could be used as a thermometer known as a 'resistance thermometer.'



Suggest **two** disadvantages of using this equipment as a thermometer compared to a liquid-in-glass thermometer.

1. _____

_____

2. _____

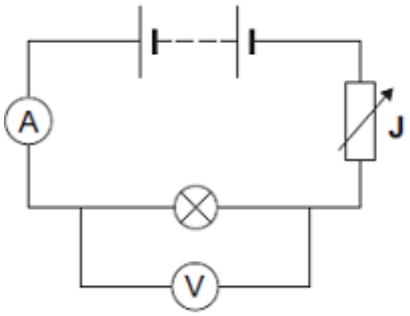
_____

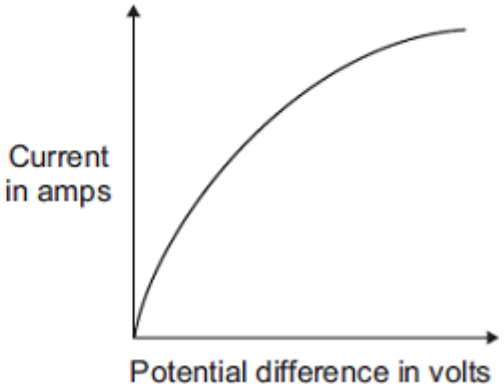
(2)

(Total 14 marks)

Q3.

(a) The diagram shows the circuit used to obtain the data needed to plot the current–potential difference graph for a filament bulb.





(i) Why is the component labelled '**J**' included in the circuit?

_____

_____

(1)

(ii) The resistance of the bulb increases as the potential difference across the bulb increases. Why?

_____

_____

(1)

(iii) The bulb is at full brightness when the potential difference across the bulb is 12 V.
The current through the bulb is then 3 A.

Calculate the power of the bulb when it is at full brightness and give the unit.

_____

_____

_____

Power = _____

(3)

(b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The table gives data about two types of light bulb people may use in their homes.

Type of light bulb	Energy efficiency	Cost of one light bulb	Average lifetime in hours
Halogen	10%	£1.95	2 000
Light Emitting Diode (LED)	32%	£11.70	36 000

Both types of light bulb produce the same amount of light.

Evaluate, in terms of cost and energy efficiency, the use of the two types of light bulb.

To gain full marks you must compare both types of light bulb and conclude which light bulb would be the best to use.

(6)

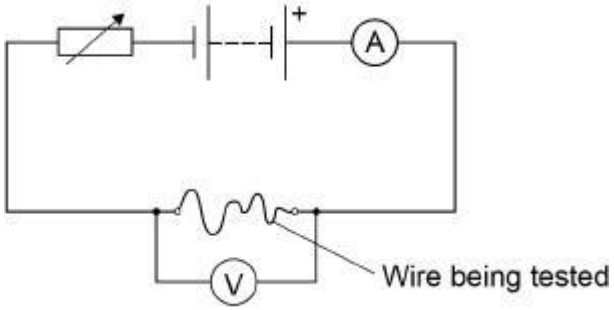
(Total 11 marks)

HIGHER

Q4.

A student investigated how the resistance of a piece of wire varies with its length.

(a) The diagram below shows the circuit used.



Explain why the student needed to adjust the variable resistor each time she changed the length of the wire.

_____

_____

_____

_____

_____

_____

(3)

(b) The student recorded three measurements of the potential difference across a 0.10 m length of wire.

The table below shows the results.

Length in m	**Potential difference in V**			
	1	2	3	Mean
0.10	**X**	0.18	0.15	0.17

Calculate **X** in table above.

_____

_____

_____

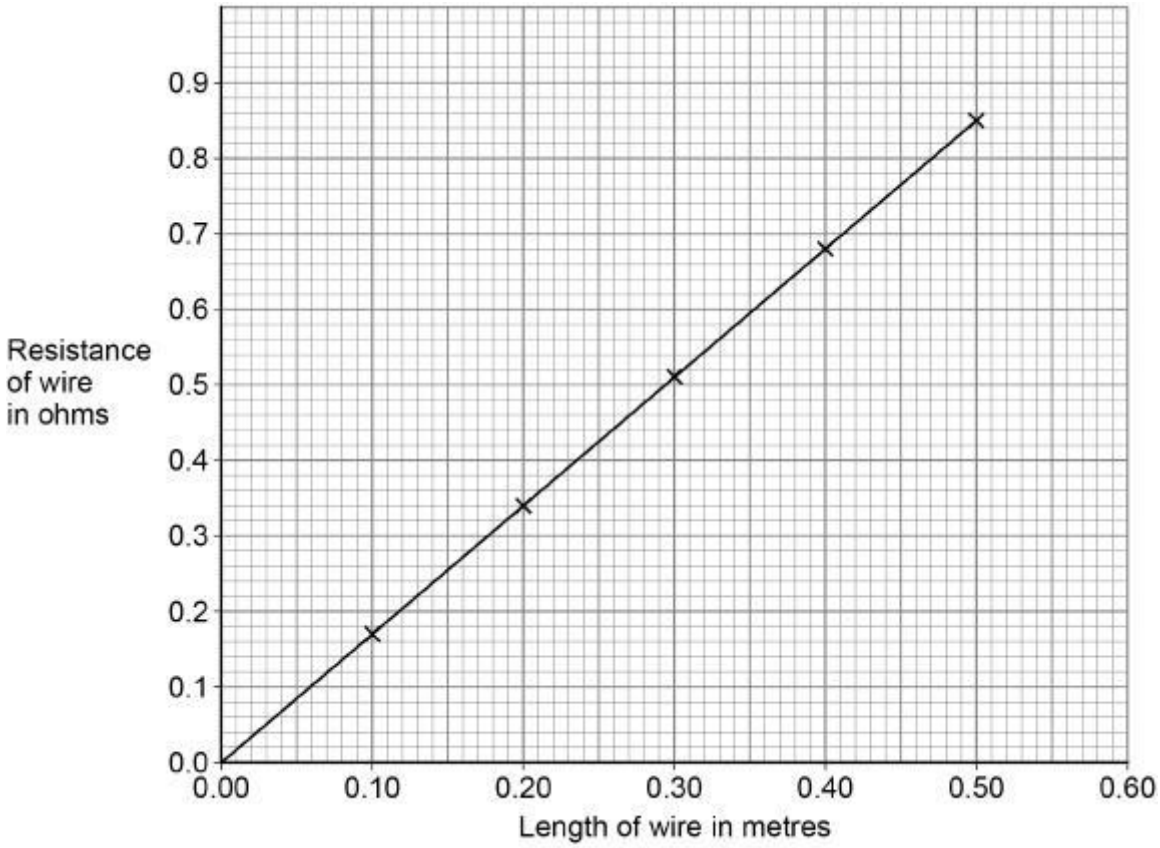
_____

X = _____ V

(2)

(c) **Figure 1** shows the results for five different lengths of the wire.

Figure 1



Describe the relationship between the length of the wire and the resistance of the wire.

_____

_____

_____

_____

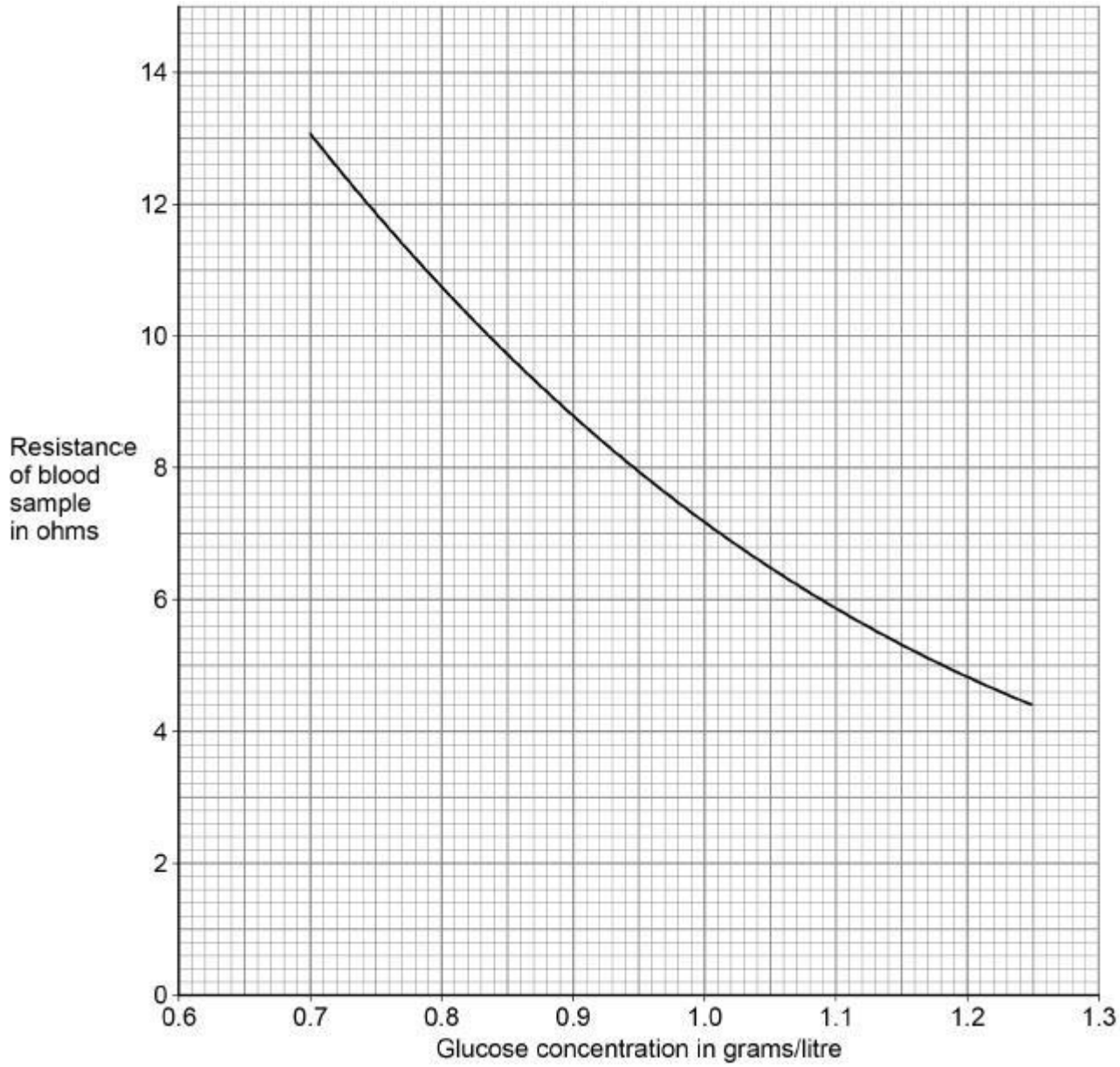
(2)

A glucometer uses the resistance of a blood sample to calculate the glucose concentration in a person's blood.

A blood sample is put into a small tube, which is put inside the glucometer. The blood then acts like a resistance wire.

Figure 2 shows the relationship between the resistance of a blood sample and the glucose concentration.

Figure 2



(d) The glucometer applies a potential difference of 0.90 volts across a blood sample.

The glucose concentration of the blood sample is 0.98 grams/litre.

Determine the current in the blood sample.

Current = _____ A

(4)

(e) A new tube is used each time a blood sample is tested.

Explain why valid results are only obtained if each tube is identical.

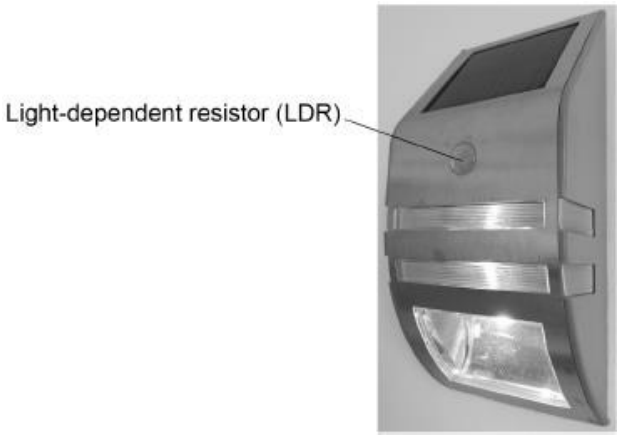
(2)

(Total 13 marks)

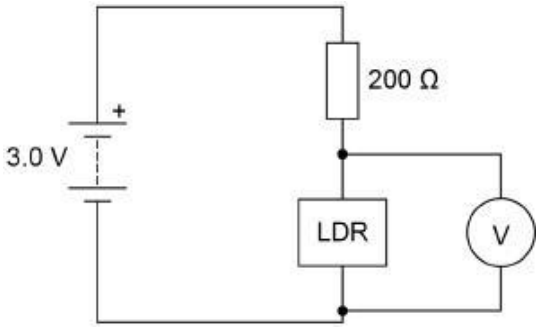
Q5.

Some security lights automatically switch on when it gets dark.

The image below shows a security light.



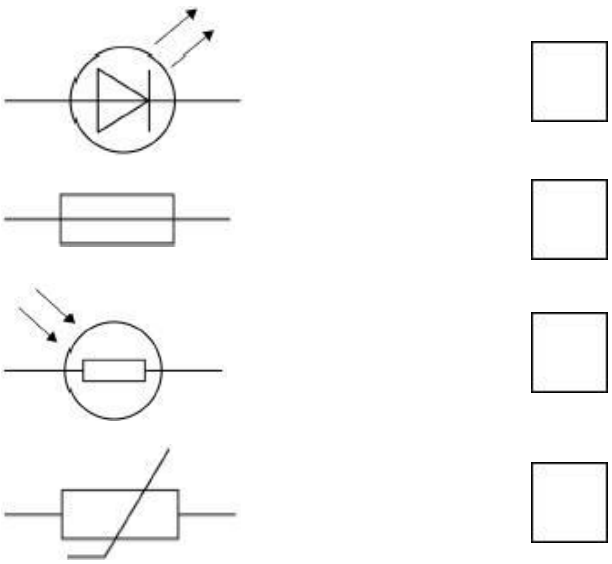
The diagram below shows part of a circuit that can be used to switch the security light on and off.



(a) The circuit symbol for the LDR in the diagram above is **not** correct.

Which is the correct circuit symbol for the LDR?

Tick (✓) **one** box.



☐

☐

☐

☐

(1)

(b) The security light turns on when the potential difference across the LDR is 2.0 V

Determine the resistance of the LDR when the potential difference across the LDR is 2.0 V

Use the diagram above.

Resistance = _____ Ω

(2)

(c) A charge of 3.24 C flows through the LDR in 40.0 minutes.

Calculate the current in the LDR.

Current = _____ A

(4)

(d) Sometimes dirt can cover the LDR on the security light.

What effect would dirt on the LDR have on the security light?

Tick (✓) **one** box.

- The security light would always be off. ☐
- The security light would always be on. ☐
- The security light would only be on during the day. ☐
- The security light would only be on during the night. ☐

(1)

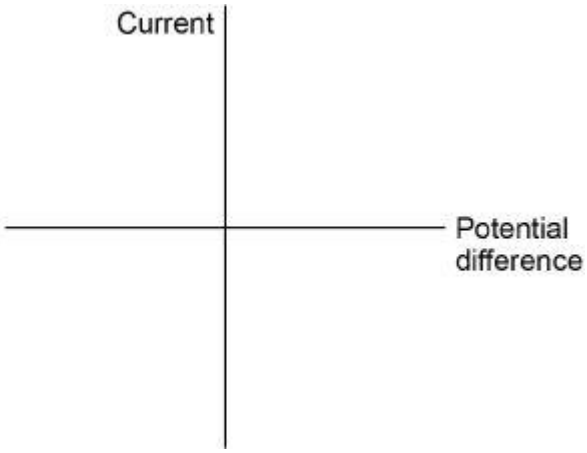
(Total 8 marks)

Q6.

A student built a circuit using filament lamps.

(a) Sketch a current potential difference graph for a filament lamp on **Figure 1**

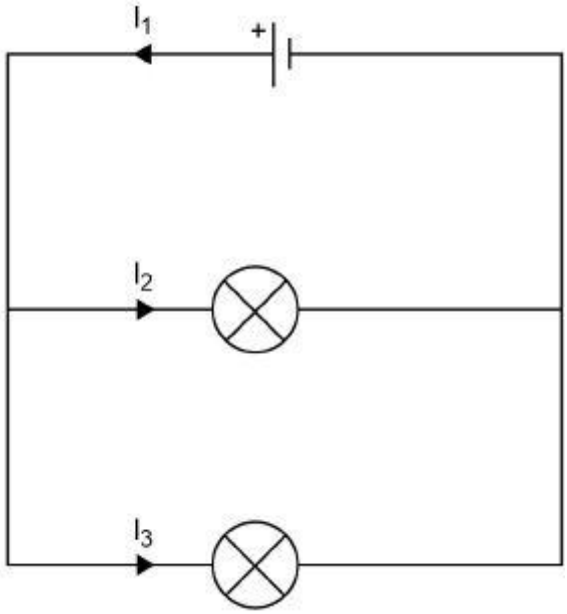
Figure 1



(2)

Figure 2 shows the circuit with two identical filament lamps.

Figure 2



(b) Compare the currents I_1, I_2 and I_3

_____

_____

_____

(2)

(c) Calculate the charge that flows through the cell in 1 minute.

Each filament lamp has a power of 3 W and a resistance of 12 Ω

Write any equations that you use.

Give the unit.

Charge = _____

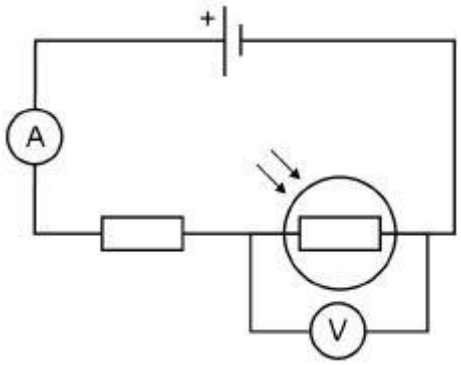
Unit = _____

(6)

(d) The student builds a different circuit.

Figure 3 shows the circuit.

Figure 3



Explain how the readings on both meters change when the environmental conditions change.

(6)

(Total 16 marks)

Mark schemes

Q1.

(a) correct circuit symbols

1

ammeter in series with filament lamp

1

voltmeter in parallel with filament lamp

1

(b) chemical

1

(c) energy is dissipated
or
energy is transferred to surroundings
or
it increases the temperature of the surroundings

1

(d) as current increases, power (output) increases

1

at an increasing rate
allow not a linear relationship

1

(e) power = current^2 × resistance

or

$P = I^2R$

1

(f) P = 1.1 (W)

1

$1.1 = 0.22^2 \times R$
allow correct substitution of an incorrect value for P for MP2, MP3 and MP4

1

$R = \frac{1.1}{0.22^2}$

R = 23 (Ω)

1

OR

1.1 = 0.22 × V (1)

V = 5.0 (V) (1)

5.0 = 0.22 × R (1)

R = 23 (Ω) (1)

1

[12]

Q2.

(a) decreases

1

(b) a filament bulb

allow bulb

1

an LED

1

(c) Marks awarded for this answer will be determined by the Quality of Communication (QoC) as well as the standard of the scientific response.

0 marks
No relevant content.

Level 1 (1−2 marks)
There is a basic description of the method. This is incomplete and would not lead to any useful results.

Level 2 (3−4 marks)
There is a description of the method which is almost complete with a few minor omissions and would lead to some results.

Level 3 (5−6 marks)
There is a detailed description of the method which would lead to valid results.
To gain full marks an answer including graph, or another appropriate representation of results, must be given.

examples of the physics points made in the response:

- read V and I
- read temperature
- apply heat

  allow hot water to cool
- read V and I at least one other temperature
- determine R from V / I
- range of temperatures above 50 °C

extra detail:
- use thermometer to read temperature at regular intervals of temperature
- remove source of heat and stir before taking readings

- details of attaining 0 °C or 100 °C
- last reading taken while boiling
- graph of R against T
- at least 3 different temperatures

6

(d) (i) Q

1

(ii) (80, 3.18)

1

(iii) any **one** from:

- measurement of V too small
- measurement of I too big
- incorrect calculation of R
- thermometer misread

allow misread meter

ignore any references to an error that is systematic

1

(iv) any **two** from:

- not portable

allow requires a lot of equipment allow takes time to set up

- needs an electrical supply
- cannot be read directly

accept it is more difficult to read compared to liquid-in-glass

2

[14]

Q3.

(a) (i) to obtain a range of p.d. values

accept increase / decrease current / p.d. / voltage / resistance

accept to change / control the current / p.d. / voltage / resistance

to provide resistance is insufficient

a variable resistor is insufficient

*do **not** accept electricity for current*

1

(ii) temperature of the bulb increases

accept bulb gets hot(ter)

accept answers correctly

expressed in terms of collisions between (free) electrons and ions / atoms

bulb gets brighter is insufficient

1

(iii) 36

*allow **1** mark for correct substitution, ie 12 × 3*
provided no subsequent step shown

2

watt(s) / W

accept joules per second / J/s

*do **not** accept w*

1

(b) **0 marks**
No relevant content.

Level 1 (1-2 marks)
There is a basic comparison of either a cost aspect or an energy efficiency aspect.

Level 2 (3-4 marks)
There is a clear comparison of either the cost aspect or energy efficiency aspect
OR
a basic comparison of both cost and energy efficiency aspects.

Level 3 (5-6 marks)
There is a detailed comparison of both the cost aspect and the energy efficiency aspect.

For full marks the comparisons made should support a conclusion as to which type of bulb is preferable.

Examples of the points made in the response:

cost

- halogen are cheaper to buy
  simply giving cost figures is insufficient
- 6 halogen lamps cost the same as one LED
- LEDs last longer
- need to buy 18 / more halogen lamps to last the same time as one LED
- 18 halogens cost £35.10
- costs more to run a halogen than LED
- LED has lower maintenance cost (where many used, eg large departmental store lighting)

energy efficiency

- LED works using a smaller current

- LED wastes less energy
- LEDs are more efficient
- LED is 22% more energy efficient
- LED produces less heat
- LED requires smaller input (power) for same output (power)

6

[11]

Q4.

(a) (the variable resistor) changes the resistance of the circuit

1

to keep the current the same

1

so the temperature of the wire is kept constant

allow to control the temperature of the wire

1

(b) $0.17 = \frac{X+0.18+0.15}{3}$

allow X = 3 × 0.17 – 0.18-0.15

1

X = 0.18 (V)

1

(c) resistance is directly proportional to length

allow length is directly proportional to resistance

allow as length increases resistance increases for 1 mark

allow positive correlation for 1 mark

2

(d) resistance = 7.5 (Ω)

allow a range from 7.4 to 7.6

1

0.90 = I × 7.5

allow their value of R read from the graph correctly substituted

1

$I = \frac{0.90}{7.5}$

allow a correct re-arrangement using their value of R read from the graph

1

I = 0.12 (A)

allow a value consistent with their value of R read from the graph

1

(e) the length/width/volume (of the blood sample) affects the resistance of the blood sample

allow length/width/volume (of the blood sample) should be a control variable

allow shape/size of the tube should be a control variable

ignore amount of blood

1

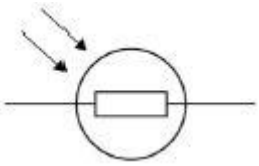
so only glucose concentration affects resistance

1

[13]

Q5.

(a)



1

(b) p.d. across 200 (Ω) resistor = 3.0 – 2.0 = 1.0 V

1

so resistance of LDR is 400 (Ω)

allow a justified calculation of current and resistance

$I = \frac{1}{200} = 5 \times 10^{-3}$ *(A) (1)*

$2 = 5 \times 10^{-3} \times R$

R = 400 (Ω) (1)

1

(c) t = 2400 (s)

1

3.24 = I × 2400

this mark may be awarded if t is incorrectly or not converted

1

$I = \frac{3.24}{2400}$

this mark may be awarded if t is

incorrectly or not converted

1

I = 0.00135 (A)
or
I = 1.35×10^{-3} (A)

allow an answer consistent with their value of t incorrectly or not converted

1

(d) the security light would always be on

1

[8]

Q6.

(a) a curve in the first and third quadrants only, passing through origin

1

decreasing gradient

1

(b) any **two** from:
- $I_1 = I_2 + I_3$
- $I_2 = I_3$
- $I_1 = 2I_2$
- $I_1 = 2I_3$

*allow **1** mark for each correct description given in words*

2

(c) $3 = I^2 \times 12$

1

$$I = \sqrt{\left(\frac{3}{12}\right)}$$

1

I = 0.5 (A)

1

Q = 0.5 × 60 = 30

allow Q = their calculated I × 60

1

Q_{total} = 60

allow an answer that is consistent with their calculated value of I

1

or

$3 = I^2 \times 12$ (1)

$$I = \sqrt{\left(\frac{3}{12}\right)}$$

I = 0.5 (A) (1)

I_{total} = 1.0 (A) (1)

allow I_{total} = their I × 2

Q = 1.0 × 60 = 60 (1)

allow an answer that is consistent with their calculated value of I

coulombs **or** C

1

*an answer of 60 scores **5** calculation marks*

(d) **Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

5–6

Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.

3–4

Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

1–2

No relevant content

0

Indicative content

- resistance of LDR changes when light intensity changes
- when light intensity increase resistance of LDR decreases

- overall resistance of circuit decreases
- potential difference across total resistance remains unchanged
- current in ammeter increases

- potential difference across fixed resistor increases
- potential difference across LDR decreases
- reading on the voltmeter decreases

- potential difference is shared between the components in series
- the lower the resistance of the LDR the smaller the share of the potential difference
- reading on the voltmeter decreases

[16]