Q1.

The image shows a battery-powered drone.

(a) The battery in the drone can store 97.5 kJ of energy.

When the drone is hovering, the power output of the battery is 65.0 W

Calculate the time for which the drone can hover.

___

___

___

___

___

___

Time = ____________________ seconds

(3)

(b) The battery powers 4 motors in the drone.

Each motor has a resistance of 1.60 Ω when the power input to each motor is 19.6 W

The 4 motors are connected in parallel with the battery.

Calculate the current through the battery.

___

___

___

___

___

___

Current = ____________________ A

(4)

(Total 7 marks)

Q2.

Figure 1 shows a Van de Graaff generator that is used to investigate static electricity.

Before it is switched on, the metal dome has no net charge.

After it is switched on, the metal dome becomes positively charged.

Figure 1

© Michael Priest

(a) Explain how an uncharged object may become positively charged.

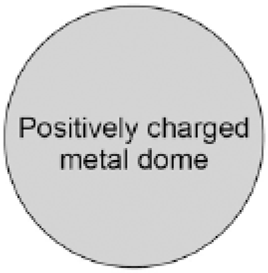
(3)

(b) **Figure 2** shows a plan view of the positively charged metal dome of a Van de Graaff generator.

Draw the electric field pattern around the metal dome when it is isolated from its surroundings.

Use arrows to show the direction of the electric field.

Figure 2

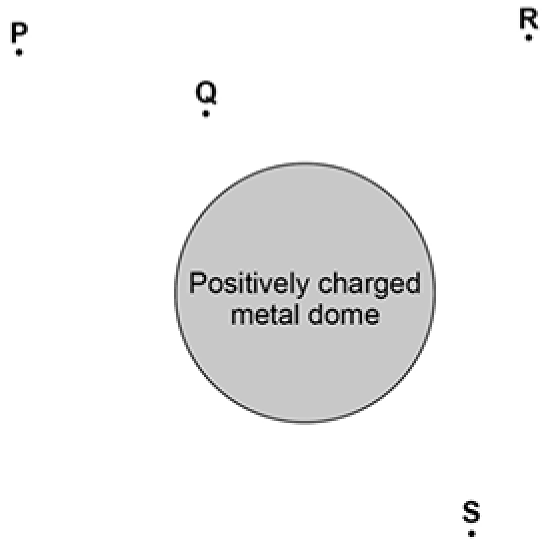


(2)

(c) Another positively charged object is placed in the electric field.

Look at **Figure 3**.

Figure 3



In which position would the object experience the greatest force?

Tick **one** box.

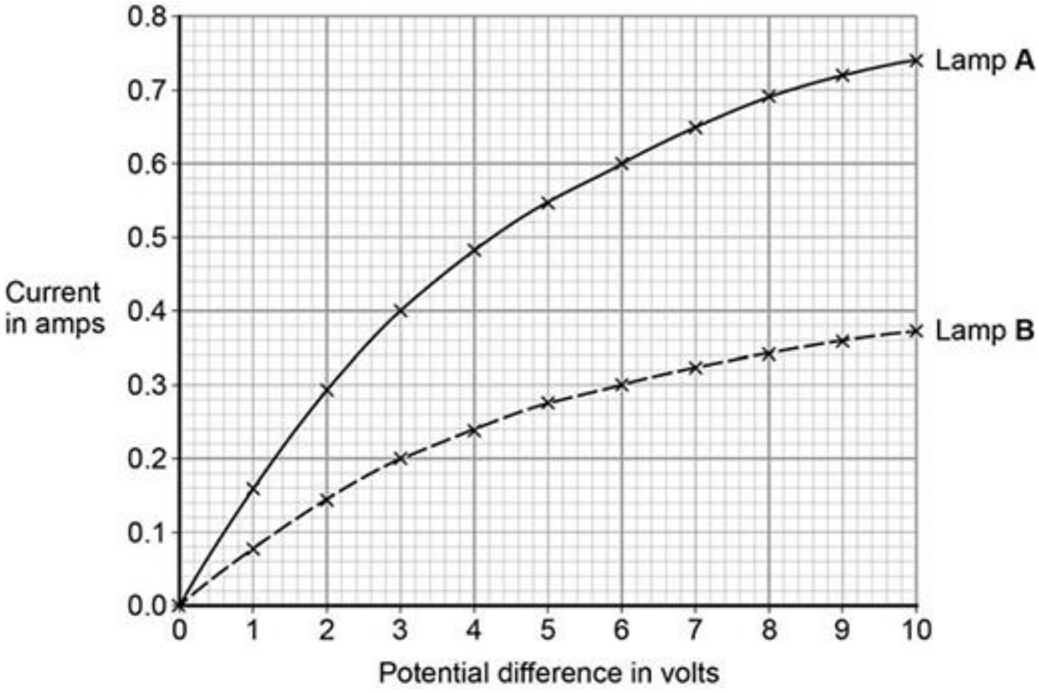
P	☐
Q	☐
R	☐
S	☐

(1)
(Total 6 marks)

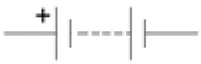
Q3.

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.

___

___

___

____

(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.

____

____

____

____

____

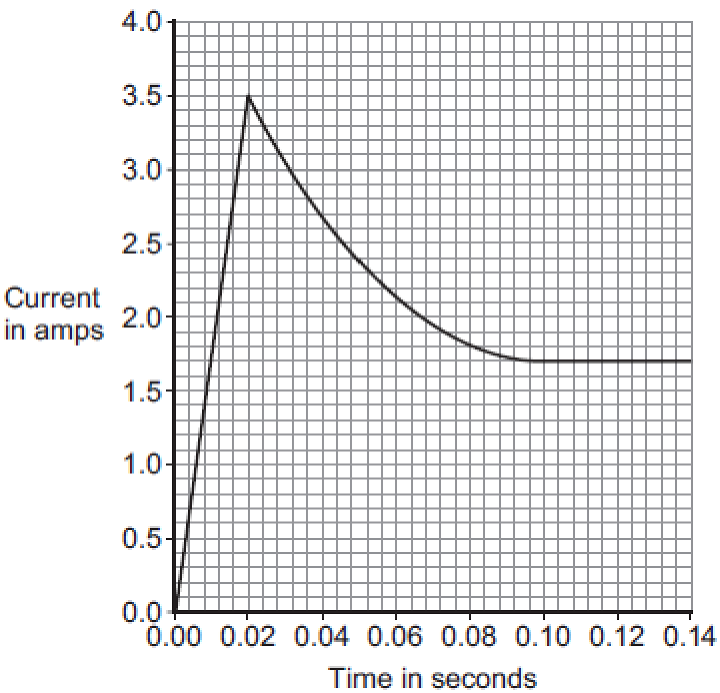
____

(3)

(Total 10 marks)

Q4.

A 12 V filament bulb is connected to a 12 V power supply.
The graph shows how the current changes after the bulb is switched on.



(a) (i) After 0.10 seconds, the bulb works at its normal brightness.

What is the current through the bulb when it is working at normal brightness?

Current = ______________________ A

(1)

(ii) The bulb works at normal brightness for 30 seconds before it is switched off.

Calculate the charge that flows through the bulb in the 30 seconds before it is switched off. Give the unit.

____

____

____

Charge = ________________ unit ________________

(3)

(iii) Calculate the energy transferred by the 12 V bulb when it is working at normal brightness for 30 seconds.

____

____

Energy transferred = ____________________ J

(2)

(b) Between 0.02 seconds and 0.08 seconds, there is an increase in both the resistance and the temperature of the metal filament inside the bulb.

Explain, in terms of the electrons and ions inside the filament, why both the temperature and the resistance increase.

____

____

____

____

____

____

(2)

(Total 8 marks)

Q5.

(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 Ω.

(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 × resistance

Show clearly how you work out your answer.

____

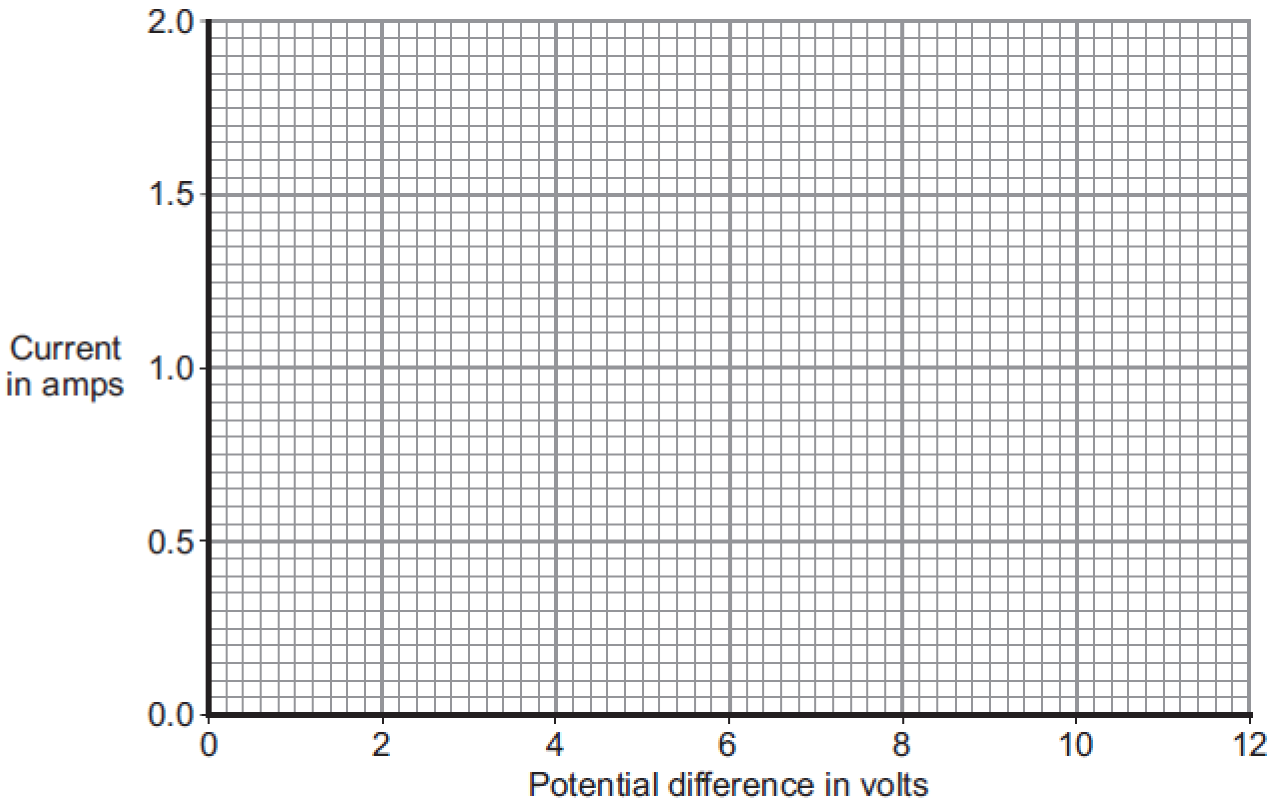
____

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)

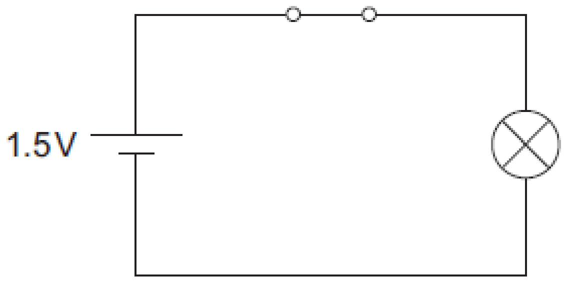
(iii) Why does the resistance of the lamp change when the current through the lamp exceeds 0.8 A?

____

____

(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)

Q6.

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

____

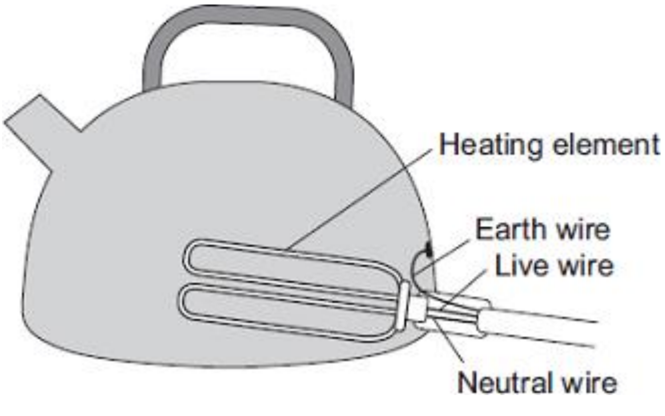
____

____

____

(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.

___

___

___

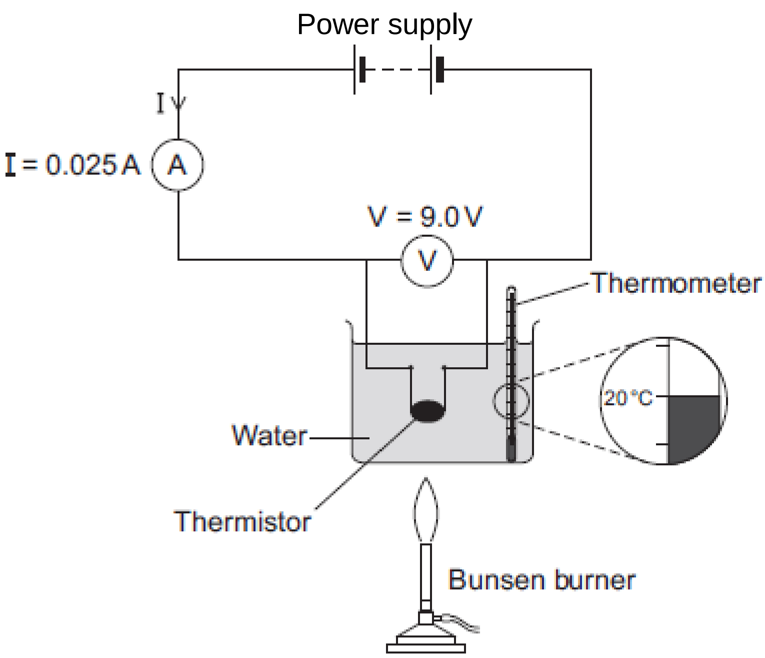
___

(2)
(Total 4 marks)

Q7.

(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 °C.

___

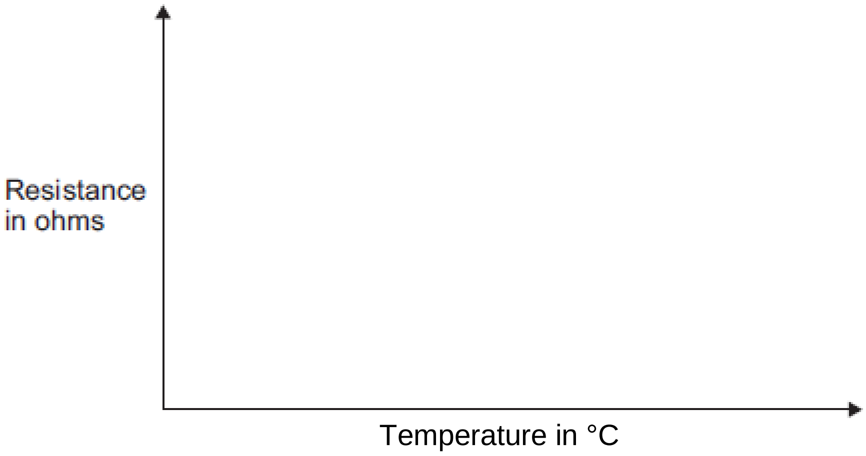
Resistance = _____________ ohms

(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 (°C)
212	Fahrenheit (°F)
80	Réaumur (°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.

___

___

___

___

(2)

(Total 9 marks)

Mark schemes

Q1.

(a) 97 500 = 65.0 × t

1

$t = \frac{97500}{65.0}$

1

t = 1500 (s)

*an answer of 1500 (s) scores **3** marks*

*an answer of 1.5 scores **2** marks*

1

(b) 19.6 = I^2 × 1.60

1

$I^2 = \frac{19.6}{1.60}$

1

I = 3.5 (A)

allow 1 mark for a correct value for I correctly multiplied by 4

1

current through battery = 14 (A)

*an answer of 14 (A) scores **4** marks*

1

[7]

Q2.

(a) negatively charged

1

electrons are transferred

1

from the (neutral) object

1

(b) minimum of four lines drawn perpendicular to surface of sphere

judge by eye

1

minimum of one arrow shown pointing away from sphere

*do **not** accept any arrow pointing inwards.*

1

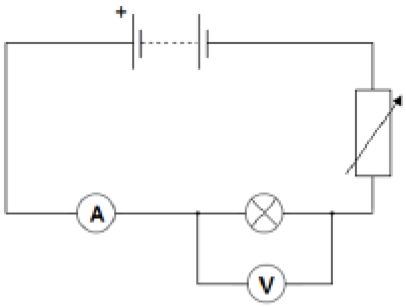
(c) Q

1

[6]

Q3.

(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]

Q4.

(a) (i) 1.7 **1**

(ii) 51
or
30 × their (i) correctly calculated

*allow **1** mark for correct substitution i.e. 1.7* $= \frac{Q}{30}$

or their (i) $= \frac{Q}{30}$

2

coulomb / C

*do **not** accept c*

1

(iii) 612

or

their (ii) × 12 correctly calculated

or

their (i) × 360 correctly calculated

*allow **1** mark for correct substitution i.e. E = 12 × 51*

or 12 × their (ii)

or their (i) × 360

2

(b) ions vibrate faster

or

ions vibrate with a bigger amplitude

accept atoms for ions throughout

accept ions gain energy

accept ions vibrate more

ions start to vibrate is insufficient

1

electrons collide more (frequently) with the ions

or

(drift) velocity of electrons decreases

electrons start to collide is insufficient

there are more collisions is insufficient, unless both electrons and ions are implied

1

[8]

Q5.

(a) (i) 2

*allow **1** mark for correct substitution i.e. 0.8 × 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 × 72 provided no further step shown*

2

[7]

Q6.

(a) d.c. flows in (only) one direction

1

a.c. <u>changes</u> direction (twice every cycle)

accept a.c. constantly changing direction

ignore references to frequency

1

(b) 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*

1

this current causes the fuse to melt

accept blow for melt

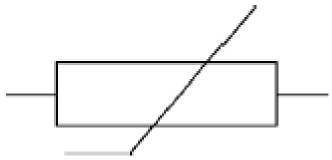
*do **not** accept break / snap / blow up for melt*

1

[4]

Q7.

(a) (i)



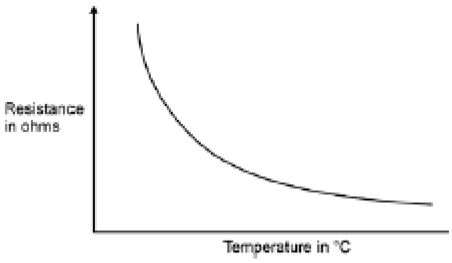
1

(ii) 360

*allow **1** mark for correct substitution, ie 9 = 0.025 × 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]

Q4.

(a) (i) Nearly all of the students scored this mark, with the most common errors being 1.6 or 1.75.

(ii) About three quarters of the students correctly calculated the numerical answer, sometimes with an error carried forward from (i). However, only about half of the students could give the correct unit.

(iii) This was poorly answered with the most common response being 12 x 30 = 360. Just less than one quarter of the students scored these two marks.

(b) This was very poorly answered with two thirds of the students scoring zero and a further tenth not attempting the question at all. A few answers suggested that the students had some notion of why the resistance increased, but the answers were too vague or imprecise to meet the second marking point.

Q5.

(a) (i) The majority of students, over 90%, scored 2 marks. Very few gained 1 mark.

(ii) Very few students produced a correct graph to gain 2 marks. A large percentage of students did not appreciate the importance of using the answer to part (a)(i). Common “wrong” answers included a straight line from the origin to (12,2), a straight line from (12,2) through (2,0.8) and continued back to the y axis, and two straight lines, one from origin to (2,0.8) and then from that point to (12,2). Otherwise, all sorts of curves, including s-shaped and convex all the way from the origin.

(iii) There were only a minority of correct answers, less that 25%. Many answers referred to how the resistance changed as the current increased but not why. There were also lots of answers given in terms of the resistance changing to allow or stop the current flowing and for safety to keep the “fuse” from blowing.

(b) The majority of students gave correct answers. The most common incorrect response was “144”, by multiplying the charge by the time in minutes. An answer scoring one mark was rare – and seemingly from students who did not possess a calculator.

Q6.

(a) This was disappointingly completed for a simple piece of recall. A small number of the students scored both marks and a small number scored one mark. Common errors where one mark was scored indicated that direct current flowed in one direction but alternating could go ‘in any direction’. Many other incorrect responses referred to oscilloscope traces, ‘positive’ and ‘negative’ and frequency.

(b) A very small number of the students gained both marks and only a small number scored one mark. The main error was for students to recall complete statements about the manner in which a fuse melts with no reference to the kettle. The earth connection was often described as an active component ‘pushing current’, ‘redirecting energy’ and undertaking other functions which indicated a complete lack of understanding.

Q7.

(a) (i) Fewer than two fifths of the students drew the correct thermistor symbol. Some of the students drew a symbol for an incorrect component, often a variable resistor, LED or LDR. Drawings of bead thermistors were quite common, as were a box or circle with just the letter T in it.

(ii) The majority of the students substituted the data and calculated the correct answer. There were very few calculation errors, but a number of the students did not rearrange the equation correctly. The most common mistake was to use the temperature value, 20°C, for either current or potential difference.

(iii) This question was poorly answered with only a small proportion of students scoring the mark. The majority of the students drew an upwards sloping straight line.

(iv) The majority of the students were able to answer this question correctly.

(b) Only a quarter of the students answered this question correctly. There were some high quality explanations of why the ammeter in series should have low resistance so as not to affect the current it is measuring. Many of the students scored zero with answers such as 'it lets the current flow easily', 'it lets more current go through' and 'it stops it overheating'.

(c) This question was well answered by just over half of the students. Some students failed to score the mark because they merely threw in a word from the 'How Science Works' lexicon, for example 'it makes it more accurate / reliable / valid / fair'. A few misunderstood the question and explained why scientists in different countries use different temperature scales or stated that it made it easier to convert the units.

(d) Nearly half of the students scored one mark, usually for recognising that a light source was needed to replace the Bunsen burner. A smaller number of the students went on to gain the second mark for realising that the thermometer was redundant and a light meter was required. Some did not know the name of the scientific apparatus but gave an acceptable description of 'a device that measures the amount of light'. Many of the students missed marks because they gave answers like 'use light not heat' but did not refer to the specific apparatus. Others stated what needed removing but not what should replace it, or vice versa. There were a few totally wrong ideas e.g. 'use a better thermometer', 'increase / decrease the battery voltage' and 'add / remove change the ammeter / voltmeter'. It was clear that many students did not make good use of the example given in the stem of the question.