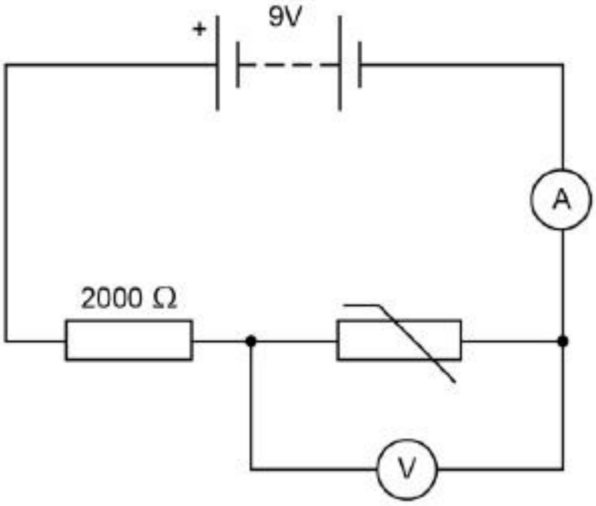
Q1.

The diagram shows a temperature sensing circuit used to control a heating system in a house.



(a) What quantity does the ammeter measure?

____

(1)

(b) The current in the circuit is 3.5 mA when the potential difference across the thermistor is 4.2 V

Calculate the resistance of the thermistor.

____

____

____

Resistance = ______________________ Ω

(3)

(c) Calculate the charge that flows through the thermistor in 5 minutes when the current is 3.5 mA.

____

____

____

Charge = ______________________ C

(3)

(d) Explain why the potential difference across the thermistor changes as the temperature in the house decreases.

____

____

____

____

(2)

(e) The circuit shown in the diagram can be modified to turn lights on and off by replacing the thermistor with a Light Dependent Resistor (LDR).

Draw the circuit symbol for an LDR in the space below.

(1)
(Total 10 marks)

Q2.

Table 1 shows information about different light bulbs.

The bulbs all have the same brightness.

Table 1

Type of bulb	Input power in watts	Efficiency
Halogen	40	0.15
Compact fluorescent (CFL)	14	0.42
LED	7	0.85

(a) (i) Calculate the useful power output of the CFL bulb.

___

___

___

Useful power output = ______________ watts

(2)

(ii) Use your answer to part **(i)** to calculate the waste energy produced each second by a CFL bulb.

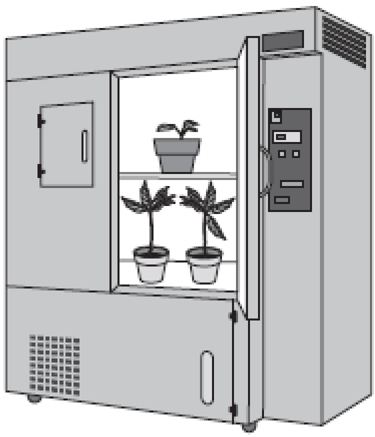
___

Waste energy per second = ______________ joules

(1)

(b) (i) A growth cabinet is used to investigate the effect of light on the rate of growth of plants.

The figure below shows a growth cabinet.



In the cabinet the factors that affect growth can be controlled.

A cooler unit is used to keep the temperature in the cabinet constant. The cooler unit is programmed to operate when the temperature rises above 20 °C.

The growth cabinet is lit using 50 halogen bulbs.

Changing from using halogen bulbs to LED bulbs would reduce the cost of running the growth cabinet.

Explain why.

____

____

____

____

____

____

(4)

(ii) A scientist measured the rate of growth of plants for different intensities of light.

What type of graph should be drawn to present the results?

____

Give a reason for your answer.

____

____

(1)

(c) **Table 2** gives further information about both a halogen bulb and a LED bulb.

Table 2

Type of bulb	**Cost to buy**	**Lifetime in hours**	**Operating cost over the lifetime of one bulb**
Halogen	£1.50	2 000	£16.00
LED	£30.00	48 000	£67.20

A householder needs to replace a broken halogen light bulb.

Compare the cost efficiency of buying and using halogen bulbs rather than a LED bulb over a time span of 48 000 hours of use.

Your comparison must include calculations.

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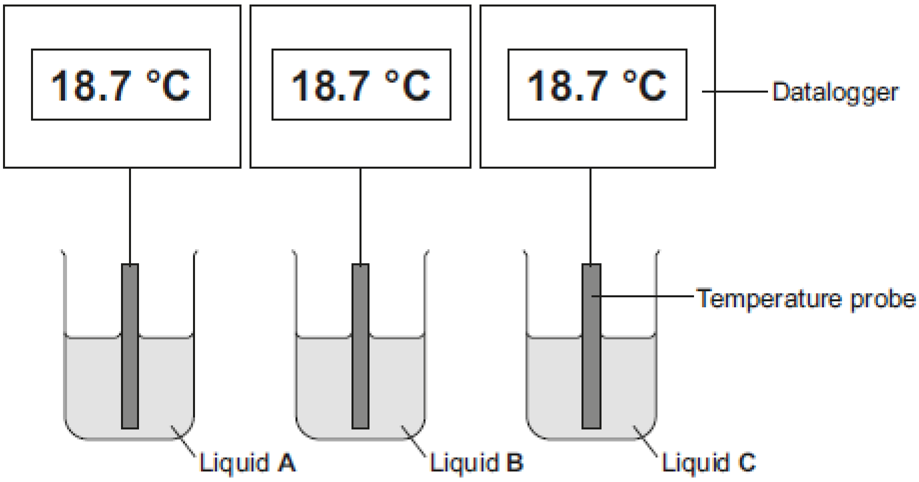
(4)

(Total 12 marks)

Q3.

A student investigated the cooling effect of evaporation.
She used the equipment in **Figure 1** to measure how the temperature of three different liquids changed as the liquids evaporated.

Figure 1



(a) The temperature and volume of each liquid was the same at the start of the investigation.

State **one** further control variable in this investigation.

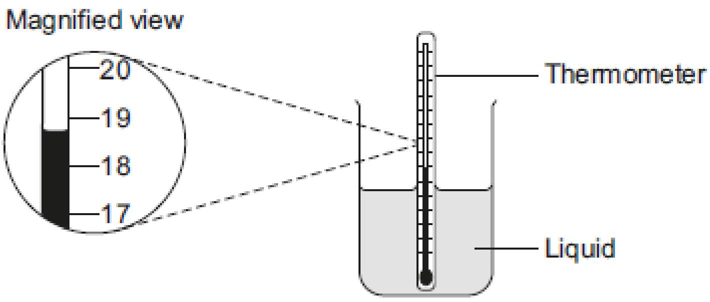
____

____

(1)

(b) Give **two** advantages of using dataloggers and temperature probes compared to using the thermometer shown in **Figure 2**.

Figure 2



1. ____

____

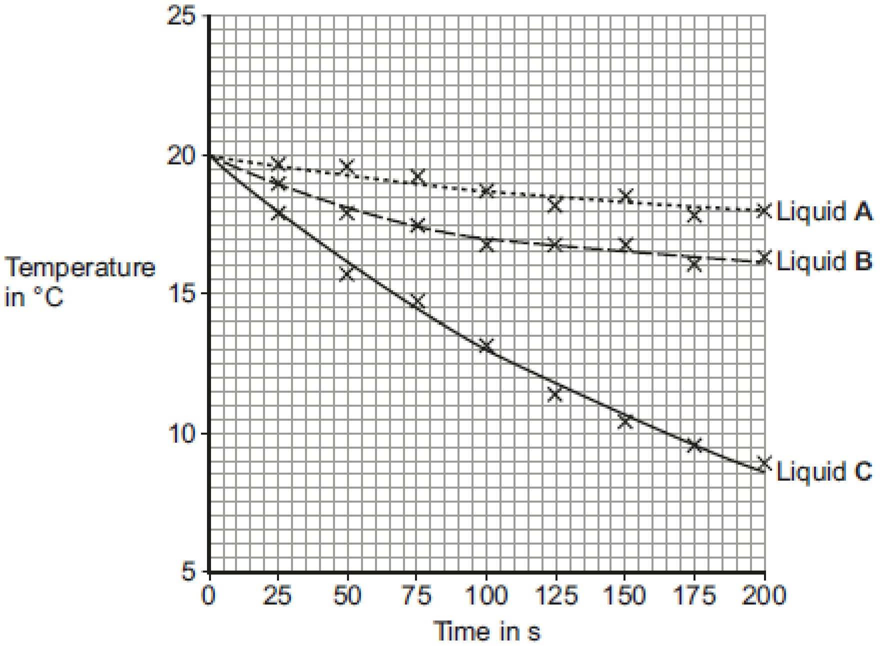
2. ____

____

(2)

(c) The student's results are shown in **Figure 3**.

Figure 3



(i) Calculate the average rate of temperature decrease of liquid **C** between 0 and 100 seconds.

____

____

Average rate of temperature decrease = __________ °C / s

(2)

(ii) Give **one** conclusion that can be made about the rate of temperature decrease of **all three** liquids from the results in **Figure 3**.

____

____

(1)

(iii) Which liquid had the lowest rate of evaporation? Give a reason for your answer.

Liquid ____

Reason ____

____

(1)

(iv) A second student did the same investigation but using a smaller volume of liquid than the first student.

All other variables were kept the same.

What effect would this have on the results of the second student's investigation?

___

___

(1)

(d) Explain how the evaporation of a liquid causes the temperature of the remaining liquid to decrease.

___

___

___

___

___

___

___

___

(3)

(Total 11 marks)

Q4.

Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

Two of its isotopes are lead-206 ($^{206}_{82}Pb$) and lead-208 ($^{208}_{82}Pb$).

(a) (i) What is meant by 'isotopes'?

___

___

___

___

(2)

(ii) How many protons are in the nucleus of a $^{206}_{82}Pb$ atom?

____

(1)

(iii) How many neutrons are in the nucleus of a $^{206}_{82}Pb$ atom?

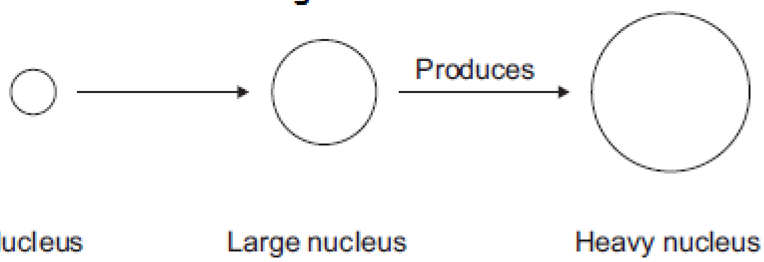
____

(1)

(b) A nucleus can be accelerated in a particle accelerator and directed at a large nucleus. This produces a heavy nucleus that will decay after a short time.

This is shown in **Figure 1**.

Figure 1



(i) In 1984, nuclei of iron (Fe) were directed at nuclei of lead (Pb). This produced nuclei of hassium (Hs).

Complete the equation for this reaction by writing numbers in the empty boxes.

$$^{58}_{\square}Fe + ^{\square}_{\square}Pb = ^{265}_{108}Hs + ^{1}_{0}X$$

(3)

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

an electron	**a proton**	**a neutron**

The particle **X** in part (b)(i) is ___________________________________ .

(1)

(iii) After acceleration the iron nuclei travel at a steady speed of one-tenth of the speed of light.

The speed of light is 3.00×10^8 m/s.

Calculate the time taken for the iron nuclei to travel a distance of 12 000 m.

____

____

Time taken = ____________________ s

(2)

(iv) Linear accelerators, in which particles are accelerated in a straight line, are **not** used for these experiments. Circular particle accelerators are used.

Suggest why.

____

____

____

____

____

____

(3)

(c) Hassium-265 ($^{265}_{108}Hs$) decays by alpha emission with a half-life of 0.002 seconds.

(i) What is meant by 'half-life'?

Tick (✓) **two** boxes.

	Tick (✓)
The average time for the number of nuclei to halve	
The time for count rate to be equal to background count	
The time for background count to halve	
The time for count rate to halve	

(2)

(ii) Complete the equation for the decay of Hs-265 by writing numbers in the empty boxes.

$$^{265}_{108}\text{Hs} = \,^{\square}_{\square}\text{Sg} + \,^{\square}_{\square}\alpha$$

(2)

(d) The table below shows how the atomic radius of some atoms varies with atomic number.

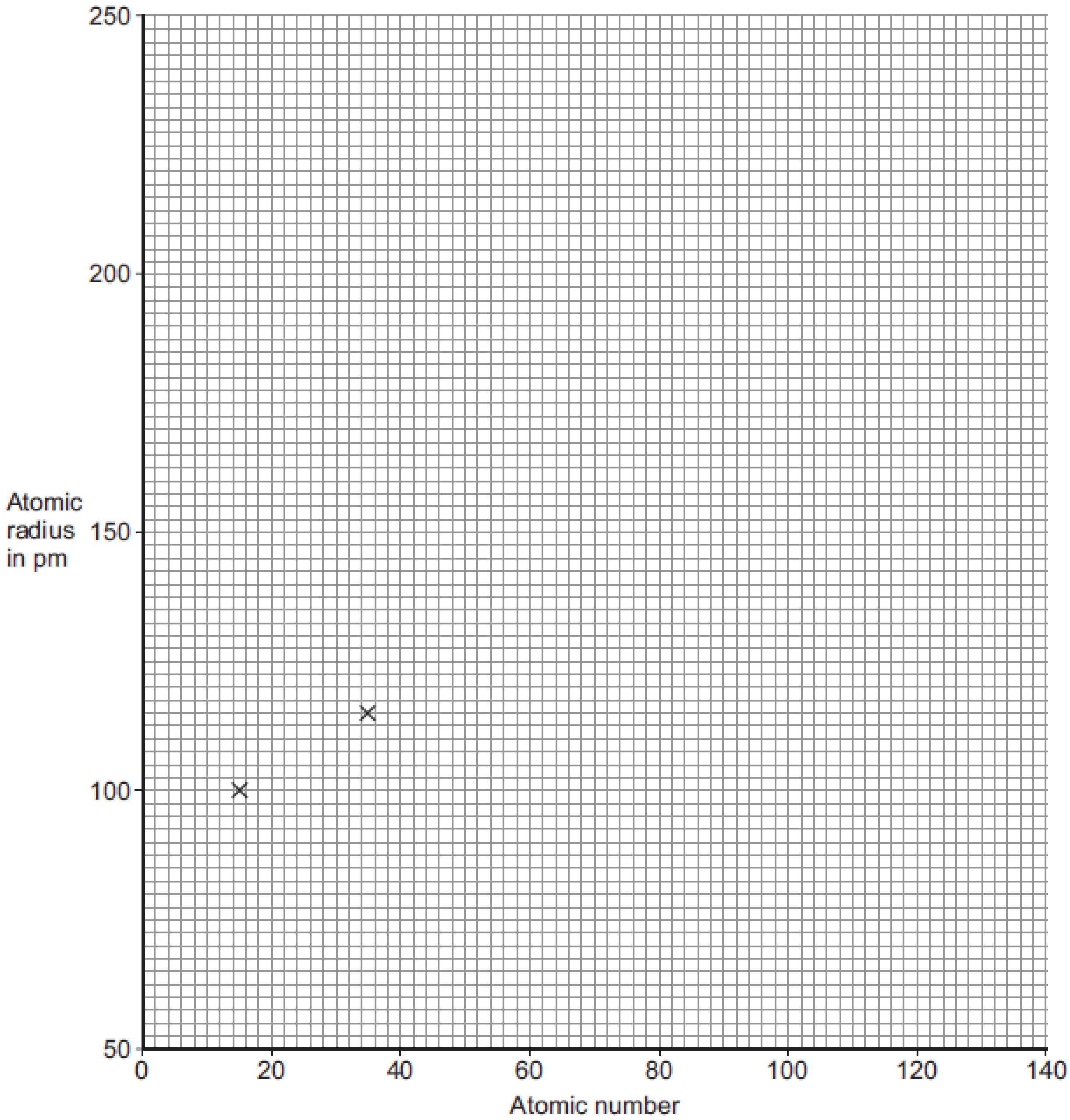
Atomic number	**Atomic radius in picometres (pm)**
15	100
35	115
50	130
70	150
95	170

1 pm = 10^{-12} m

(i) On **Figure 2**, use the data from the table above to plot a graph of atomic radius against atomic number and draw a line of best fit.

Two points have been plotted for you.

Figure 2



(2)

(ii) Scientists believe that the element with atomic number 126 can be produced and that it will be stable.

Use your graph in **Figure 2** to predict the atomic radius of an atom with atomic number 126.

Atomic radius = ____________________ pm

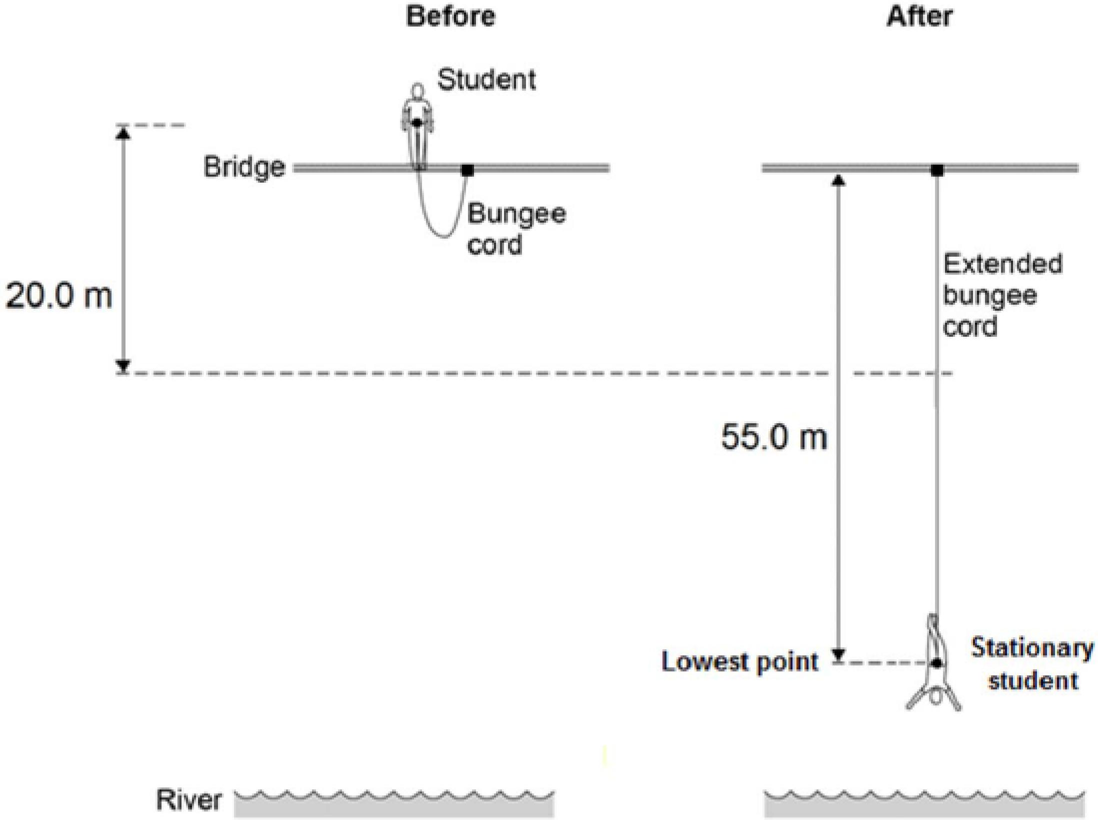
(1)

(Total 20 marks)

Q5.

The figure below shows a student before and after a bungee jump.

The bungee cord has an unstretched length of 20.0 m.



The mass of the student is 50.0 kg.

The gravitational field strength is 9.8 N / kg.

(a) Write down the equation which links gravitational field strength, gravitational potential energy, height and mass.

____

(1)

(b) Calculate the change in gravitational potential energy from the position where the student jumps to the point 20.0 m below.

____

____

____

Change in gravitational potential energy = ______________ J

(2)

(c) 80% of this change in gravitational potential energy has been transferred to the student's kinetic energy store.

How much has the student's kinetic energy store increased after falling 20.0 m?

Kinetic energy gained = ________________________ J

(1)

(d) Calculate the speed of the student after falling 20.0 m.

Give your answer to two significant figures.

___

___

___

___

Speed = __________________________ m / s

(4)

(e) At the lowest point in the jump, the energy stored by the stretched bungee cord is 24.5 kJ.

The bungee cord behaves like a spring.

Calculate the spring constant of the bungee cord.

Use the correct equation from the Physics Equation Sheet.

___

___

___

___

___

___

Spring constant = ________________________ N / m

(3)

(Total 11 marks)

Mark schemes

Q1.

(a) current

1

(b) $4.2 = 3.5 \times 10^{-3} \times R$

1

$R = 4.2 / 3.5 \times 10^{-3}$

1

R = 1200 (Ω)

*an answer of 1200 (Ω) scores **3** marks*

*an answer of 1.2 scores **2** marks*

1

(c) conversion from minutes to seconds (300 s)

1

Q = 0.0035 × (5 × 60)

1

Q = 1.05 C

*an answer of 1.05 (C) scores **3** marks*

*an answer of 17.5 scores **1** mark*

*an answer of 1050 or 0.0175 scores **2** marks*

1

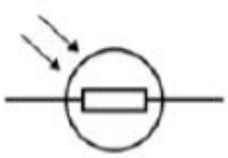
(d) (potential difference) increases

1

(because thermistor) resistance increases

2nd mark dependent on scoring 1st mark

1

(e) 

1

[10]

Q2.

(a) (i) 5.88 (watts)

*an answer of 5.9 scores **2** marks*

*allow **1** mark for correct substitution ie*

$0.42 = \frac{\text{power out}}{14}$

*allow **1** mark for an answer of 0.0588 or 0.059*

2

(ii) 8.12

allow 14 – their (a)(i) correctly calculated

1

(b) (i) input power / energy would be (much) less (reducing cost of running)

accept the converse

electricity is insufficient

1

(also) produce less waste energy / power

accept 'heat' for waste energy

1

(as the waste energy / power) increases temperature of the cabinet

1

so cooler on for less time

1

(ii) line graph

need to get both parts correct

accept scattergram or scatter graph

both variables are continuous

allow the data is continuous

1

(c) number of bulbs used-halogen=24 (LED=1)

1

total cost of LED = £30 + £67.20 = £97.20

accept a comparison of buying costs of halogen £36 and LED £30

1

total cost of halogen= 24 x £1.50 + 24 x £16.00 = £420
or
buying cost of halogen is £36 **and** operating cost is £384

accept a comparison of operating costs of halogen £384 and LED £67.20

*allow for **3** marks the difference in total cost is £322.80 if the number 24 has not been credited*

1

statement based on correct calculations that overall LED is cheaper

*must be **both** buying **and** operating costs*

an alternative way of answering is in terms of cost per hour:

buying cost per hour for LED $\left(\frac{£30.00}{48000}\right)$ = 0.0625p/£0.000625

buying cost per hour for halogen = $\left(\frac{£1.50}{2000}\right)$ = 0.075p/£0.00075

*a calculation of both buying costs scores **1** mark*

operating cost per hour for LED = $\left(\frac{£67.20}{48000}\right)$ = 0.14p/£0.0014 operating cost per hour for halogen= $\left(\frac{£16.00}{2000}\right)$ = 0.8p/£0.008

*a calculation of both operating costs scores **1** mark*

all calculations show a correct unit

***all** units correct scores **1** mark*

statement based on correct calculations of **both** buying **and** operating costs, that overall LED is cheaper

*correct statement scores **1** mark*

1

[12]

Q3.

(a) surface area

or

duration of experiment

accept shape of beaker

size of beaker is insufficient

1

(b) any **two** from:

- takes readings automatically

  *ignore easier **or** takes readings for you*

- takes readings more frequently
- reduces / no instrument reading error

  ignore human error

- higher resolution

  allow better resolution

- don't need to remove probe to take reading
- more accurate

2

(c) (i) 0.07 (°C/s)

*allow **1** mark for obtaining a temperature drop of 7 (°C)*

*allow **1** mark for an answer between 0.068 and 0.069 (°C/s)*

2

(ii) rate of temperature change is greater at the start

accept rate of evaporation is greater at the start

or

rate of temperature change decreases

allow rate of evaporation decreases

allow temperature decreases faster at the start

1

(iii) A

reason only scores if A is chosen

lower temperature decrease (over 200 seconds) *accept lower gradient* 1

(iv) no effect (as rate of evaporation is unchanged)

allow larger temperature change (per second as mass of liquid is lower) 1

(d) particles with more energy

accept particles with higher speeds 1

leave the (surface of the) liquid 1

(which) reduces the average (kinetic) energy (of the remaining particles)

allow reference to the total energy of the liquid reducing 1

[11]

Q4.

(a) (i) (atoms with the) same number of protons

allow same atomic number

***or** same proton number* 1

(atoms with) different number of neutrons

allow different mass number 1

(ii) 82 1

(iii) 124 1

(b) (i) $^{58}_{26}\text{Fe} + ^{208}_{82}\text{Pb}$

***1** mark for each correct box* 3

(ii) (a) neutron 1

(iii) 4.0×10^{-4} (s)

or

0.0004

$3.00 \times 10^{8} \times 0.1 = 12\ 000 / t$

*gains **1** mark* 2

(iv) particles need to travel a large distance 1

equipment would have to be very long 1

with circular paths long distances can be accommodated in a smaller space 1

(c) (i) the average time for the number of nuclei to halve 1

the time for count rate to halve 1

(ii) $^{261}_{106}\text{Sg} + {}^{4}_{2}\alpha$

__1__ mark if top boxes total = 265
__and__ bottom boxes total = 108
__1__ mark for 4 and 2 for alpha 2

(d) (i) 3 plotted points
± ½ small square 1

best line through points 1

(ii) 190−205 (pm)
or correct from student's line 1

[20]

Q5.

(a) g.p.e. = mass × gravitational field strength × height
accept $E_p = mgh$ 1

(b) $E_p = 50 \times 9.8 \times 20$ 1

9800 (J)
allow 9800 (J) with no working shown for __2__ marks
answer may also be correctly calculated using W = Fs
ie allow W = 490 × 20 for __1__ mark
or answer of 9800 (J) using this method for __2__ marks 1

(c) 7840 (J)

allow ecf from '11.2'

1

(d) 7840 = ½ × 50 × v^2

1

$$v = \sqrt{\frac{7840}{1/2 \times 50}}$$

allow $v^2 = \frac{7840}{(1/2 \times 50)}$ *for this point*

1

17.7(0875) (m / s)

1

18 (m / s)

*allow ecf from '11.3' correctly calculated for **3** marks*

*allow 18 (m / s) with no working for **2** marks*

answer may also be correctly calculated using $v^2 - u^2 = 2as$

1

(e) extension = 35 (m) and conversion of 24.5 kJ to 24500 J

1

24 500 = ½ × k × 35^2

1

40

1

*allow 40 with no working shown for **3** marks*

*an answer of '16.2' gains **2** marks*

[11]