GCSE

eduqas
Part of WJEC

WJEC Eduqas GCSE in

COMBINED SCIENCE

ACCREDITED BY OFQUAL

SAMPLE ASSESSMENT MATERIALS

Teaching from 2016

wjec
cbac

This Ofqual regulated qualification is not available for candidates in maintained schools and colleges in Wales.

For teaching from 2016
For award from 2018

GCSE (9-1) COMBINED SCIENCE

SAMPLE ASSESSMENT MATERIALS

Contents

Component 3 – Concepts in Physics

Component 4 – Applications in Science

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 1

Concepts in Biology

FOUNDATION TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**4**	
3.	**14**	
4.	**4**	
5.	**9**	
6.	**18**	
7.	**11**	
8.	**10**	
9.	**5**	
10.	**8**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

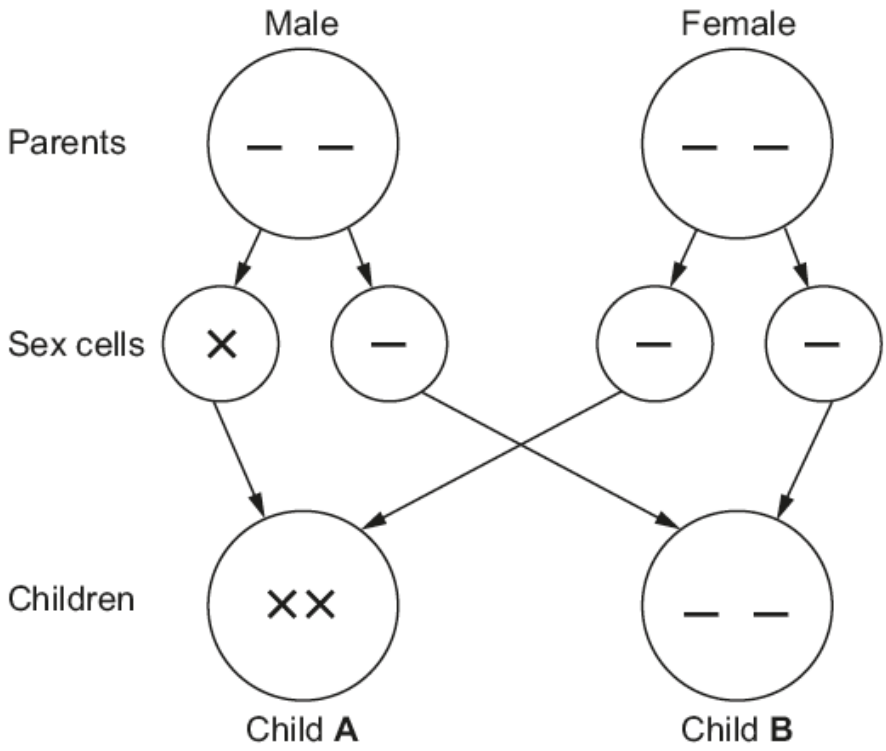
Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **7(b)**.

Answer **all** *questions.*

1. (a) (i) **Complete the diagram below** to show the sex chromosomes present in the cells of two parents and two of their children. [3]



(ii) State the sex of child **A**. ……. [1]

(iii) State the probability of their third child being male. ……. [1]

(b) (i) An egg cell of a dog (*Canis familiaris*) contains 39 chromosomes. Calculate the number of chromosomes in a **fertilised** egg cell of a dog. [1]

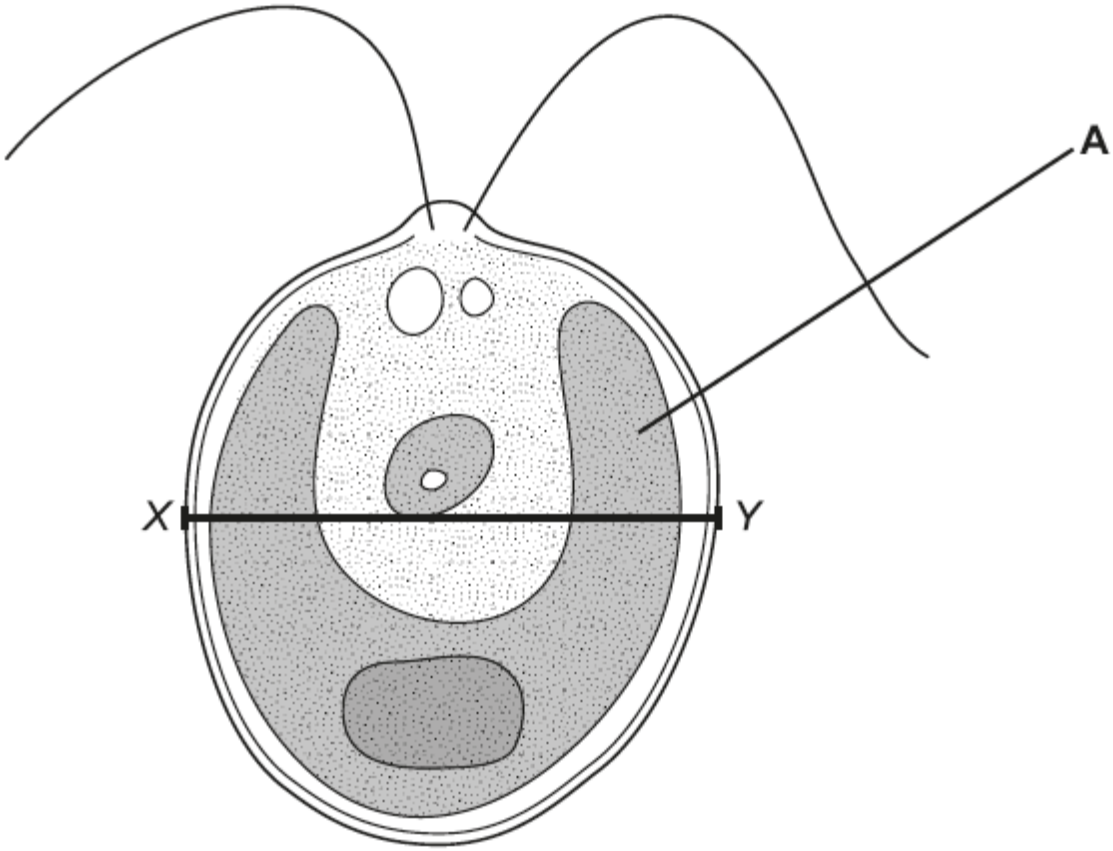
number of chromosomes = ……..

(ii) The fertilised egg cell divides to form two cells.
State the name of this type of cell division. [1]

……

7

2. The diagram shows an alga called *Chlamydomonas.*



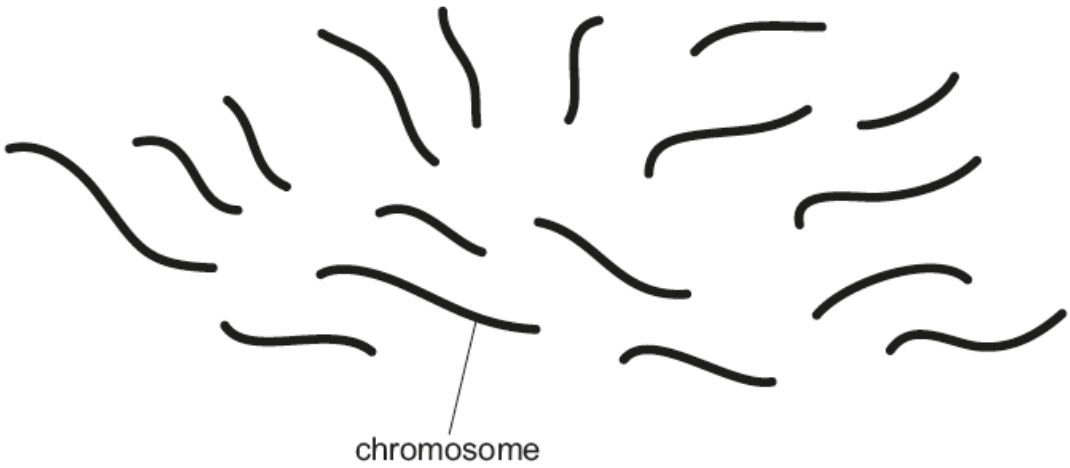
(a) (i) The length of the line X – Y on the diagram is 71 mm.
The diagram of *Chlamydomonas* is magnified × 500.
Calculate the actual width of *Chlamydomonas* at X – Y [1]

actual width = ……mm

(ii) Structure **A** contains chlorophyll. State the name of structure **A**. [1]

……..……..

(b) The diagram below shows all the 17 chromosomes which are present in *Chlamydomonas*.



Chlamydomonas has about 600 genes. Calculate the mean number of genes on each chromosome. [2]

mean number of chromosomes = …….

4

3. Some students were studying photosynthesis.

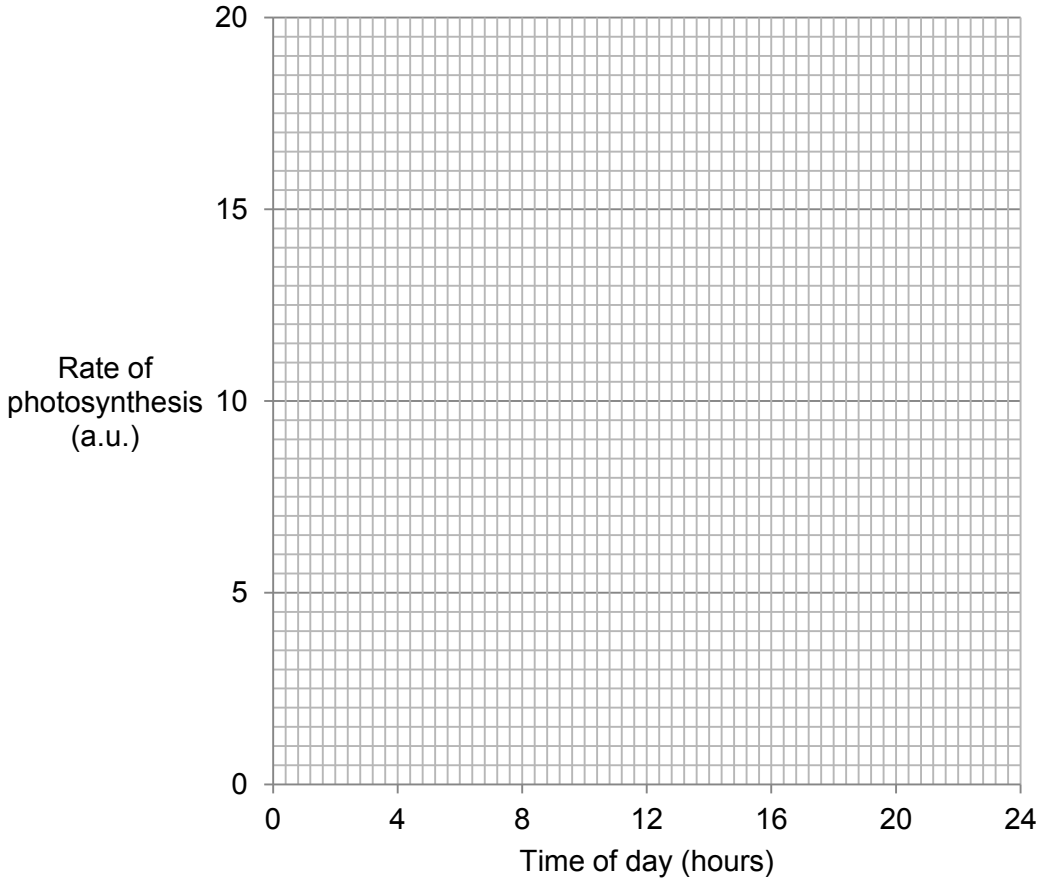
(a) State the name of **two** products of photosynthesis. [2]

…… and ……

(b) The students monitored the rate of photosynthesis by algae in a pond between 06.00 hrs and 18.00 hrs during one day in April. The results are shown in the table below.

Time of day	Rate of photosynthesis (a.u.)
06.00	0.0
08.00	1.0
10.00	4.5
12.00	10.0
14.00	16.5
16.00	8.0
18.00	7.0

(i) Draw a line graph of the results on the grid below by plotting the points and joining the points with a ruler. [3]



(ii) The students concluded that changes in light intensity affected the rate of photosynthesis. Explain how the graph supports this conclusion. [3]

……

……

……

……

(c) Give **three** other factors that would change in the pond during the day and which would affect the rate of photosynthesis. [3]

……

……

……

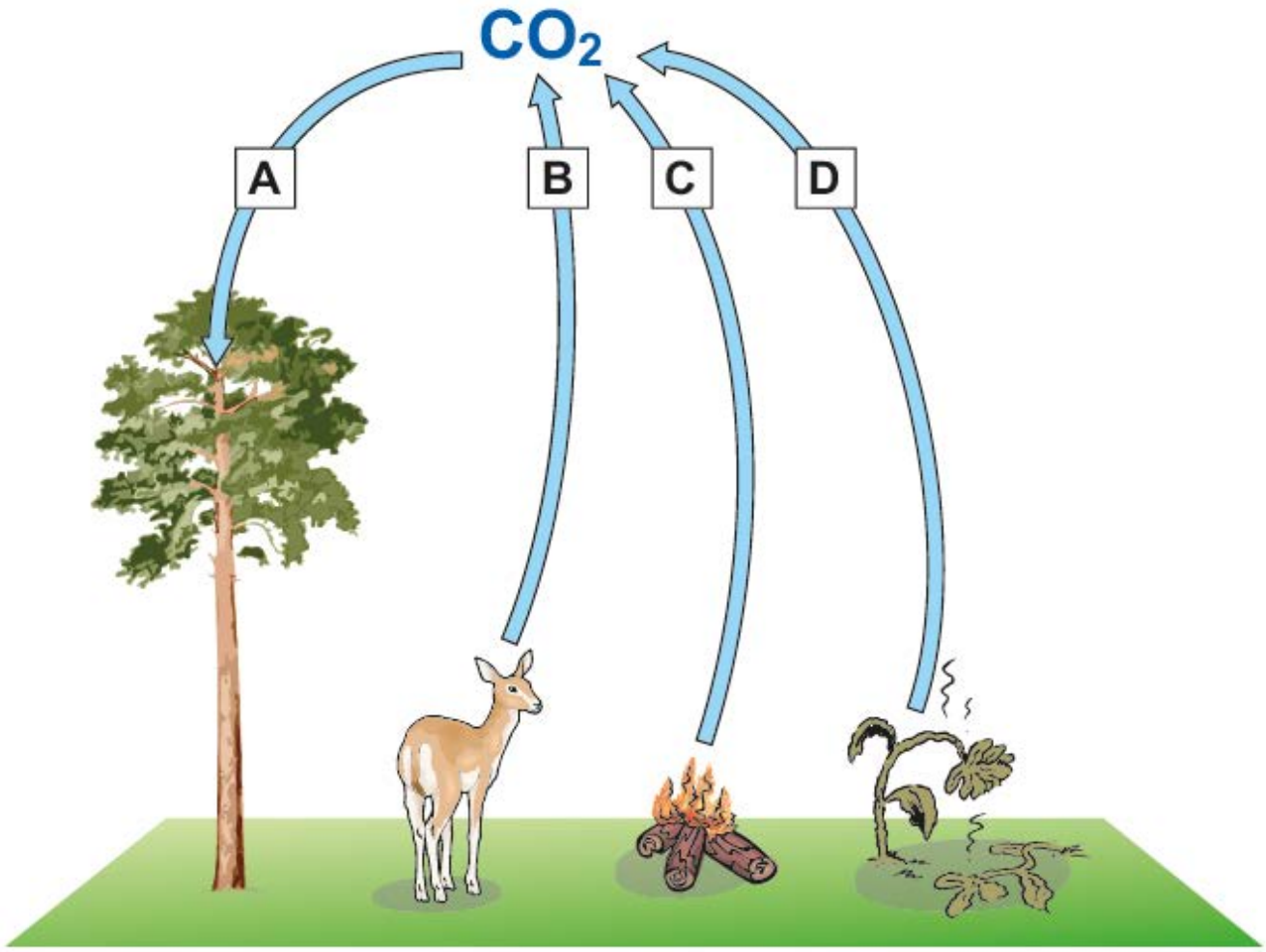
(d) What further readings should the students take to increase the confidence in the conclusion? [3]

……

……

14

4. The diagram shows four processes **A** – **D** in the carbon cycle.



Answer the questions below by using the letters **A** – **D.** [4]

(a) Which process is endothermic? .....

(b) Which process involves the action of microorganisms? .....

(c) Which process does **not** involve the action of enzymes? .....

(d) Which process takes place only in the light? .....

4

5. (a) UV radiation can cause genes to change.

(i) Complete the sentence below. [1]

A change to a gene is known as a …….

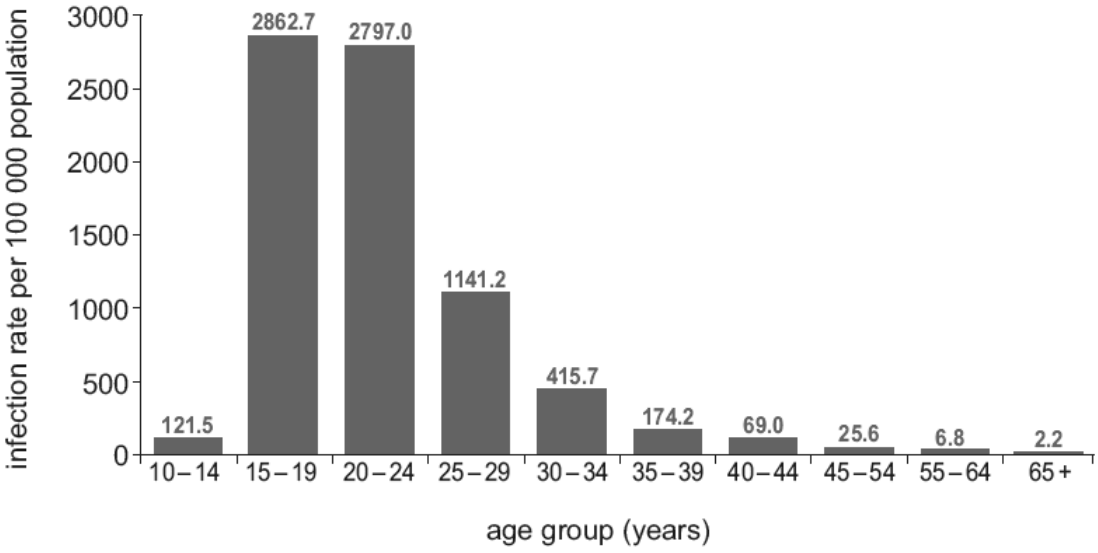
(ii) Explain how wearing a sun hat and using sun cream at the beach may help to reduce the risk of developing skin cancer. [2]

……

……

……

(b) The chart below shows Chlamydia infection rates among females in the UK in 2006.



(i) Calculate the infection rate in all females below the age of 25 years per 100 000 population. [2]

infection rate =……per 100 000

(ii) The Government recommends that all women under the age of 25 are checked for Chlamydia every year.
Suggest reasons for this recommendation. [2]

……

……

……

(iii) A newspaper used the results shown in the chart to claim that:

*"*Chlamydia numbers continue to rise in all parts of the UK.*"*

What further information is needed in order to support the claim made by the newspaper? [2]

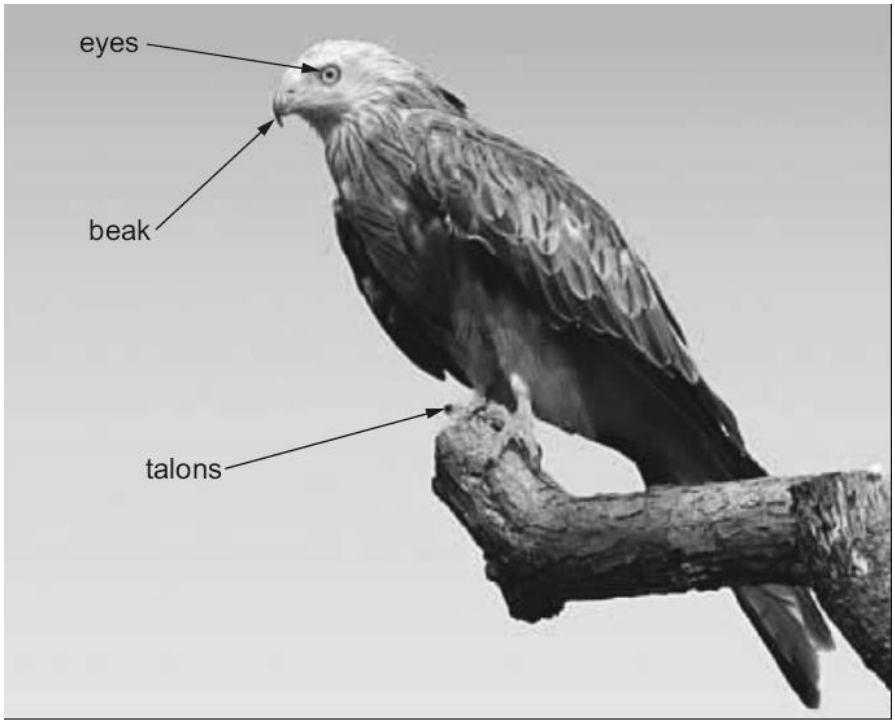
……

……

……

9

6. The photograph shows a Red Kite (*Milvus milvus*). It also shows three structures which help Red Kites get their food.



(a) Red Kites are carnivores.

Describe **two** of the structures labelled in the photograph and explain how each is adapted to help Red Kites get their food. [4]

……

……

……

……

……

……

……

……

(b) An investigation of the diet of Red Kites made in March and June 2015 produced the results shown in the table.

Part of diet	% of diet	
	March	**June**
mice and voles	12.0	24.0
rats	32.0	9.0
rabbits	20.0	
pheasant	14.0	5.0
woodpigeon	20.0	18.0
earthworms	1.0	7.0
frogs	1.0	2.0

(i) I Calculate the percentage of rabbits in the diet in June. [2]

% of rabbits = ……

II State which part of the diet showed the greatest change between March and June: [1]

……

(ii) Rabbits eat plants.
Construct a food chain in the spaces below linking plants, rabbits and Red Kites. [2]

…… …… ……

(c) Read the following information.

- At one time, Red Kites were common in the UK.
- Then, for many years, Red Kites were hunted by farmers and gamekeepers.
- In 1950 there were 200 Red Kites.
- In 1981, Red Kites were protected by law.
- There were 2 000 Red Kites in the UK in 2015.

(i) Calculate the percentage increase in Red Kites between 1950 and 2015. [2]

percentage increase = …….. %

(ii) Use the information above to explain why the Red Kite was made a protected species. [2]

……

……

……

(d) In the 1950s, rabbits in the UK became serious pests, destroying large areas of crop plants. Use the above information to suggest **one** reason why the rabbits became serious pests. Explain your answer. [2]

……

……

……

(e) A farmer cut down all the trees in an area of woodland on her farm. She used the space to grow wheat. Describe and explain the effect of her actions on local biodiversity. [3]

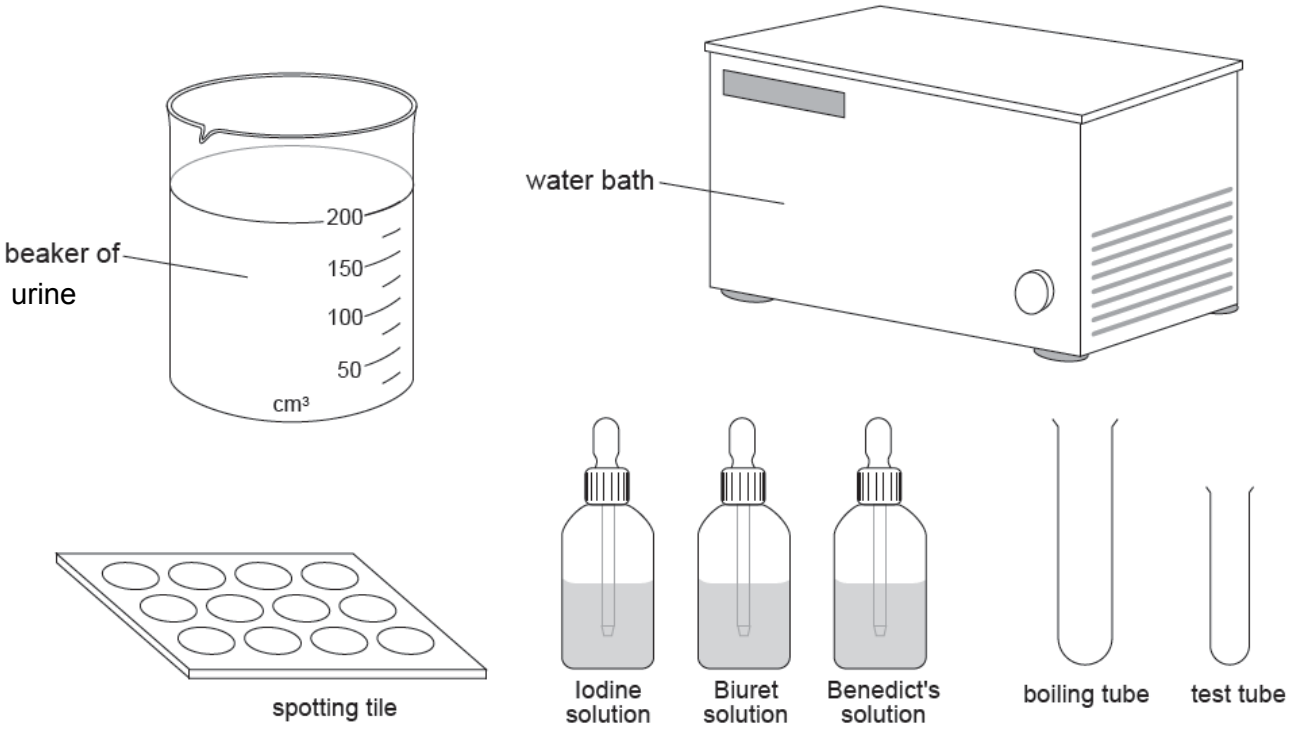
……

……

……

7. Unless diabetes is controlled, blood glucose concentration can rise to dangerous levels. In some patients, their kidneys are damaged and both glucose and protein are excreted in their urine.

A student was asked to select the apparatus needed to test for glucose and protein in a sample of urine. The apparatus he selected is shown in the diagram below.



(a) From the diagram, which apparatus should not have been selected. Give reasons for your answer. [3]

Apparatus:

……..

……..

Reason:

……..

……..

……..

……..

(b) Describe how a diabetic could use some of the apparatus selected to test the urine sample for the presence of glucose. Explain why this test could not be used to determine how much insulin a diabetic would need to inject to control his blood glucose levels. [6 QER]

……

……

……

……

……

……

……

……

……

……

……

……

……

……

(c) (i) Suggest **one** practical problem of testing *real* human blood for the presence of protein. [1]

……

(ii) Suggest one hazard associated with taking human blood. [1]

……

11

8. There are three main types of blood vessel in the human body. They all have different roles in the body and so have different structures.

(a) Give **three** differences between the structure of an artery and a vein which will allow you to distinguish between them. [3]

1. ……

2. ……

3. ……

(b) (i) Describe how the structure of capillaries allows the movement of molecules between the blood and the body tissues. [1]

……

(ii) Explain the importance of a concentration gradient in maintaining the movement of molecules **from** the blood to the body tissues. [2]

……

……

(c) (i) State **two** molecules that pass from the blood to the body tissues. [2]

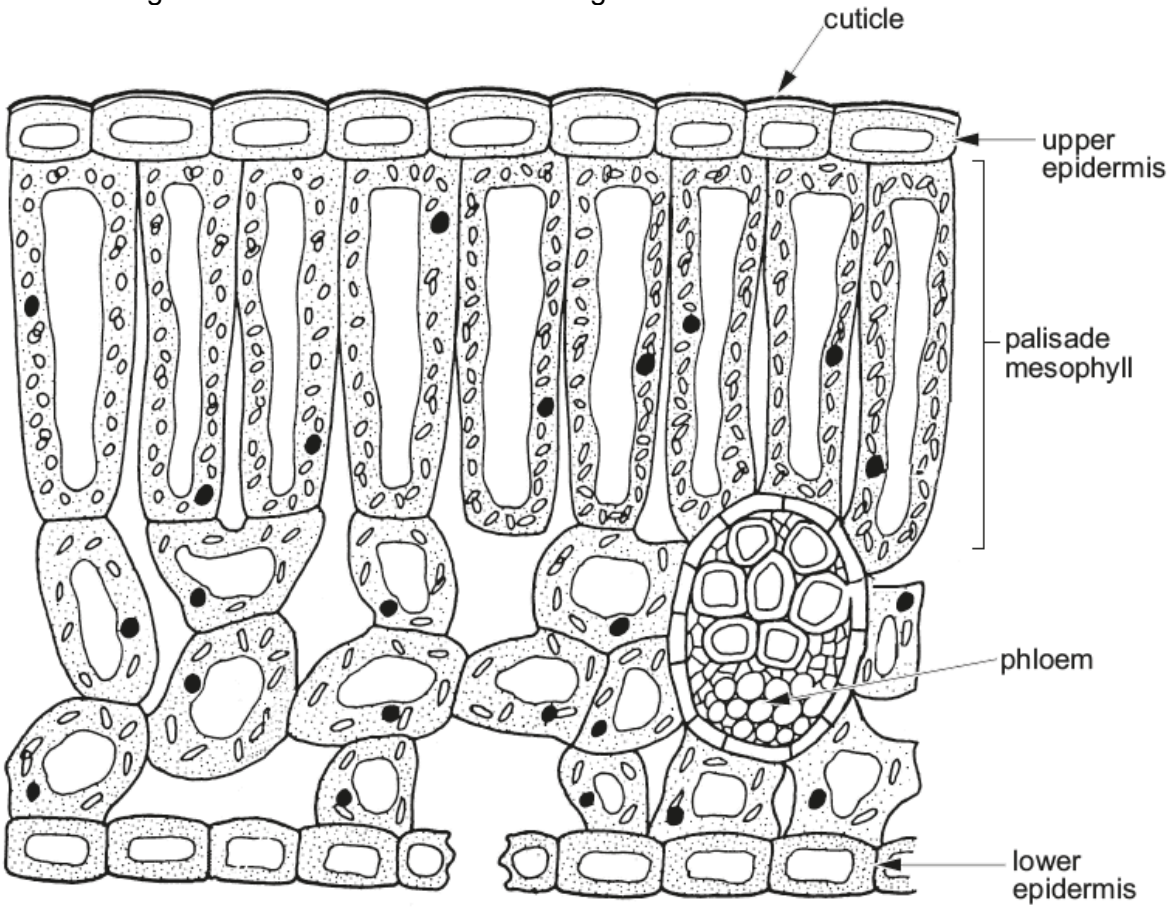
……

(ii) State **two** molecules that pass **into** the blood from the body tissues.[2]

……

10

9. The diagram below shows a section through a leaf.



(a) (i) State the number of stomata shown in the diagram. [1]

……..

(ii) **On the diagram** label the xylem. [1]

(iii) Draw an arrow **on the diagram** to show the path of water molecules from the xylem to the air outside the leaf. [1]

(b) Explain the effect of **increasing** air temperature on the rate of transpiration from the leaf. [2]

……..……..…

……..……..…

5

10. John and Susan carried out an investigation into reflex actions. Susan applied a hairpin sharply to John's hand and he moved his hand away quickly. A wifi touch sensor was attached to the tip of the hairpin and a movement sensor attached to John's little finger. The time taken for the hand to move, after the hairpin was applied, was recorded on a laptop monitor. The hairpin was applied seven more times to John's hand. The results are shown in the table below.

Trial	1	2	3	4	5	6	7	8
Time taken to move hand (s)	0.22	0.27	0.23	0.23	0.27	0.22	0.25	0.24

The table below shows how the mean value for moving the hand changed with the number of readings they took.

Trials used to calculate mean	1 & 2	1, 2 & 3	1, 2, 3 & 4	1, 2, 3, 4 & 5	1, 2, 3, 4, 5 & 6	1, 2, 3, 4, 5, 6 & 7	1, 2, 3, 4, 5, 6, 7 & 8
Mean value of time to move hand (s)	0.245	0.240	0.238	0.244	0.240	0.241	0.241

(a) What is the name given to this type of reflex action? [1]

……

(b) For the example shown, describe the path taken by the nerve impulse as it passes from the receptor in the skin to the effector in the arm. [3]

……

……

……

……

(c) (i) Check that Susan and David have correctly calculated the mean for all eight readings (0.241 s). *Show your workings.* [1]

(ii) Susan says that:

- they have not recorded the mean to the correct number of decimal places;
- they did not need to take so many repeats.

Explain whether Susan is correct. [3]

……

……

……

……

……

8

COMPONENT 1 - Concepts in Biology

FOUNDATION TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
1	(a)	(i)		Parents: XY XX (1) Sex cells: (X) Y X X (1) Children: (XX) XY (1) (accept YX)	3			3		
		(ii)		Female	1			1		
		(iii)		0.5		1		1	1	
	(b)	(i)		78		1		1		
		(ii)		Mitosis	1			1		
				Question 1 total	**5**	**2**	**0**	**7**	**1**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		$\frac{71}{500} = 0.142$		1		1		1
		(ii)		Chloroplast	1			1		
	(b)			$\frac{600}{17}$ (1) = 35.3 (1)		2		2	1	
				Question 2 total	**1**	**3**	**0**	**4**	**1**	**1**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Glucose (1) Oxygen (1)	2			2		
	(b)	(i)		All 7 points plotted correctly **award 2 marks** 6 points plotted correctly **award 1 mark** Straight lines through centre of plots (1)		3		3	3	
		(ii)		Low in morning and evening (or specified hrs) (1) Peak around 14.00 (1) Lowering when less light available (1)			3	3		
	(c)			Carbon dioxide concentration Temperature pH	3			3		
	(d)			Measure light intensity (1) Take a reading at 20.00 / every hour / more frequently (1) Repeat on another day (1)			3	3		3
				Question 3 total	**5**	**3**	**6**	**14**	**3**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			A		1		1		
	(b)			D		1		1		
	(c)			C		1		1		
	(d)			A		1		1		
				Question 4 total	**0**	**4**	**0**	**4**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)		Mutation	1			1		
		(ii)		Blocks / reduces uv light reaching skin (1) [excess] uv light increases chance of mutation (1)		2		2		
	(b)	(i)		121.5 + 2 862.7+ 2 797.0 (1) 5 781.2 (1)		2		2	2	
		(ii)		Most at risk/largest numbers (1) can reduce fertility/damage unborn baby (1)	1	1		2		
		(iii)		Survey all regions (1) over several years (1)			2	2		
				Question 5 total	**2**	**5**	**2**	**9**	**2**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			Any **two (×1)** from: 1 mark for each described adaptation (to a maximum of 2 marks) 1 mark for each adaptation in action (to a maximum of 2 marks) • large eyes/good eyesight; • to find/spot/hunt (prey); • large/strong/sharp beak; • to tear/rip meat/flesh/prey; • large/strong/sharp talons; • to catch/pounce/grip meat/flesh/prey;	2	2		4		
	(b)	(i)	I	24.0 + 9.0 + 5.0 + 18.0 + 7.0 + 2.0 (1) 100 – 65 = 35 (1)		2		2		
			II	Rats		1		1		
		(ii)		plants ➔ rabbits ➔ Red Kite 1 mark for correct names in correct sequence 1 mark for arrows (correct direction)		2		2		
	(c)	(i)		2 000 - 200 = 1 800 (1) $\left(\frac{1800}{200}\right) \times 100 = 900\%$ (1)		2		2	2	
		(ii)		Hunting reduced numbers to less than 100 (1) If not protected may become extinct in UK (1)			2	2		
	(d)			The numbers (of Red Kites) fell, so fewer rabbits eaten (1) so rabbit numbers grew / more survived / more reproduced (1)		1	1	2		
	(e)			Reduced biodiversity (1) Reduced habitat (1) Decreased food sources (1)			3	3		
				Question 6 total	**2**	**10**	**6**	**18**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			**Apparatus**: iodine and spotting tile (1) **Reason**: Iodine – because it is used to test for starch (1) Spotting tile – because the test is carried out in a test tube (biuret) / boiling tube (Benedict's) (1)	3			3		3
	(b)			**Indicative content:** **AO1 allocation** - Heat the water bath to a high temperature / 80 – 90 °C. Mix (equal volumes of) urine and Benedict's solution in a boiling tube and place in the water bath. If glucose present then you should observe a colour change from blue to brick red if there is a high concentration of glucose present or to green if there is a low concentration of glucose present. **AO2 allocation** - The test is qualitative / does not give numerical results / actual quantities / is not accurate. It relies on a colour change only which could be subjective. Testing urine may not give an actual measure of blood glucose levels. The concentration of glucose in the urine could be due to how badly the kidneys are damaged and not the blood glucose levels. **5 – 6 marks** : Gives a correct method for carrying out Benedict's test for glucose including the need to heat to a high temperature and the possible colour changes observed with high and low glucose levels in the urine. Explains that a diabetic needs to know accurate blood glucose levels to inject the correct amount of insulin. Explains that the test is qualitative and only shows presence or absence of glucose or at best a rough indication of glucose concentrations. Clear understanding of the subjective nature of the test and that the level of glucose in the urine may be affected by the health of the kidneys and not reflect actual blood glucose levels. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.*	3	3		6		6

				3 – 4 marks: Describes how to carry out a Benedict's test including the need to heat to a high temperature. The expected colour change is described but only for high glucose levels. Explains the need for accurate blood glucose levels to be measured by a diabetic and understands that the test is subjective and therefore cannot give quantitative results. Effort made to relate urine glucose levels to possible kidney damage or an understanding that urine glucose levels may not reflect blood glucose levels. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1 – 2 marks**: A method for carrying out a Benedict's test is described with some errors, e.g. does not describe the need to heat or includes an imprecise colour change. A limited understanding that a diabetic needs to know accurate blood glucose levels ; that the test is subjective or that glucose levels in urine do not reflect blood glucose levels. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure*. *There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks:** *No attempt made or no response worthy of credit.*						
	(c)	(i)		Difficult to see the colour change			1	1		1
		(ii)		Risk of infection		1		1		1
				Question 7 total	**6**	**4**	**1**	**11**	**0**	**11**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			Larger lumen/diameter (1) Thinner walls (1) Less muscle (1)	3			3		
	(b)	(i)		Thin walls / pores or gaps between cells / one cell thick	1			1		
		(ii)		Always greater concentration in the blood (than tissue fluid) (1) To allow for diffusion to take place (1)	2			2		
	(c)	(i)		Any **two (×1)** from: • oxygen • named nutrient / glucose / amino acids • Hormone / named hormone	2			2		
		(ii)		Any **two (×1)** from: • carbon dioxide • urea • hormone/ named hormone • water	2			2		
				Question 8 total	**10**	**0**	**0**	**10**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		1	1			1		
		(ii)		Xylem correctly labelled (area above phloem)	1			1		
		(iii)		Arrow tail starting in xylem passes through spongy mesophyll space and out through a stoma Allow arrow to show symplastic as well as apoplastic transport		1		1		
	(b)			Water molecules move faster (have more energy) (1) more rapid loss of water/higher transpiration rate (1)	2			2		
				Question 9 total	**4**	**1**	**0**	**5**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			Withdrawal	1			1		
	(b)			Sensory neuron from receptor in skin (1) To coordinator / spinal cord / relay neuron (1) To motor neuron to the effector in the arm (1)		3		3		
	(c)	(i)		$\frac{(0.22+0.27+0.23+0.23+0.27+0.22+0.25+0.24)}{8} = 0.241$ [s]		1		1	1	
		(ii)		She is correct (marks are awarded for reasoning) Measurements were to 2 decimal places therefore mean should be to 2 decimal places (1) The first three readings gave a mean of 0.24 (1) Additional readings did not improve this value (1)			3	3	2	
				Question 10 total	**1**	**4**	**3**	**8**	**3**	**0**

COMPONENT 1 - Concepts in Biology

FOUNDATION TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	5	2	0	7	1	0
2	1	3	0	4	1	1
3	5	3	6	14	3	3
4	0	4	0	4	0	0
5	2	5	2	9	2	0
6	2	10	6	18	2	0
7	6	4	1	11	0	11
8	10	0	0	10	0	0
9	4	1	0	5	0	0
10	1	4	3	8	3	0
TOTAL	36	36	18	90	12	15

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 1

Concepts in Biology

HIGHER TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**5**	
3.	**8**	
4.	**11**	
5.	**8**	
6.	**13**	
7.	**12**	
8.	**9**	
9.	**14**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **9(c).**

Answer **all** *questions.*

1. There are three main types of blood vessel in the human body. They all have different roles in the body and so have different structures.

(a) Give **three** differences between the structure of an artery and a vein which will allow you to distinguish between them. [3]

1. ……

2. ……

3. ……

(b) (i) Describe how the structure of capillaries allows the movement of molecules between the blood and the body tissues. [1]

……

(ii) Explain the importance of a concentration gradient in maintaining the movement of molecules **from** the blood to the body tissues. [2]

……

……

(c) (i) State **two** molecules that pass from the blood to the body tissues. [2]

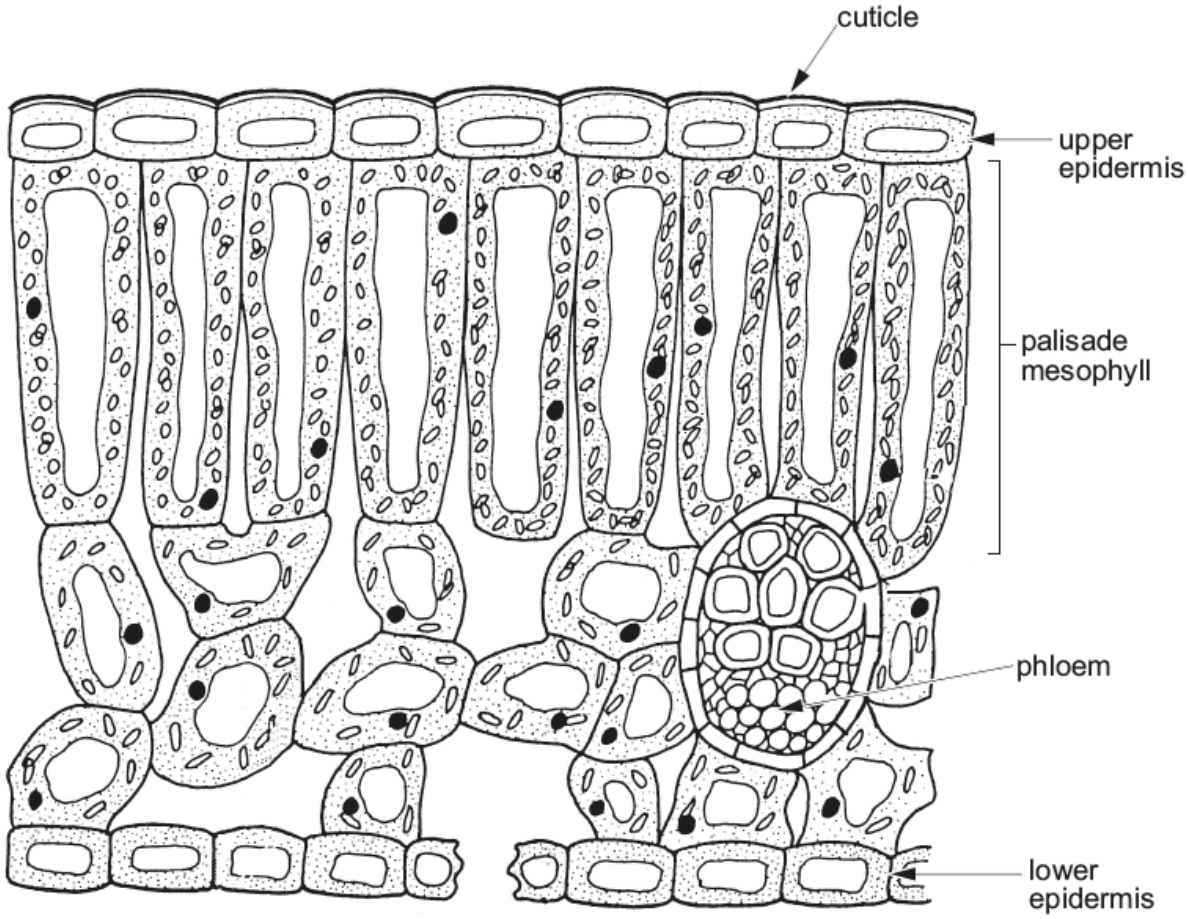
……

(ii) State **two** molecules that pass **into** the blood from the body tissues.[2]

……

10

2. The diagram below shows a section through a leaf.



(a) (i) State the number of stomata shown in the diagram. [1]

……..……...

(ii) **On the diagram** label the xylem. [1]

(iii) Draw an arrow **on the diagram** to show the path of water molecules from the xylem to the air outside the leaf. [1]

(b) Explain the effect of **increasing** air temperature on the rate of transpiration from the leaf. [2]

……..……..…

……..……..…

5

3. John and Susan carried out an investigation into reflex actions. Susan applied a hairpin sharply to John's hand and he moved his hand away quickly. A wifi touch sensor was attached to the tip of the hairpin and a movement sensor attached to John's little finger. The time taken for the hand to move, after the hairpin was applied, was recorded on a laptop monitor. The hairpin was applied seven more times to John's hand. The results are shown in the table below.

Trial	1	2	3	4	5	6	7	8
Time taken to move hand (s)	0.22	0.27	0.23	0.23	0.27	0.22	0.25	0.24

The table below shows how the mean value for moving the hand changed with the number of readings they took.

Trials used to calculate mean	1 & 2	1, 2 & 3	1, 2, 3 & 4	1, 2, 3, 4 & 5	1, 2, 3, 4, 5 & 6	1, 2, 3, 4, 5, 6 & 7	1, 2, 3, 4, 5, 6, 7 & 8
Mean value of time to move hand (s)	0.245	0.240	0.238	0.244	0.240	0.241	0.241

(a) What is the name given to this type of reflex action? [1]

……

(b) For the example shown, describe the path taken by the nerve impulse as it passes from the receptor in the skin to the effector in the arm. [3]

……

……

……

……

(c) (i) Check that Susan and David have correctly calculated the mean for all eight readings (0.241 s). *Show your workings.* [1]

(ii) Susan says that:

- they have not recorded the mean to the correct number of decimal places;
- they did not need to take so many repeats.

Explain whether Susan is correct. [3]

……

……

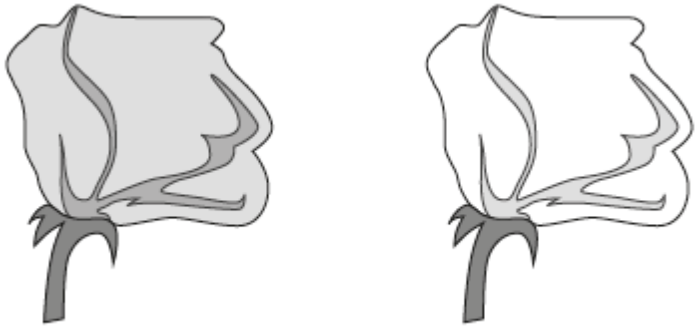
……

……

……

8

4. When Mendel crossed purple flowered pea plants with white flowered pea plants all the F1 were purple flowered.



(a) (i) Using the letters **D** and **d** to represent the alleles complete the following genotypes: [1]

Purple flowered pea plant …….. x White flowered pea plant ……..

(ii) **Complete** the Punnett squares to show:

I the cross between the purple and white flowered plants. [2]

F1

Gametes		

II the genotypes produced when the F1 generation are selfed. [2]

F2

Gametes		

III Give the ratio of the phenotypes in the F2 generation. [1]

……..……..……..... : ….....……

(b) When Mendel selfed two of the F1 plants he obtained a large number of seeds which he sowed. When these seeds grew he obtained:

705 purple flowered plants and 224 white flowered plants

(i) What ratio of purple flowered plants to white flowered plants did Mendel obtain? [1]

…… : ……

(ii) Suggest **two** reasons why the ratio Mendel obtained differed from the ratio given in your answer in (a)(ii)III above. [2]

……..……...

……..……...

(c) A commercial seed producer wanted to sell pea seeds that she could guarantee would produce purple flowering plants.

Select from the list below all the genetic crosses she could carry out which would guarantee only purple flowering plants.

Underline **all** correct answers. [2]

(i)	homozygous dominant	×	homozygous dominant
(ii)	heterozygous	×	heterozygous
(iii)	homozygous dominant	×	recessive
(iv)	recessive	×	recessive
(v)	homozygous dominant	×	heterozygous

11

5. (a) Mitosis and meiosis are the two types of cell division which occur in animals and plants. How do the outcomes of these two types of cell division differ? [3]

……..……..……...

……..……..……...

……..……..……...

……..……..……...

(b) (i) Myeloma is a cancer of the bone marrow. What is cancer? [1]

…..……..

(ii) Stem cells can be used to help treat some types of cancer such as myeloma. What are stem cells? [1]

…..……..

(iii) Stem cells can be used to treat many diseases and conditions in humans.Once obtained they can be grown in a laboratory in order to multiply in number. They can then be injected into the body.

There are three main sources of stem cells:

I **Own-donor stem cells** - these are removed from the body and then injected back into the donor's body.

II **Embryonic stem cells** – these are obtained from embryos produced by in-vitro fertilization and then injected into a patient.

III **Cord stem cells** – these are obtained from the umbilical cord of babies, after they are born, and then injected into a patient.

Compare the ethical issues that may exist in the use of these three different sources of stem cells. [3]

……

……

……

……

……

8

6. Rhian investigated osmosis in a school laboratory. She cut 15 potato chips, each exactly 5 cm long and with a cross sectional area of 1 cm^2. Five of the chips were placed in water, five in a 0.4% sugar solution and the remaining five in a 10% sugar solution.
After two hours the chips were removed and their lengths measured. The results are recorded in the table below.

Length of potato chips after 2 hours (cm)		
Water	**0.4% sugar solution**	**10% sugar solution**
5.10	5.00	4.70
5.20	5.00	4.40
5.30	5.00	4.65
5.20	5.00	4.30
5.25	5.00	4.60
mean = 5.21 cm	mean = 5.00 cm	mean = 4.53 cm

(a) The mean length of the chips kept in water was greater than the mean length of the chips kept in 10% sugar solution. Explain, in detail, this observation. [4]

……

……

……

……

……

……

……

……

……

……

(b) Explain why there was no change in length in the chips kept in 0.4% sugar solution. [2]

……

……

(c) Explain why this experiment will not work if boiled potato is used. [1]

……

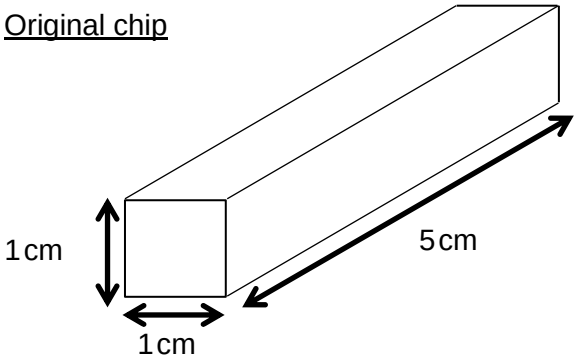
……

(d) Give **one** example of the use of osmosis in a living plant. [1]

……

(e) Rhian repeated part of her investigation with 5 larger chips. She placed 5 cm chips, with a cross sectional area of 4 cm^2, in water. She left the chips for 2 hours.

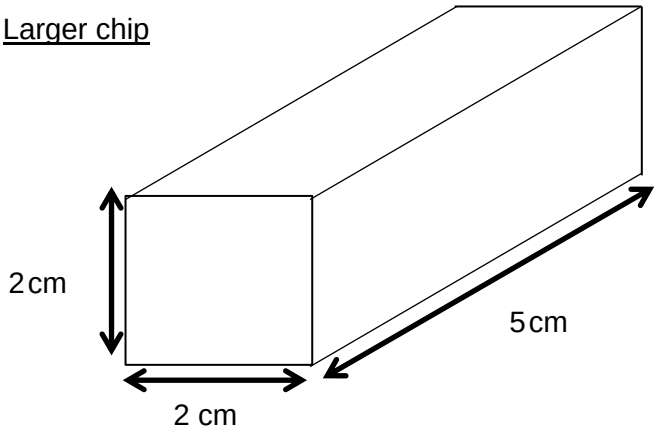
<u>Original chip</u>



Height = 1 cm
Width = 1 cm
Length = 5 cm

Surface area = 22 cm^2
Volume = 5.0 cm^3

<u>Larger chip</u>



Height = 2 cm
Width = 2 cm
Length = 5 cm

Volume = 20.0 cm^3

(i) Calculate the surface area of the larger chip. [2]

surface area = …….cm^2

After leaving the larger chips in water for 2 hours Rhian found that their mean increase in length was less than that found in the smaller chips.

(ii) Explain this observation in terms of surface area : volume ratio. [1]

……..……..

……..……..

……..……..

(f) The table shows the concentration of certain mineral ions in the soil solution and in the root hair cells of a plant.

	Concentration (mmol dm^{-3})		
	potassium	**sodium**	**chloride**
soil solution	0.1	1.1	1.3
vacuole of root hair cells	93.0	51.0	58.0

(i) From the table, give the evidence that shows that the uptake of mineral ions from the soil is by active transport. [1]

……..……..

……..……..

(ii) Explain why the active transport of these mineral ions stops if a respiratory poison is applied to the roots of the plant. [1]

……..……..

13

7. (a) Write the word equation for photosynthesis in the space below. [2]

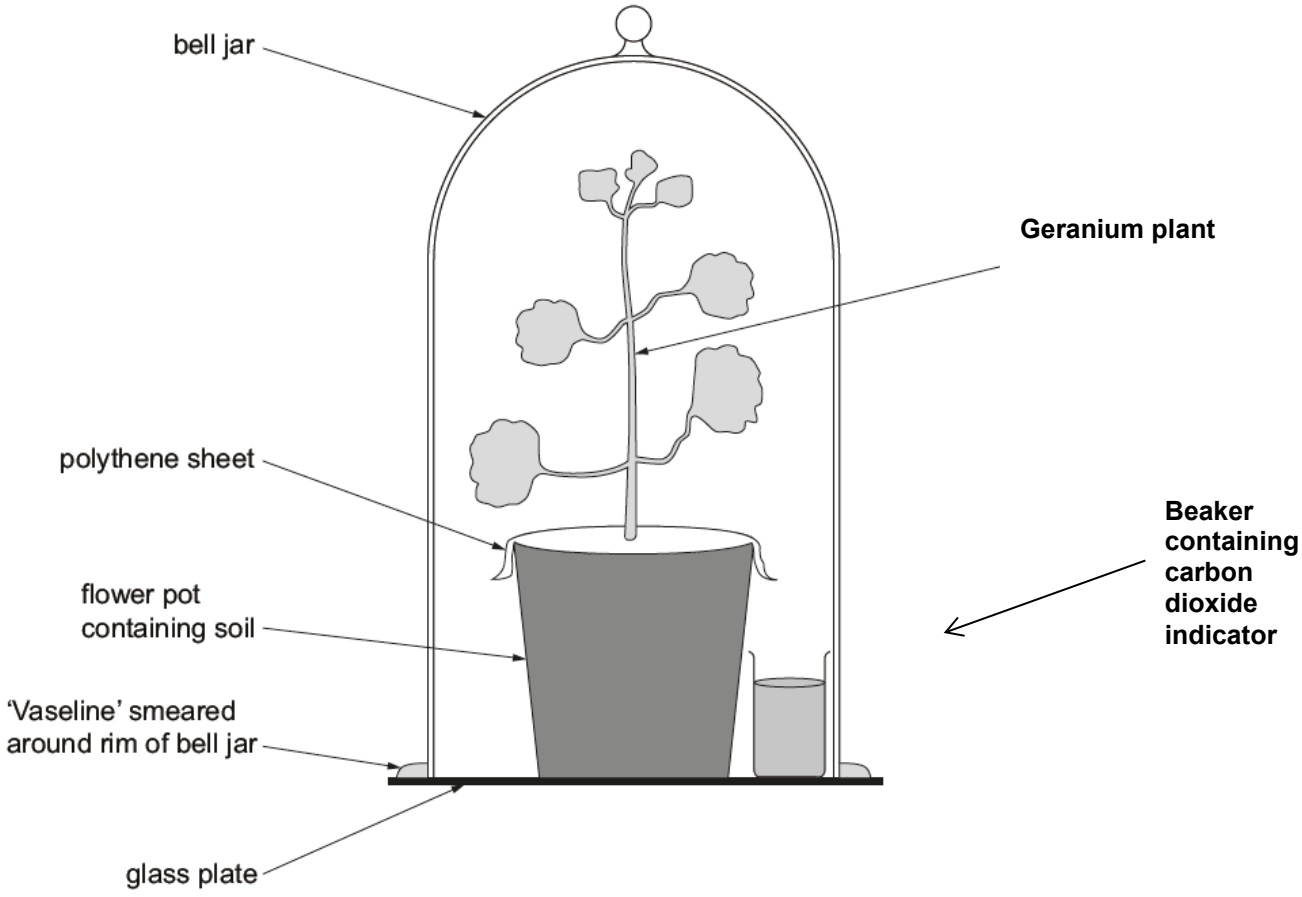
(b) State why chloroplasts are important in the process of photosynthesis. [2]

……..……...……

……..……...……

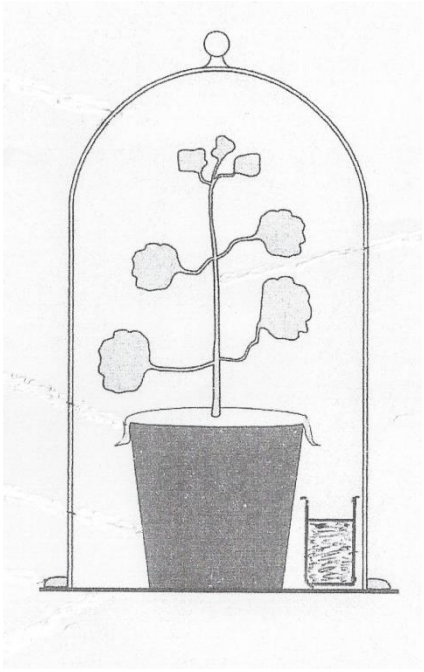
……..……...……

(c) The following apparatus was set up to investigate some of the factors affecting photosynthesis.

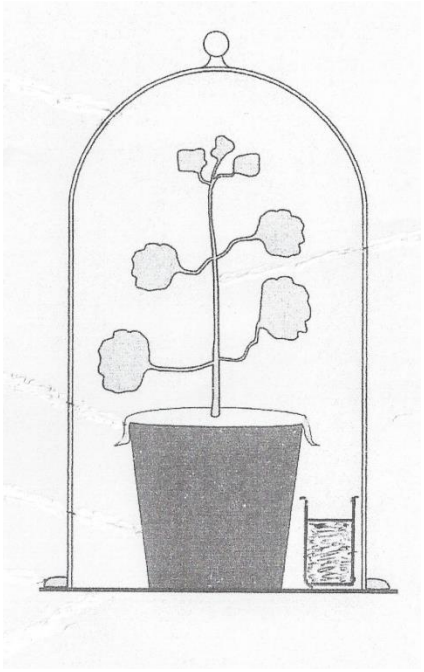


Three identical sets of the apparatus were set up and treated as shown below

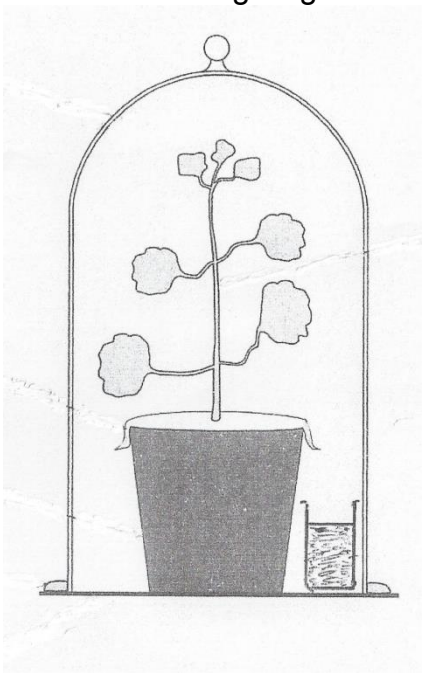
A
Plant in darkness



B
Plant in shaded conditions



C
Plant in bright light



The beaker in each flask contained a carbon dioxide indicator which changes colour as shown in the table below.

Concentration of carbon dioxide in air	**Colour of indicator**
less than normal	purple
normal	red
more than normal	yellow

(i) **Complete the table below** to show the expected final colour of the indicator and the reason for the final colour. [6]

Bell jar	Expected final colour of indicator	Reason for final colour of indicator
A		
B		
C		

(ii) Temperature, light intensity and carbon dioxide concentration are the limiting factors which affect the rate of photosynthesis.

Which of these limiting factors were being investigated in the above experiment? Underline the correct answer. [1]

(I) temperature
(II) light intensity and carbon dioxide concentration
(III) light intensity
(IV) carbon dioxide concentration
(V) temperature and light intensity

(iii) Explain why the soil in the flower pot was covered with a polythene sheet. [1]

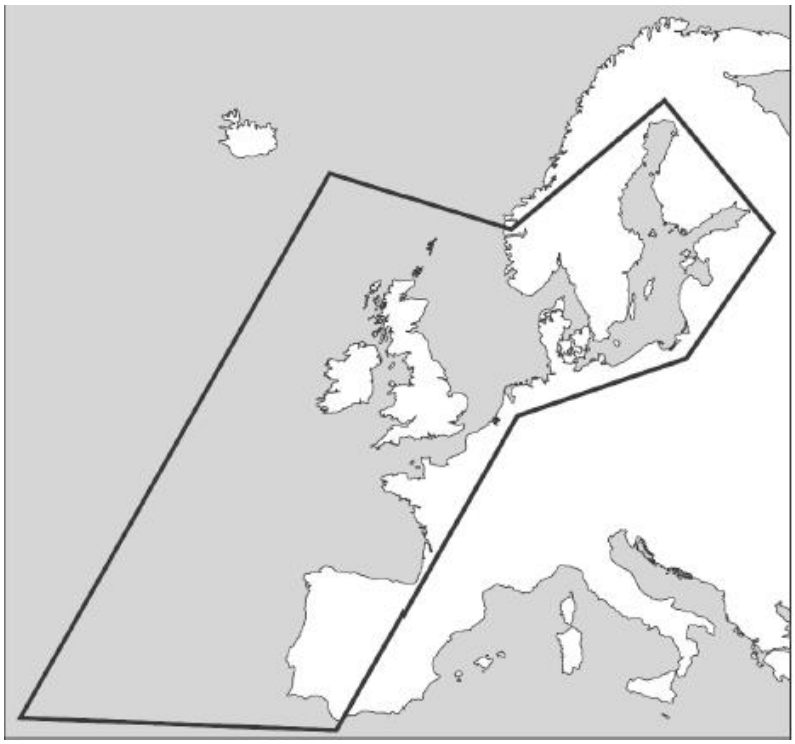
……..……..

……..……..

12

8. EARTHDIVE is a global diving organisation that encourages recreational divers to report sightings of various indicator species in the regions of the world in which they are diving. Divers upload data from their sightings online into the EARTHDIVE Global Dive Log.

EARTHDIVE divides the world's seas and oceans into 30 eco-regions.
Eco-region 6a is Europe – Temperate.



In this Eco-region the five indicator species, or groups of indicator species monitored by divers are:

- all marine lobsters
- all marine mussels
- John Dory *(Zeus faber)*
- scallops
- European plaice *(Pleuronectes platessa)*

(a) (i) What is meant by an indicator species? [2]

……

……

(ii) Shown below are two *Post-dive logs* recorded by the same diver in the same part of Eco-region 6a on two different dates.

Species	**Number of indicator species seen during dive**	
	20.06.2009	**04.06.2014**
lobsters	18	4
mussels	>250	>250
John Dory	48	18
scallops	41	17
plaice	19	3

I Explain whether the following statement is correct:
"The % decrease in numbers of John Dory between 20.06.09 and 04.06.2014 > 60%." [2]
Show any calculations that you make.

……

……

II Based upon these two *Post-dive logs* what has happened to the biodiversity between 2009 and 2014? [3]

……

……

……

……

……

……

(b) EARTHDIVE estimates that there are over 2 million recreational divers in the world. Suggest why EARTHDIVE are prepared to collect data from these divers rather than just depending on data collection from professional divers and marine biologists. [2]

……

……

……

……

……

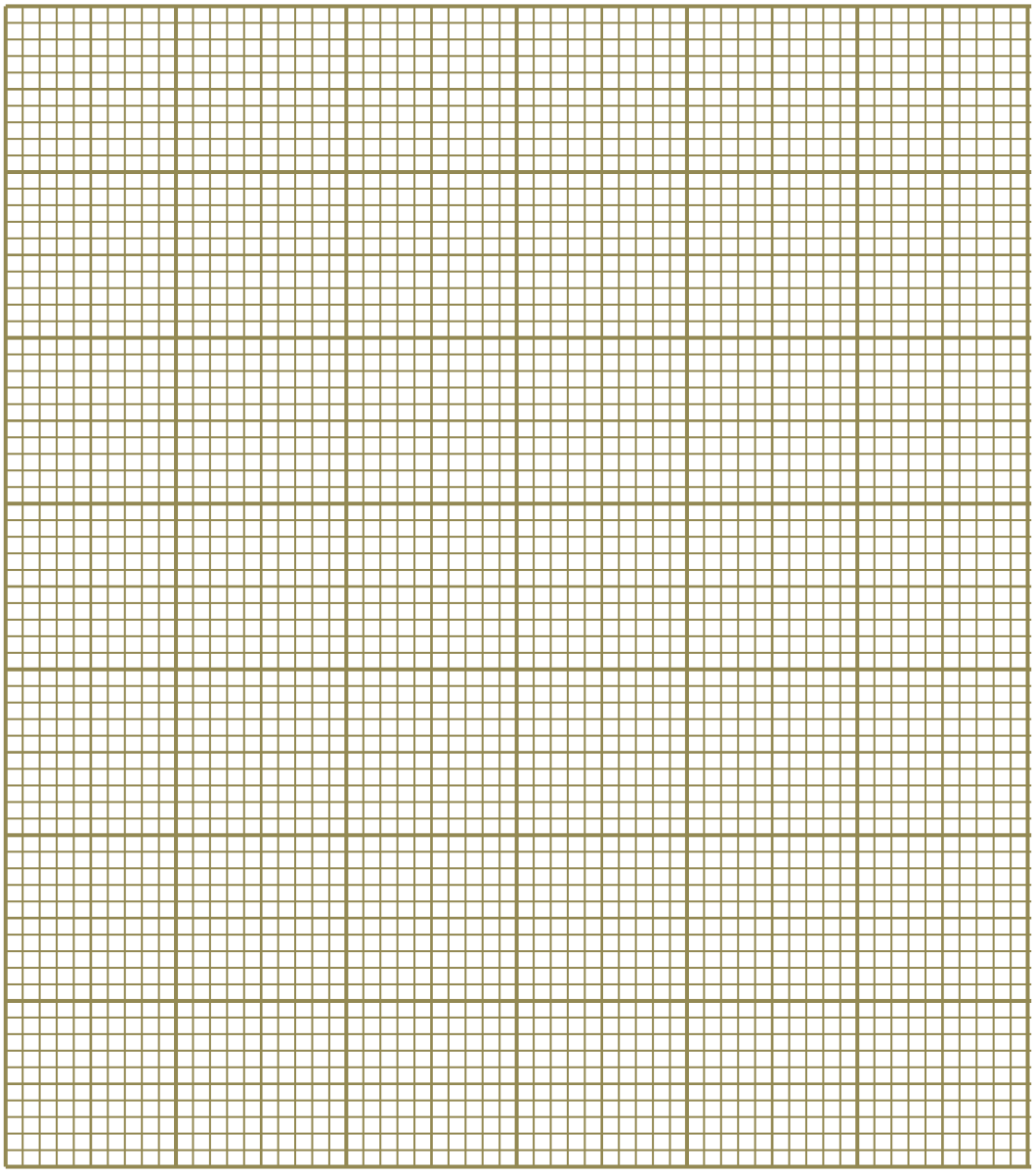
9

9. Some women experience difficulty in becoming pregnant. One method of treating infertility is to artificially induce the production of more eggs by a woman's ovaries. These are then harvested, fertilized and the resulting embryos implanted into the woman's uterus.

The table below shows how the number of eggs released by a group of women undergoing infertility treatment depends on the volume of fertility drug injected.

Volume of fertility drug injected (arbitrary units)	**Total number of eggs released per menstrual cycle**
0	1
5	5
10	7
15	26
20	57
25	65

(a) (i) Plot the data as a line graph on the grid below and join the plots. Label the axes and use a suitable scale. [3]



(ii) I Describe the trend shown in the graph. [1]

……..

……..

II Estimate the volume of fertility drug required to produce 45 eggs. [1]

……a.u.

(b) Puregon is a synthetic form of a human hormone which is used to treat infertility in women by inducing the production of large numbers of eggs.

It can be produced by genetic engineering using Chinese hamster ovary (CHO) cells. Name the synthetic hormone found in Puregon and outline how CHO cells could be modified to produce Puregon. [3]

……

……

……

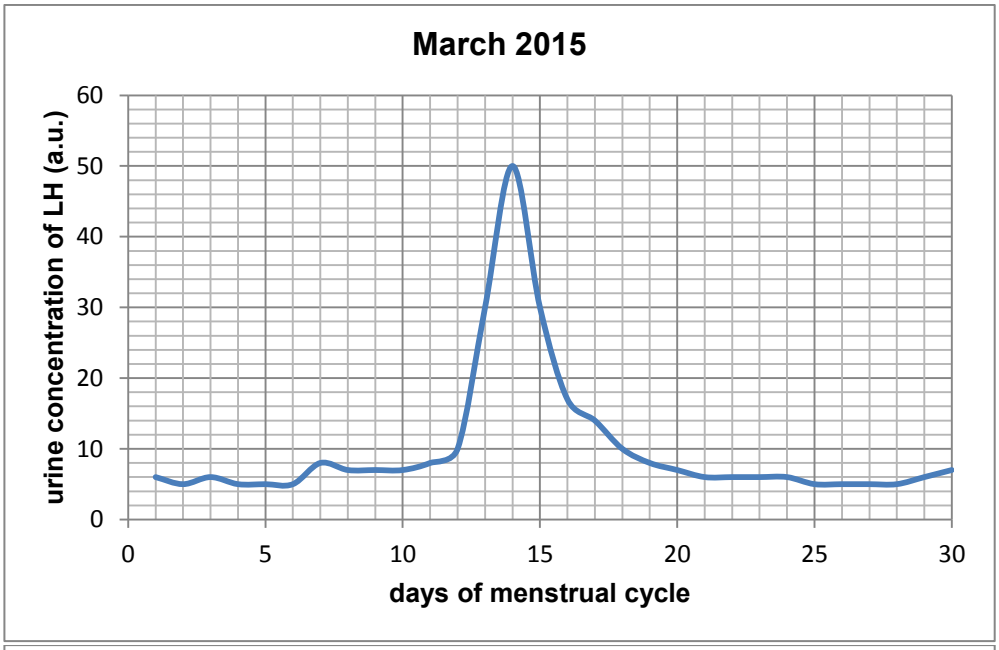
……

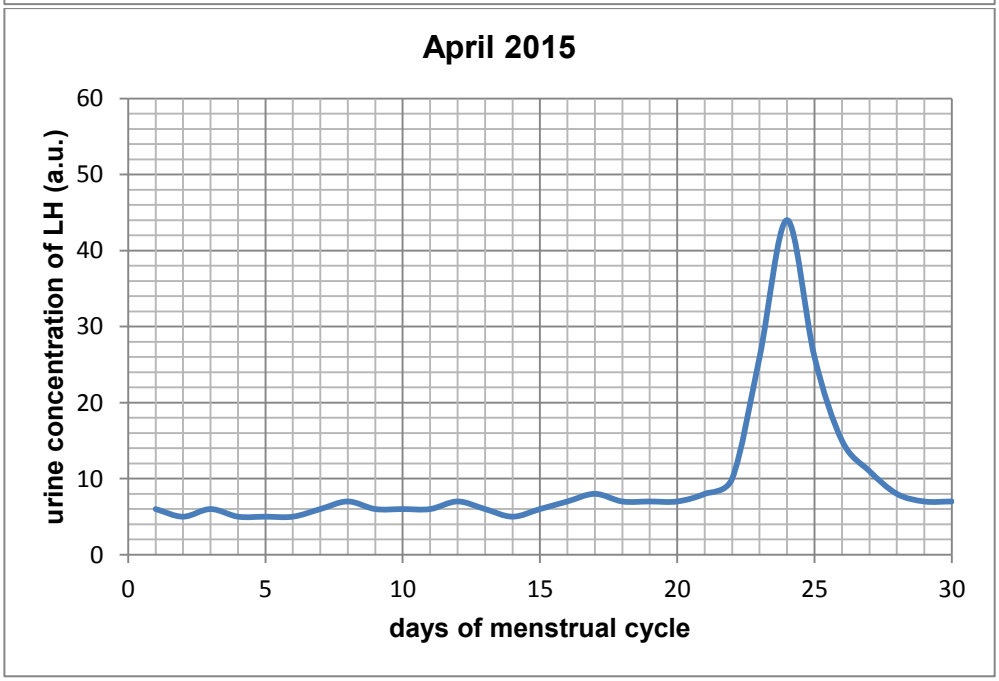
……

……

……

(c) Estimating the day of ovulation during the menstrual cycle can be used by women who want to increase their chance of becoming pregnant. Test kits are available which detect the level of luteinising hormone (LH) in urine. Ovulation usually occurs 24 – 28 hours following the appearance of a high level of LH in urine.
The graphs below show how the urine concentration of LH varies for the same woman.





Explain the changes in LH concentration in a typical cycle and explain why, in this case, measuring the LH concentration may not help the woman identify her most fertile time in the month. [6 QER]

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

14

COMPONENT 1 - Concepts in Biology

HIGHER TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			Larger lumen/diameter (1) Thinner walls (1) Less muscle (1)	3			3		
	(b)	(i)		Thin walls / pores or gaps between cells / one cell thick	1			1		
		(ii)		Always greater concentration in the blood (than tissue fluid) (1) To allow for diffusion to take place (1)	2			2		
	(c)	(i)		Any **two (×1)** from: • Oxygen • Named nutrient / glucose / amino acids • Hormone / named hormone	2			2		
		(ii)		Any **two (×1)** from: • Carbon dioxide • Urea • Hormone/ named hormone • Water	2			2		
				Question 1 total	**10**	**0**	**0**	**10**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		1	1			1		
		(ii)		Xylem correctly labelled (area above phloem)	1			1		
		(iii)		Arrow tail starting in xylem passes through spongy mesophyll space and out through a stoma Allow arrow to show symplastic as well as apoplastic transport		1		1		
	(b)			Water molecules move faster (have more energy) (1) more rapid loss of water/higher transpiration rate (1)	2			2		
				Question 2 total	**4**	**1**	**0**	**5**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Withdrawal	1			1		
	(b)			Sensory neuron from receptor in skin (1) To coordinator / spinal cord / relay neuron (1) To motor neuron to the effector in the arm (1)		3		3		
	(c)	(i)		$\frac{(0.22+0.27+0.23+0.23+0.27+0.22+0.25+0.24)}{8} = 0.241$ [s]		1		1	1	
		(ii)		She is correct (marks are awarded for reasoning) Measurements were to 2 decimal places therefore mean should be to 2 decimal places (1) The first three readings gave a mean of 0.24 (1) Additional readings did not improve this value (1)			3	3	2	
				Question 3 total	**1**	**4**	**3**	**8**	**3**	**0**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>4</td><td>(a)</td><td>(i)</td><td></td><td>DD and dd – both required for mark</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>I</td><td>F1
<table><tr><td>Gametes</td><td>D</td><td>D</td></tr><tr><td>d</td><td>Dd</td><td>Dd</td></tr><tr><td>d</td><td>Dd</td><td>Dd</td></tr></table>All 4 gametes correct (1)
[allow ecf from (i)]
Mechanics of cross correct (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td></td><td></td><td>II</td><td>F2
<table><tr><td>Gametes</td><td>D</td><td>d</td></tr><tr><td>D</td><td>DD</td><td>Dd</td></tr><tr><td>d</td><td>Dd</td><td>dd</td></tr></table>All 4 gametes correct (1)
allow ecf from (ii)I
Mechanics of cross correct (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>III</td><td>3 Purple flowered : 1 White flowered
(answer must include phenotype to gain mark)</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td></td><td>3.147:1 / 3.15:1 / 3.2:1</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>Any two (×1) from:
• Because when sown not all the seeds germinated/grew
• Not all the seeds grew after fertilisation
• Fertilisation is random
• Due to chance</td><td></td><td></td><td>2</td><td>2</td><td></td><td></td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			(i) homozygous dominant × homozygous dominant (ii) heterozygous × heterozygous (iii) homozygous dominant × recessive (iv) recessive × recessive (v) homozygous dominant × heterozygous All 3 correct = 2 marks 2 correct = 1 mark		2		2		
				Question 4 total	**0**	**9**	**2**	**11**	**1**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			A comparison is needed in each of the following 3 pairs of answers below before a mark is awarded - Mitosis produces 2 daughter cells **and** meiosis produces 4 daughter cells (1) Mitosis retains chromosome number of parent cell **and** meiosis halves chromosome number (1) In mitosis daughter cells are genetically identical **and** in meiosis daughter cells are genetically different (1)	3			3		
	(b)	(i)		Changes in cells lead to uncontrolled growth and division	1			1		
		(ii)		Cells that have not lost the ability to differentiate (into different types of cells)	1			1		
		(iii)		Own-donor stem cells have no ethical issues because the donor receives his/her own cells back (1) The major ethical issue surrounding the use of embryonic stem cells is the **destruction** of a potential life (1) Some people consider the use of cord stem cells to raise an ethical issue because of the introduction of DNA from another person/many people do not consider the use of cord stem cells to raise an ethical issue because it does not involve the destruction of life (1)			3	3		
				Question 5 total	**5**	**0**	**3**	**8**	**0**	**0**

Question				Marking details	Marks Available					
					AO	AO2	AO3	Total	Maths	Prac
6	(a)			During osmosis water moves from where it is high concentration to where it is lower concentration (1) The chips in the water have a higher concentration of water outside than in the cells therefore water moves into the potato increasing the length (1) The chips in the 10% sugar solution have a greater concentration of water in the cells than in the solution therefore water moves out of the potato decreasing their length (1) Osmosis can only take place through a selectively permeable membrane. The cell membrane and cytoplasm of the cell act as a SPM (1)	1 1	 1 1		4		
	(b)			The concentration of water inside the cell is the same as the concentration outside/ reference to isotonicity (1) Therefore there is no net movement of water / rate of movement into potato = rate of movement out so length does not change (1)	2			2		2
	(c)			Cell membrane broken down therefore osmosis does not occur		1		1		
	(d)			Absorption of water by roots/ turgidity/water transport	1			1		
	(e)	(i)		Ends: 4 + 4 **and** Sides:10 + 10 + 10 + 10 (1) 48 cm^2 (1)		2		2	2	
		(ii)		Smaller chip has the larger surface area : volume ratio and so more water can be absorbed in a given time			1	1		2
	(f)	(i)		Higher concentration inside the root hair cell than outside therefore ions have been absorbed against a concentration gradient			1	1		
		(ii)		active transport requires a supply of ATP		1		1		
				Question 6 total	**5**	**6**	**2**	**13**	**2**	**4**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>7</td><td>(a)</td><td></td><td></td><td>carbon dioxide + water $\longrightarrow$ glucose + oxygen
reactants (1)
products (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Contain chlorophyll (1)
which absorbs light needed to provide energy for photosynthesis (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td></td><td>
<table>
<tr><th>Bell jar</th><th>Expected final colour of indicator</th><th>Reason for final colour of indicator</th></tr>
<tr><td>A</td><td>yellow</td><td>No photosynthesis taking place but plant is carrying out respiration releasing carbon dioxide</td></tr>
<tr><td>B</td><td>red/ slightly yellow</td><td>Some photosynthesis taking place in shaded conditions and plant is producing carbon dioxide by respiration. Carbon dioxide taken in = carbon dioxide produced</td></tr>
<tr><td>C</td><td>purple</td><td>Rate of photosynthesis is greater than rate of respiration. Therefore more carbon dioxide taken in for photosynthesis than released by respiration</td></tr>
</table>
Each row = 2 marks
[NB Expected colour change correct but explanation incorrect = 1 mark
Colour change incorrect but explanation correct = 0 marks]
Colour change = AO3, Explanation = AO2</td><td></td><td>3</td><td>3</td><td>6</td><td></td><td>6</td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(c)	(ii)		(III) light intensity	1			1		1
		(iii)		To prevent the respiratory activity of soil organisms from interfering with the experiment		1		1		1
				Question 7 total	**5**	**4**	**3**	**12**	**0**	**8**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)		A **species** whose number/ population density in a given area (1) indicates certain environmental or ecological conditions (1)	2			2		
		(ii)	I	Percentage increase = $(48-18) \times \frac{100}{48}$ (1) = 62.5% which is **greater** than 60% (1)		2		2	2	
			II	Biodiversity decreased (1) Even though number of species has stayed the same (1) Numbers of all, except mussels, have decreased (1)			3	3		
	(b)			The large number of recreational divers produce huge amounts of data (1) More data available for statistical analysis leads to greater accuracy / confidence (1)			2	2		
				Question 8 total	**2**	**2**	**5**	**9**	**2**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		All plots correct and joined (1) Axes labelled (1) Suitable scales on both x and y axes (1)		3		3	3	
		(ii)	I	As the volume of fertility drug increases so does the number of eggs released		1		1		
			II	18.5 [a.u.]		1		1	1	
	(b)			Follicle stimulating hormone (FSH) (1) Cut out gene for human FSH from human cells and insert into CHO cells (1) Using enzymes (1)	1	1 1		3		
	(c)			**Indicative content:** **AO1 allocation** - Oestrogen (produced by the ovary) causes LH to surge (from the pituitary gland). LH stimulates enzymes in the dominant follicle and along with the increased pressure causes the follicle to rupture and release the egg (ovulation). The egg travels into the fallopian tube, ready for fertilisation. The egg can survive for 12 to 24 hours after ovulation. following ovulation fertilisation can occur **AO2 allocation** -This woman has irregular LH release on the 14th and 24th days of successive months. This leads to irregular ovulation therefore fertilisation is unpredictable.	3	3		6		

				5-6 marks Detailed explanation of changes in terms of production of oestrogen causing LH release stimulating release of egg. Interprets data from successive months clearly explaining LH release is irregular leading to irregular ovulation making fertilisation unpredictable. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.* **3-4 marks** Explanation in terms of oestrogen causing LH to surge, LH release stimulating release of egg. Recognises LH release is irregular for this woman leading to irregular ovulation which makes fertilisation unpredictable. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1-2 marks** Recognises that LH peaks each month and this is connected to ovulation. LH release is irregular in this woman. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure*. *There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks**: *No attempt made or no response worthy of credit.*						
				Question 8 total	**4**	**10**	**0**	**14**	**4**	**0**

COMPONENT 1 - Concepts in Biology

HIGHER TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	**10**	**0**	**0**	**10**	**0**	**0**
2	**4**	**1**	**0**	**5**	**0**	**0**
3	**1**	**4**	**3**	**8**	**3**	**0**
4	**0**	**9**	**2**	**11**	**1**	**0**
5	**5**	**0**	**3**	**8**	**0**	**0**
6	**5**	**6**	**2**	**13**	**2**	**4**
7	**5**	**4**	**3**	**12**	**0**	**8**
8	**2**	**2**	**5**	**9**	**2**	**0**
9	**4**	**10**	**0**	**14**	**4**	**0**
TOTAL	**36**	**36**	**18**	**90**	**12**	**12**

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 2

Concepts in Chemistry

FOUNDATION TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	**9**	
2	**3**	
3	**6**	
4	**8**	
5	**8**	
6	**7**	
7	**9**	
8	**11**	
9	**6**	
10	**12**	
11	**11**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

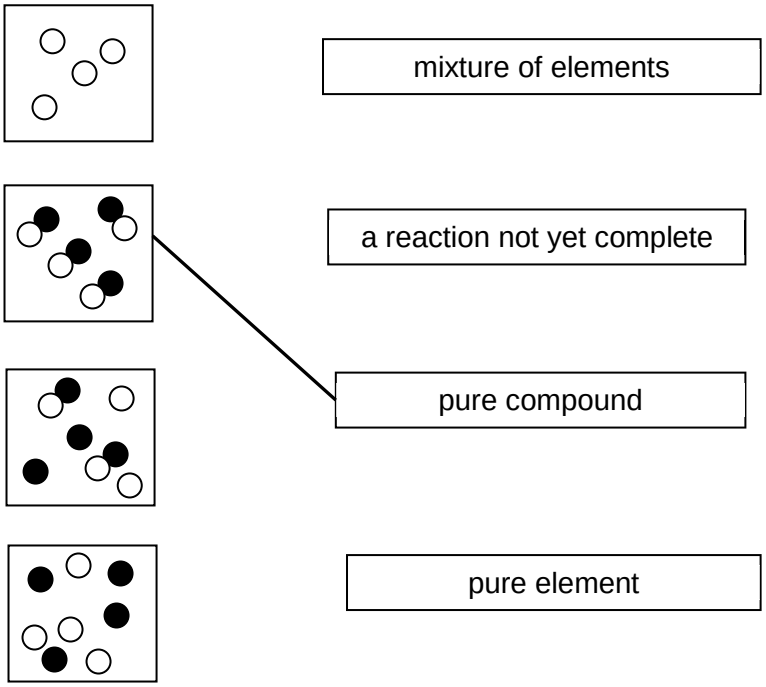
Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

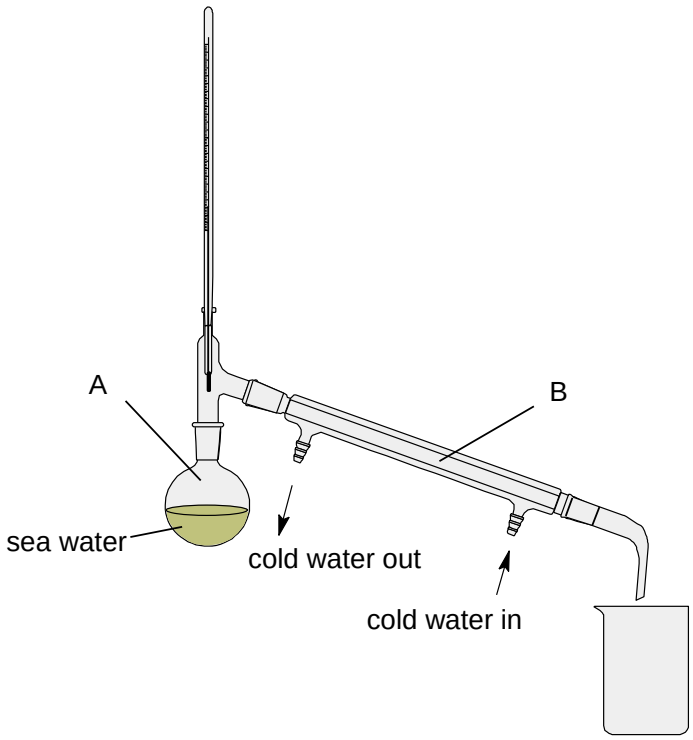
The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **9.**

Answer **all** *questions.*

1. (a) Draw lines to match each diagram below with the correct description. One has been done for you. [2]



(b) The following diagram shows the apparatus that can be used to collect pure water from sea water.



(i) Underline the name given to this method of separation. [1]

distillation **filtration** **crystallisation**

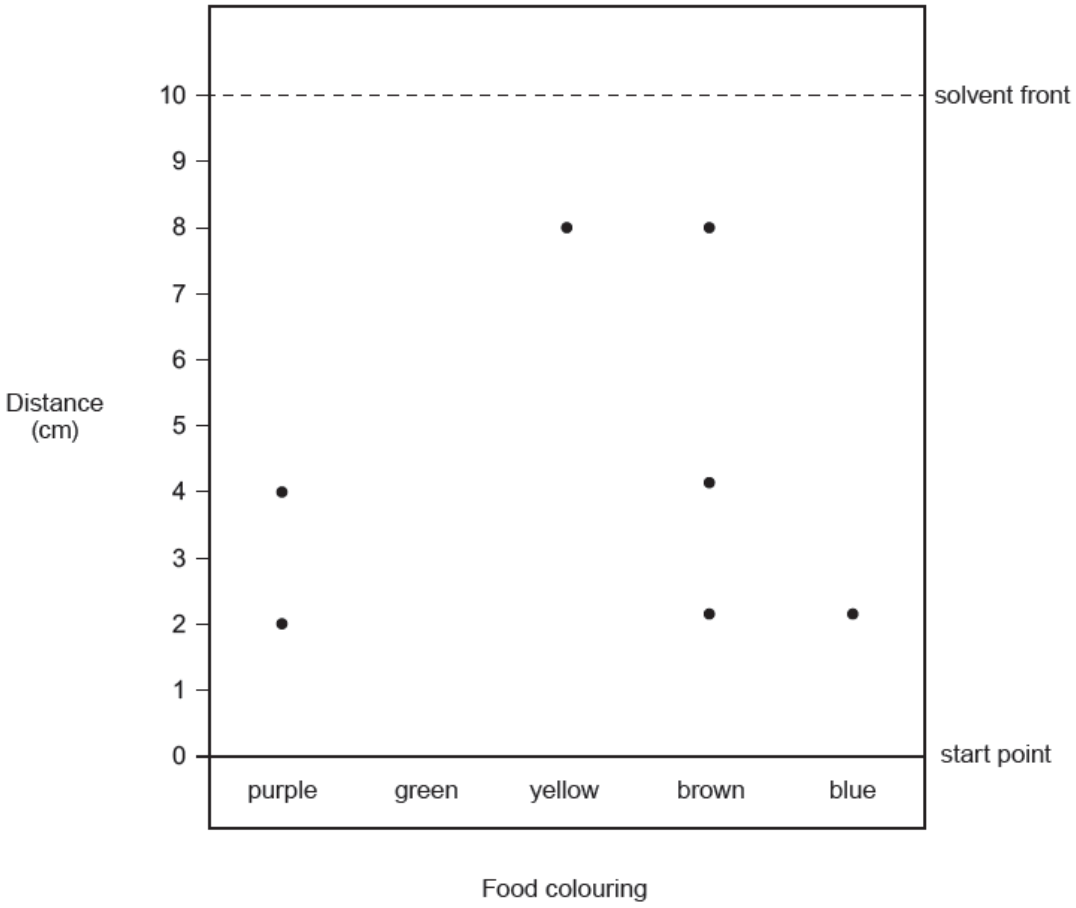
(ii) Choose from the box below, the changes of state that take place at **A** and **B** in the apparatus. [2]

boiling	**freezing**	**condensing**	**melting**

A .....

B .....

(c) Paper chromatography was used to show the pigments present in different food colourings.



(i) Give the **two** food colourings that are mixed to make **brown** food colouring. [1]

..…….. and ……..……..

(ii) Green food colouring is made by mixing together blue and yellow food colourings.
Draw on the diagram the result that you would expect to see for the green food colouring. [1]

(iii) The R_f value of a substance can be used to identify that substance. The R_f value for the pigment in red food colouring is 0.4.

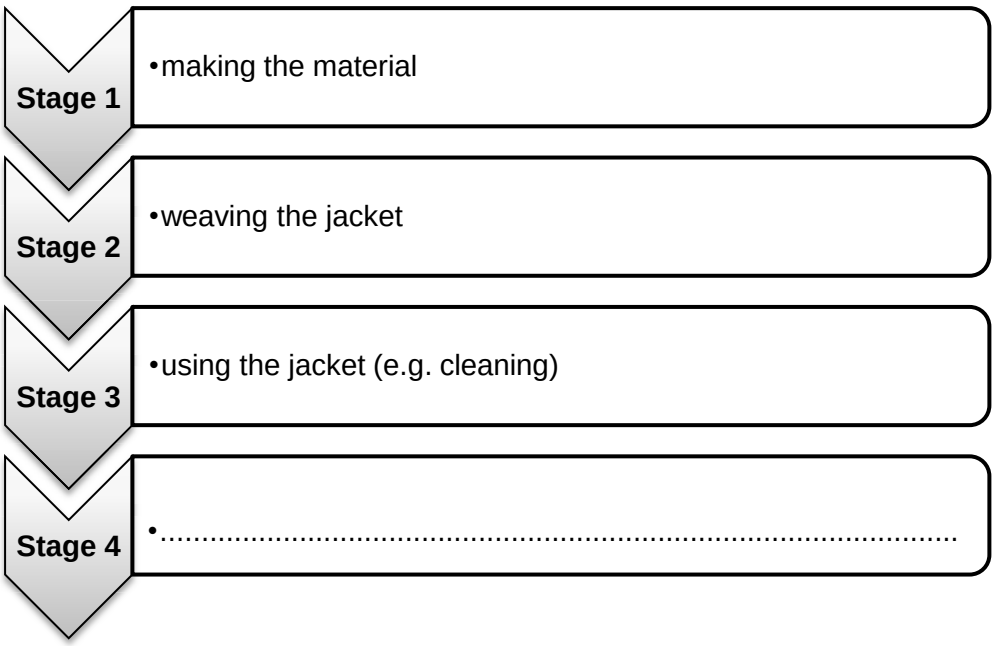
Use the equation below to calculate the distance this red food colouring would have moved on the diagram. [2]

distance moved = R_f × distance moved by the solvent

distance moved = …… cm

9

2. (a) Life cycle assessment (LCA) is used to measure the impact of a product on the environment. The diagram below shows the main stages of the LCA of a jacket.



Add the correct statement from the box below to **Stage 4** of the LCA. [1]

disposing of the jacket	**buying the jacket**	**designing the jacket**

(b) Jackets can be made from either cotton or polyester.

The table below gives data for the complete life cycle assessment of jackets made from cotton and polyester.
Use this information to answer the following question.

Factor	Polyester per kg	Cotton per kg
energy used (MJ)	171.3	140.1
fuel (oil or gas) used (kg)	1.53	0
fertilisers used (kg)	0	467
emissions:		
carbon dioxide (kg)	3.8	5.3
sulfur dioxide (g)	0.2	4.0
water used (dm^3)	1 900	26 700

Give **one** advantage and **one** disadvantage of using cotton rather than polyester to make jackets. [2]

Advantage: ……

……

Disadvantage: ……

……

3

3. (a) Crude oil is an important raw material obtained from the Earth's crust. It is formed from the remains of simple marine organisms.

(i) **Circle** below the time it takes to form crude oil. [1]

hundreds of years **millions of years** **tens of years** **thousands of years**

(ii) Choose from the box the name given to the type of compound present in crude oil. [1]

hydrocarbons	**monomers**	**plastics**	**polymers**

Answer ……

(b) A barrel of crude oil contains 42 gallons. It is separated into fractions which have different uses. The following table shows the amount of each fraction obtained from this barrel.

Fraction obtained	Number of gallons obtained from this 42 gallon barrel
gases	2.9
petrol	21.0
kerosene	……
diesel fuel	8.6
lubricants	0.6
fuel oil	3.7
bitumen	1.2

(i) Use the figures in the table to calculate the number of gallons of kerosene that are obtained from this barrel. Show your working. [2]

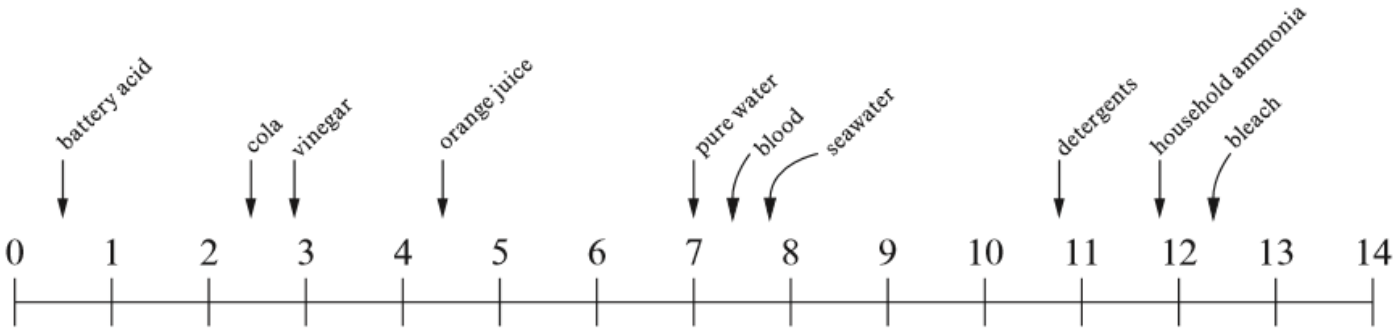
number of gallons = ……

(ii) Calculate the percentage of petrol present in this barrel of crude oil. Show your working. [2]

percentage of petrol = …….. %

6

4. (a) The following diagram shows the pH values of some common substances.



Complete the following table by choosing the substance that matches each description. [2]

Description	Substance
the strongest acid	
a neutral substance	

(b) John added hydrochloric acid to three different substances **A**, **B** and **C**. He recorded his observations and temperature changes in a table.

Substance	Observations	Temperature change (°C)
A	bubbles of gas produced the gas turned limewater milky a blue solution formed	+4
B	no gas produced a blue solution formed	0
C	no visible change	+8

Identify **A**, **B** and **C** from the substances in the box. [3]

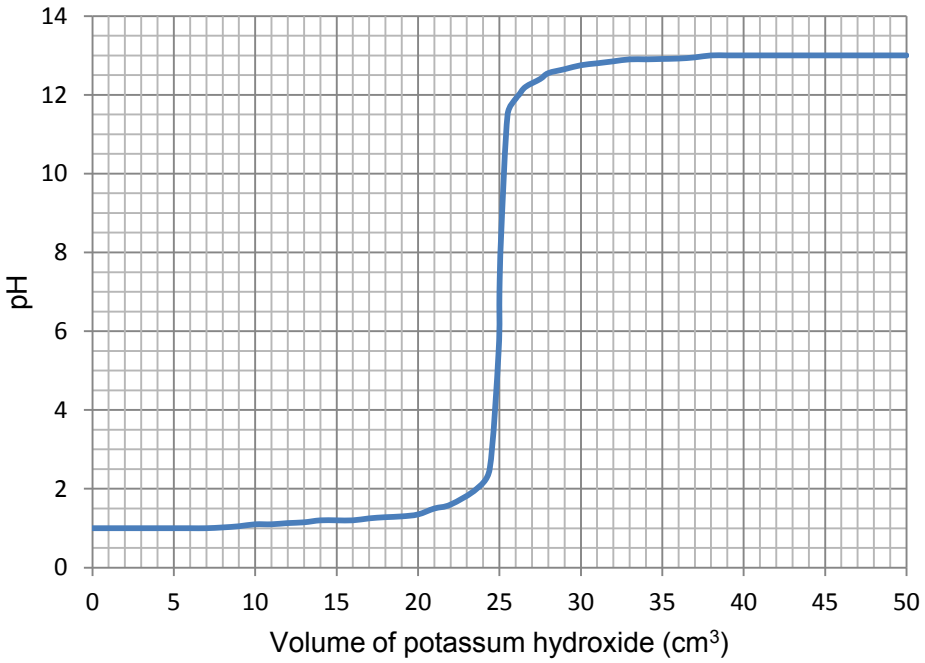
copper(II) carbonate	**copper(II) oxide**	**magnesium**
copper(II) chloride	**copper**	**sodium hydroxide**

A ……

B ……

C ……

(c) Syra investigated how pH changed during the reaction between hydrochloric acid and potassium hydroxide.
She slowly added potassium hydroxide solution to 25 cm^3 of dilute hydrochloric acid and recorded the pH using a pH sensor.
Her results are shown in the graph.



(i) Use the graph to find the pH of the hydrochloric acid before any potassium hydroxide was added. [1]

……

(ii) Use the graph to find the volume of potassium hydroxide required to neutralise the acid. [1]

…… cm^3

(iii) Give **one** advantage of using a pH sensor to investigate changes in pH. [1]

.....

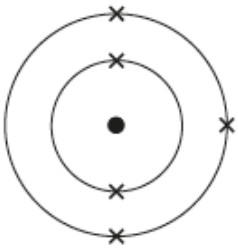
.....

8

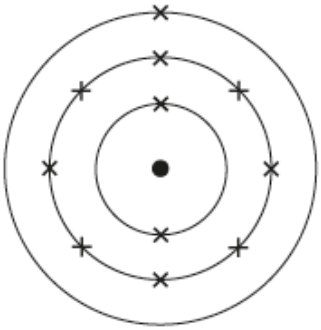
5. (a) The following diagrams represent atoms of 5 different elements, **A**, **B**, **C**, **D** and **E**.

A, **B**, **C**, **D** and **E** are **not** chemical symbols.

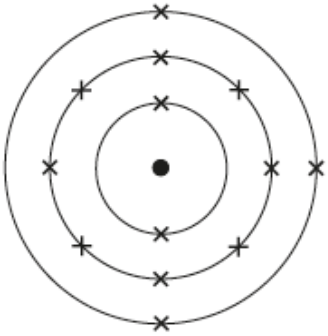
A



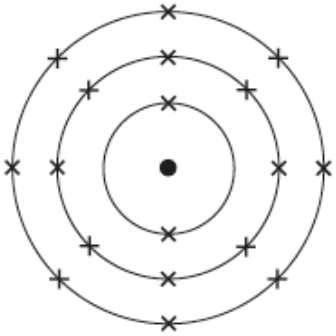
B



C



D



E

(i) Give the electronic structure of **E.** ……..……..... [1]

(ii) Which **letter** represents aluminium? ..... [1]

(iii) Give the letters of the **two** elements which are found in the same group of the Periodic Table and give a reason for your choice. [2]

.....

.....

(b) (i) Calculate the relative formula mass (M_r) of sodium carbonate, Na_2CO_3. [2]

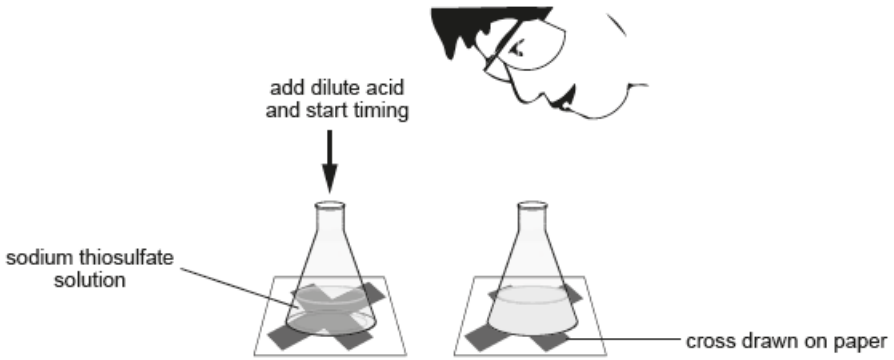
relative formula mass = ……

(ii) Using your answer to part (i), calculate the percentage by mass of oxygen in sodium carbonate, Na_2CO_3. [2]

percentage by mass of oxygen = …….. %

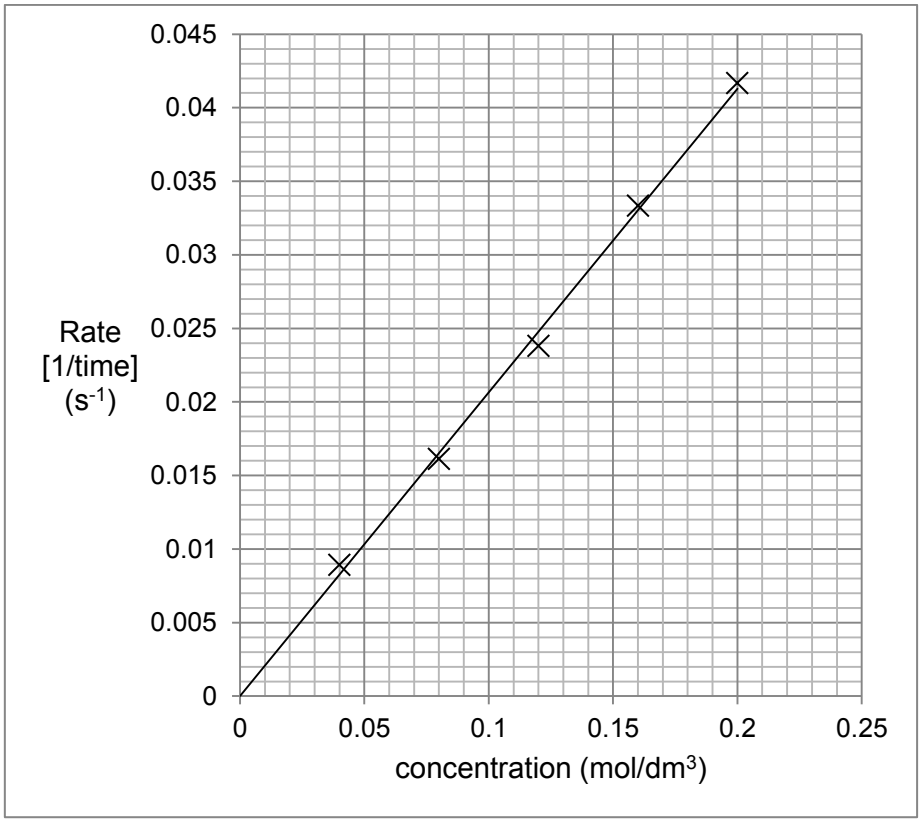
8

6. When sodium thiosulfate solution reacts with dilute acid, the solution becomes cloudy. The rate of reaction can be measured using the 'disappearing cross' method.



(a) Katie studied the effect of concentration of sodium thiosulfate on the rate of the reaction.
Her results table and the graph she plotted are shown below.

Concentration	**Time for cross to disappear (s)**	**Rate 1/time (s^{-1})**
0.2	24	0.042
0.16	30	0.033
0.12	42	0.024
0.08	62	0.016
0.04	112	0.009



(i) I Write down the intercept on the *y*-axis of the straight line in Katie's graph. [1]

intercept = …….

II Katie measured the gradient of the line in the graph to be **0.2**.
Show that her value is correct to one decimal place.
You must show your workings. [1]

`

III **Circle** the equation of the straight line in Katie's graph. [1]

A rate = concentration + 0.2

B rate = 0.2 x concentration

C concentration = 0.2 x rate

D concentration = rate + 0.2

(ii) I Katie predicts the **reaction rate** to be **0.052 s^{-1}** when the concentration of the thiosulfate is 0.25 mol/dm^3.
Estimate how long it would take for a cross to disappear at this concentration. Your estimate should be to the nearest whole number.
Show your workings.

[2]

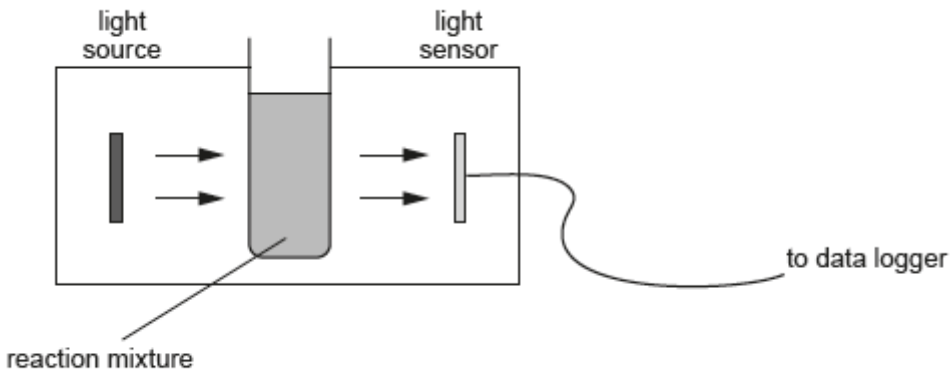
time = …….s

II Give **one** reason why this value is unlikely to be exactly the same as the one measured experimentally. [1]

……

……

(b) Another pupil used a light sensor and data logger to study the reaction.



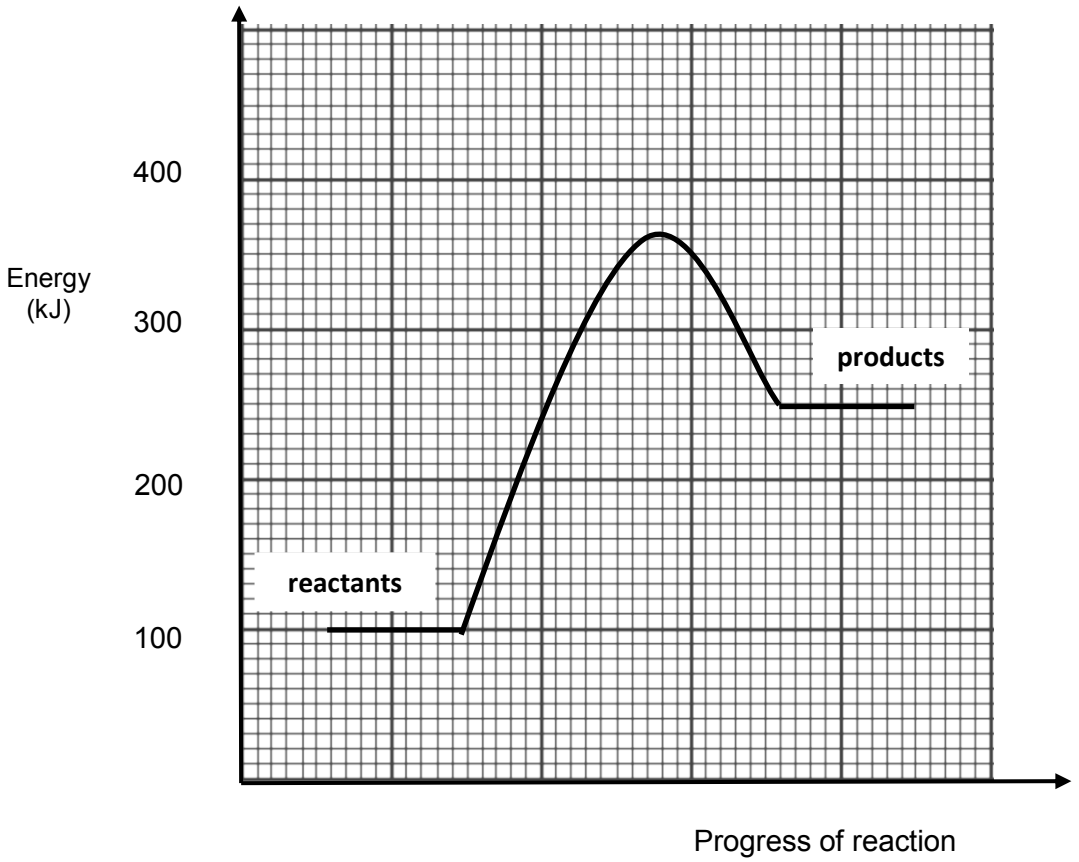
Describe **one** advantage of using the light sensor and data logger to follow the rate of reaction in preference to judging the disappearance of the cross by eye. [1]

.....

.....

7

7. Reactions can be described as either being exothermic or endothermic, depending upon whether they give out or take in heat.
The grid below shows the energy profile diagram of an endothermic reaction.



(a) (i) Use the diagram to calculate the activation energy for the reaction. [2]

activation energy = …… kJ

(ii) Put a tick(✓) in the box next to the statement which describes an endothermic reaction. [1]

energy of the reactants < energy of products ☐

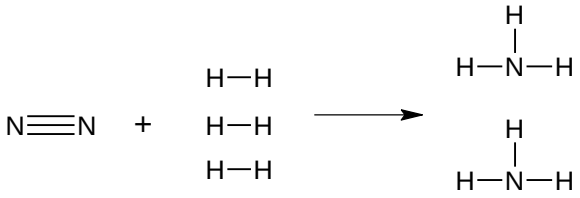
energy of the reactants > energy of products ☐

energy of reactants = energy of products ☐

energy of the products ~ energy of reactants ☐

(b) **Sketch on the diagram** the energy profile that you would expect to see if the reaction were carried out using a catalyst. [2]

(c) When chlorine reacts with hydrogen, hydrogen chloride is formed.



The relative energies of these bonds are given in the table below.

Bond	Bond energy (kJ)
H – H	436
N≡N	941
N—H	391

(i) Calculate the energy needed to break all the bonds in the reactants.[1]

energy needed = ……. kJ

(ii) Calculate the energy released when all the bonds in the product are formed. [1]

energy released = ……. kJ

(iii) Calculate the overall energy change for the reaction. State whether the reaction is exothermic or endothermic and give a reason for your answer. [2]

energy change = ... kJ

.....

.....

8. (a) Atoms consist of particles called protons, neutrons and electrons.
Complete the table below. [2]

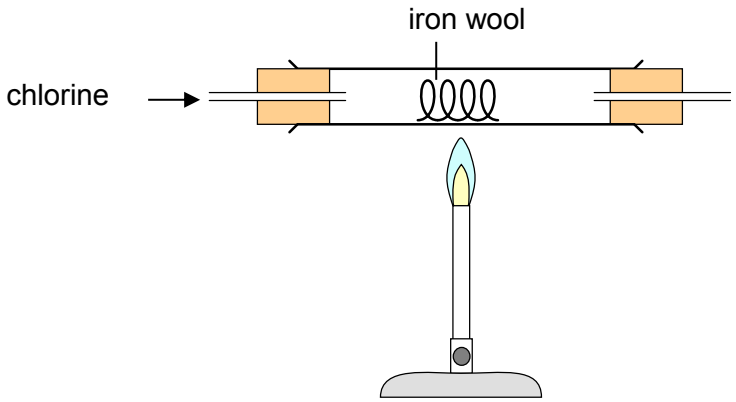
Particle	Mass	Charge
proton	1	positive (+)
neutron	.....	neutral (0)
electron	negligible	.....

(b) Potassium is represented as $^{39}_{19}\mathrm{K}$.
Element X has 9 electrons, 10 neutrons and 9 protons.

Write the information for element X in the same form as above. [1]

..... X
.....

(c) The diagram below shows chlorine gas passing over hot iron wool.



(i) Iron turns into iron(III) chloride.
Iron(III) chloride contains Fe^{3+} and Cl^- ions.

Write the formula for iron(III) chloride. ……. [1]

(ii) Give the reason why the experiment is carried out in a fume cupboard. [1]

…..……...

(iii) Give the name of a Group 7 element that will react more vigorously with iron. Give a reason for your choice. [2]

.....

.....

(iv) Sodium also reacts with chlorine.
Put a tick (✓) in the box next to the correct equation for this reaction.

[1]

Na	+	Cl	⟶	NaCl	☐
Na	+	Cl_2	⟶	$NaCl_2$	☐
2Na	+	Cl_2	⟶	2NaCl	☐
2Na	+	2Cl	⟶	2NaCl	☐

(d) The labels on sodium and potassium bottles have come off.
Describe an experiment a technician could carry out to identify the metals in each bottle.
Include the observations the technician will use to identify each metal.

[3]

.....

.....

.....

.....

.....

.....

11

9. Elements can be classified as metals or non-metals. The table below describes some physical properties of silicon.

Element	**Melting point (°C)**	**Boiling point (°C)**	**Appearance**	**Density (g/cm^3)**	**Electrical conductivity**	**Behaviour when hit with a hammer**
silicon	1414	3265	shiny	2.3	good	brittle

Note: The density of iron is 7.9 g/cm^3 while that of phosphorus is 1.8 g/cm^3.
Use **all** the information above to discuss the classification of silicon. [6 QER]

……

……

……

……

……

……

……

……

……

……

……

……

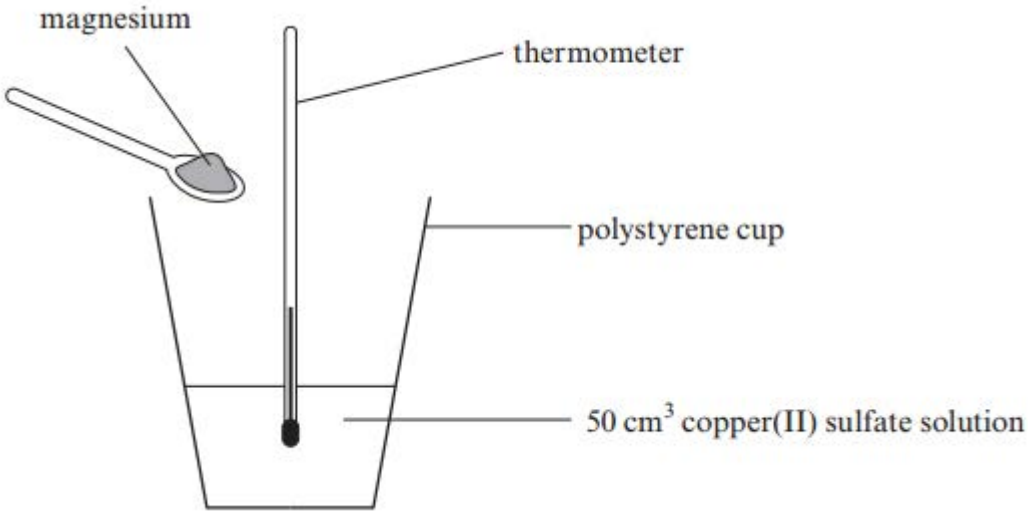
……

……

……

6

10. Four pupils investigated the temperature change which occurred when powdered magnesium was added to 50 cm^3 of copper(II) sulfate solution in a polystyrene cup.



- In the first experiment, each pupil weighed 0.2 g of magnesium.
- 50 cm^3 of copper(II) sulfate solution was then added to a polystyrene cup and the temperature of the solution recorded.
- Magnesium was then added to the solution while the polystyrene cup was swirled. The maximum temperature rise was recorded.
- The experiment was repeated using 0.4, 0.6, 0.8 and 1.0 g of magnesium powder with new copper(II) sulfate solution each time.

The table shows the results recorded.

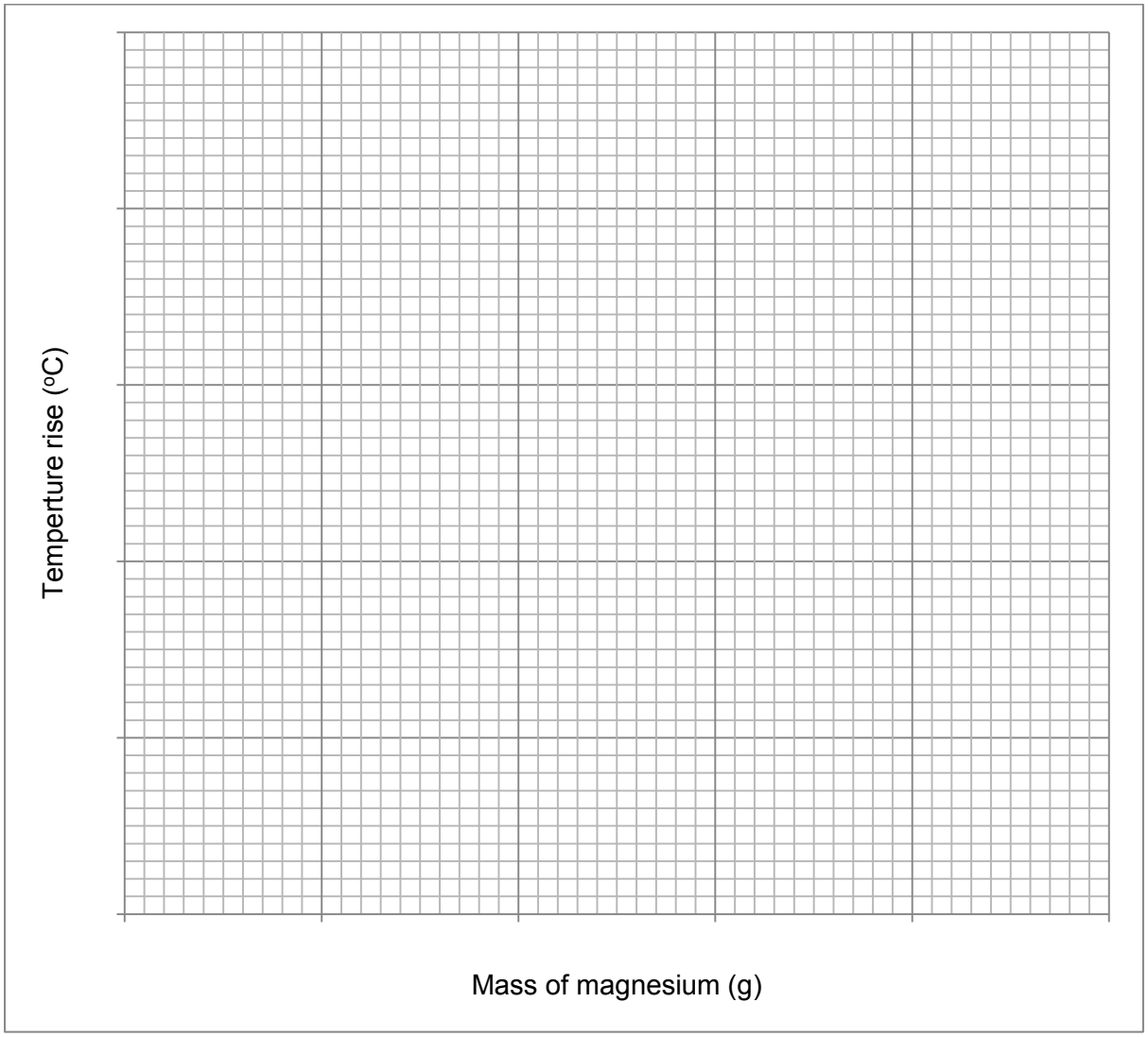
Mass of powdered magnesium (g)	**Maximum temperature rise (°C)**				
	Pupil A	**Pupil B**	**Pupil C**	**Pupil D**	**Mean**
0.2	3.5	3.5	3.7	3.7	3.6
0.4	6.0	5.9	6.1	6.0	6.0
0.6	7.8	8.0	8.2	8.0	8.0
0.8	9.1	9.0	3.0	8.9	9.0
1.0	8.8	9.1	8.9	9.2	9.0

(a) (i) **Circle** the anomalous result **not** used in calculating one of the mean temperature rises. [1]

(ii) Suggest **one** possible cause for this anomalous result. [1]

.....

(b) (i) On the grid below, plot the mean temperature rise against the mass of magnesium added. Draw a suitable line. [3]



(ii) Find the smallest mass of magnesium needed to react with all of the copper(II) sulfate. Give a reason for your answer. [1]

.....

.....

(c) In north Wales, there is a large copper mine called Parys Mountain. Unwanted rock from mining has been dumped forming waste tips. As rainwater passed through the waste tips, it dissolved copper salts such as copper(II) sulfate. This water filled large pits.

In the 18th century scrap iron was placed into the water and after a few months the pits were drained and copper-rich sludge was collected.

(i) Explain the reaction taking place in the pits. [2]

……..…..

……..……

……..…….

(ii) Write the **word** equation for the reaction taking place. [2]

…….. + ……..…….. → ……..…..… + ……...…….

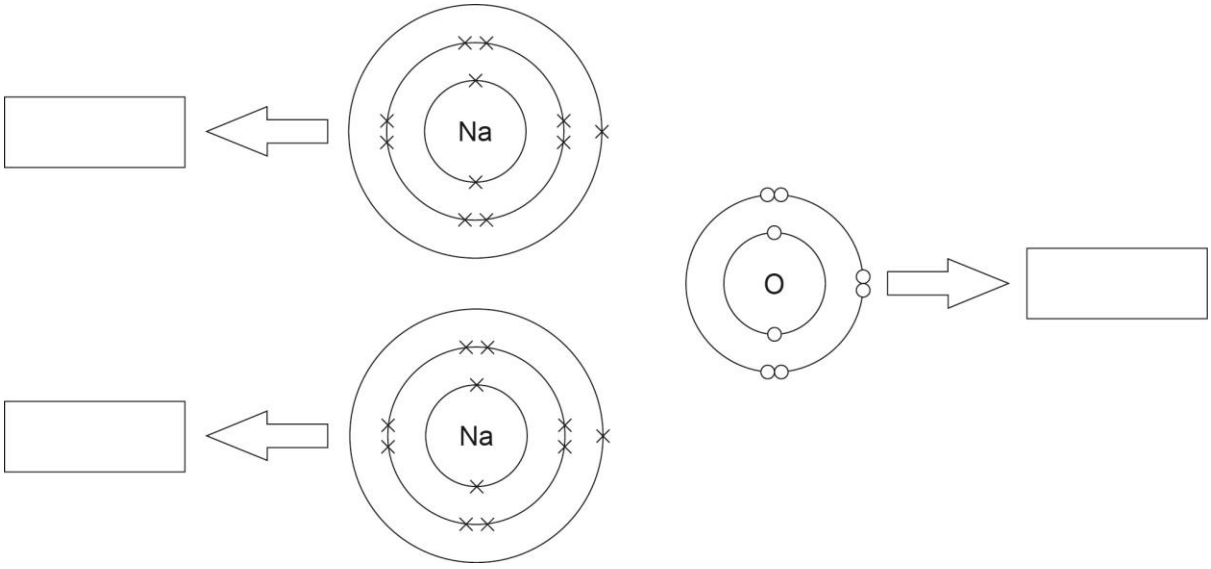
(d) A similar reaction takes place between copper and silver nitrate. One of the products formed is copper(II) nitrate, $Cu(NO_3)_2$.

Write the balanced **symbol** equation for this reaction. [2]

…….. + ……..…….. → ……..…..… + ……...…….

12

11. (a) Sodium reacts with oxygen to form sodium oxide.
The diagram below can be used to show the electronic changes that occur as sodium oxide is formed.



(i) **Draw arrows on the diagram** to show the movement of electrons that leads to the formation of ions. [1]

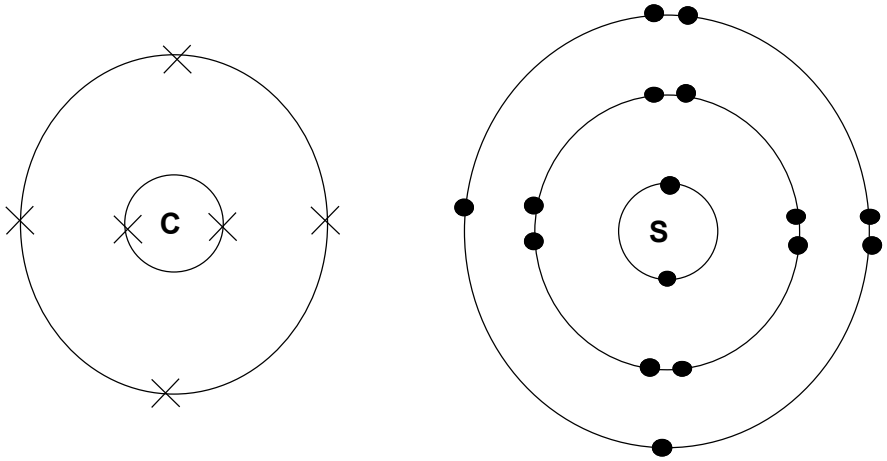
(ii) **Write in the boxes**, the electron configurations of the sodium and oxide **ions** that are formed. Include the charges on these ions. [2]

(iii) Explain why the ions become joined together. [2]

.....

.....

(iv) The electronic configuration of carbon and sulfur are shown below.



Circle the letter **A**, **B**, **C** or **D** next to the correct statement about the compound formed between carbon and sulfur. [1]

A Electrons are transferred from carbon to sulfur to form a covalent compound with the formula CS_2.

B Electrons are shared between carbon and sulfur to form a covalent compound with the formula CS_2.

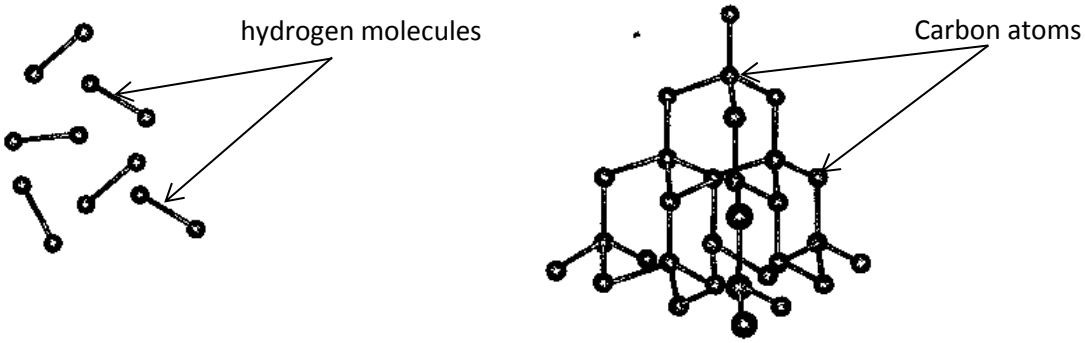
C Electrons are transferred from carbon to sulfur to form a covalent compound with the formula CS.

D Electrons are shared between carbon and sulfur to form a covalent compound with the formula CS.

(b) Using the electronic structures given, draw a dot and cross diagram to show the bonding in a molecule of water, H_2O. [2]

hydrogen = 1 oxygen = 2,6

(c) The following diagrams show the structures of hydrogen and diamond.



Explain why diamond has a higher melting point than hydrogen. [3]

.....

.....

.....

.....

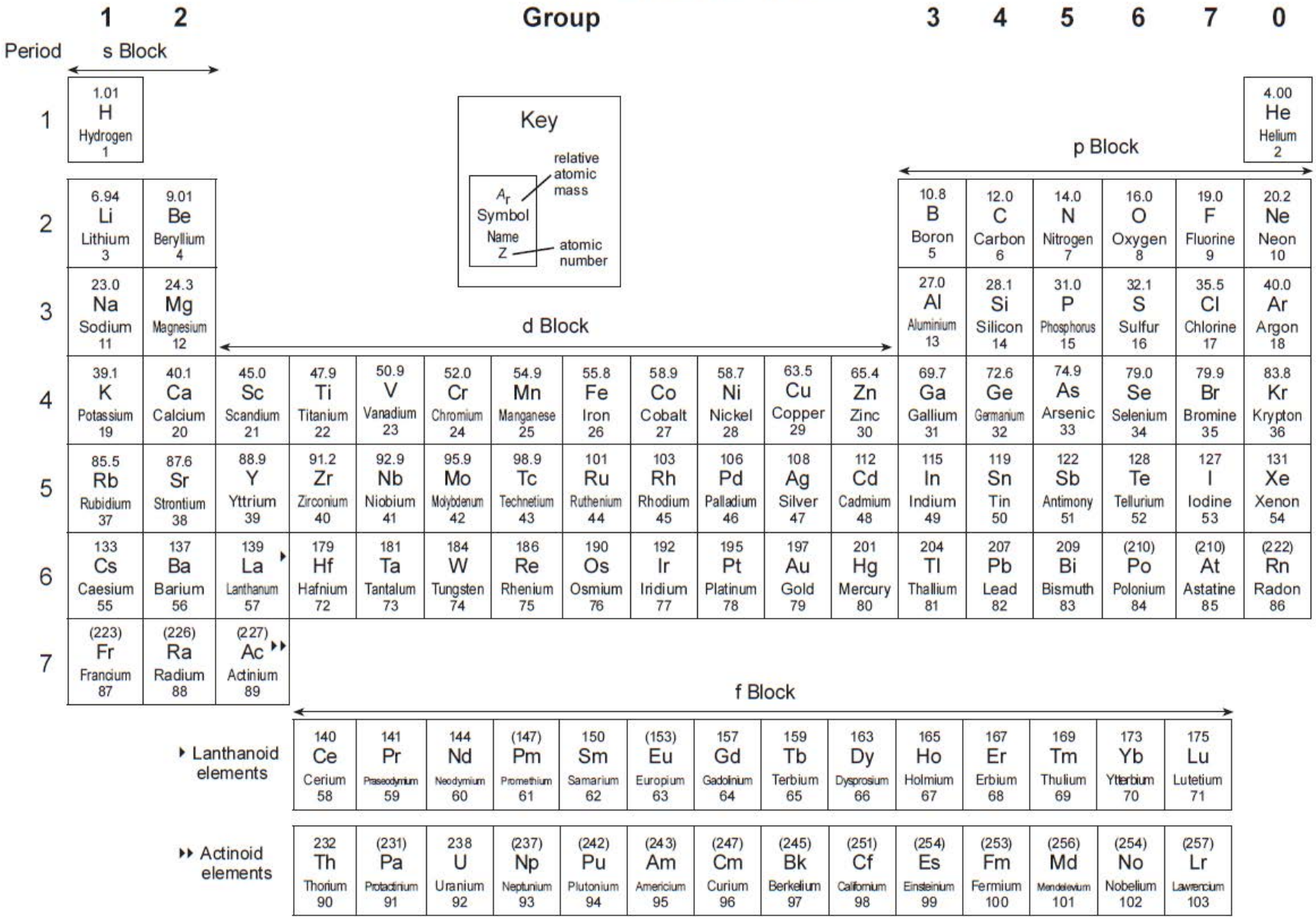
11

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	Formula	Name	Formula
Aluminium	Al^{3+}	Bromide	Br^{-}
Ammonium	NH_4^{+}	Carbonate	CO_3^{2-}
Barium	Ba^{2+}	Chloride	Cl^{-}
Calcium	Ca^{2+}	Fluoride	F^{-}
Copper(II)	Cu^{2+}	Hydroxide	OH^{-}
Hydrogen	H^{+}	Iodide	I^{-}
Iron(II)	Fe^{2+}	Nitrate	NO_3^{-}
Iron(III)	Fe^{3+}	Oxide	O^{2-}
Lithium	Li^{+}	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}		
Nickel	Ni^{2+}		
Potassium	K^{+}		
Silver	Ag^{+}		
Sodium	Na^{+}		
Zinc	Zn^{2+}		

Avogadro's number, $L = 6 \times 10^{23}$

THE PERIODIC TABLE



COMPONENT 2 – Concepts in Chemistry

FOUNDATION TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

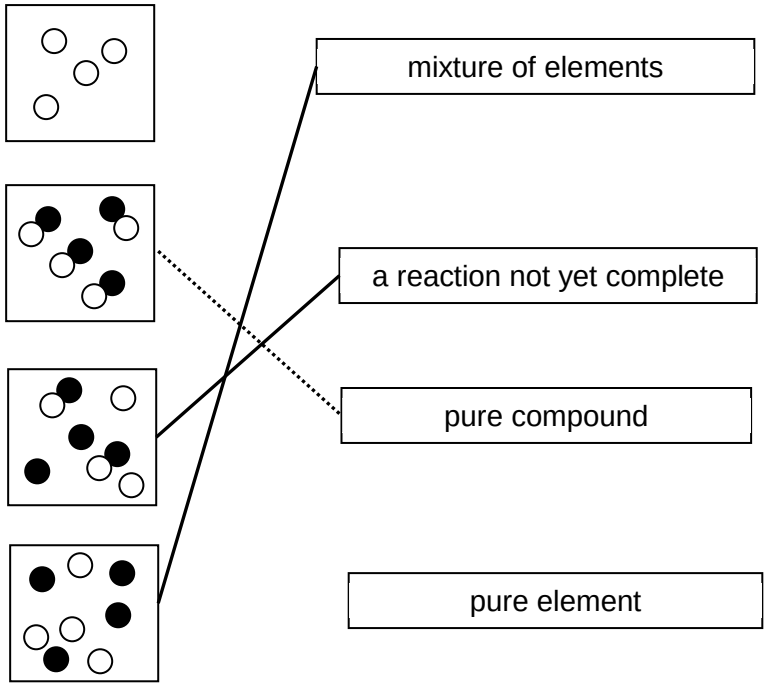
Extended response question

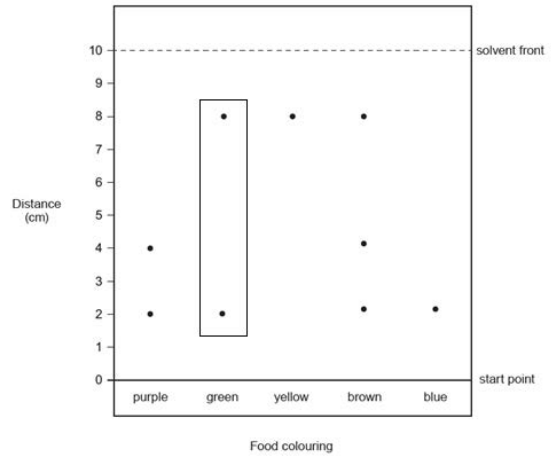
A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			 All correct for (2) Two correct for (1)	2			2		
	(b)	(i)		Distillation	1			1		1
		(ii)		Boiling (1) Condensing (1)	2			2		2

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(c)	(i)		Purple and yellow – **both** needed			1	1		1
		(ii)					1	1		1
		(iii)		0.4 × 10 (1) 4 (1)	1	1		2		2
				Question 1 total	**6**	**1**	**2**	**9**	**0**	**7**

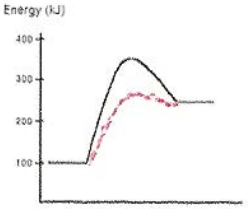
Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			Disposing of the jacket	1			1		
	(b)			**Advantage**: cotton less energy used / less fuel used with cotton (1) **Disadvantage**: fertiliser used for cotton/ more emissions (of carbon dioxide /sulfur dioxide) / more water used (1)			2	2		
				Question 2 total	**1**	**0**	**2**	**3**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)		Millions of years	1			1		
		(ii)		Hydrocarbons	1			1		
	(b)	(i)		Sum of other fractions = 38 (1) Answer = 4 (1)	2			2		
		(ii)		21x100/42 (1) Answer = 50 (1)	1	1		2	2	
				Question 3 total	**5**	**1**	**0**	**6**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Battery acid (1) Pure water (1)	2			2		
	(b)			**A** Copper(II) carbonate (1) accept copper carbonate **B** Copper(II) oxide (1) accept copper oxide **C** Sodium hydroxide (1)			3	3		3
	(c)	(i)		1		1		1		1
		(ii)		25			1	1		1
		(iii)		Any of the following for (1) Measures continuously Measures more precisely Data can be plotted in real time Stores data			1	1		1
				Question 4 total	**2**	**1**	**5**	**8**	**0**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)		2, 8, 8		1		1		
		(ii)		**D**		1		1		
		(iii)		**B** and **D** – **both** needed (1) Must be correct in order to award second mark Same number of electrons in **outer** shell (1)	1	1		2		
	(b)	(i)		$(2 \times 23) + 12 + (3 \times 16)$ (1) Answer = 106 (1)		2		2	2	
		(ii)		$\left(\frac{46}{106}\right) \times 100$ (1) Answer = 45 (1) [%] accept 45.3 / 45.28		2		2	2	
				Question 5 total	**1**	**7**	**0**	**8**	**4**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
6	(a)	(i)	I	intercept = 0 (1)		1		1	1	1
			II	Workings = 0.41/0.15 = 0.2 [s^{-1}] to 1 dp The mark is for a suitable triangulation ratio that gives 0.2 to 1dp		1		1	1	
			III	rate = 0.2 x concentration Allow ecf		1		1	1	1
		(ii)	I	time = 1/0.052 (substitution) = 19 [s]	1	1		2	2	2
			II	Any of the following for (1) Reaction time in seeing change and stopping stopwatch Not always clear when cross has vanished concentrations/ temperatures may not be exactly correct Do not just accept: experimental error in measurements			1	1		1
	(b)			Any of the following for (1) Watch stops at precisely the same point in the reaction each time Measures accurately as there is no delay in stopping watch Data can be plotted in real time Credit other sensible advantages			1	1		1
				Question 6 total	**1**	**4**	**2**	**7**	**5**	**6**

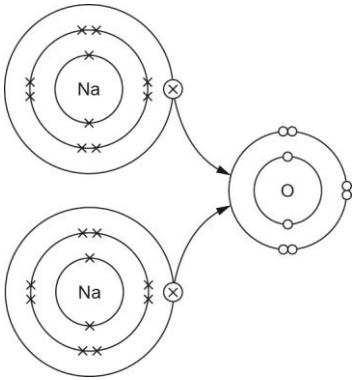
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		365* – 100 (1) *Accept value between 360 – 365 Answer = 265 (1) Use value from first line to award mark		2		2	1	
		(ii)		energy of the reactants < energy of products ✓	1			1		
	(b)			Lower energy reaction profile drawn with: same start/end point (1) lower activation energy (1) 	2			2		
	(c)	(i)		941+(3x436) selection and working =2249		1		1	1	
		(ii)		391x3x2 selection and working =2346		1		1	1	
		(iii)		–97 / Allow 97 Allow ecf (1) Exothermic reaction **because** more energy is given out (in forming bonds) than is required (in breaking bonds) (1)	1	1		2		
				Question 7 total	**4**	**5**	**0**	**9**	**3**	**0**

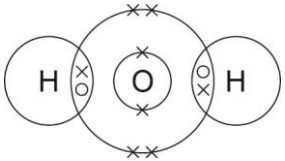
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>8</td><td>(a)</td><td></td><td></td><td>
<table>
<tr><th>Particle</th><th>Mass</th><th>Charge</th></tr>
<tr><td>proton</td><td>1</td><td>positive (+)</td></tr>
<tr><td>neutron</td><td>1</td><td>neutral (0)</td></tr>
<tr><td>electron</td><td>negligible</td><td>negative (–)</td></tr>
</table>
Each correct answer (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>…19…
X
…9…
Both correct for 1 mark</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		$FeCl_3$		1		1		
		(ii)		Chlorine is toxic / poisonous Do not accept: harmful/dangerous	1			1		1
		(iii)		Fluorine (1) Reactivity decreases down the group (1)	1		1	2		
		(iv)		$2Na + Cl_2 \longrightarrow 2NaCl$		1		1		
	(d)			Suggest suitable test (add each metal to water / burn each metal in air) (1) Correct observations for given test i.e. Adding water - sodium does not burn but potassium burns (1) with lilac flame (1), or Burn each metal in air - potassium burns with lilac flame (1), sodium with yellow (1)	2	1		3		2
				Question 8 total	**6**	**4**	**1**	**11**	**0**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9				**Indicative content:** Silicon has some typical properties of a metal i.e. high melting point & boiling point, shiny, electrical conductor. However, silicon also has properties typical of a non-metal i.e. low density & brittle. Interprets density of silicon - closer to the non-metal phosphorus than the metal iron. Silicon shows properties of both metals & non-metals and is therefore difficult to classify. Lies between metal aluminium and non-metal sulfur in periodic table and shows properties of both. **AO allocations** AO1 - Properties metals / non-metals AO3 - Classification of silicon in light of interpreting information in table **5-6 marks**: Correctly groups each property of silicon as typical of metal or non-metal. Comments on density information of iron & phosphorus to substantiate that silicon's density is typical of non-metal. Comments on positioning between metal and non-metal in periodic table. Formulates a response to the observations made. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.* **3-4 marks**: Correctly groups most properties of silicon as typical of metals or non-metal. Recognises this causes a difficulty in classifying silicon. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1-2 marks**: Correctly recognises that at least one property of silicon is typical of a metal and at least one property typical of a non-metal. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks**: *No attempt made or no response worthy of credit.*	3		3	6		
				Question 9 total	**3**	**0**	**3**	**6**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		3.0 identified as anomalous result			1	1		1
		(ii)		Any of following points for (1) Not enough magnesium added Too much solution used Reading taken too quickly after addition / without stirring			1	1		1
	(b)	(i)		Both scales correct (1) All 5 points plotted correctly (1) Smooth curve drawn (1)		3		3	3	
		(ii)		0.8 g **because** no additional temperature increase when a greater mass added			1	1		1
	(c)	(i)		Iron is more reactive than copper (1) Displacement reaction occurs / iron displaces the copper (1)	1	1		2		2
		(ii)		Reactants – copper(II) sulfate **and** iron (1) Products – iron(II) sulfate **and** copper (1) Accept iron sulfate		2		2		
	(d)			$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$ (2) If equation not correct award (1) for $AgNO_3$ and Ag included on appropriate sides		2		2		
				Question 10 total	**1**	**8**	**3**	**12**	**3**	**5**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)	(i)		 Movement of electrons as shown		1		1		
		(ii)		$[2:8]^{+}$ Electron configuration of sodium ions with + charge (1) Accept if this is shown only once $[2:8]^{2-}$ Electron configuration of oxide ion with 2– charge (1)		2		2		
		(iii)		Sodium and oxide ions have opposite charges (1) Strong attraction holds them together (1)	2			2		
		(iv)		B		1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			 Correct diagram as shown (2) Award (1) if hydrogen and oxygen atom included and correct representation of one bonding pair between them [hydrogen's only electrons]		2		2		
	(c)			Strong bonds between all atoms in diamond (1) Weak forces between hydrogen molecules (1) Requires lots of heat/energy to break the bonds in diamond but only small amount to overcome forces in hydrogen (1)	3			3		
				Question 11 total	**5**	**6**	**0**	**11**	**0**	**0**

COMPONENT 2 – Concepts in Chemistry

FOUNDATION TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	1	2	9	0	7
2	1	0	2	3	0	0
3	5	1	0	6	2	0
4	2	1	5	8	0	6
5	1	7	0	8	4	0
6	1	4	2	7	5	6
7	4	5	0	9	3	0
8	6	4	1	11	0	3
9	3	0	3	6	0	0
10	1	8	3	12	3	5
11	5	6	0	11	0	0
TOTAL	35	37	18	90	17	27

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 2

Concepts in Chemistry

HIGHER TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	**12**	
2	**11**	
3	**9**	
4	**7**	
5	**16**	
6	**9**	
7	**20**	
8	**6**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

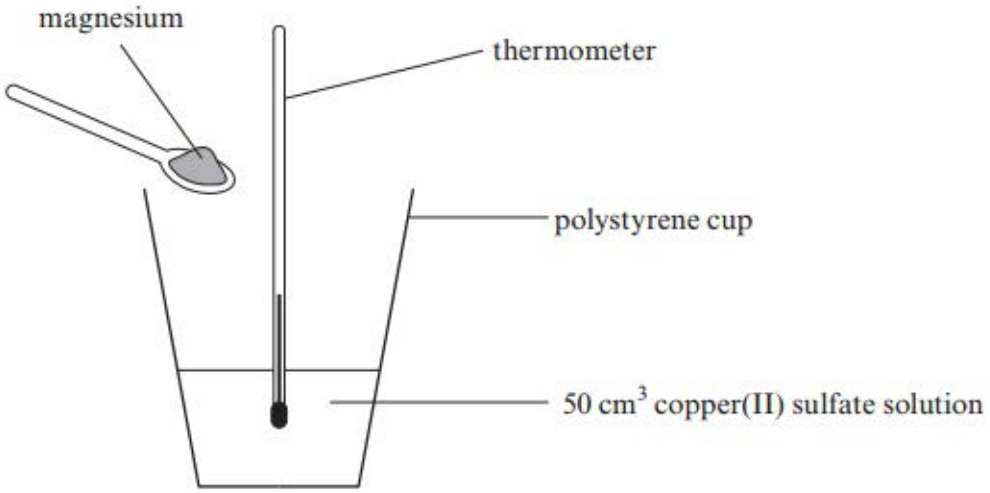
Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **8**.

Answer **all** *questions*

1. Four pupils investigated the temperature change which occurred when powdered magnesium was added to 50 cm^3 of copper(II) sulfate solution in a polystyrene cup.



- In the first experiment, each pupil weighed 0.2 g of magnesium.
- 50 cm^3 of copper(II) sulfate solution was then added to a polystyrene cup and the temperature of the solution recorded.
- Magnesium was then added to the solution, while the polystyrene cup was swirled. The maximum temperature rise was recorded.
- The experiment was repeated using 0.4, 0.6, 0.8 and 1.0 g of magnesium powder with new 50 cm^3 of copper(II) sulfate solution each time.

The table shows the results recorded.

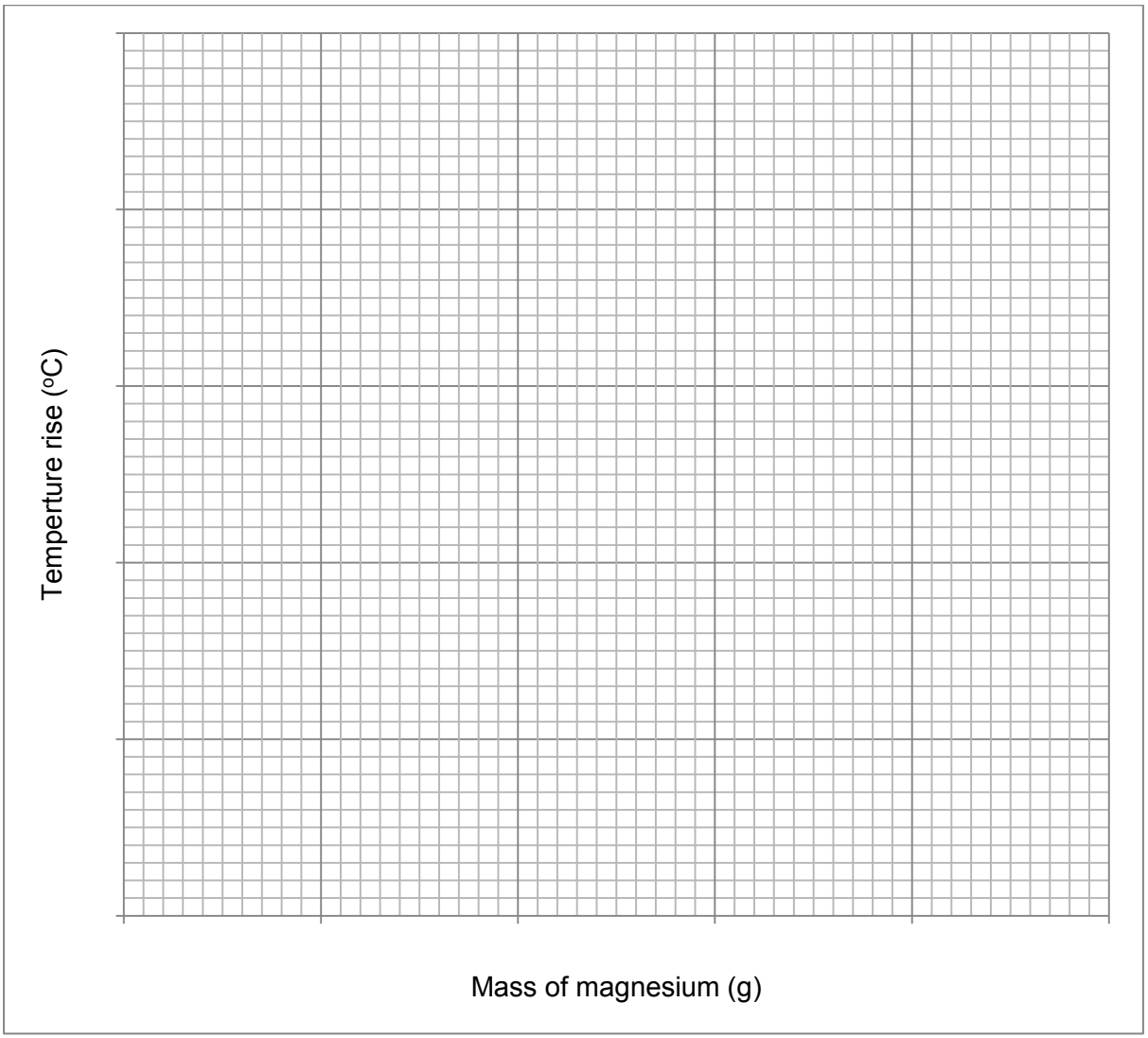
Mass of powdered magnesium (g)	**Maximum temperature rise (°C)**				
	Pupil A	**Pupil B**	**Pupil C**	**Pupil D**	**Mean**
0.2	3.5	3.5	3.7	3.7	3.6
0.4	6.0	5.9	6.1	6.0	6.0
0.6	7.8	8.0	8.2	8.0	8.0
0.8	9.1	9.0	3.0	8.9	9.0
1.0	8.8	9.1	8.9	9.2	9.0

(a) (i) **Circle** the anomalous result **not** used in calculating one of the mean temperature rises. [1]

(ii) Suggest **one** possible cause for this anomalous result. [1]

.....

(b) (i) On the grid below, plot the mean temperature rise against the mass of magnesium added. Draw a suitable line. [3]



(ii) Find the smallest mass of magnesium needed to react with all of the copper(II) sulfate. Give a reason for your answer. [1]

.....

.....

(c) In north Wales, there is a large copper mine called Parys Mountain. Unwanted rock from the mining process has been dumped forming waste tips. As rainwater passed through the waste tips it dissolved copper salts such as copper(II) sulfate. This water filled pits.

In the 18th century scrap iron was placed into the water and after a few months the pits were drained and copper-rich sludge was collected.

(i) Explain the reaction taking place in the pits. [2]

……..…..

……..…….

……..

(ii) Write the **word** equation for the reaction taking place. [2]

…….. + ……..…….. → ……..….. + ……...…….

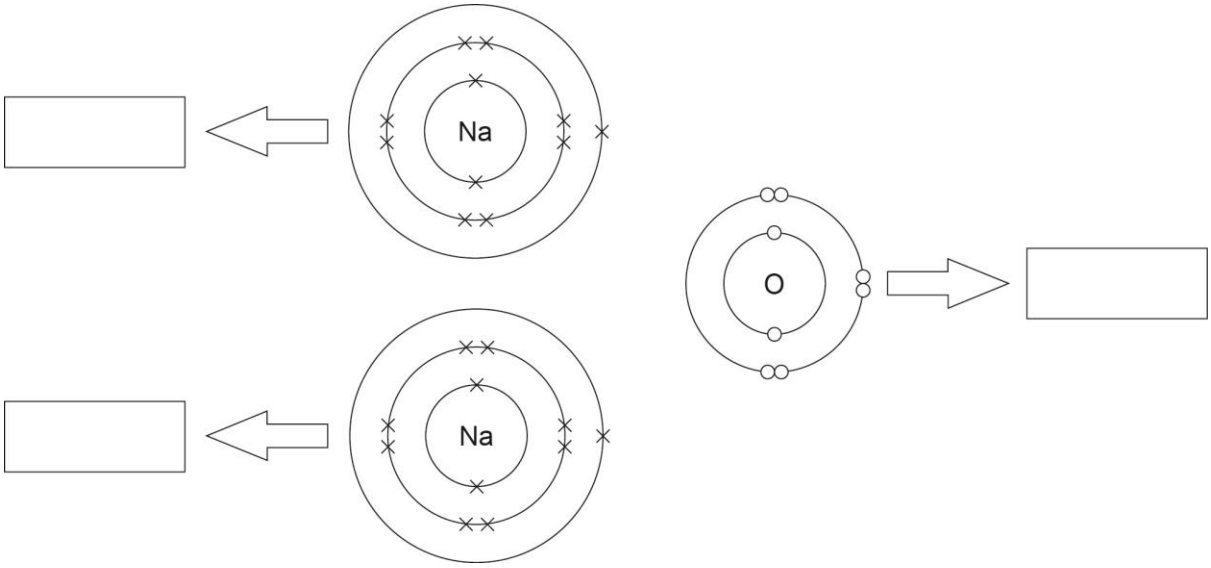
(d) A similar reaction takes place between copper and silver nitrate. One of the products formed is copper(II) nitrate, $Cu(NO_3)_2$.

Write the balanced **symbol** equation for this reaction. [2]

…….. + ……..…….. → ……..….. + ……...…….

12

2. (a) Sodium reacts with oxygen to form sodium oxide.
The diagram below can be used to show the electronic changes that occur as sodium oxide is formed.



(i) **Draw arrows on the diagram** to show the movement of electrons that leads to the formation of ions. [1]

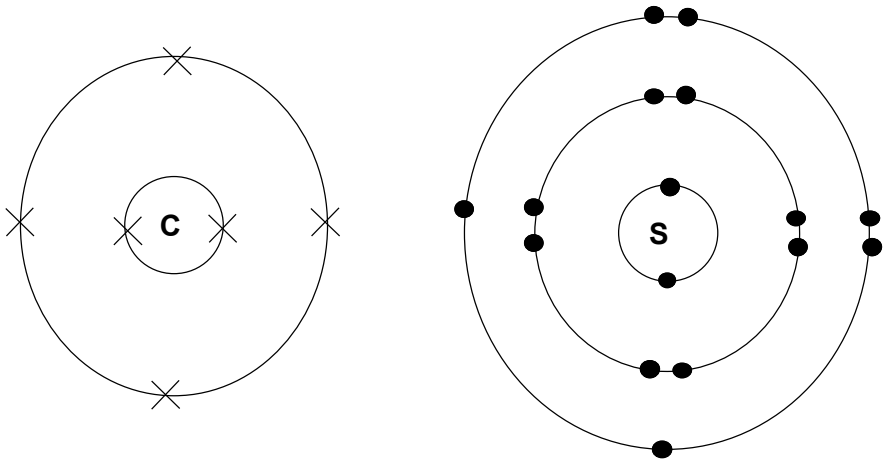
(ii) **Write in the boxes**, the electron configurations of the sodium and oxide **ions** that are formed. Include the charges on these ions. [2]

(iii) Explain why the ions become joined together. [2]

.....

.....

(iv) The electronic configuration of carbon and sulfur are shown below.



Circle the letter **A**, **B**, **C** or **D** next to the correct statement about the compound formed between carbon and sulfur. [1]

A Electrons are transferred from carbon to sulfur to form a covalent compound with the formula CS_2.

B Electrons are shared between carbon and sulfur to form a covalent compound with the formula CS_2.

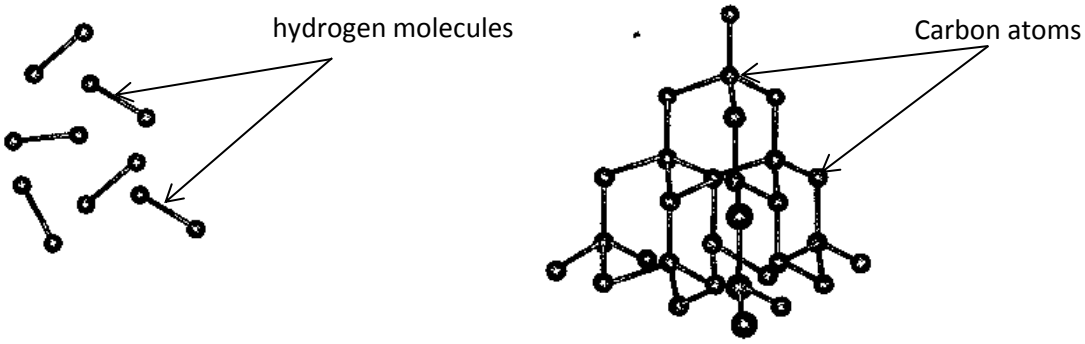
C Electrons are transferred from carbon to sulfur to form a covalent compound with the formula CS.

D Electrons are shared between carbon and sulfur to form a covalent compound with the formula CS.

(b) Using the electronic structures given, draw a dot and cross diagram to show the bonding in a molecule of water, H_2O. [2]

hydrogen = 1 oxygen = 2,6

(c) The following diagrams show the structures of hydrogen and diamond, which is a form of carbon.



Explain why diamond has a higher melting point than hydrogen. [3]

.....

.....

.....

.....

11

3. The following table contains information about the number of particles contained within atoms and ions **A** - **G**.

A, **B**, **C**, **D**, **E**, **F** and **G** are not chemical symbols.

	A	**B**	**C**	**D**	**E**	**F**	**G**
Number of electrons	8	10	9	10	10	11	10
Number of neutrons	10	10	10	10	12	12	12
Number of protons	8	8	9	10	10	11	11

(a) State the atomic number of **C**. ..... [1]

(b) Using the number of electrons, state to which group and period of the Periodic Table element **A** belongs. Explain your answer. [3]

Group ..... Period .....

.....

.....

(c) Choose a letter **A** - **G** which represents: [2]

a positive ion .....

a negative ion .....

(d) Give the letter **A** - **G** which represents an atom/ion with a mass number of 20. [1]

.....

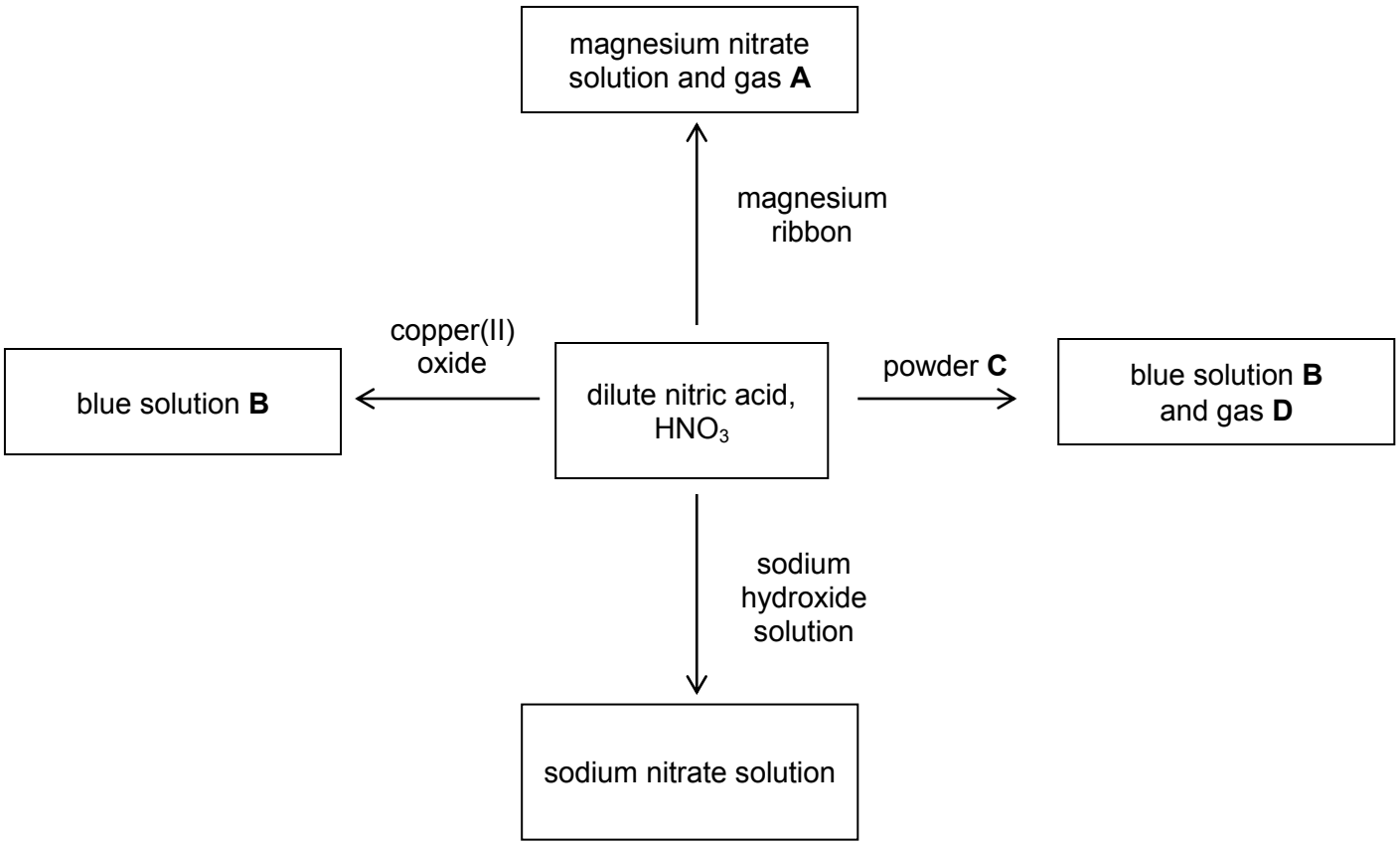
(e) State what is meant by the term isotope. Use information from the table to exemplify your answer. [2]

.....

.....

9

4. The following diagram shows some reactions of dilute nitric acid.



(a) Name the following substances. [3]

powder **C** …….

solution **B** …….

gas **D** …….

(b) Name gas **A** and describe how it can be identified. [2]

…….....

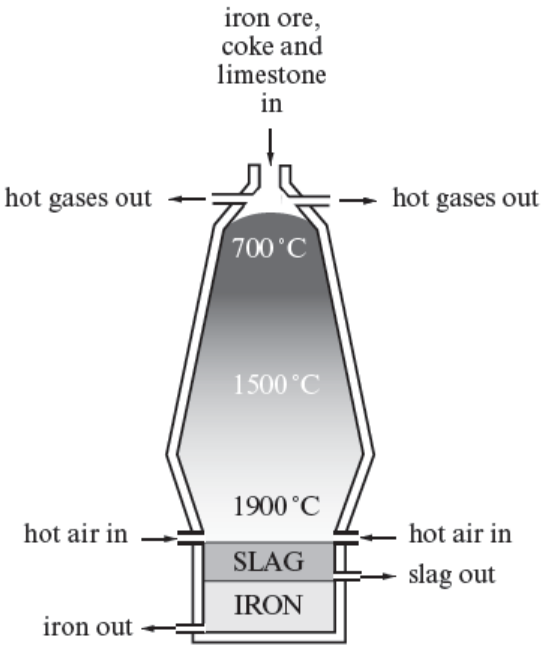
…….....

(c) Write a balanced **symbol** equation for the reaction between nitric acid and sodium hydroxide to form sodium nitrate. [2]

……..

7

5. (a) Iron can be extracted from its ore in the blast furnace.



In extracting the iron from its ore, the following reactions take place inside the furnace.

Reaction 1 $C + O_2 \rightarrow CO_2$

Reaction 2 $CO_2 + C \rightarrow 2CO$

Reaction 3 $2Fe_2O_3 + 3CO \rightarrow 4Fe + 3CO_2$

Reaction 4 $CaCO_3 \rightarrow CaO + CO_2$

Reaction 5 $CaO + SiO_2 \rightarrow CaSiO_3$

Explain the terms *reduction* and *neutralisation* with reference to suitable reactions occurring in the blast furnace. [5]

(i) reduction
*In your answer you need to refer to **two** reactions.*

.....

.....

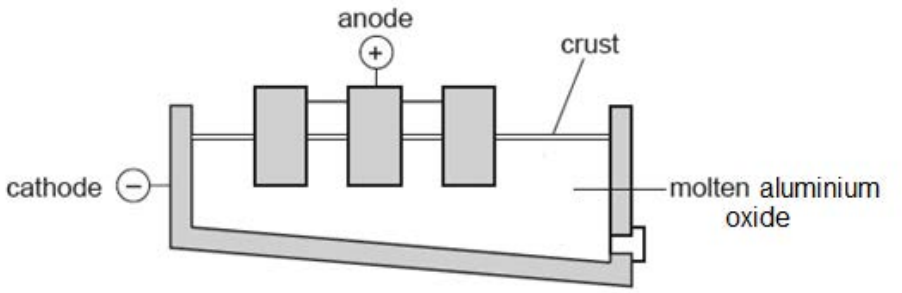
.....

(ii) neutralisation
*In your answer you need to refer to **one** reaction.*

.....

.....

(b) Aluminium is obtained by the electrolysis of molten aluminium oxide.



(i) Explain why aluminium is formed at the cathode. Include an electrode equation in your answer. [3]

.....

.....

.....

(ii) The equation below shows the overall reaction that takes place during electrolysis of aluminium oxide.

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Aluminium oxide is obtained from the ore bauxite. Bauxite from one mine contains 45 % aluminium oxide. Calculate the maximum mass of aluminium that could be produced from 1.02×10^6 kg of this bauxite.

[4]

mass = ... kg

(iii) Aluminium is a good electrical conductor and is therefore used to make power cables.

Give **two** *different* properties of aluminium and a use which relies on **both** of these properties. [2]

……

……

……

(c) The table below shows some information about three compounds which can be electrolysed to form chlorine.

Compound	Melting point (°C)	Solubility
lead(II) chloride	501	insoluble
sodium chloride	808	soluble
lead(II) chloride	373	insoluble

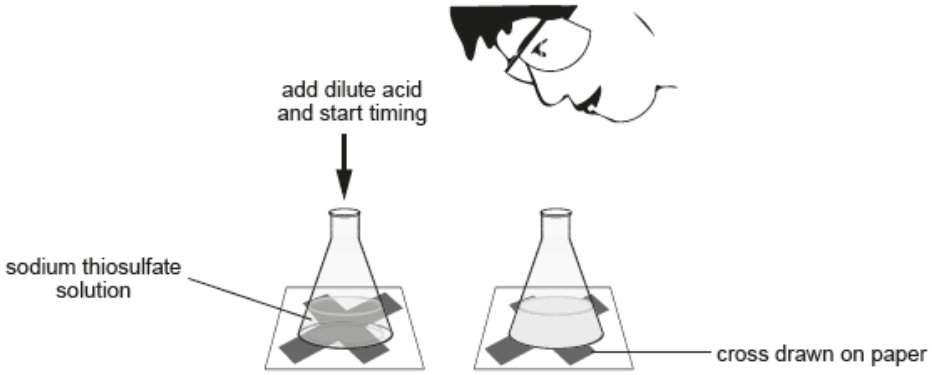
A teacher wanted her students to obtain a sample of chlorine by electrolysis. Explain which compound would be the **safest** for the students to use. [2]

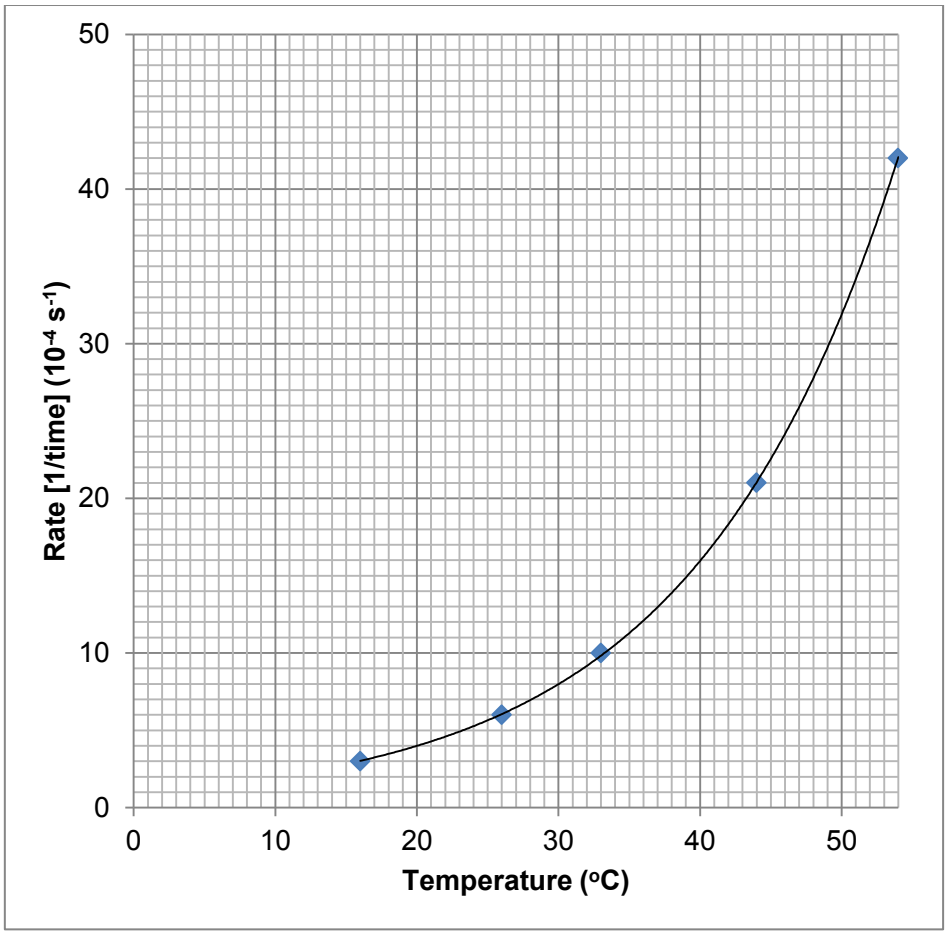
.....

.....

16

6. (a) The graph below shows how the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid changes with temperature.
The rate of reaction was measured by the 'disappearing cross'.





(i) Account for the relationship shown in the graph using particle theory. [3]

……

……

……

……

(ii) Use the graph to find the time taken, in seconds, for the cross to disappear at 50 °C. *Show your workings.* [2]

time taken = ……..seconds

(iii) Use the graph to find the temperature increase that is needed to double the rate. *Show your reasoning*. [2]

……

……

……

temperature increase = ……°C

(b) Nitric acid can be manufactured industrially in a reaction involving a platinum catalyst. Explain why using the platinum catalyst makes the reaction economic. [2]

……..……

……..……...

……..……..……

9

7. (a) Crude oil is a mixture of hydrocarbon compounds. Crude oil can be separated into simpler mixtures called fractions. Each fraction contains hydrocarbons of similar chain lengths.

(i) Explain how oil is separated into fractions. [2]

.....

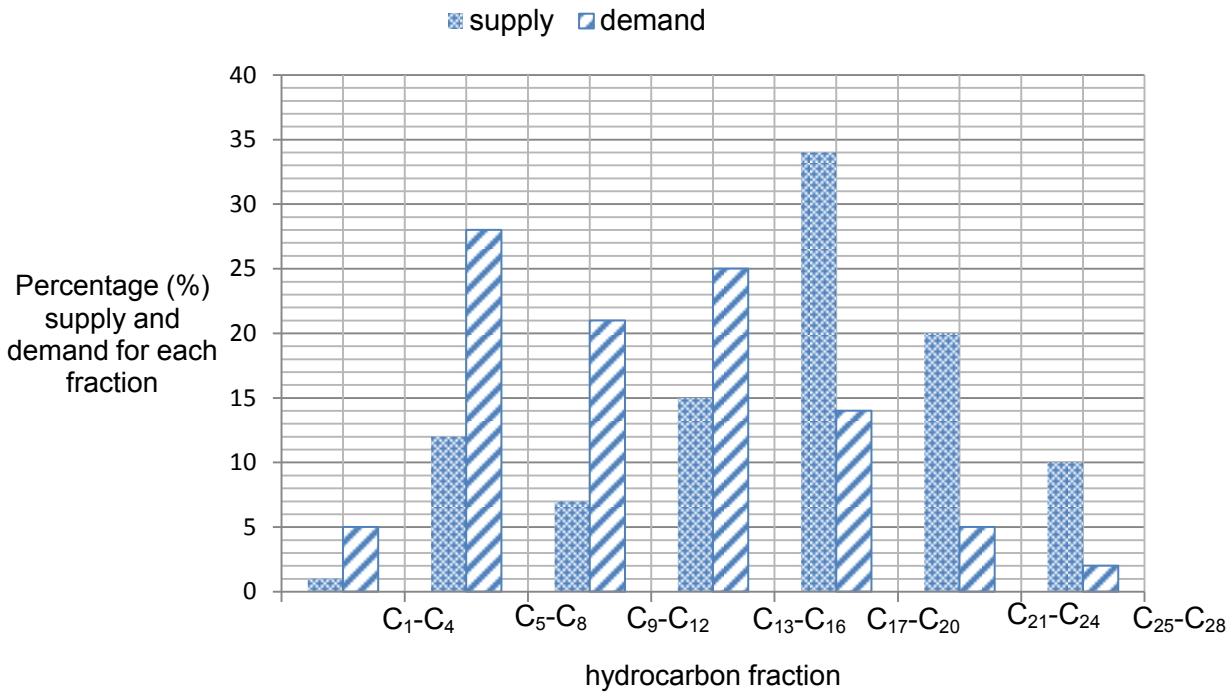
.....

.....

(ii) The C_{17}-C_{20} fraction contains a number of different alkanes. Give the formulae of an alkane found in this fraction. [1]

.....

(iii) The bar chart below shows the relative amounts of 'supply' and 'demand' for some hydrocarbon fractions.



Explain how oil companies process crude oil to address the differences in supply and demand of each fraction. [3]

.....

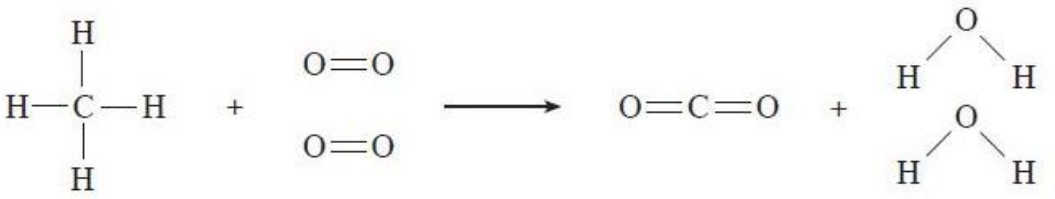
.....

.....

.....

(b) Methane and propane are used as fuels.

The burning of methane in air can be represented by the following equation.



The relative energies of these bonds are given in the table below.

Bond	Bond energy (kJ)
C – H	413
O = O	498
O – H	464
C = O	805

Calculate the overall energy change for the reaction. State whether the reaction is exothermic or endothermic and give a reason for your answer. [4]

energy change = ... kJ

…….....

…….....

(c) Propane is another fuel that burns in air.

(i) A sample of propane contains 0.72 g of carbon and 0.16 g of hydrogen.

Use this information to show that the formula of propane is C_3H_8. [3]

(ii) Calculate how many molecules there are in 132 g of propane. [3]

number of molecules = ...

(d) Polyester is produced from compounds formed from crude oil. Cotton is grown from plants.
The table below gives data for the complete life cycle assessment of jackets made from cotton and polyester.

Factor	Polyester per kg	Cotton per kg
energy used (MJ)	171.3	140.1
fuel (oil or gas) used (kg)	1.53	0
fertiliser used (kg)	0	467
sulfur dioxide emissions (g)	0.2	4.0

Jacqueline claims that making jackets from cotton rather than polyester is better for the environment because cotton comes from plants.
Use information from the table to discuss whether Jacqueline's claim is correct. [4]

……..……..……..

……

……..……..……..

……..……..……..

……...……..

……..……

20

8. Potassium chloride can be made by reacting an acid with an alkali.

Describe a laboratory method for making **crystals** of potassium chloride from a suitable acid and alkali. [6 QER]

Include a chemical equation in your answer.

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

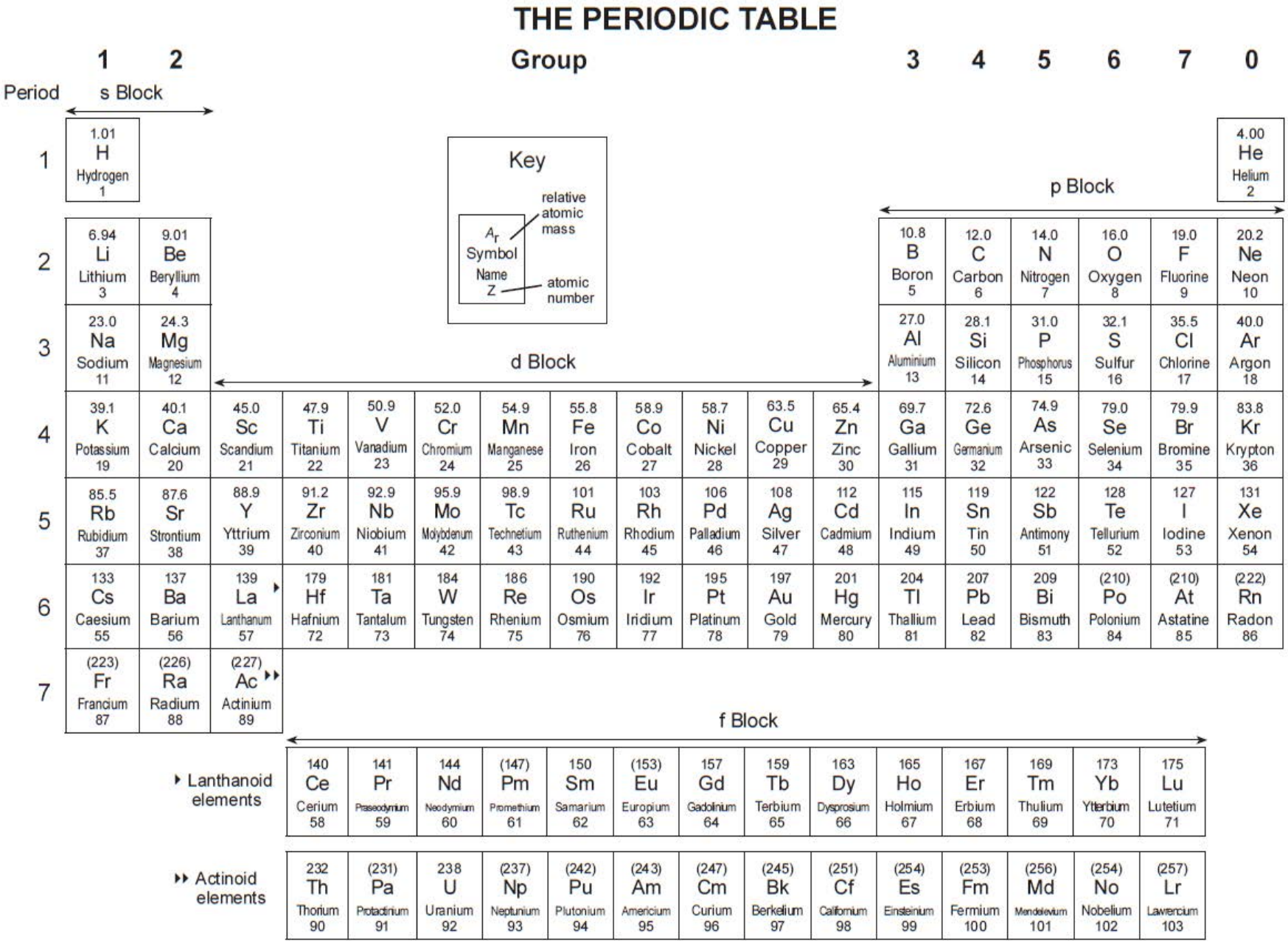
6

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	Formula	Name	Formula
Aluminium	Al^{3+}	Bromide	Br^-
Ammonium	NH_4^+	Carbonate	CO_3^{2-}
Barium	Ba^{2+}	Chloride	Cl^-
Calcium	Ca^{2+}	Fluoride	F^-
Copper(II)	Cu^{2+}	Hydroxide	OH^-
Hydrogen	H^+	Iodide	I^-
Iron(II)	Fe^{2+}	Nitrate	NO_3^-
Iron(III)	Fe^{3+}	Oxide	O^{2-}
Lithium	Li^+	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}		
Nickel	Ni^{2+}		
Potassium	K^+		
Silver	Ag^+		
Sodium	Na^+		
Zinc	Zn^{2+}		

Avogadro's number, $L = 6 \times 10^{23}$

THE PERIODIC TABLE



COMPONENT 2 – Concepts in Chemistry

HIGHER TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

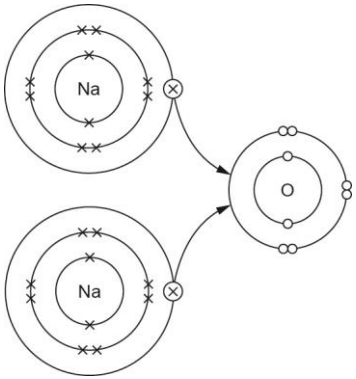
A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

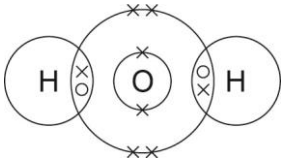
Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)		3.0 identified as anomalous result			1	1		1
		(ii)		Any of following points for (1) Not enough magnesium added Too much solution used Reading taken too quickly after addition / without stirring			1	1		1
	(b)	(i)		Both scales correct (1) All 5 points plotted correctly (1) Smooth curve drawn (1)		3		3	3	
		(ii)		0.8 g **because** no additional temperature increase when a greater mass added			1	1		1
	(c)	(i)		Iron is more reactive than copper (1) Displacement reaction occurs / iron displaces the copper (1)	1	1		2		2
		(ii)		Reactants – copper(II) sulfate **and** iron (1) Products – iron(II) sulfate **and** copper (1) Accept iron sulfate		2		2		
	(d)			$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$ (2) If equation not correct award (1) for $AgNO_3$ and Ag included on appropriate sides		2		2		
				Question 1 total	**1**	**8**	**3**	**12**	**3**	**5**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		 Movement of electrons as shown		1		1		
		(ii)		$[2:8]^{+}$ Electron configuration of sodium ions with + charge (1) Accept if this is shown only once $[2:8]^{2-}$ Electron configuration of oxide ion with 2– charge (1)		2		2		
		(iii)		Sodium and oxide ions have opposite charges (1) Strong attraction holds them together (1)	2			2		
		(iv)		B		1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			 Correct diagram as shown (2) Award (1) if hydrogen and oxygen atom included and correct representation of one bonding pair between them [hydrogen's only electrons]		2		2		
	(c)			Strong bonds between all atoms in diamond (1) Weak forces between hydrogen molecules (1) Requires lots of heat/energy to break the bonds in diamond but only small amount to overcome forces in hydrogen (1)	3			3		
				Question 2 total	**5**	**6**	**0**	**11**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			9		1		1		
	(b)			Group 6 **and** Period 2 (1) Group linked to number of electrons in outer shell (1) Period linked to number of (occupied) shells (1)	 1 1	1		 3		
	(c)			Positive ion – **G** (1) Negative ion – **B** (1)		2		2		
	(d)			**D**		1		1		
	(e)			Atoms having the same atomic number but different mass number/number of neutrons (1) Shown by **D** and **E** from the table – one has 10 neutrons and the other has 12 (1)	 2			 2		
				Question 3 total	**4**	**5**	**0**	**9**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			**C** – copper(II) carbonate (1) **B** – copper(II) nitrate (1) **D** – carbon dioxide (1)			3	3		
	(b)			**A** – hydrogen (1) Test with lighted splint – gives 'pop' (1)	1	1		2		1
	(c)			$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$ 1 mark RHS 1 mark LHS		2		2		
				Question 4 total	**1**	**3**	**3**	**7**	**0**	**1**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)		Reduction involves the loss of oxygen (1) Reaction 2 – carbon dioxide is reduced to carbon monoxide (1) Reaction 3 - iron(III) oxide is reduced to iron (1)	3			3		
		(ii)		Reaction between acid and base (1) In reaction 5, CaO (base) reacts with SiO_2 (acid) (1)	2			2		
	(b)	(i)		Aluminium ions are positive therefore attracted to cathode / negative electrode (1) Aluminium ions gain 3 electrons to form aluminium atoms (1) $Al^{3+} + 3e^- \rightarrow Al$ (1)	1 1	 1		 3		
		(ii)		$\left(\frac{45}{100}\right) \times 1.02 \times 10^6$ (1) M_r Al_2O_3 = 102 (1) Mass ratio 204 : 108 (1) Answer = 2.43×10^5 (1) Accept calculation by alternative method using mole ratios	1	 1 1 1		 4	 4	

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		Any two correct properties of aluminium – other than good electrical conductivity (1) Use linked to **both** properties (1) For example, low density and corrosion resistant therefore used to build aircraft (2)	2			2		
	(c)			Sodium chloride (1) Soluble therefore can be used in aqueous condition…no need for melting (1) Both needed for the mark			2	2		2
				Question 5 total	**10**	**4**	**2**	**16**	**4**	**2**

Question				Marking details	Marks Available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
6	(a)	(i)		Higher the temperature, the faster the rate (1) Particles given more energy, therefore more faster (1) Greater chance of collision (1)	1 1	1		3		
		(ii)		Rate = $\frac{1}{32 \times 10^{-4}}$ (1) 312.5 (1)		2		2	2	
		(iii)		10 °C change in temp doubles rate (1) Should demonstrate this using at least three temperature that show 10 °C show doubling (1) e.g. Temp (°C) rate (s^{-1}) 20 4 × … 30 8 × … 40 16 ×			2	2		
	(b)			The catalyst increases the rate of reaction (1) Otherwise higher temperature would be required which has higher cost (1)	2			2		
				Question 6 total	**4**	**3**	**2**	**9**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		By fractional distillation (1) Which separates fractions by differences in boiling point (1)	2			2		
		(ii)		One of $C_{17}H_{36}$ / $C_{18}H_{38}$ / $C_{19}H_{40}$ / $C_{20}H_{42}$		1		1		
		(iii)		Process of cracking used (1) which involves breaking longer chain molecules into smaller molecules (1) Since demand for C_{17}-C_{20} > supply then cracking produces smaller molecules which are in greater demand (1)	1	1	1	3		
	(b)			Energy required (in breaking bonds) = 2648 (1) Energy released (in forming bonds) = 3266 (1) –818 / 818 (1) Exothermic reaction **because** more energy is given out (in forming bonds) than is required (in breaking bonds) (1)	1	1 1 1		4	3	
	(c)	(i)		C $\frac{0.72}{12}$ H $\frac{0.16}{1}$ (1) C : H ratio is 0.06 : 0.16 (1) Simplest ratio is 3 : 8 therefore formula is C_3H_8 (1)			3	3	2	
		(ii)		M_r C_3H_8 = 44 (1) Number of moles = 3 (1) Number of molecules = $3 \times 6 \times 10^{23} = 1.8 \times 10^{24}$ (1)	1 1	1		3	3	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)			Marks awarded for discussion: Cotton • requires fertilisers to produce it • gives emissions of SO_2 – polyesters do not Both required for (1) Negative environmental impact of one of these e.g. SO_2 linked to acid rain (1) However less energy and fuel is used with cotton (1) Environmental benefit of this observation e.g. less use of crude oil reducing pollution risk (1)			4	4		
				Question 7 total	**6**	**6**	**8**	**20**	**8**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8				**Indicative content:** **AO2 allocation** - Suitable acid = hydrochloric acid, alkali = potassium hydroxide Word equation / symbol equation **AO1 allocation** - Acid /alkali interchangeable - measured amount of alkali in conical flask - add indicator *e.g. phenolphthalein* - add acid……. drop-wise near end point/ colour change….. to alkali - record volume of acid added - repeat without indicator ……..adding recorded volume of acid (or remove indicator with charcoal) - boil off some of the water - leave solution to evaporate - dry crystals obtained *Accept sequenced labelled diagrams* **5-6 marks**: Selects appropriate acid base. Detailed description of titration technique with indicator. Understands need to repeat titration without indicator. Describes how to reduce volume water (not to dryness) and then to obtain crystals. Balanced symbol equation. Described technique would allow candidate to obtain crystals. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.*	5	1		6		6

				3-4 marks: Selects appropriate acid & base. Description of titration technique with indicator. Understands need to repeat titration without indicator. Describes how to obtain crystals. Attempt at balanced symbol equation. Described technique would be suitable with some more detail. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1-2 marks**: Suitable acid and base identified. Basic description of a technique which involves neutralisation. May not describe all stages (e.g. need to repeat without indicator may be missing). Word equation. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure*. *There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks**: *No attempt made or no response worthy of credit.*						
				Question 8 total	**5**	**1**	**0**	**6**	**0**	**6**

COMPONENT 2 – Concepts in Chemistry

HIGHER TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	1	8	3	12	3	5
2	5	6	0	11	0	0
3	4	5	0	9	0	0
4	1	3	3	7	0	1
5	10	4	2	16	4	2
6	4	3	2	9	2	0
7	6	6	8	20	8	0
8	5	1	0	6	0	6
TOTAL	36	36	18	90	17	14

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 3

Concepts in Physics

FOUNDATION TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**5**	
2.	**5**	
3.	**6**	
4.	**7**	
5.	**10**	
6.	**8**	
7.	**15**	
8.	**11**	
9.	**6**	
10.	**8**	
11.	**9**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **8(a).**

EQUATION LIST

final velocity = initial velocity + acceleration × time	$v = u + at$
distance = ½ (initial velocity + final velocity) × time	$x = \frac{1}{2}(u + v)t$
(final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance	$v^2 = u^2 + 2ax$
change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2}kx^2$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_1I_1 = V_2I_2$

Answer **all** *questions*.

1. Study the table below which gives information about 4 domestic appliances.

Appliance	Voltage (V)	Power (kW)	Current (A)	Time used each day (hours)	Units used each day kWh
kettle	230	2.30	10.0	1.6	3.68
toaster	230	0.46	2.0	0.5	0.23
lamp	230	0.005	0.02	3	0.015
microwave oven	230	1.15	5.0	0.8	0.92

(a) Write down the power of the toaster in watts. [1]

……W

(b) Which appliance uses the least energy each day? [1]

……

(c) Appliances are protected with fuses rated in amps.
Circle the best fuse rating to use with the kettle. [1]

3 5 10 13

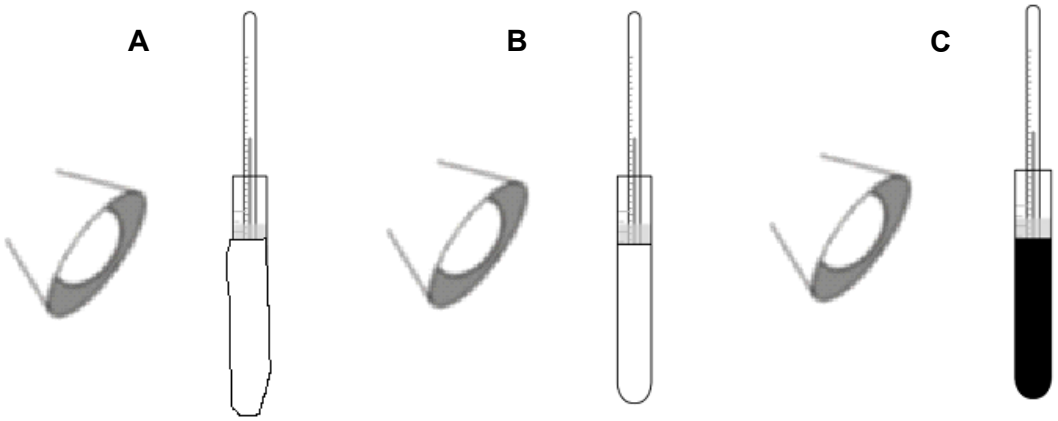
(d) Which appliance costs the most to use each day? …… [1]

(e) Which appliance uses half the energy used by the kettle every second? [1]

……

5

2. A group of pupils set up the following experiment to study how the colour and surface can have an effect on the transfer of energy.

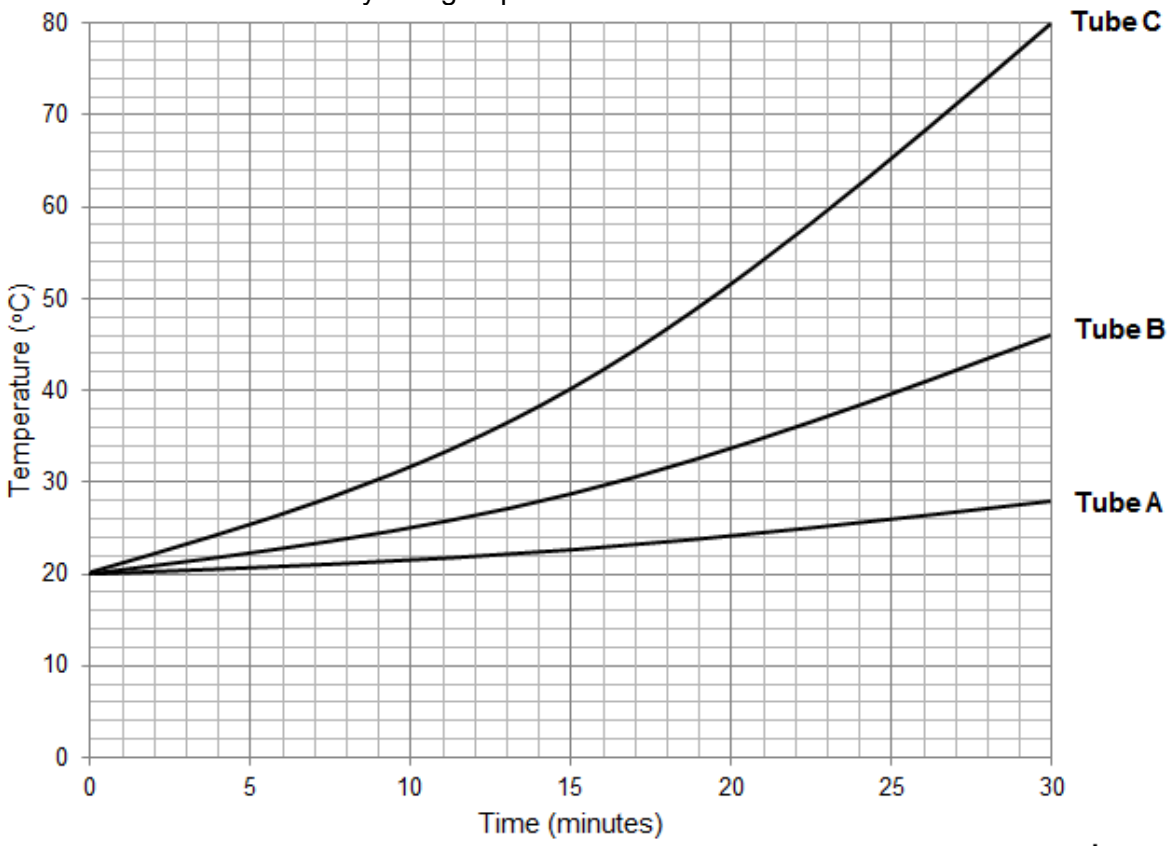


Boiling tube covered in shiny foil

Boiling tube painted white

Boiling tube painted black

The results obtained by one group are shown below.



(a) (i) Write down the starting temperature of the water. [1]

..... °C

(ii) Write down the time taken for the temperature of the water in tube **B** to rise to 36 °C. [1]

..... minutes

(iii) Determine the temperature difference between tubes **C** and **A** at the end of the experiment. [1]

..... °C

(b) Before the pupils did the experiment, they identified the variables that needed to be controlled.

This is the outline procedure they were given:

1. Fill each boiling tube with some water.
2. Place a thermometer in each tube.
3. Place each boiling tube near to a lamp. (The lamp used should be identical in each case.)
4. Record the temperature every 2 minutes to 30 minutes.

What variable did they need to control in: [2]

line 1 of the procedure;

……

line 3 of the procedure?

……

5

3. Newton's laws of motion are important in the way rockets move.

(a) **Tick (✓)** the box next to the statement that correctly completes each sentence.

(i) Newton's **3rd** Law states: [1]

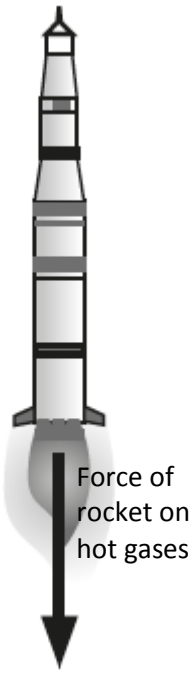
The forces of two objects on each other (action and reaction) are always:

- equal and act in opposite directions ☐
- equal and act in the same direction ☐
- different but act in opposite directions ☐
- different but act in the same direction ☐

(ii) A rocket exerts a force of 15 000 000 N on hot gases. The hot gases exert a force of: [1]

- 0 N ☐
- less than 15 000 000 N on the rocket ☐
- 15 000 000 N on the rocket ☐
- more than 15 000 000 N on the rocket ☐

(b) The diagram shows the direction of the force produced by a rocket on the hot gases.



Add an arrow to the diagram to show the direction of the force of the hot gases on the rocket. [1]

(c) (i) A model rocket has a weight of 5 N. The upward thrust on the rocket is 20 N. Calculate the resultant force on the rocket. [1]

resultant force = ...N

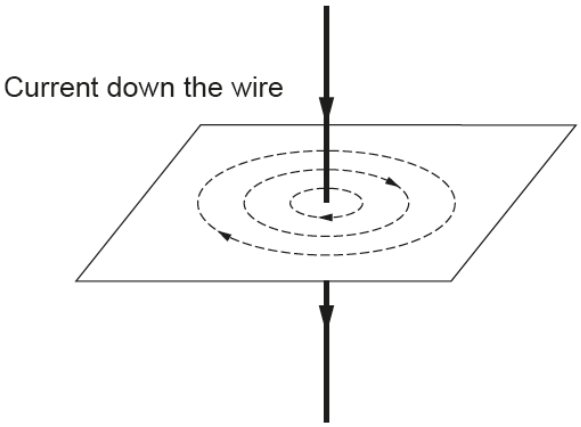
(ii) The mass of this rocket is 0·5 kg.
Calculate the acceleration of the model rocket using your answer to (c)(i) and the equation: [2]

force = mass × acceleration

acceleration = ...m/s^2

6

4. The diagram shows the shape of the magnetic field (as dashed lines) around a long straight wire. A current flows down the wire.



(a) Describe how you would show the shape and direction of the magnetic field around the current in a long straight wire, including the apparatus you would use. [2]

.....

.....

.....

..

(b) Describe the shape of the magnetic field lines around the wire. [1]

.....

(c) The current is now reversed. State how this affects the magnetic field. [1]

.....

(d) State what happens to the magnetic field when the current is turned off. [1]

.....

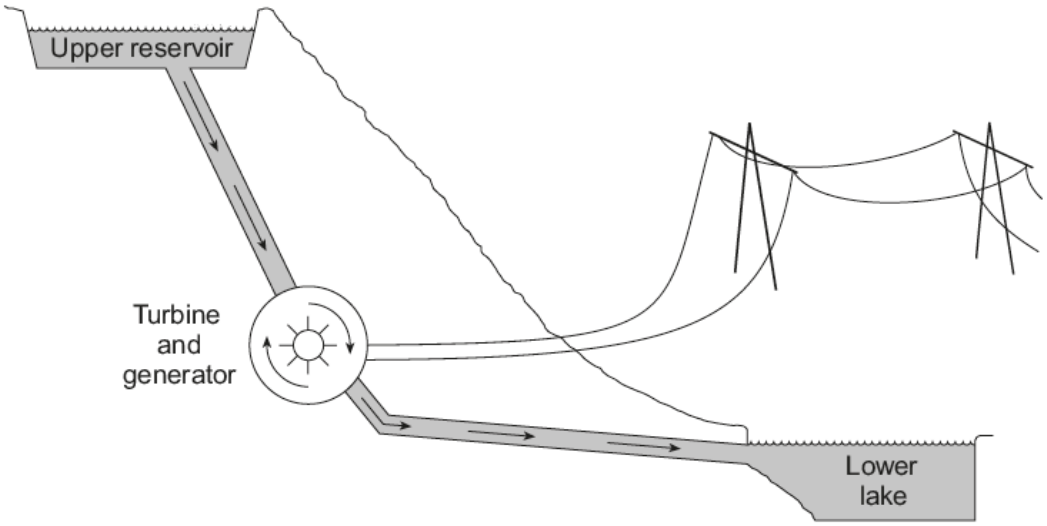
(e) State the **two** factors that affect the strength of the magnetic field near the wire. [2]

1. .....

2. .....

7

5. The diagram shows how electricity is generated in a hydroelectric power station that is in a National Park – an area of outstanding natural beauty.



The upper reservoir holds water that flows through the pipes to the lower lake. The electricity that is generated is transmitted along wires that are underground inside the National Park and along wires supported by pylons after that.

The upper reservoir is re-filled by pumping water back up from the lower reservoir.

The power station is only used when we need more electricity than all the other power stations in the National Grid can supply.

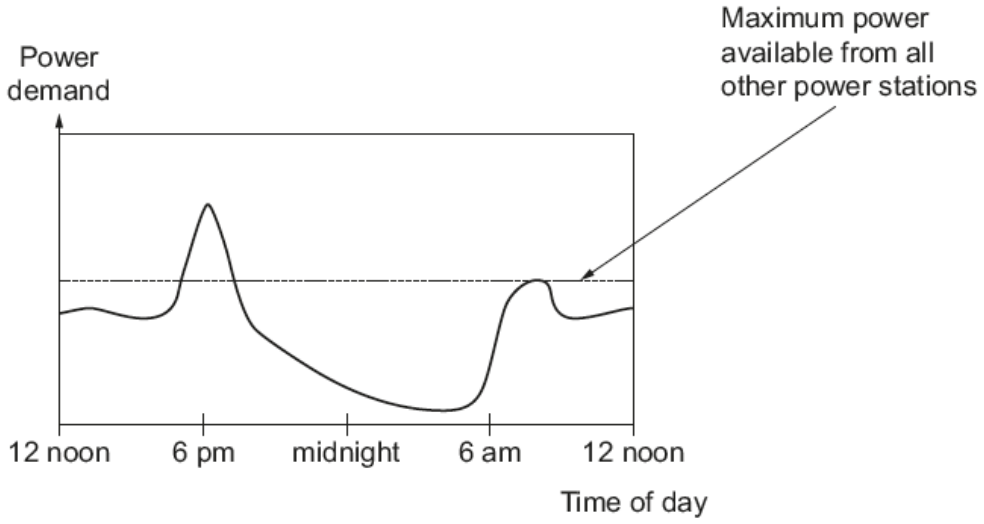
(a) Give a reason why the electrical wires are taken underground for the first few kilometres. [1]

.....

(b) Give a reason why this power station is used when there is a sudden increase in demand. [1]

.....

(c) The need for electricity changes through the day in the way shown below.



Explain what is happening in this hydroelectric power station between the times of:

(i) 4 pm. to 7 pm [2]

.....

.....

(ii) midnight to 3 am [2]

.....

.....

(d) (i) Each generator in this power station supplies 600 A at 440 000 V to the National Grid. There are **6** of these generators in the power station. Calculate the total power output of this power station. [3]

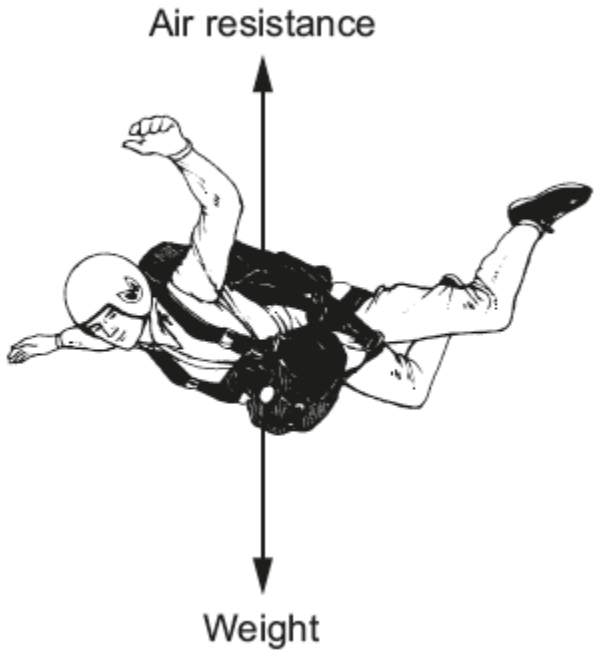
total power output = ...W

(ii) The mean power used by a home is 2 kW. Calculate the number of homes that could be supplied by this power station. [1]

number of homes = ...

10

6. A skydiver falls vertically.
She is acted upon by two forces as shown in the diagram.

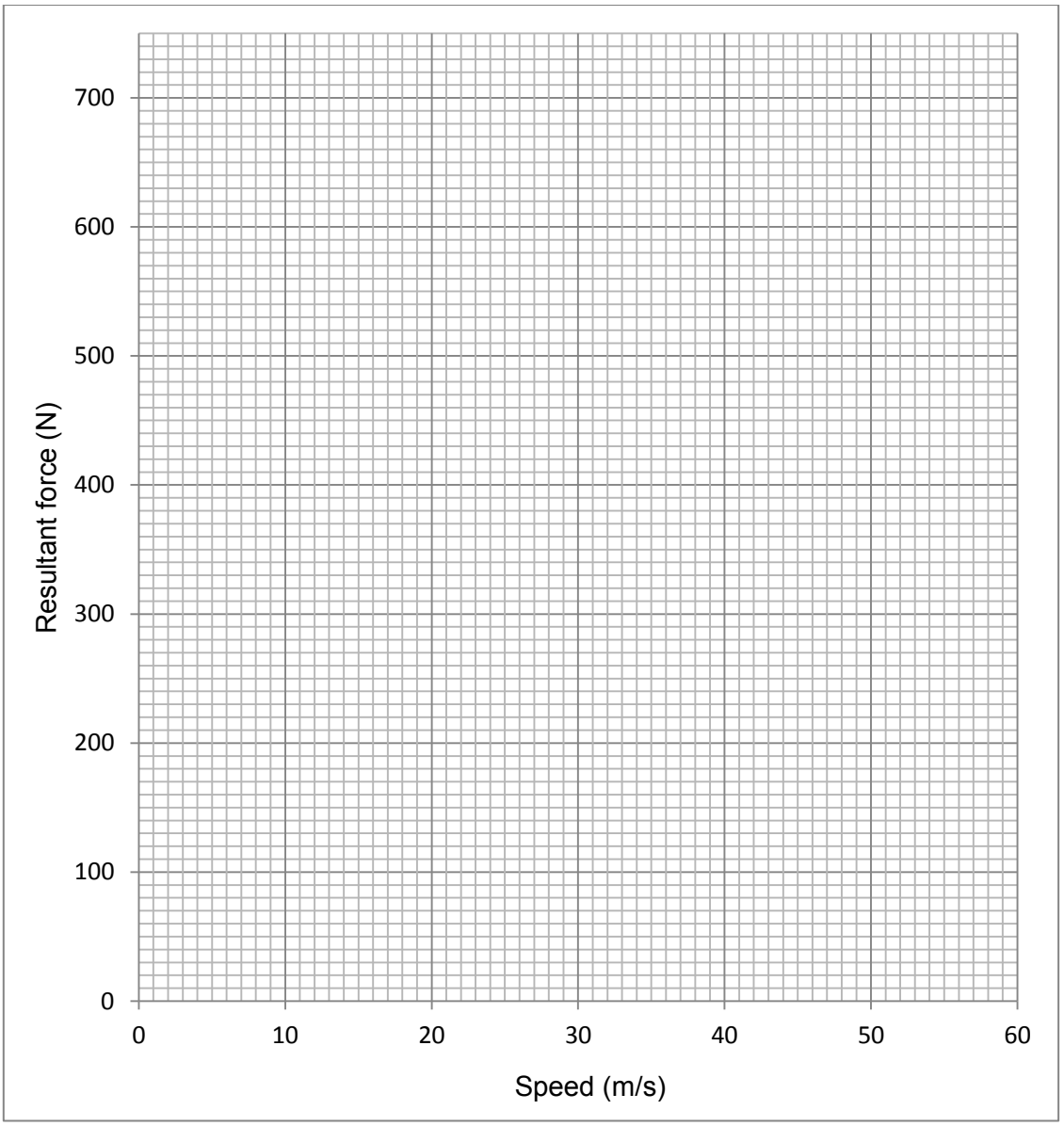


(a) The table gives some information about the forces on the skydiver during her fall.

Speed (m/s)	**Weight (N)**	**Air resistance (N)**	**Resultant force (N)**
0	700	0	700
10	……	280	420
20	700	490	210
30	……	630	70
50	700	……..	0

(i) **Complete** the table. [2]

(ii) Use the information in the table to plot a graph of resultant force against speed and draw a suitable line. [3]



(b) (i) State the value of the skydiver's speed when she is no longer accelerating. [1]

speed = ... m/s

(ii) The skydiver estimated that the air resistance is over 550 N at 25 m/s. Use the graph to calculate the air resistance and explain if she is correct. [2]

air resistance = ……. N

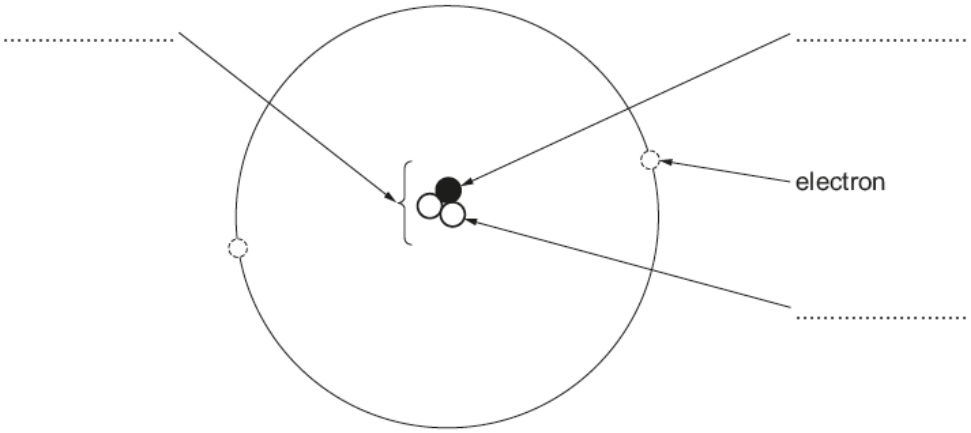
…….

8

7. The diagram shows the structure of a **neutral** atom of helium-3 ($^{3}_{2}\mathrm{He}$).

(a) Use the words in the box to label the parts of the atoms shown. [3]

electron	proton	isotope	neutron	nucleus



(b) Explain why there are **two** electrons in the atom. [2]

.....

.....

(c) Compare the structure of a helium-3 atom ($^{3}_{2}\mathrm{He}$) with a helium-4 atom ($^{4}_{2}\mathrm{He}$) in terms of the particles in the atoms. [3]

.....

.....

.....

.....

(d) Name the **force** acting in each case below. [2]

(i) Earth orbiting the Sun.

.....

(ii) The particle orbiting the centre of an atom.

.....

(e) Helium-7 ($^{7}_{2}\mathrm{He}$) is unstable and emits beta particles. It also emits electromagnetic radiation with a frequency of 7×10^{25} Hz.

(i) Explain what is meant by "electromagnetic radiation with frequency of 7×10^{25} Hz". [2]

……..

……

……..

(ii) Three different regions of the electromagnetic spectrum are **A**, **B** and **C.** The wavelength of the three regions is shown in metres (m) in the table below.

Region of electromagnetic spectrum	**Wavelength (m)**
A	$<1 \times 10^{-12}$
B	1×10^{-11} to 1×10^{-8}
C	1×10^{-7} to 4×10^{-7}

The speed of light is 300 000 000 m/s.

speed of light = frequency × wavelength

Use the information above to explain which part of the electromagnetic spectrum, **A**, **B** or **C,** the radiation emitted by helium-7 belongs to.
You should show any calculations that you make. [3]

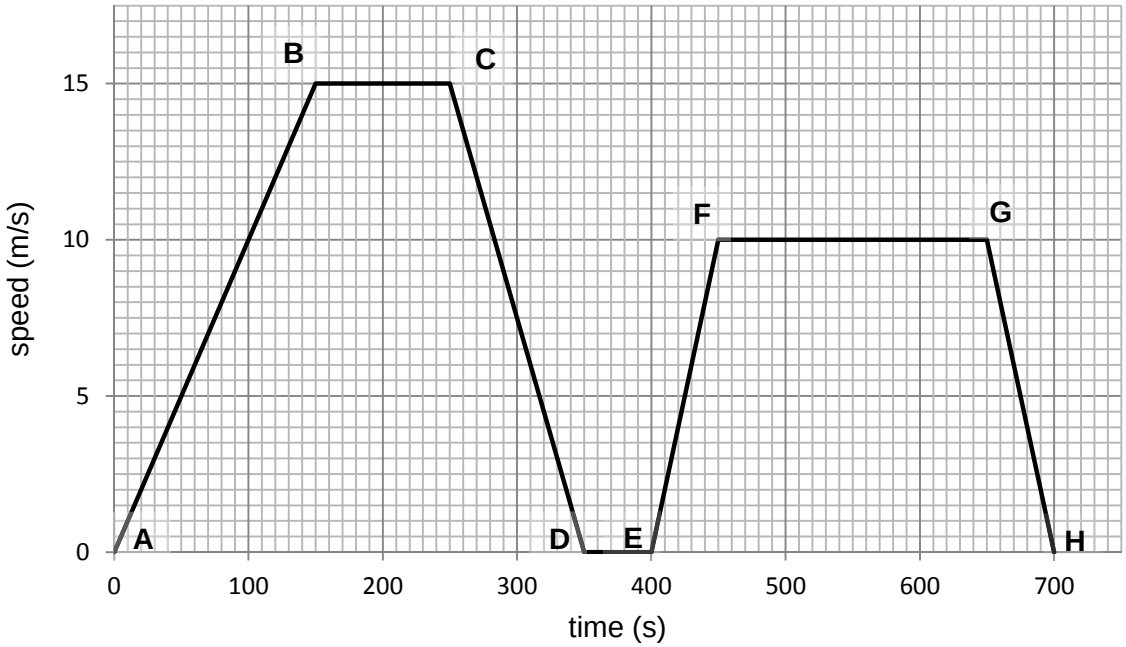
.....

.....

15

8. A student cycled from home to school and stopped briefly at a pedestrian crossing after travelling for 350 s.

The graph below shows how her speed changed along the journey.



(a) Describe fully the motion during the first 350 s. You should include some calculations relating to the motion.
*Do **not** include calculations of distance travelled*. [6 QER]

.....

.....

.....

.....

.....

.....

.....

.....

(b) (i) For how many seconds did the cyclist stop at the crossing? [1]

..... s

(ii) Between which **two** letters on the graph did the cyclist travel fastest? [1]

.....

(iii) Compare the distances travelled during the times when she travelled at constant speed. [3]

.....

.....

.....

11

9. (a) The time it takes to accelerate from 0 to 60 mph (i.e. 0 to 27 m/s) is a commonly used performance measure for cars. A car is advertised to accelerate from stationary (0 m/s) to a velocity of 27 m/s in 6.5 seconds.

Select a suitable equation from page 2 and use it to calculate its acceleration in that time. [4]

acceleration …… m/s^2

(b) Explain in terms of kinetic energy why reducing the speed limit on roads makes the risk of accidents less. [2]

.....

.....

.....

.....

6

10. Four competitors in a weightlifting competition have to lift a weight above their heads.

Their best lifts are displayed in the table below.

Weightlifter	Mass lifted (kg)	Force needed (N)	Distance lifted (m)	Work done (J)
A	68	680	2.4	1 632
B	72	……	2.3	1 656
C	74	740	2.4	…….
D	80	800	2.0	1 600

(a) **Complete** the table. [2]

(b) (i) Weightlifter **D** is the winner of the competition as he lifted the largest mass.
Using information from the table explain why he does the least amount of work. [2]

.....

.....

(ii) Weightlifter **D** lifts the weight in a time of 5 seconds.
Calculate the mean power for his lift. [2]

mean power = ... W

(iii) All four weightlifters lift their maximum weight in 5 seconds.
State and explain which weightlifter uses the least amount of energy per second. [2]

.....

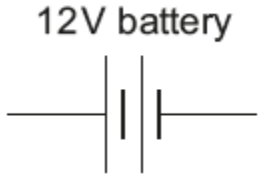
.....

.....

8

11. Students are given this information to set up a circuit in their physics lesson.
A 2 Ω resistor, a 4 Ω resistor and an ammeter are connected in series with a 12 V battery.

(a) Using the correct symbols complete the circuit diagram. [3]



(b) (i) Calculate the **total resistance** in the circuit. [1]

total resistance = ... Ω

(ii) Calculate the reading on the ammeter. [3]

ammeter reading ..... A

(iii) Both of the resistors get hot. Power depends both on the current and resistance. Explain which of the two resistors in this circuit will get hotter. [2]

.....

.....

.....

9

COMPONENT 3 – Concepts in Physics

FOUNDATION TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			460 [W]		1		1		
	(b)			Lamp			1	1		
	(c)			13 circled			1	1		
	(d)			Kettle			1	1		
	(e)			Microwave oven			1	1		
				Question 1 total	**0**	**1**	**4**	**5**	**0**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)		20 [^{o}C]	1			1		1
		(ii)		22 [minutes]		1		1	1	1
		(iii)		80 – 28 = 52 [^{o}C]		1		1		1
	(b)			line 1 volume/amount of water (1) line 3 distance between lamps and boiling tubes (1)			2	2		2
				Question 2 total	**1**	**2**	**2**	**5**	**1**	**5**

Question				Marking details	Marks Available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
3	(a)	(i)		Tick in box 1 i.e. equal and act in opposite directions Any extra ticks don't award the mark	1			1		
		(ii)		Tick in box 3 Any extra ticks don't award the mark		1		1		
	(b)			Arrow pointing upwards		1		1		
	(c)	(i)		20 - 5 = 15 [N]		1		1		
		(ii)		Manipulation and substitution: $\frac{15}{0.5}$ (1) Acceleration = 30 [m/s^2] (1)		2		2	2	
				Question 3 total	**1**	**5**	**0**	**6**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			Sprinkle iron filings on the card (1) Then follow the direction of a plotting compass around the circles to identify direction (1) **Alternative answer:** Place plotting compasses at a number of places on the card (1) And mark where the compasses point to build up the picture (1)	2			2		2
	(b)			Circles	1			1		1
	(c)			Direction reverses [but shape is unchanged]	1			1		1
	(d)			There is no field	1			1		1
	(e)			The distance of the point from the wire (1) The current in the wire (1)	2			2		2
				Question 4 total	**7**	**0**	**0**	**7**	**0**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			The power station is within an area of outstanding natural beauty			1	1		
	(b)			Capable of responding to sudden changes in demand / small start-up time	1			1		
	(c)	(i)		It is generating electricity (1) Because the demand is greater than all the other power stations can supply (1)			2	2		
		(ii)		It is pumping water to the upper reservoir (1) Because the demand is smaller than all the other power stations can supply / most people are asleep and not using much electricity (1)			2	2		
	(d)	(i)		Recall of: $P = V \times I$ (1) Power from one generator is: Substitution: P = 440 000 × 600 = 264 000 000 [W](1) Total power = 6 × 264 000 000 = 1 584 000 000 [W] (1)	1 1	 1		3	2	
		(ii)		$\frac{1584\,000\,000}{2\,000}$ = 792 000		1		1	1	
				Question 5 total	**3**	**2**	**5**	**10**	**3**	**0**

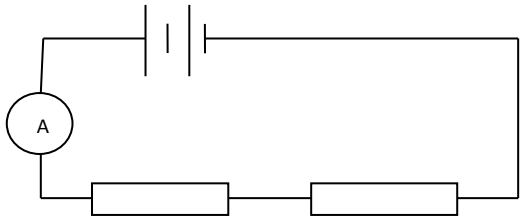
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)		700 in both cells in the weight column (1) 700 in bottom cell in air resistance column (1)	1	1		2		
		(ii)		All 5 points plotted correctly **award 2 marks** 4 points plotted correctly **award 1 mark only** Good curve of best fit consistent with the data (1)		3		3	3	
	(b)	(i)		50 [m/s]			1	1		
		(ii)		Resultant force = 120 [N] from graph (1) Air resistance = 700 – 120 = 580 [N] which is (just) over 550[N] and is therefore consistent with skydiver's estimate (1) Both 580[N] and explanation required to earn second mark		1	1	2		
				Question 6 total	**1**	**5**	**2**	**8**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Nucleus on left side (1) Neutron on upper right side(1) Proton on lower right side (1)	3			3		
	(b)			They have equal and opposite charge to the protons in the nucleus (1) So need to have two for the atom to be neutral over all (1)	1	1		2		
	(c)			They both have the same number of protons / 2 protons (1) And the same number of electrons / 2 electrons (1) But the $^{4}_{2}\mathrm{He}$ isotope has 1 more neutron in its nucleus (1)	3			3		
	(d)	(i)		Gravitational (accept gravity)	1			1		
		(ii)		Electrostatic (accept electric)	1			1		
	(e)	(i)		Electromagnetic radiation is a transverse wave / radiation that travels at the speed of light (1) Frequency is the number of waves produced by a source each second / 7×10^{25} waves produced by a source each second / 7×10^{25} waves per second / the number of waves per second (1)	2			2		
		(ii)		Wavelength = $\frac{300\,000\,000}{7 \times 10^{25}}$ (1) = 2.2×10^{-16} which is less than 1×10^{-12} (1) so it belongs to A (1) Allow **ecf** Conclusion must be consistent with calculations to award the mark		1	1 1	3	2	
				Question 7 total	**11**	**2**	**2**	**15**	**2**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			**Indicative content:** From A to B the speed increases uniformly from 0 m/s to 15 m/s in a time of 150 s, giving an acceleration value of 0.1 m/s^2. From B to C the speed stays constant at 15 m/s for 100 s. From C to D the speed drops uniformly from 15 m/s to 0 m/s between 250 s and 350 s giving an acceleration of – 0.15 m/s^2 (or a deceleration of + 0.15 m/s^2). **AO allocation** AO1 – Description of motion AO2 – Acceleration and deceleration calculations **5 – 6 marks** Detailed description of motion with calculations of acceleration and deceleration present. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.* **3 – 4 marks** A description of motion with calculation of either acceleration or deceleration present. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1 – 2 marks** A basic description of motion is given. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks** *No attempt made or no response worthy of credit.*	4	2		6	6	
	(b)	(i)		50		1		1	1	
		(ii)		BC		1		1		
		(iii)		From BC: Distance travelled = 1 500 [m] (1) From FG: Distance travelled = 2 000 [m] (1) She travels 500 m more from F to G than from B to C (1)		1 1	1	3	3	
				Question 8 total	**4**	**6**	**1**	**11**	**10**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			Selection of: $v = u + at$ (1) Manipulation of equation: $a = \frac{(v-u)}{t}$ accept by implication (1) Substitution: $\frac{27}{6.5}$ (1) Acceleration = 4.2 [m/s^2] (accept 4.1, 4.15) (1)	1	1 1 1		4	3	
	(b)			A car travelling at a slower speed has significantly less KE (1) So less time needed to stop the car / less stopping distance (1)		2		2		
				Question 9 total	**1**	**5**	**0**	**6**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			720 in cell in the force needed column (1) 1 776 in cell in the work done column (1)		2		2	2	
	(b)	(i)		Smallest distance lifted compared to the other weightlifters (1) Relevant work done = force × distance comment e.g. weightlifter D has the lowest product of force and distance (1)	1	1		2		
		(ii)		Recall of: $\text{power} = \frac{\text{energy transferred}}{\text{time}}$ (1) $\frac{1600}{5} = 320$ [W] (1)	1	1		2	1	
		(iii)		Competitor D (1) Least work done in set time (1)		2		2		
				Question 10 total	**2**	**6**	**0**	**8**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			Single complete loop (1) Resistor symbol correct (1) Ammeter symbol correct (1)  	3			3		3
	(b)	(i)		4 + 2 = 6 [Ω]	1			1		1
		(ii)		Recall of: $V = IR$ (1) Manipulation: $I = \frac{12}{6}$ (1) Ammeter reading = 2 [A] (1)	1	1 1		3		3
		(iii)		The 4 Ω resistor gets the hottest / has the biggest power (1) Identical (current)^2 through each resistor but multiplied by higher resistance (1)			2	2		2
				Question 11 total	**5**	**2**	**2**	**9**	**0**	**9**

COMPONENT 3 – Concepts in Physics

FOUNDATION TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
1	0	1	4	5	0	0
2	1	2	2	5	1	5
3	1	5	0	6	2	0
4	7	0	0	7	0	7
5	3	2	5	10	3	0
6	1	5	2	8	3	0
7	11	2	2	15	2	0
8	4	6	1	11	10	0
9	1	5	0	6	3	0
10	2	6	0	8	3	0
11	5	2	2	9	0	9
TOTAL	**36**	**36**	**18**	**90**	**27**	**21**

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 3

Concepts in Physics

HIGHER TIER

SAMPLE PAPER

(1 hour 45 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**8**	
3.	**9**	
4.	**9**	
5.	**7**	
6.	**10**	
7.	**11**	
8.	**9**	
9.	**4**	
10.	**11**	
11.	**6**	
Total	**90**	

ADDITIONAL MATERIALS
In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer all questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **11**.

EQUATION LIST

final velocity = initial velocity + acceleration × time	$v = u + at$
distance = ½ (initial velocity + final velocity) × time	$x = \frac{1}{2}(u + v)t$
(final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance	$v^2 = u^2 + 2ax$
distance = initial velocity × time + ½ × acceleration × time^2	$x = ut + \frac{1}{2}at^2$
change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2}kx^2$
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length	$F = BIl$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in second coil	$V_1I_1 = V_2I_2$

Answer **all** *questions*.

1. (a) The time it takes to accelerate from 0 to 60 mph (i.e. 0 to 27 m/s) is a commonly used performance measure for cars. A car is advertised to accelerate from stationary (0 m/s) to a velocity of 27 m/s in 6.5 seconds.

Select a suitable equation from page 2 and use it to calculate its acceleration in that time. [4]

acceleration …… m/s^2

(b) Explain in terms of kinetic energy why reducing the speed limit on roads makes the risk of accidents less. [2]

.....

.....

.....

.....

6

2. Four competitors in a weightlifting competition have to lift a weight above their heads.

Their best lifts are displayed in the table below.

Weightlifter	Mass lifted (kg)	Force needed (N)	Distance lifted (m)	Work done (J)
A	68	680	2.4	1 632
B	72	……	2.3	1 656
C	74	740	2.4	…….
D	80	800	2.0	1 600

(a) **Complete** the table. [2]

(b) (i) Weightlifter **D** is the winner of the competition as he lifted the largest mass.
Using information from the table explain why he does the least amount of work. [2]

.....

.....

(ii) Weightlifter **D** lifts the weight in a time of 5 seconds.
Calculate the mean power for his lift. [2]

mean power = ... W

(iii) All four weightlifters lift their maximum weight in 5 seconds.
State and explain which weightlifter uses the least amount of energy per second. [2]

.....

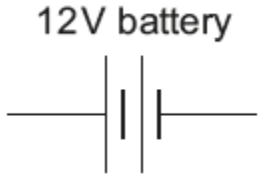
.....

.....

8

3. Students are given this information to set up a circuit in their physics lesson.
A 2 Ω resistor, a 4 Ω resistor and an ammeter are connected in series with a 12 V battery.

(a) Using the correct symbols complete the circuit diagram. [3]



(b) (i) Calculate the **total resistance** in the circuit. [1]

total resistance = ... Ω

(ii) Calculate the reading on the ammeter. [3]

ammeter reading ..... A

(iii) Both of the resistors get hot. Power depends both on the current and resistance. Explain which of the two resistors in this circuit will get hotter. [2]

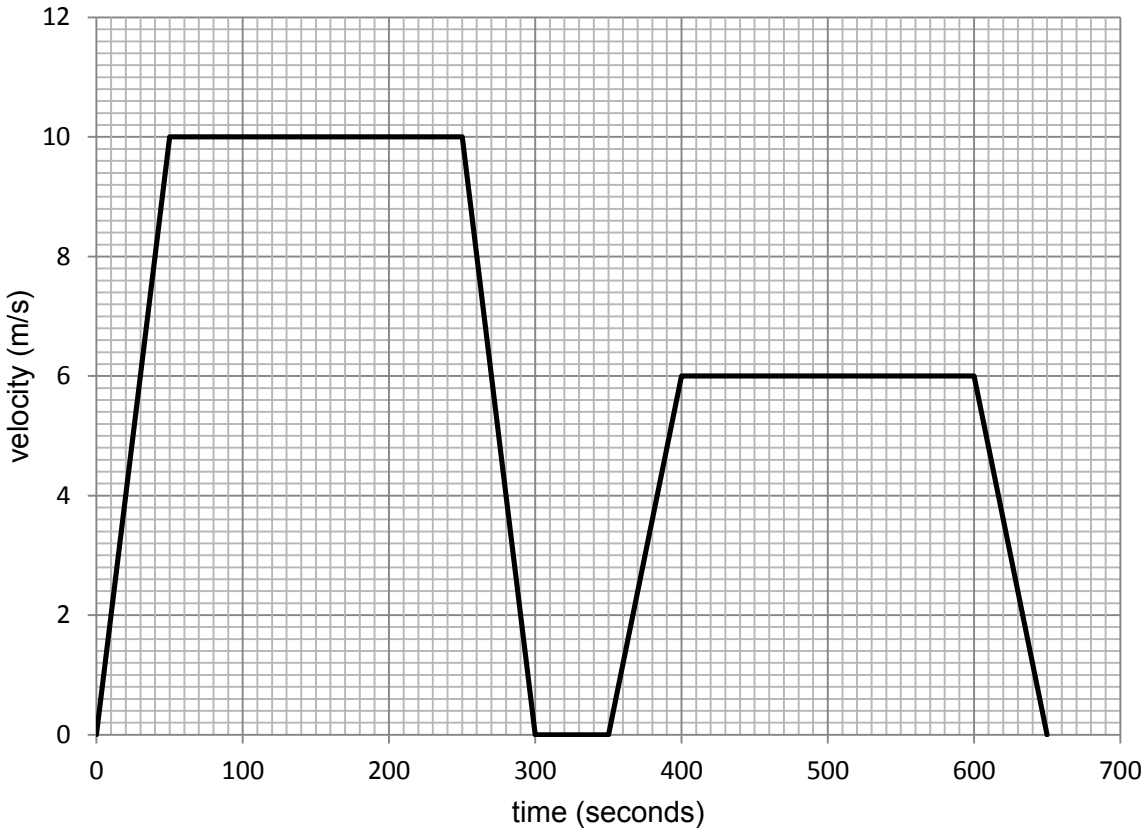
.....

.....

.....

9

4. A student cycles from school to her home. The graph represents her whole journey. She has to stop during her journey at a pedestrian crossing.



(a) (i) Calculate the change in velocity as she approaches and stops at the pedestrian crossing. [1]

change in velocity ..... m/s

(ii) Calculate the student's deceleration when she is approaching the crossing. [3]

deceleration = ... m/s^2

(b) The student and her bike have a total mass of 55 kg. Calculate the resultant force acting on the student and her bike as she decelerates to the crossing. [3]

resultant force = ... N

(c) Explain how the graph shows that the cyclist's mean velocity for the part of her journey before stopping at the pedestrian crossing is greater than for the part of her journey after stopping. [2]

.....

.....

.....

9

5. The game of squash uses a small hollow rubber ball. One measure of the bounciness of a squash ball is the coefficient of restitution, e.

$$e = \frac{\text{velocity after bounce}}{\text{velocity before bounce}}$$

For a ball dropped on to a surface, the coefficient of restitution can also be calculated using:

$$e = \frac{\sqrt{(\text{height from which the ball is dropped})}}{\sqrt{(\text{height to which the ball bounces})}}$$

Jacob is a keen squash player. He used the procedure below to measure the coefficient of restitution of a squash ball.

Procedure

1. Place a squash ball into the water bath set to 15°C so it is completely submerged and leave for 5 minutes.
2. Set up the metre ruler so one end is on the floor using the clamp and stand to support it.
3. Use the tongs to remove the squash ball.
4. Drop the ball from level with the top of the metre ruler and watch carefully to record the height to which it bounces.
5. Increase the temperature of the water bath by 10° and repeat steps 1 to 4 .

(a) Suggest **two** ways in which Jacob could change the procedure to improve the reliability of his results. [2]

……

……

(b) Jacob's results are shown below.

Temperature of ball (°C)	Height dropped from (m)	Height ball bounced to (m)	Coefficient of restitution
15	1.00	0.15	0.38729
25	1.00	0.20	0.4472
35	1.00	0.30	0.5477
45	1.00	0.35	0.5916

Comment on the number of significant figures he used to record the coefficient of restitution. [1]

……

……

(c) Jacob knows from experience that the ball gets faster as a game progresses and he uses this to his advantage when playing less experienced players. Use the data from the experiment to help explain his observation. [4]

……

……

……

……

……

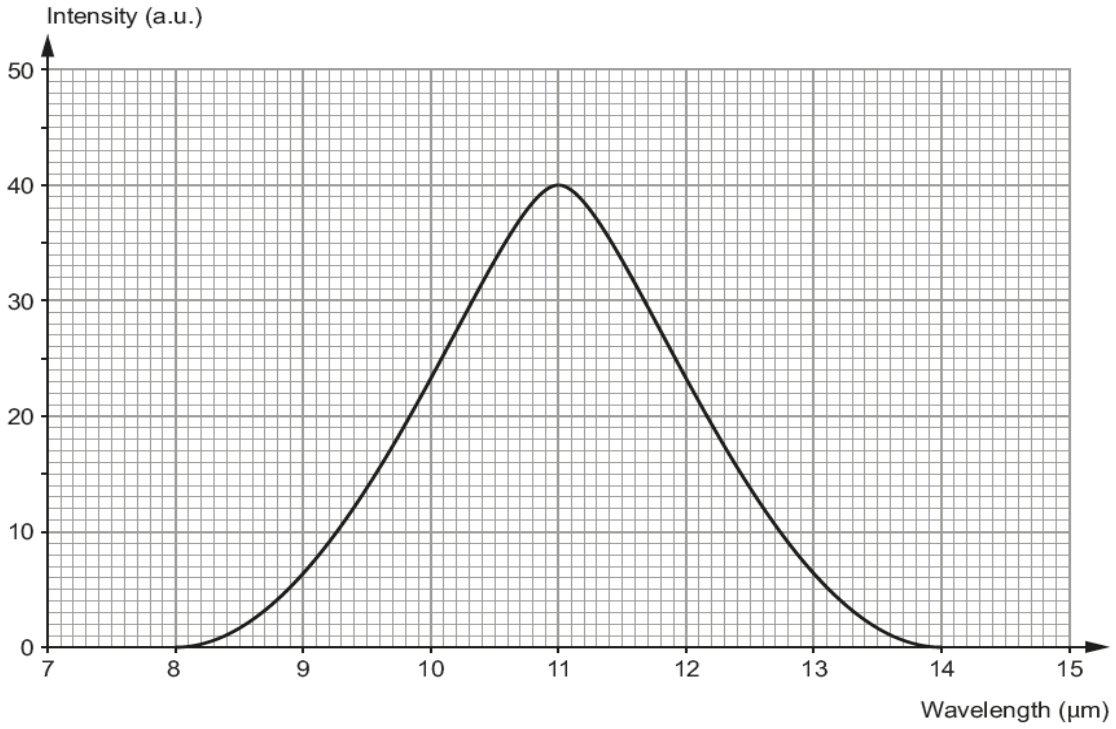
7

6. Explosions on the surface of the Sun happen frequently. After an explosion a pulse of electromagnetic waves (em waves) immediately followed by a stream of charged particles is radiated out into space.

(a) The em pulse takes 500 seconds to travel from the Sun to the surface of the Earth. The stream of charged particles travels at a speed of 3.2×10^6 m/s. Calculate how long it take for the charged particles to arrive at Earth. (speed of light, $c = 3 \times 10^8$ m/s) [4]

time = …….. s

(b) The pulse of em waves emitted from the Sun is shown on the graph below.



The wavelength range of different parts of the electromagnetic spectrum is shown below.

Electromagnetic radiation	Wavelength (nm)
gamma radiation	$<10^{-3}$
X-rays	1 - 0.001
ultraviolet	400 - 1
visible	750 - 400
infra-red	2 500 - 750
microwave	10^6 – 2 500
radio waves	$>10^6$

1×10^6 μm = 1 m
1×10^9 nm = 1 m

(i) State from which part of the electromagnetic spectrum the wavelength of the most intense part of the pulse is found. [1]

.....

(ii) An em wave sensor based on Earth is used as an early warning system. It can only detect em waves in the frequency range 1.2×10^7 Hz to 6.0×10^9 Hz.
Determine if the most intense part of the em pulse would be detected by the sensor. [3]
Speed of light, c = 3×10^8 m/s

.....

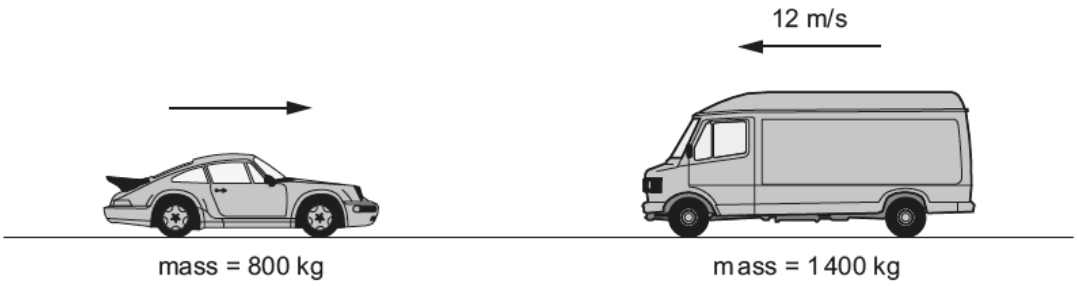
.....

(c) A series of nuclear reactions occur in the Sun leading to the formation of new elements. One step involves helium-7 ($^7_2\mathrm{He}$) which decays emitting both gamma radiation and beta particles.
Complete the following equation to show the decay of the helium-7 nucleus. [2]

$$^{7}_{2}\mathrm{He} \rightarrow {}^{\cdots}_{\cdots}\beta + {}^{\cdots}_{\cdots}\mathrm{Li}$$

10

7. (a) CCTV (closed-circuit television) recorded a head-on crash between a car and van. The film showed that the vehicles came to an immediate stop when they collided. The tachometer (onboard computer) of the van reads a speed of 12 m/s at the point of impact.



(a) (i) Calculate the momentum of the van before the collision. [2]

momentum = ... kg m/s

(ii) State the principle of conservation of momentum. [2]

.....

.....

.....

(iii) Use the principle of conservation of momentum to find the speed of the car just before the collision. [2]

speed = …… m/s

(iv) The speed limit on the road is 30 miles per hour (30 mph). The car driver claims to have been driving below the speed limit.
Explain whether the statement made by the driver is consistent with the evidence from the CCTV.
2 mph is equivalent to 0.90 m/s. [2]

.....

.....

(b) The front of the car is designed to crumple in a head-on collision.
Using the concept of momentum, explain why a crumple zone should reduce passenger injury in this type of crash. [3]

.....

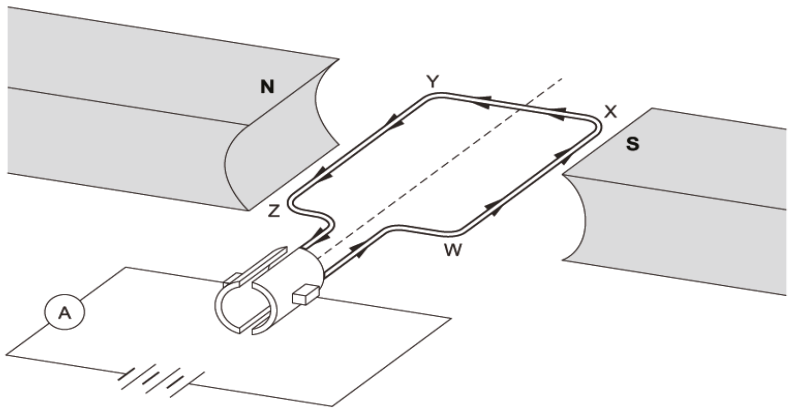
.....

.....

.....

11

8. The diagram represents a simple electric motor that a pupil investigates in their lesson.
The current in the coil flows from **W** to **Z**. This is shown on the diagram.
An ammeter is used to measure the current through the coil.



(a) Use the diagram to explain how you can determine the direction in which the coil rotates. [3]

.....

.....

.....

(b) The pupil would like the motor coil to rotate in the opposite direction. Give **two** different ways that could make this happen. [2]

.....

.....

(c) The length of **YZ** is 0.12 m and the magnetic field strength is 5 mT. Select an equation from page 2, to calculate the reading on the ammeter if the force is 2.4×10^{-3} N. [2]

ammeter reading ..... A

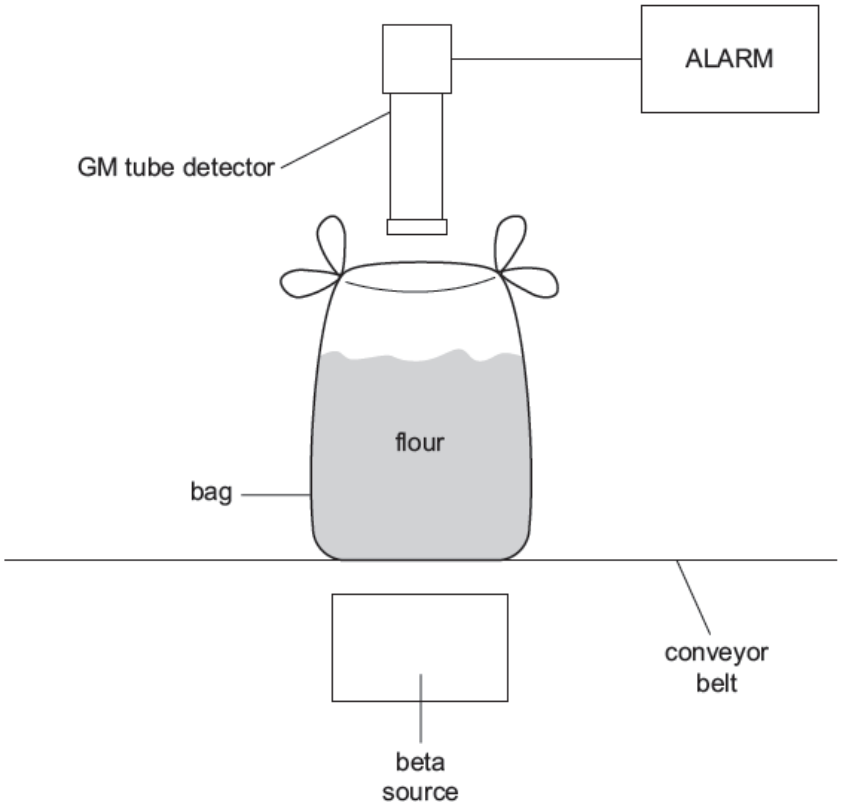
(d) Explain what the effect would be on the coil if the current supplied were doubled and the magnetic field strength halved. [2]

.....

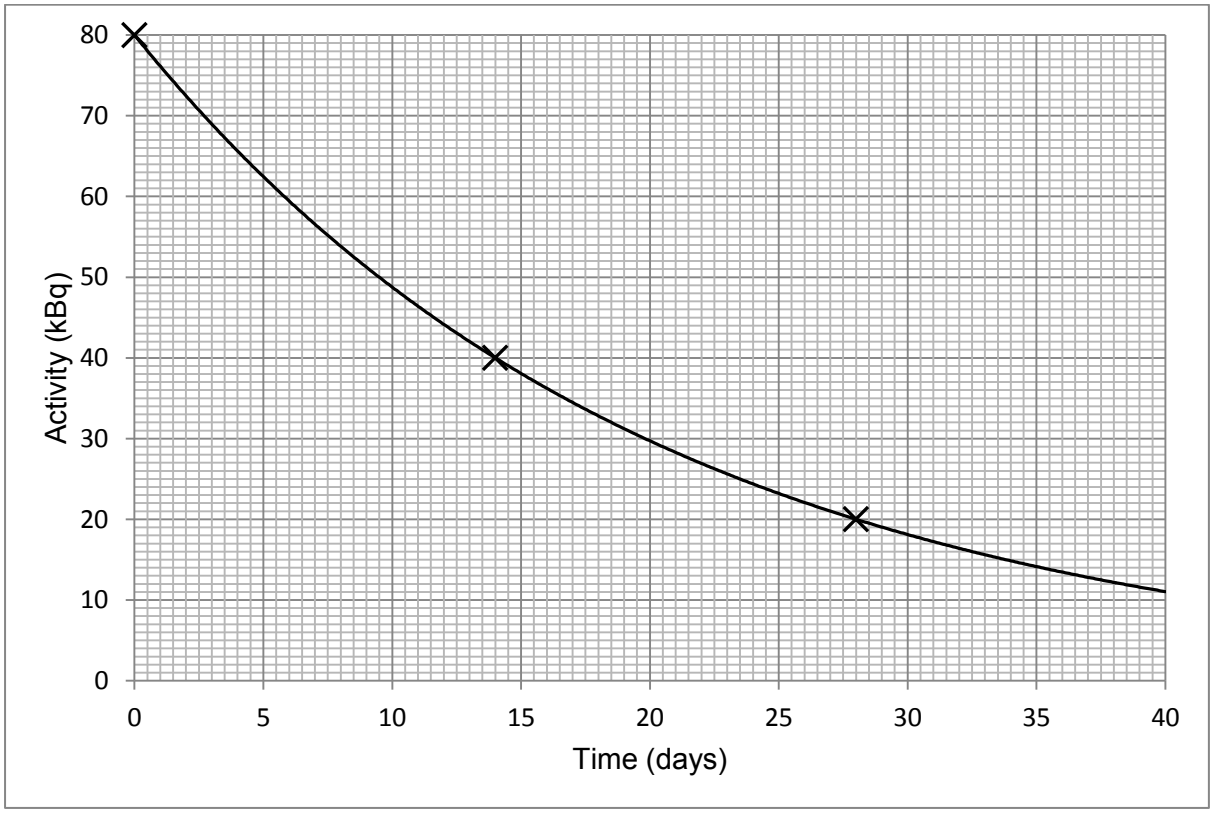
.....

.....

9. Bags of flour move along a conveyor belt in a factory. A radioactive beta (β) source is used to monitor the amount of flour contained. If the count rate from the GM tube drops below a certain level, then the bag is too full and an alarm sounds.



The company who sell the radioactive source to the factory also supply them with a graph of information about the beta (β) radioisotope.



(a) The factory is advised to replace their radioactive source after 6 half-lives. Using data from the graph, calculate the maximum number of days the source can be used before it needs to be replaced. [2]

maximum number of days = …….

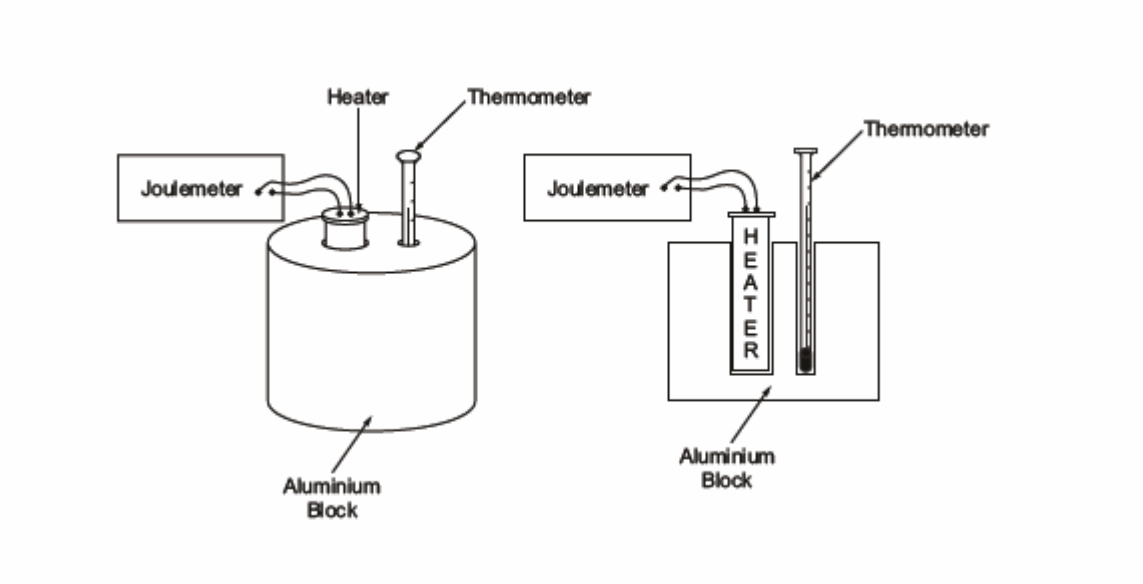
(b) The source currently being used was bought with an activity of 960 kBq. When tested it was found to have an activity of only 14 kBq. Use this information to explain any action the factory needs to take, if any, to improve testing. [2]

.....

.....

7

10. This apparatus was used by a pupil to determine the specific heat capacity of an aluminium block.

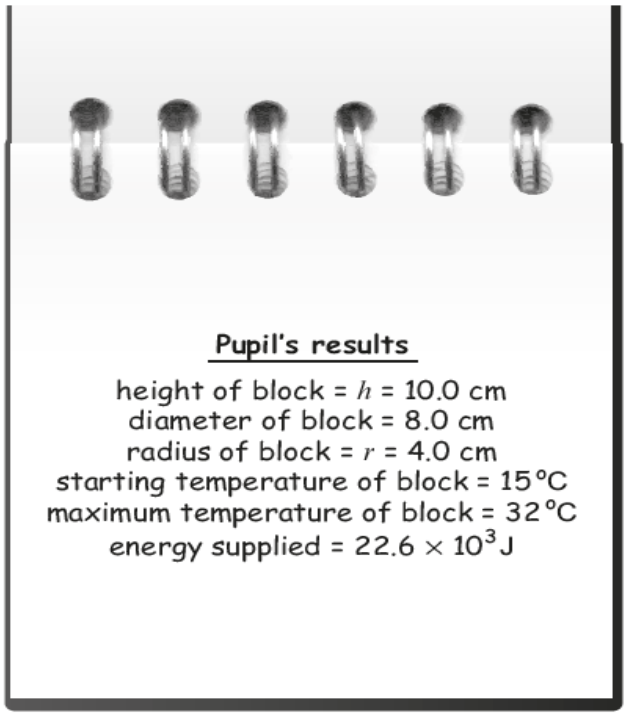


(a) State why a small amount of oil is placed in the two holes that contain the thermometer and heater. [1]

.....

.....

(b) The digital balance is broken so the mass of the block can't be directly measured. A pupil measures the diameter and height of the block with a ruler. Their teacher tells them that the density of aluminium is 2.7 g/cm^3.



(i) Calculate the mass of the block, in kg. [5]
(Use the equation $V = \pi r^2 h$ for the volume)

mass = ... kg

(ii) Using an appropriate equation from page 2 and some of the data from the pupil's results, calculate a value for the specific heat capacity of aluminium. [3]

specific heat capacity = ... J/kg °C

(c) The aluminium block is not wrapped in any insulation. Explain how this affects the value of the specific heat capacity calculated for this experiment. [2]

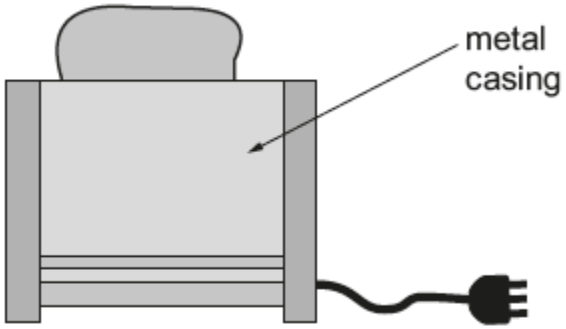
.....

.....

.....

11

11. A **metal cased** toaster has a power rating of 1.6 kW and operates on mains voltage, 230 V a.c. Describe the key electrical safety features in the design of the toaster and explain how they work and why they are necessary.
Use a calculation to support your answer. [6 QER]



.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

6

COMPONENT 3 – Concepts in Physics

HIGHER TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

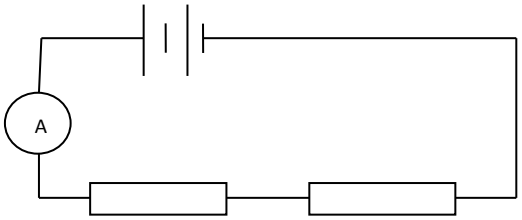
Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			Selection of: $v = u + at$ (1) Manipulation of equation: $a = \frac{(v-u)}{t}$ accept by implication (1) Substitution: $\frac{27}{6.5}$ (1) Acceleration = 4.2 [m/s^2] (accept 4.1, 4.15) (1)	1	1 1 1		4	3	
	(b)			A car travelling at a slower speed has significantly less KE (1) So less time needed to stop the car / less stopping distance (1)		2		2		
				Question 1 total	**1**	**5**	**0**	**6**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			720 in cell in the force needed column (1) 1 776 in cell in the work done column (1)		2		2	2	
	(b)	(i)		Smallest distance lifted compared to the other weightlifters (1) Relevant work done = force × distance comment e.g. weightlifter D has the lowest product of force and distance (1)	1	1		2		
		(ii)		Recall of: $\text{power} = \frac{\text{energy transferred}}{\text{time}}$ (1) $\frac{1600}{5} = 320$ [W] (1)	1	1		2	1	
		(iii)		Competitor D (1) Least work done in set time (1)		2		2		
				Question 2 total	**2**	**6**	**0**	**8**	**3**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			Single complete loop (1) Resistor symbol correct (1) Ammeter symbol correct (1)  	3			3		3
	(b)	(i)		4 + 2 = 6 [Ω]	1			1		1
		(ii)		Recall of: $V = IR$ (1) Manipulation: $I = \frac{12}{6}$ (1) Ammeter reading = 2 [A] (1)	1	1 1		3		3
		(iii)		The 4 Ω resistor gets the hottest / has the biggest power (1) Identical $(\text{current})^2$ through each resistor but multiplied by higher resistance (1)			2	2		2
				Question 3 total	**5**	**2**	**2**	**9**	**0**	**9**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4	(a)	(i)		[-] 10 [m/s]		1		1		
		(ii)		Recall of: $a = \frac{\Delta v}{t}$ (1) Substitution: $\boldsymbol{a} = \frac{10}{50}$ (1) Deceleration = 0.2 [m/s^2] (1)	1 1	 1		 3	 2	
	(b)			Recall of: $F = ma$ (1) Substitution: 55×0.2 (1) Resultant force =11 [N] (**ecf**) (1)	1 1	 1		 3	 2	
	(c)			Larger distance covered / bigger area / velocity is more (1) In the same time interval / same 300 s (1)			2	2	2	
				Question 4 total	**4**	**3**	**2**	**9**	**6**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
5	(a)			Use a video camera to record the height to which the ball bounces / have one person drop the ball and a different person to record the height to which it bounces (1) Ensure there is repeat data for each temperature (1)			2	2		2
	(b)			Too many significant figures used/ should use 2 significant figures			1	1		1
	(c)			Low COR value shows (a lot of) energy lost as heat (1) raising the temperature of the ball. (1) At higher temperatures COR is higher (1) so the ball bounces back faster (1)			4	4		
				Question 5 total	**0**	**0**	**7**	**7**	**0**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			Recall of: distance = speed × time (1) Substitution: $3 \times 10^8 \times 500 = 1.5 \times 10^{11}$ [m] (1) Substitution into: $\text{Time} = \frac{\text{Distance}}{\text{Speed}}$ i.e. $t = \frac{1.5 \times 10^{11}\text{(ecf)}}{3.2 \times 10^6}$ (1) t = 46 875 [s] (1)	1 1	 1 1		4	3	
	(b)	(i)		Microwave			1	1		
		(ii)		$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{11 \times 10^{-6}}$ (1) **ecf** on λ = 2.7×10^{13} [Hz] (1) (**ecf** on conversion) Not detected as higher value than frequency range stated (1) (**ecf** on previous answer) **Alternative solution:** $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^9}$ (1) = 5×10^{-2} [m] (1) Not detected as much higher value than the peak value (1)		1 1	1	3	3	
	(c)			0 (top) and -1 (bottom) for beta (1) 7 top and 3 bottom for Li (1)	2			2		
				Question 6 total	**4**	**4**	**2**	**10**	**6**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		Recall of: $p = m\,v$ (1) p = 1 400 × 12 = [-]16 800 [kg m/s] (1)	1	1		2	1	
		(ii)		Total momentum before = total momentum after (1) No external forces act (1)	2			2		
		(iii)		[-]16 800 = 800 × v (1) v = [-] 21 [m/s] (1)		2		2	2	
		(iv)		$\left(\frac{30}{2}\right)$ × 0.9 = 13.5 [m/s] which is less than speed of the car (1) Allow ecf on calculation The claim of the driver is not consistent with the evidence from the CCTV (1)			2	2	1	
	(b)			Longer time (1) For same momentum change (1) Smaller resultant force (1)	3			3		
				Question 7 total	**6**	**3**	**2**	**11**	**4**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			Left hand motor rule (1) First finger of (left hand) represents B-field direction (N to S) **and** second finger of (left hand) represents current direction (+ to -) (1) Direction thumb points gives the force direction (1) (coil will rotate clockwise)	3			3		3
	(b)			Reverse current (1) Reverse magnetic field (1)	2			2		2
	(c)			Manipulation of $F = BIl$ i.e. $I = \frac{F}{Bl}$ (1) $I = \frac{2.4 \times 10^{-3}}{(5 \times 10^{-3} \times 0.12)} = 4$ [A] (1)		2		2	2	
	(d)			Current doubles force but field is half the force (1) Net effect is zero (1)		2		2		2
				Question 8 total	**5**	**4**	**0**	**9**	**2**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			Half-life = 14 days (1) 14 × 6 = 84 days (1) **ecf**		2		2	1	
	(b)			Original activity of 960 kBq will drop to 15 kBq after six half-lives (1) The measured count rate is less than 15 kBq so the radioactive source needs to be replaced (1)		1	1	2	1	
				Question 9 total	**0**	**3**	**1**	**4**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			Good thermal contact between block and thermometer/heater	1			1		1
	(b)	(i)		Substitution: $V = \pi \times 4^2 \times 10$ (1) Volume = 502.7 [cm^3] (1) Recall of: $\text{density} = \frac{\text{mass}}{\text{volume}}$ Manipulation: $2.7 \times 502.7 = 1\,357$ g (1) allow ecf Conversion into kg: 1.357 [kg] (1)	1 1	1 1 1		5	3	5
		(ii)		Temperature change $\Delta\theta = 32 - 15 = 17\,^{o}C$ (1) Manipulation of $\Delta Q = mc\Delta\theta$ i.e. $\boldsymbol{c} = \frac{22.6 \times 10^3}{1.357 \times 17}$ (1) c = 980 J/kg ^{o}C (1)	1	 1 1		3	2	3
	(c)			Measured temperature rise will be less (1) Calculated specific heat capacity is greater (1)			2	2		2
				Question 10 total	**4**	**5**	**2**	**11**	**5**	**11**

Question	Marking details	Marks available					
		AO1	AO2	AO3	Total	Maths	Prac
10	**Indicative content:** **AO1 allocation** - An earth wire is one safety feature. It is connected to the metal casing of the toaster and provides a low resistance path to earth so that if a fault develops which makes the metal casing live then the user is protected from electrocution by the current going to earth through the wire rather than through the user. A fuse is another safety feature and is found in the plug. It is connected to the live wire and its fuse wire breaks when too much current flows through the toaster due to a fault occurring. This breaks the circuit and safeguards the lead from overheating and causing a fire. **AO2 allocation** - The value of the fuse is calculated from $I = \frac{P}{V} = \frac{1600}{230}$ = 7.0 [A]. Therefore a 10 or 13 A fuse should be fitted in its plug. **5 – 6 marks** A detailed description of both safety features with calculation present. Clear explanations of purpose and principle of both safety feature. *There is a sustained line of reasoning which is coherent, substantiated and logically structured. The information included in the response is relevant to the argument.* **3 - 4 marks** Description of safety features with calculation present. Explanations of purpose and principle of both safety features. One of these features is explained in some detail. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1-2 marks** Basic description of safety features. There is little in the way of explanation of the features. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks** *No attempt made or no response worthy of credit.*	4	2		6	1	
	Question 10 Total	**4**	**2**	**0**	**6**	**1**	**0**

COMPONENT 3 – Concepts in Physics

HIGHER TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	1	5	0	6	3	0
2	2	6	0	8	3	0
3	5	2	2	9	0	9
4	4	3	2	9	6	0
5	0	0	7	7	0	3
6	4	4	2	10	6	0
7	6	3	2	11	4	0
8	5	4	0	9	2	7
9	0	3	1	4	2	0
10	4	5	2	11	5	11
11	4	2	0	6	1	0
TOTAL	**35**	**37**	**18**	**90**	**32**	**30**

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 4

Applications in Science

FOUNDATION TIER

SAMPLE PAPER

(1 hour 45 minutes)

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**3**	
	2.	**9**	
	3.	**11**	
	4.	**11**	
	5.	**7**	
	6.	**9**	
	7.	**11**	
	8.	**6**	
	9.	**8**	
Section B	**10.**	**15**	
	Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator, a ruler and a resource booklet.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B**.
Section **A**: 75 marks. Answer **all** questions. You are advised to spend about 1 hour 20 minutes on this section.
Section **B**: 15 marks. Read the article in the resource booklet carefully then answer **all** questions. You are advised to spend about 25 minutes on this section.
The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **8**.

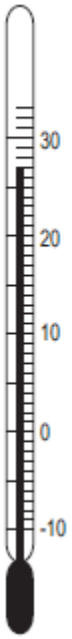
EQUATION LIST

final velocity = initial velocity + acceleration × time	$v = u + at$
distance = ½ (initial velocity + final velocity) × time	$x = \frac{1}{2}(u + v)t$
(final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance	$v^2 = u^2 + 2ax$
change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2}kx^2$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_1I_1 = V_2I_2$

SECTION A

Answer **all** *questions.*

1. Lowri is setting up a water bath for an enzyme experiment. The diagram below shows a piece of laboratory equipment.



(a) State the name of the piece of apparatus shown above. [1]

……

(b) Write down the reading shown and give the unit. [1]

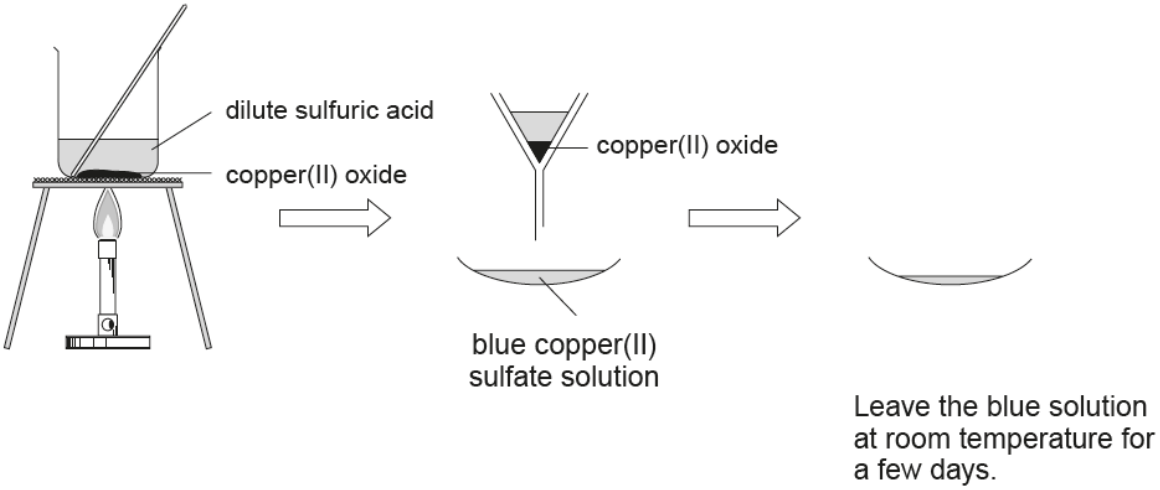
……

(c) Why is this particular piece of apparatus **not** suitable for taking the temperature in this experiment? [1]

.....

3

2. One method used to prepare a salt involves reacting a base with a dilute acid. The diagrams below show the stages a pupil follows to make a salt.



Stage 1 **Stage 2** **Stage 3**

(a) What name is given to the type of reaction occurring in the beaker above? [1]

……

(b) Use the information in the diagrams to decide which of the following statements is correct. Tick (✓) only **one** box. [1]

Exactly the correct amount of copper(II) oxide needed to use up all the sulfuric acid has been added	☐
More sulfuric acid than can react with the copper oxide has been added	☐
More copper(II) oxide than can react with all the sulfuric acid has been added	☐

(c) Name the salt produced in this experiment. [1]

……..

(d) Describe what happens in **Stage 3** and state how this process could be carried out more quickly. [2]

……

……

……

(e) A carbonate also reacts with an acid to give a salt.

(i) Name the other products formed in the reaction between lead carbonate and sulfuric acid other than lead sulfate. [2]

……

(ii) Use the following information to explain whether this could be a suitable method to prepare crystals of either, or both of: [2]

1. lead sulfate from lead carbonate and sulfuric acid;
2. lead nitrate from lead carbonate and nitric acid.

Compound	**Soluble in water?**
lead carbonate	No
lead sulfate	No
lead nitrate	Yes

……

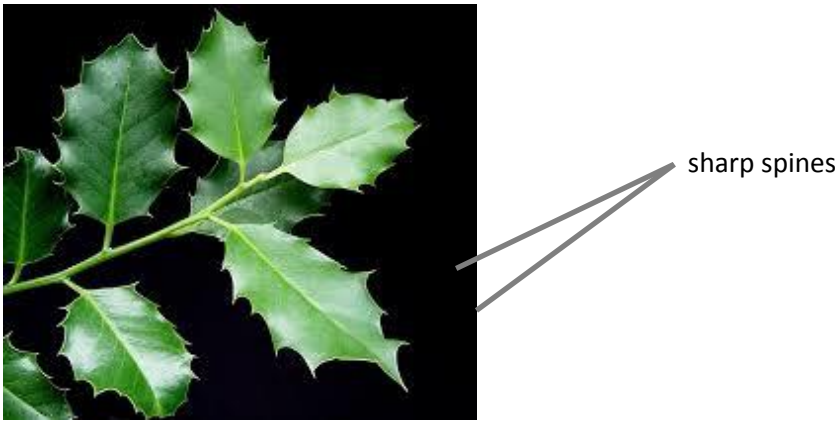
……

……

9

3. Holly (*Ilex*) is a common British tree.

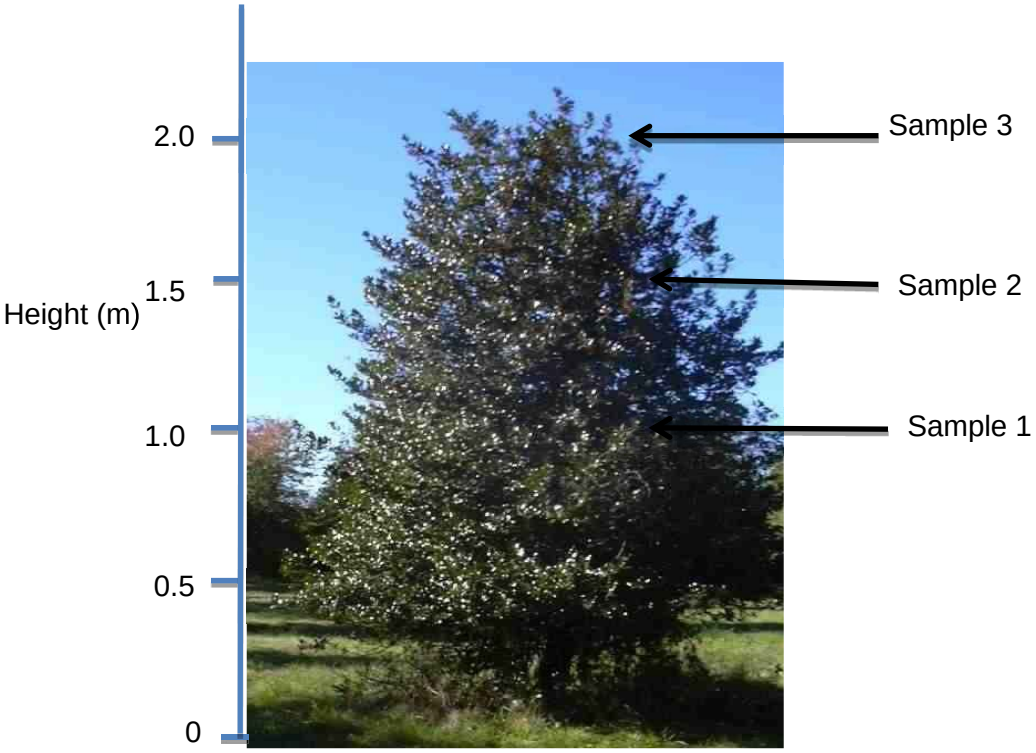
(a) Holly leaves have sharp spines on their edges.



Darren designed an investigation titled:

'Does the number of spines on the leaves of holly trees change with the height of the tree?'

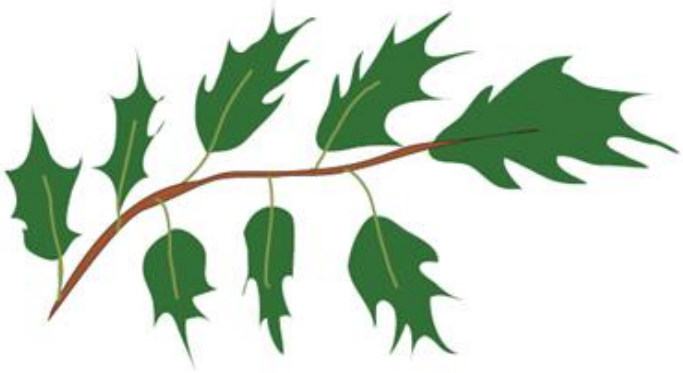
Darren collected leaves from the holly tree shown, at heights of 1.0, 1.5 and 2.0 m from the ground.



The samples he collected are shown below.

Sample 1

Sample 2



Sample 3

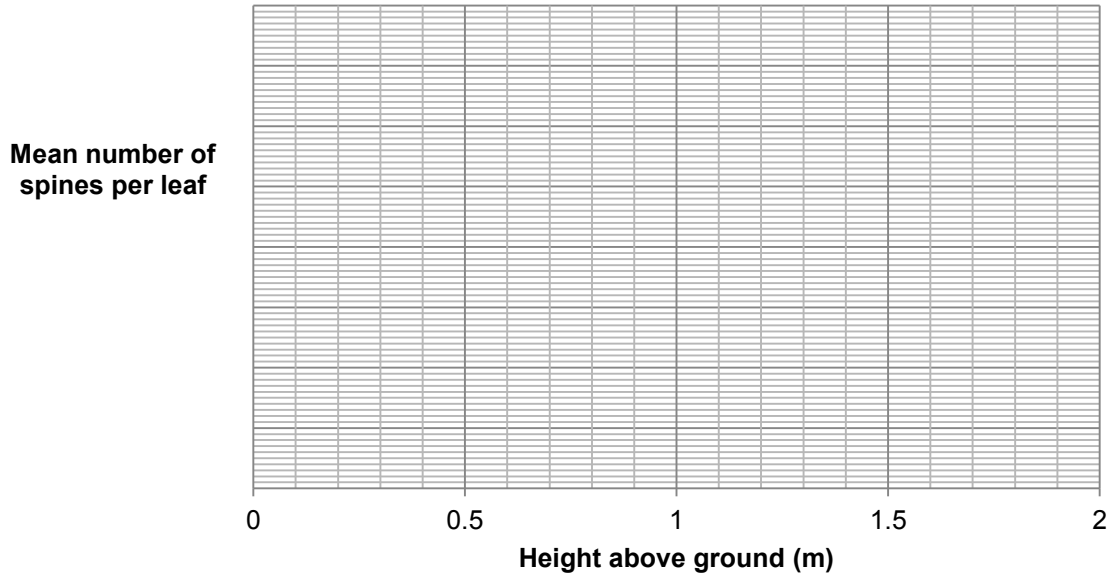
(i) Count the spines on each of Darren's leaf samples and use the results to complete the table below. [3]

Sample number	Height above ground (m)	Number of leaves	Total number of spines	Mean number of spines on each leaf to one decimal place
1				
2				
3				

(ii) Complete a scatter graph for the mean number of spines per leaf on the grid below by:

I choosing a scale for the vertical axis; [1]

II plotting the points for the mean number of spines per leaf to the nearest whole number. [1]



(iii) What conclusion can Darren make from these results? [1]

.....

(iv) Why is it important to calculate the mean in this investigation? [1]

.....

(v) Darren wrote this in his notebook:

'*I need to do further work before I can come to a firm conclusion.*'

What further work should Darren do to increase his confidence in making a firm conclusion? [3]

.....

.....

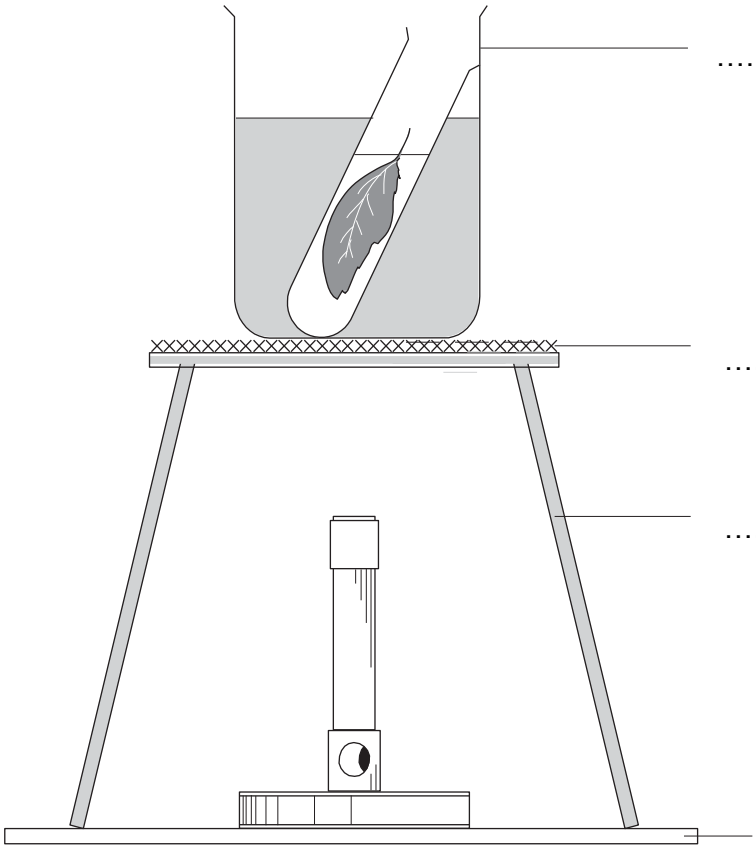
.....

.....

(b) Suggest how sharp spines on the leaves are useful to holly trees. [1]

.....

4. Sharon took a leaf from a plant that had been growing in bright light.
She tested the leaf for starch using the following apparatus.



……

……

……

……

(a) **Complete the labels** on the diagram. [3]

(b) Before starting the test, Sharon did a risk assessment for using ethanol in her experiment. **Complete** the risk assessment form below. [2]

Hazard	**Risk**	**Control measure**
ethanol is flammable		

(c) State why the ethanol turns green in this experiment. [1]

.....

(d) Sharon removed the leaf from the hot ethanol and rinsed it in water. She then spread the leaf out on a white tile and covered it in iodine solution. State why it is necessary:

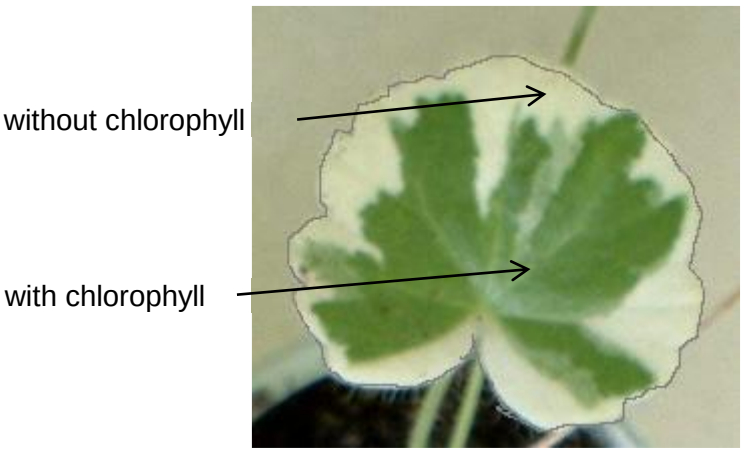
(i) to rinse the leaf in water [1]

.....

(ii) to use a colourless leaf. [1]

.....

(e) Sharon used a leaf in which only part had chlorophyll, as shown in the diagram below.



(i) Complete the table below to show the expected results. [1]

Part of leaf	**Colour of part after adding iodine solution**
with chlorophyll	……
without chlorophyll	……

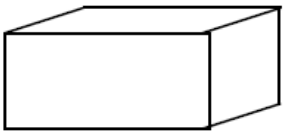
(ii) Explain your answer for **both** parts of the leaf. [2]

.....

.....

.....

5. (a) Describe how the volume of a regular aluminium block could be found. [2]

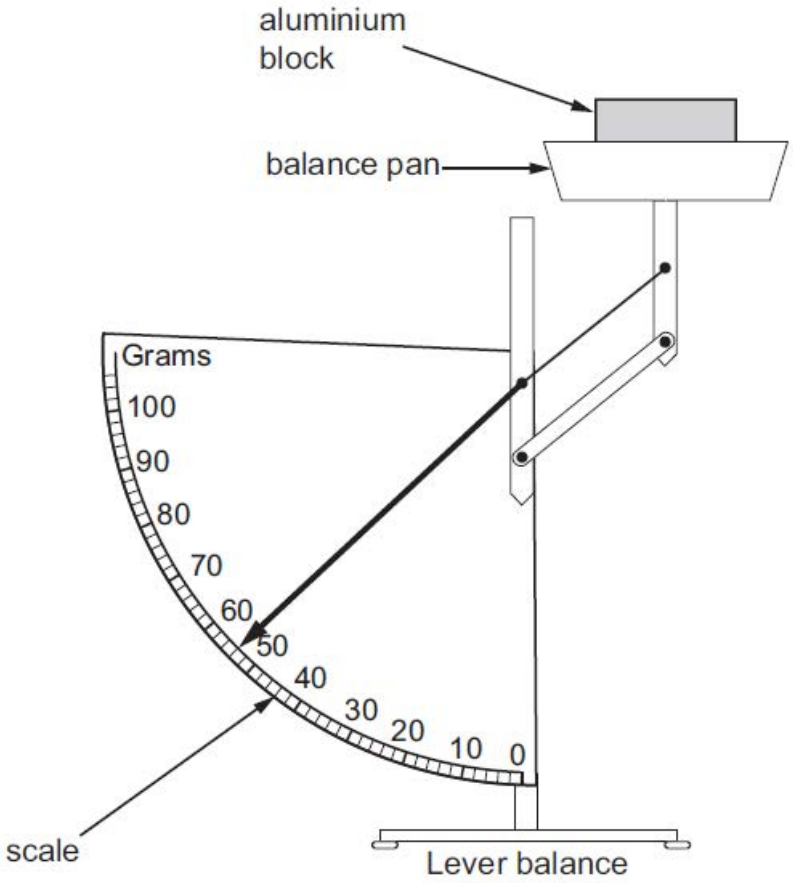


.....

.....

.....

(b) A student weighs an aluminium block on the scales shown.



(i) Write down the mass of the aluminium block shown in the diagram. [1]

mass = ... g

(ii) The volume of the aluminium block is also measured and found to be 20 cm^3. Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

to calculate the density of aluminium. [2]

density = ... g/cm^3

(c) An aluminium block of volume 40 cm^3 (twice as big as the one above) is now weighed.

(i) State its density. [1]

density = ... g/cm^3

(ii) State its mass. [1]

mass = ... g

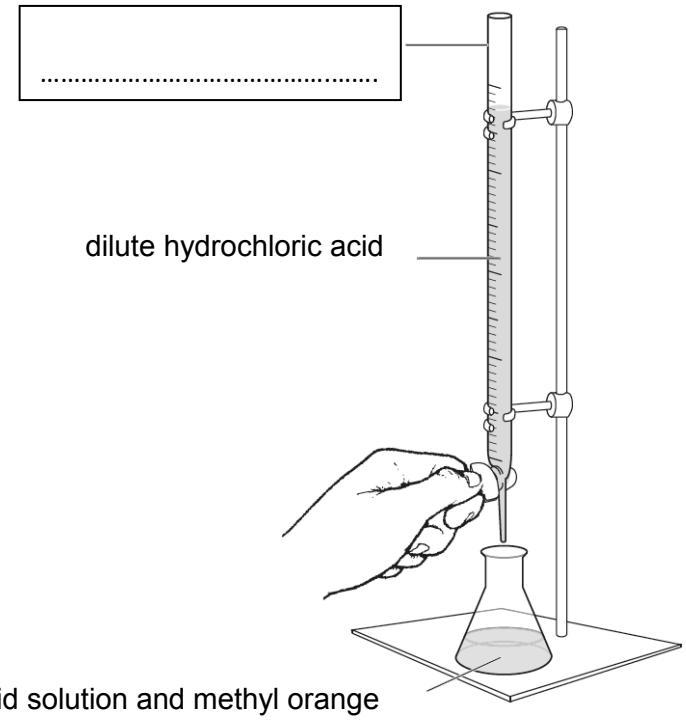
7

6. Antacid tablets are used to treat indigestion which is caused by excess acid in the stomach. Antacids contain calcium carbonate which reacts with the excess acid.

A group of pupils were given three different brands of antacid tablets; **X**, **Y** and **Z**. They carried out the following experiment to find the best antacid to neutralise the excess acid.

1. Tablet **X** was crushed and added to 50 cm^3 of water in a conical flask.
2. Five drops of methyl orange were added.
3. The mixture was titrated with dilute hydrochloric acid.
4. The acid was added 0.5 cm^3 at a time and the flask swirled. This was continued until the methyl orange turned red.
5. The total volume of acid added was recorded.
6. This procedure was repeated using **Y** and then **Z.** The same mass of tablet was used in each case.

Diagram of apparatus



The results collected are shown in the following table.

	Tablet X	**Tablet Y**	**Tablet Z**
Final volume (cm^3)	13.5	27.0	38.0
Initial volume (cm^3)	1.0	13.5	27.0
Volume added (cm^3)	…….	…….	…….

(a) **Add the missing label on the diagram**. [1]

(b) Give the name for substances, such as methyl orange, which have one colour in acids and a different colour in alkalis. [1]

……

(c) Explain why it was necessary to swirl the flask with each addition of hydrochloric acid. [1]

……

……

(d) **Complete the table** of results and use the information to identify the best antacid tablet. Give **one** reason for your answer. [4]

……

……

……

……

(e) State how the method could be changed in order to provide more accurate results. Explain your answer. [2]

……

……

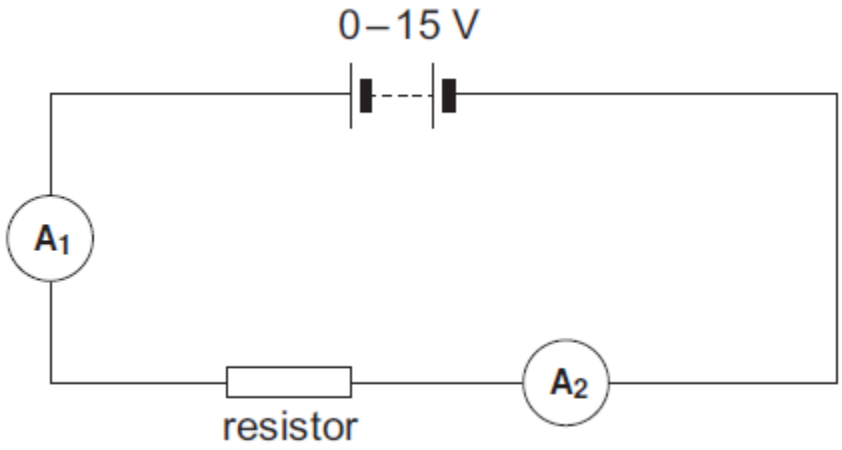
……

……

9

7. A group of pupils in a class are asked to find how the current through a resistor changes when the potential difference applied to it is changed.

The circuit they set up is shown below. It contains two ammeters, shown as A_1 and A_2.



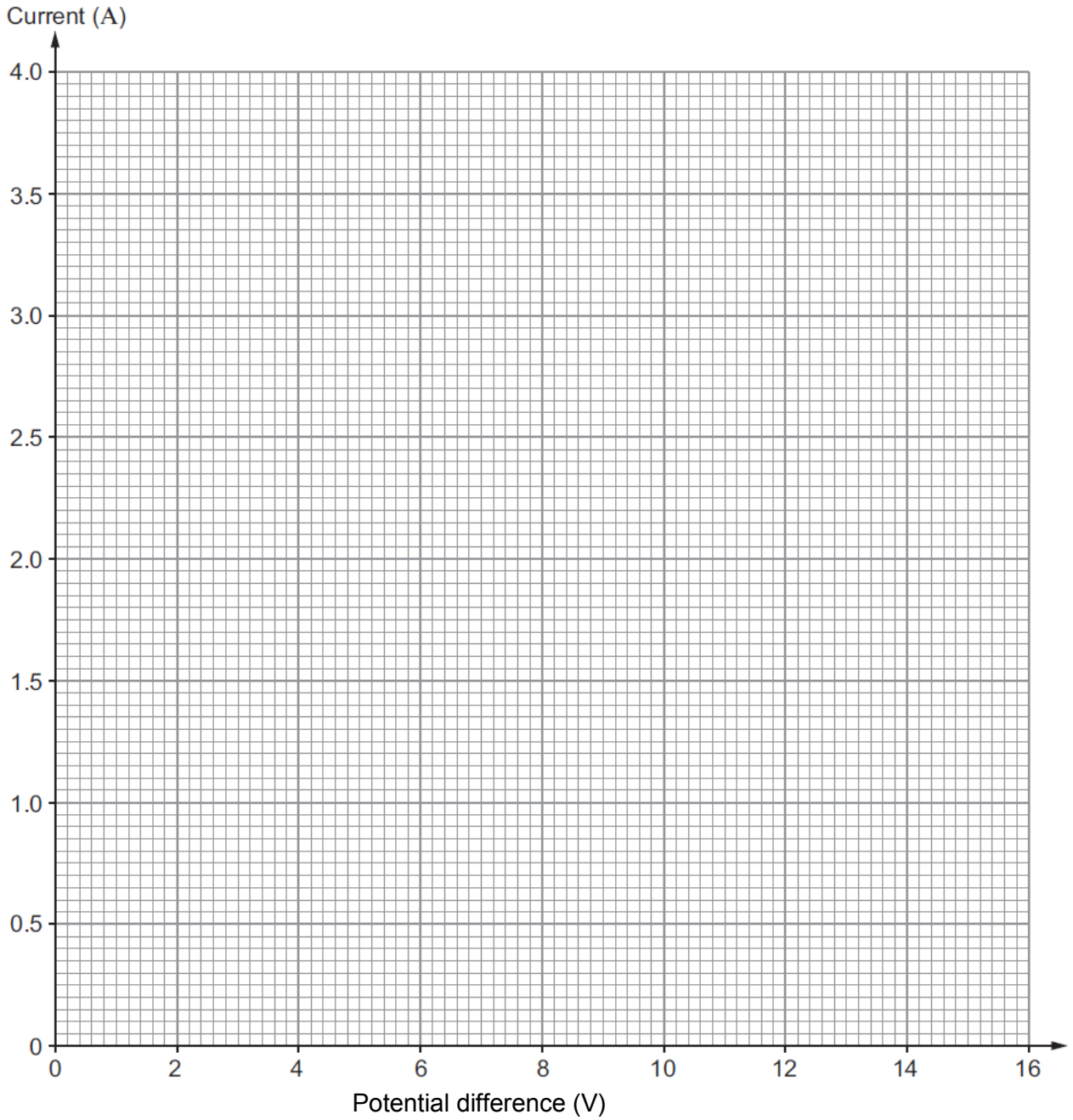
The potential differences and some of the currents are shown in the table below.

Battery potential difference (V)	**Ammeter A_1 reading (A)**
1	0.25
2	
3	0.75
6	1.50
10	2.50
12	3.00
15	3.75

(a) Complete the following sentence by underlining the correct phrase in the brackets. [1]

When ammeter A_1 reads 0.5 A, the reading on ammeter A_2 is (**less than** / **equal to** / **more than**) 0.5 A.

(b) (i) Use the data in the table to plot points on the grid and draw a suitable line. [3]



(ii) Find the current when the voltage is 2 V. [1]

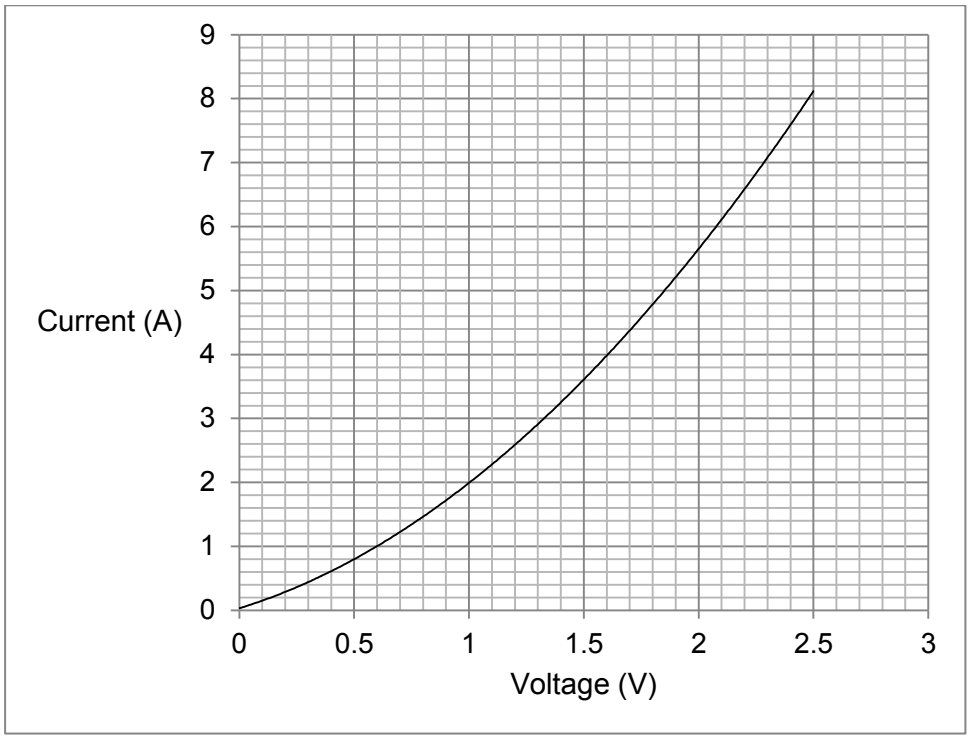
current = ... A

(iii) Calculate the resistance of the resistor. [3]

resistance = ... Ω

(c) **On the grid opposite,** draw a line for a resistor that has a constant resistance of 10 Ω. [2]

(d) The pupils set up a new circuit replacing the resistor with another component. They obtained the following results.



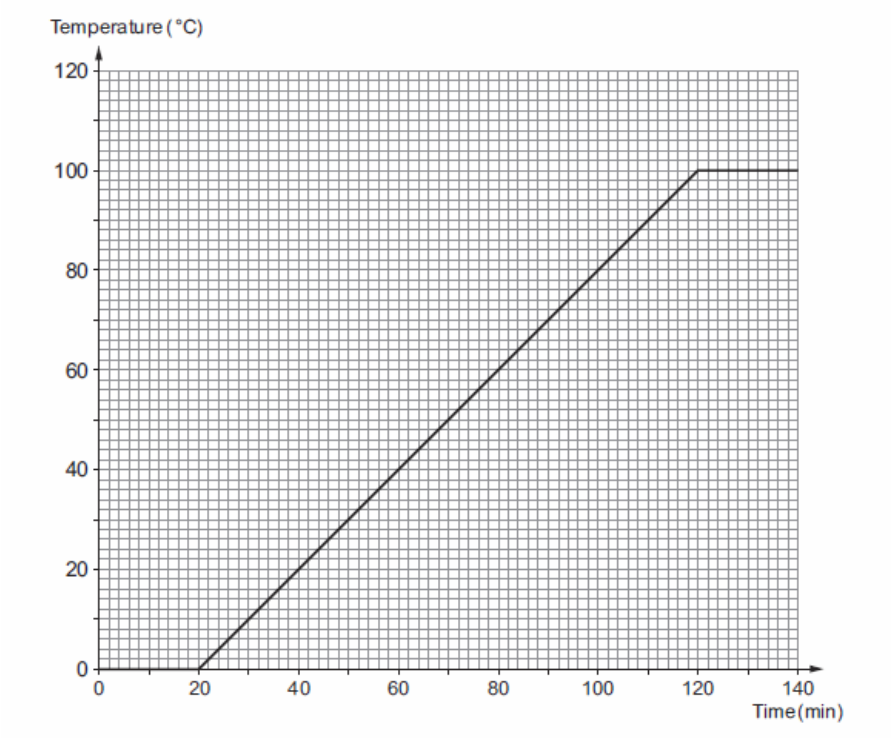
A pupil made this conclusion: "The graph shows that this component obeys Ohm's law". Give **one** reason whether you agree with the conclusion made by the pupil. [1]

……..

……..

11

8. The temperature of a mixture of ice and liquid water is recorded as it is heated over a Bunsen burner during a lesson. Some of the water is boiled away by the end of the lesson. **The starting temperature is 0 °C**.
The following graph is drawn from the results of the experiment.



Describe fully what the graph tells you about water as it is heated. [6 QER]
[Do not refer to the behaviour of particles in your answer.]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

6

9. A group of students wanted to find the time taken to produce 100 cm^3 of gas when dilute hydrochloric acid reacts with marble chips.

(a) Describe a method that they could use in their experiment. You may include a diagram as part of your answer. [3]

……

……

……

(b) The students investigated the effect of temperature on the rate of the reaction. The results they obtained are below.

James used hydrochloric acid at 21°C and recorded a time of 2 minutes 33 seconds.

Syra heated her acid to 40 °C and the reaction took 39 seconds.

Abigail stopped her watch after 1 minute 17 seconds. Her acid had a starting temperature of 30 °C.

Draw a table with labelled columns. Record the students' results in your table with the times given in **seconds**. [3]

(c) Estimate how long the reaction will take at 50°C and explain how you came to this value. [2]

……

……

……

8

SECTION B

Read the article in the resource booklet carefully and answer **all** *the questions that follow.*

10. (a) Methane has a larger GWP than carbon dioxide. It is claimed that methane should be burned rather than released into the atmosphere.

(i) Methane burns in air to produce carbon dioxide and water. Complete the balanced **symbol** equation for this reaction. [2]

$CH_4 + 2O_2 \rightarrow$ ..... + ...

(ii) Burning 100 kg of methane produces 275 kg of carbon dioxide. Use **Equation 1** and the information in **Table 1** to answer the following questions.

I Calculate the greenhouse contribution of 100 kg of methane. [2]

greenhouse contribution = ... kg CO_2eq

II Explain whether or not burning methane has less effect on global warming than just releasing it into the atmosphere. [2]

.....

.....

(b) Use the information in **Table 2** to answer the following questions.

(i) I Jack travels 100 km each day. He is concerned about his carbon footprint. Why would he choose a Voltec car rather than an Amptec car? [1]

.....

II Calculate the mass of CO_2 produced if the Amptec is driven 280 km. [2]

mass = …… g

(ii) Using a charger the Voltec can be charged fully by 32 kWh. When 1 kWh of electricity is used it produces 0.45 kg of carbon dioxide every hour.

Calculate how much carbon dioxide is produced to fully charge the Voltec. [2]

mass = ... kg

(iii) Explain why the data for the Voltec may be misleading. [2]

.....

.....

(c) Suggest **two** reasons why the government gives a grant to purchase electric vehicles. [2]

1. .....

2. .....

15

GCSE COMBINED SCIENCE

COMPONENT 4

Applications in Science

FOUNDATION TIER

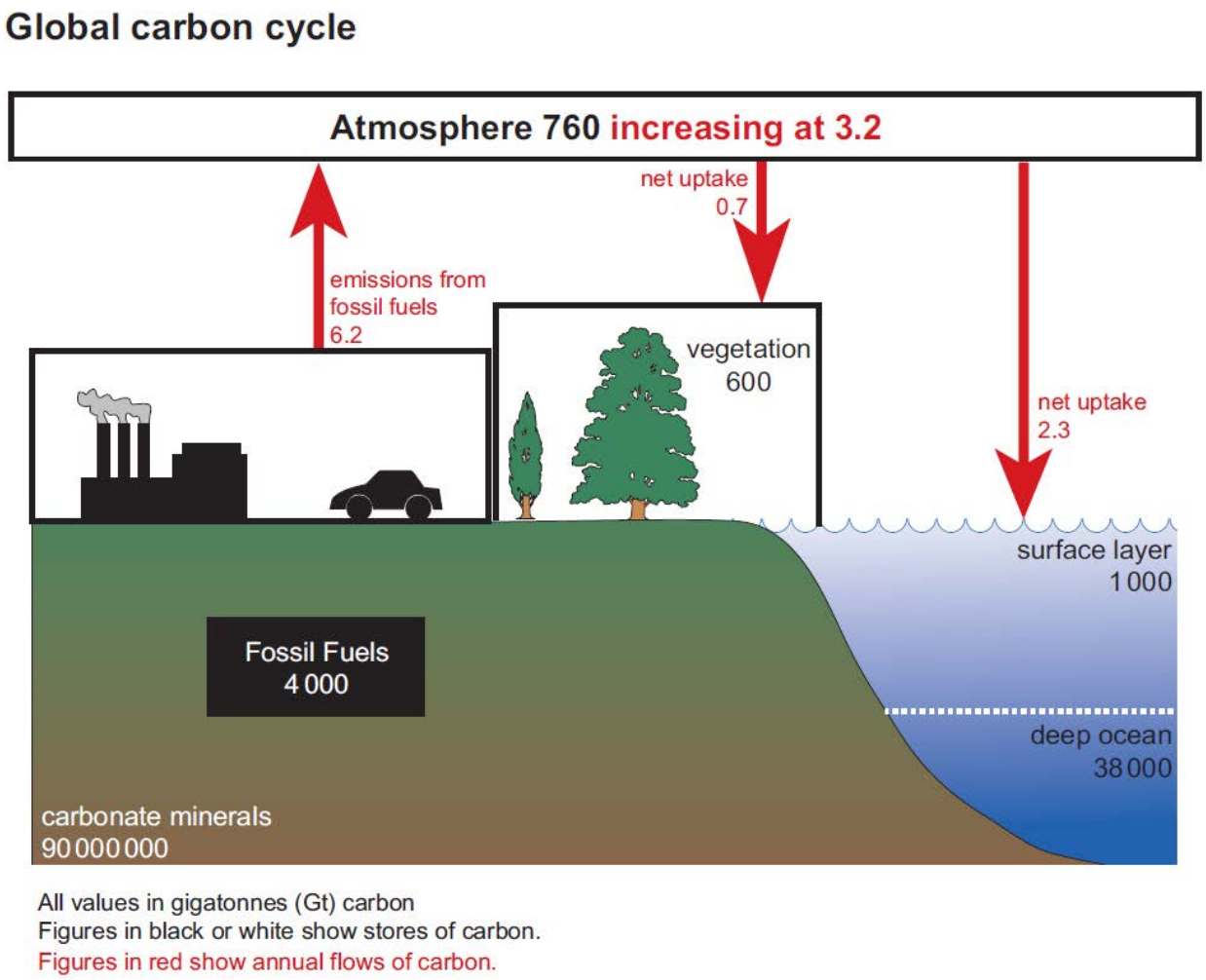
SAMPLE ASSESSMENT MATERIALS

RESOURCE BOOKLET
for use in Section B

EXPLORING THE GREENHOUSE EFFECT

On Earth, carbon is recycled as shown in **Diagram 1** below.

Diagram 1



It is claimed that global warming is caused by humans adding greenhouse gases (GHG) to the atmosphere. Two GHG are carbon dioxide (CO_2) and methane (CH_4).

Greenhouse gases can be compared using their Global Warming Potential (GWP). GWP is the ability of a GHG to trap heat in the atmosphere compared to an equal amount of carbon dioxide. **Table 1** gives the GWP of both GHG.

Table 1

Greenhouse gas	GWP
CO_2	1
CH_4	21

Equation 1

$$\text{greenhouse contribution in kg } CO_2\text{eq} = \text{mass of gas (kg)} \times \text{GWP}$$

The Government gives a grant to buyers of electric vehicles. This is intended to reduce the amount of GHG we produce.

Two such electric vehicles are the Amptec and the Voltec. The Voltec car has an electric motor only. The Amptec car has both an electric motor and a petrol engine. **Table 2** gives information about these electric vehicles and of a petrol engine car.

Table 2

	Typical petrol engine car	Amptec	Voltec
Range per charge (km)	not applicable	80	200
Range on one tank of fuel (km)	700	660	not applicable
Mean fuel used (litres per 100 km)	6.0	1.2	0
Official CO_2 produced (g/km) (Tested over 100 km)	100	27	0

COMPONENT 4 – Applications in Science

FOUNDATION TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

SECTION A

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			Thermometer	1			1		1
	(b)			27 ^{o}C/Celsius/Centigrade	1			1		1
	(c)			Ref to inappropriate scale/not able to measure temperature above 33 ^{o}C			1	1		1
				Question 1 total	**2**	**0**	**1**	**3**	**0**	**3**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	(a)			Neutralisation	1			1		1
	(b)			Tick in third box i.e. More copper(II) oxide than can react has been added to use up all the sulfuric acid If two or more boxes ticked award no marks		1		1		1
	(c)			Copper(II) sulfate		1		1		1
	(d)			[Blue] crystals are formed (1) The solution could be heated to remove some water/reduce the volume of water (1) Do not accept: boil all the water off		2		2		2
	(e)	(i)		carbon dioxide (1) water (1)	2			2		2
		(ii)		lead sulfate – no **and lead** nitrate - yes. Both must be correct to award the mark (1) lead sulfate cannot be separated from lead carbonate because both are insoluble (1)			2	2		2
				Question 2 total	**3**	**4**	**2**	**9**	**0**	**9**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>3</td><td>(a)</td><td>(i)</td><td></td><td>1 mark for each correct row
<table><tr><th>Sample number</th><th>Height above ground (m)</th><th>Number of leaves</th><th>Total number of spines</th><th>Mean number of spines on each leaf to one decimal place</th></tr><tr><td>1</td><td>1.0</td><td>5</td><td>36</td><td>7.2</td></tr><tr><td>2</td><td>1.5</td><td>8</td><td>47</td><td>5.9</td></tr><tr><td>3</td><td>2.0</td><td>4</td><td>19</td><td>4.8</td></tr></table></td><td></td><td>3</td><td></td><td>3</td><td>3</td><td>3</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>I</td><td>Linear scale exceeding half of vertical axis</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>II</td><td>All three points plotted accurately</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td>1</td></tr>
<tr><td></td><td></td><td>(iii)</td><td></td><td>Spine number per leaf decreases with increasing height</td><td></td><td>1</td><td></td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>(iv)</td><td></td><td>[To compensate for] variation in leaf number between samples</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>(v)</td><td></td><td>Any three × (1) from:
• Sample at all heights
• Increase sample size/ use more leaves
• Take leaves at random [not from one stem]
• Same age/ length/ size</td><td></td><td></td><td>3</td><td>3</td><td></td><td>3</td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Protect from herbivores/being eaten</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 3 total</td><td>0</td><td>7</td><td>4</td><td>11</td><td>5</td><td>10</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			• Heat proof mat • Tripod • Gauze • Beaker All 4 correct = 3 marks 3 correct = 2 marks 2 correct 1 mark	3			3		3
	(b)			Risk: Bunsen burner flame could ignite ethanol (1) Control measure: Turn off Bunsen burner/no naked flame before using ethanol (1)	2			2		2
	(c)			Chlorophyll soluble in ethanol	1			1		1
	(d)	(i)		Soften leaf	1			1		1
		(ii)		So the colour [change] can be seen	1			1		1
	(e)	(i)		With chlorophyll: blue/black Without chlorophyll: brown **Both** needed for the mark		1		1		1
		(ii)		Starch resulting from <u>photosynthesis</u> (1) Chlorophyll needed for photosynthesis, so only present where there had been chlorophyll (1)		2		2		2
				Question 4 total	**8**	**3**	**0**	**11**	**0**	**11**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Measuring its length, breadth and height using a ruler (1) Multiplying these dimensions together (1) **Alternative solution: (by displacement)** Totally immerse it in a measured volume of water in a measuring cylinder (1) Take the new reading and subtract the two (1)	2			2		2
	(b)	(i)		54 [g]	1			1		1
		(ii)		Substitution: $\frac{54\textbf{(ecf)}}{20}$ (1) Density = 2.7 [g/cm^3] (1)	1	1		2	1	2
	(c)	(i)		2.7 [g/cm^3] **ecf** from (b)(ii)		1		1		1
		(ii)		108 [g] **ecf** from (b)(i)	1			1		1
				Question 5 total	**5**	**2**	**0**	**7**	**1**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			Burette	1			1		1
	(b)			Indicators	1			1		
	(c)			Allows mixing to make sure that acid reacts		1		1		1
	(d)			Completion of table: 12.5 (in first box) **and** 13.5 (in second box) (1) Both must be correct for mark 11.0 (in third box) (1) Do not accept 11 Y – best tablet (1) Neutralises more acid (1)		1 1	1 1	4		4
	(e)			The experiment could be repeated and mean values used (1) this would take operator errors into account (1)			2	2		2
				Question 6 total	**2**	**3**	**4**	**9**	**0**	**8**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Equal to	1			1		1
	(b)	(i)		All 6 points plotted correctly **award 2 marks** 5 points plotted correctly **award 1 mark only** Straight line through the points (1)		3		3	3	3
		(ii)		0.5[0 A]		1		1		1
		(iii)		Recall of: $R = \frac{V}{I}$ (1) Substitution: $\frac{1}{0.25}$ (or any matching pair of values) (1) Resistance = 4 [Ω] (1)	1 1	1		3	2	3
	(c)			Straight line from the origin (1) Passing through / towards coordinate (10,1) (1)		2		2	2	2
	(d)			Ohm's law gives a straight line graph but this is not a straight line so the pupil's conclusion is wrong. Mark is for the reason not just 'no'			1	1		1
				Question 7 total	**3**	**7**	**1**	**11**	**7**	**11**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8				**Indicative content:** From 0 to 20 minutes, the ice and water mixture is heated but there is no rise in temperature. Heat energy is taken in and produces a change of state from solid (ice) to liquid (water). This provides the latent heat of fusion needed to melt the ice so this identifies the melting point of water as 0 ^{o}C. Between 20 and 120 minutes the temperature rises uniformly providing the specific heat needed to increase the water's temperature. At 120 minutes a second change of state begins from water to steam. The boiling point of water is 100 ^{o}C. Beyond 120 minutes the temperature remains constant again because heat is being taken in as the latent heat of vaporisation that is needed to change the state from water to steam. **5 – 6 marks** Detailed description of changes of state with clear reference to all significant aspects of the graph using scientific terminology. Melting and boiling temperatures clearly related to graph. Latent heat of fusion and vapourisation referred to. *There is a sustained line of reasoning which is coherent, substantiated and logically structured. The information included in the response is relevant to the argument.* **3 – 4 marks** A description of changes of state provided with the melting and boiling points identified. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1 – 2 marks** A basic description of the changes of state is given. Melting or boiling point is identified *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks** *No attempt made or no response worthy of credit.*	6			6	2	6
				Question 8 total	**6**	**0**	**0**	**6**	**2**	**6**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>9</td><td>(a)</td><td></td><td></td><td>Conical flask containing hydrochloric acid and marble chips (1) fitted with bung and connected by suitable tubing to gas syringe /inverted measuring cylinder over water (1)
Allow fully labelled diagram to earn marks
Measure time taken to collect 100 cm^3 using stopwatch (1)</td><td>3</td><td></td><td></td><td>3</td><td></td><td>3</td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Construction of suitable table (1)
Correct title and units in columns 2 & 3 (1)
Correct data in columns 2 & 3. Time must be in seconds (1)

<table><tr><th>Name of student</th><th>Start temperature (^oC)</th><th>Time for reaction (seconds)</th></tr><tr><td>James</td><td>21</td><td>150</td></tr><tr><td>Abigail</td><td>30</td><td>76</td></tr><tr><td>Syra</td><td>40</td><td>38</td></tr></table>
Alternative response:

<table><tr><th>Name of student</th><th>James</th><th>Abigail</th><th>Syra</th></tr><tr><td>Start temperature (^oC)</td><td>21</td><td>30</td><td>40</td></tr><tr><td>Time for reaction (seconds)</td><td>150</td><td>76</td><td>38</td></tr></table></td><td></td><td>3</td><td></td><td>3</td><td>1</td><td>3</td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>Any time estimate between 18 and 20 seconds (1)
The reaction rate [approximately] doubles / time for the reaction [approximately] halves for every 10 ^oC rise [in temperature] (1)</td><td></td><td></td><td>2</td><td>2</td><td>1</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 9 total</td><td>3</td><td>3</td><td>2</td><td>8</td><td>2</td><td>8</td></tr>
</table>

SECTION B

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		2 H_2O (1) + CO_2 (1)	2			2		
		(ii)	I	100 × 21 (1) = 2 100 [kg CO_2eq] (1)		2		2	1	
			II	Carbon dioxide produced by burning has a greenhouse contribution of 275 [kg CO_2eq] (1) Which is less than that of methane (1)			2	2		
	(b)	(i)	I	Doesn't burn fossil fuels / produce CO_2		1		1		
			II	280 × 27 (1) 7 560 [g] (1)		2		2	2	
		(ii)		32 × 0.45 (1) = 14.4 [kg] (1)		2		2	2	
		(iii)		Ignores carbon dioxide produced during charging (1) Which is equivalent to 72 g/km (1)			2	2		
	(c)			They are then cheaper so encourages us to buy electric vehicles (1) Meets [government] targets on CO_2 production / decrease carbon footprint of user (1)	2			2		
				Question 10 total	**4**	**7**	**4**	**15**	**5**	**0**

COMPONENT 4 – Applications in Science

FOUNDATION TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

	Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
Section A	1	2	0	1	3	0	3
	2	3	4	2	9	0	9
	3	0	7	4	11	5	10
	4	8	3	0	11	0	11
	5	5	2	0	7	1	7
	6	2	3	4	9	0	8
	7	3	7	1	11	7	11
	8	6	0	0	6	2	6
	9	3	3	2	8	2	8
Section B	10	4	7	4	15	5	0
	TOTAL	**36**	**36**	**18**	**90**	**22**	**73**

Candidate Name	Centre Number					Candidate Number				

GCSE COMBINED SCIENCE

COMPONENT 4

Applications in Science

HIGHER TIER

SAMPLE PAPER

(1 hour 45 minutes)

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**15**	
Section B	**2.**	**8**	
	3.	**15**	
	4.	**15**	
	5.	**9**	
	6.	**10**	
	7.	**8**	
	8.	**10**	
	Total	**90**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator, a ruler and a resource booklet.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B**.
Section **A**: 15 marks. Answer **all** questions. You are advised to spend about 25 minutes on this section.
Section **B**: 75 marks. Read the article in the resource booklet carefully then answer **all** questions. You are advised to spend about 1 hour 20 minutes on this section.
The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **8(a).**

EQUATION LIST

final velocity = initial velocity + acceleration × time	$v = u + at$
distance = ½ (initial velocity + final velocity) × time	$x = \frac{1}{2}(u+v)t$
(final velocity)^2 = (initial velocity)^2 + 2 × acceleration × distance	$v^2 = u^2 + 2ax$
distance = initial velocity × time + ½ × acceleration × time^2	$x = ut + \frac{1}{2}at^2$
change in thermal energy = mass × specific heat capacity× change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2}kx^2$
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length	$F = BIl$
potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in second coil	$V_1I_1 = V_2I_2$

SECTION A

Read the article in the resource booklet carefully and answer **all** *the questions that follow.*

1. (a) Methane has a larger GWP than carbon dioxide. It is claimed that methane should be burned rather than released into the atmosphere.

(i) Methane burns in air to produce carbon dioxide and water. Complete the balanced **symbol** equation for this reaction. [2]

$CH_4 + 2O_2 \rightarrow$ ..... + ...

(ii) Burning 100 kg of methane produces 275 kg of carbon dioxide. Use **Equation 1** and the information in **Table 1** to answer the following questions.

I Calculate the greenhouse contribution of 100 kg of methane. [2]

greenhouse contribution = ... kg CO_2eq

II Explain whether or not burning methane has less effect on global warming than just releasing it into the atmosphere. [2]

.....

.....

(b) Use the information in **Table 2** to answer the following questions.

(i) I Jack travels 100 km each day. He is concerned about his carbon footprint. Why would he choose a Voltec car rather than an Amptec car? [1]

.....

II Calculate the mass of CO_2 produced if the Amptec is driven 280 km. [2]

mass = …… g

(ii) Using a charger the Voltec can be charged fully by 32 kWh. When 1 kWh of electricity is used it produces 0.45 kg of carbon dioxide every hour.

Calculate how much carbon dioxide is produced to fully charge the Voltec. [2]

mass = ... kg

(iii) Explain why the data for the Voltec may be misleading. [2]

.....

.....

(c) Suggest **two** reasons why the government gives a grant to purchase electric vehicles. [2]

1. .....

2. .....

15

SECTION B

Answer **all** *questions.*

2. A group of students wanted to find the time taken to produce 100 cm^3 of gas when dilute hydrochloric acid reacts with marble chips.

(a) Describe a method that they could use in their experiment. You may include a diagram as part of your answer. [3]

……

……

……

(b) The students investigated the effect of temperature on the rate of the reaction. The results they obtained are below.

James used hydrochloric acid at 21°C and recorded a time of 2 minutes 33 seconds.

Syra heated her acid to 40 °C and the reaction took 39 seconds.

Abigail stopped her watch after 1 minute 17 seconds. Her acid had a starting temperature of 30 °C.

Draw a table with labelled columns. Record the students' results in your table with the times given in **seconds**. [3]

(c) Estimate how long the reaction will take at 50°C and explain how you came to this value. [2]

.....

.....

.....

.....

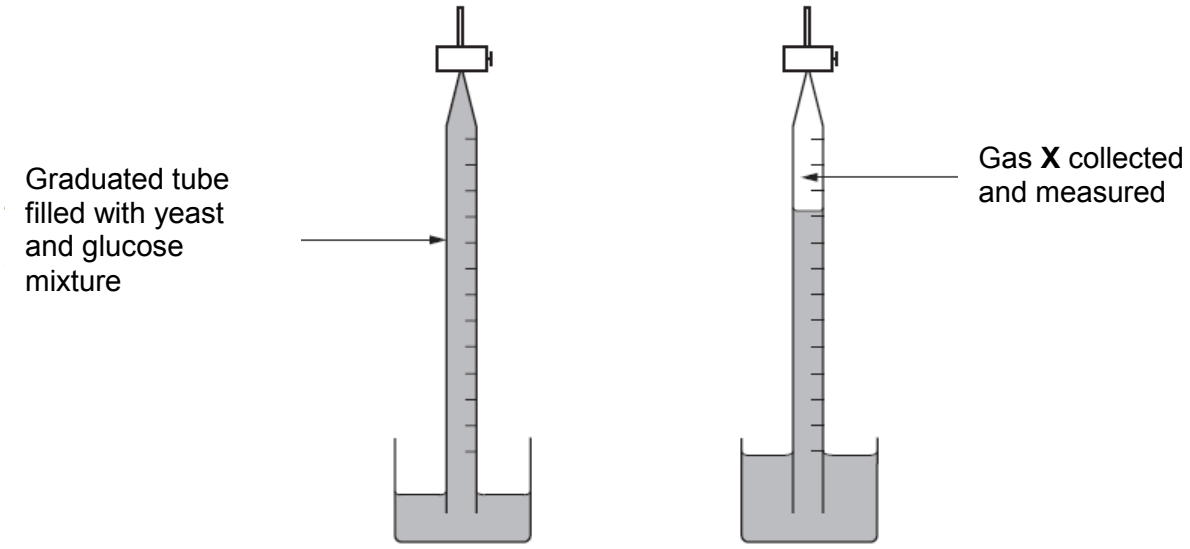
8

3. Scientists at a large brewery carried out an investigation into the effectiveness of three different strains of yeast which were fermenting glucose.

The basic outline of the investigative procedure is given below:

- boil and rapidly cool 2 litres of sterilized water to remove dissolved gases
- add 5 g of yeast to sterilized water
- dissolve glucose in the yeast-sterilized water mixture and pour into 3 sterilized graduating tubes until full
- measure the volume of gas given off every 15 minutes.

The apparatus is shown below.



Results table

		Volume of gas produced after 15 min (cm^3)	Volume of gas produced after 30 min (cm^3)	Volume of gas produced after 45 min (cm^3)	Volume of gas produced after 60 min (cm^3)	Volume of gas produced after 75 min (cm^3)
Strain of yeast	***Saccharomyces uvarum***	11.4	26.6	41.7	43.2	43.2
	Brettanomyces lambicus	6.1	14.8	22.1	23.9	23.9
	Saccharomyces cerevisiae	11.4	29.5	43.0	44.6	44.6

(a) (i) Name gas **X** shown in the diagram and explain its production. Include the relevant word equation in your answer. [4]

.....

.....

.....

.....

(ii) State which strain of yeast would be most effective at producing ethanol and explain your answer. [3]

Strain of yeast .....……

Explanation

.....

.....

.....

(iii) Why was it important to:

I completely fill the tubes at the start of the investigation [2]

.....

.....

II sterilize the water and graduated tubes? [1]

.....

(iv) The mean rate for the production of X in the first 45 minutes using Saccharomyces uvarum was 0.93 cm^3 of X/min.

I Calculate the mean rate of the production of gas X between 45 and 60 minutes for the same yeast. [2]

mean rate = …….. cm^3 of X/min

II Give **two** reasons why the rate of production of gas **X** may have slowed after 45 minutes. [2]

.....

.....

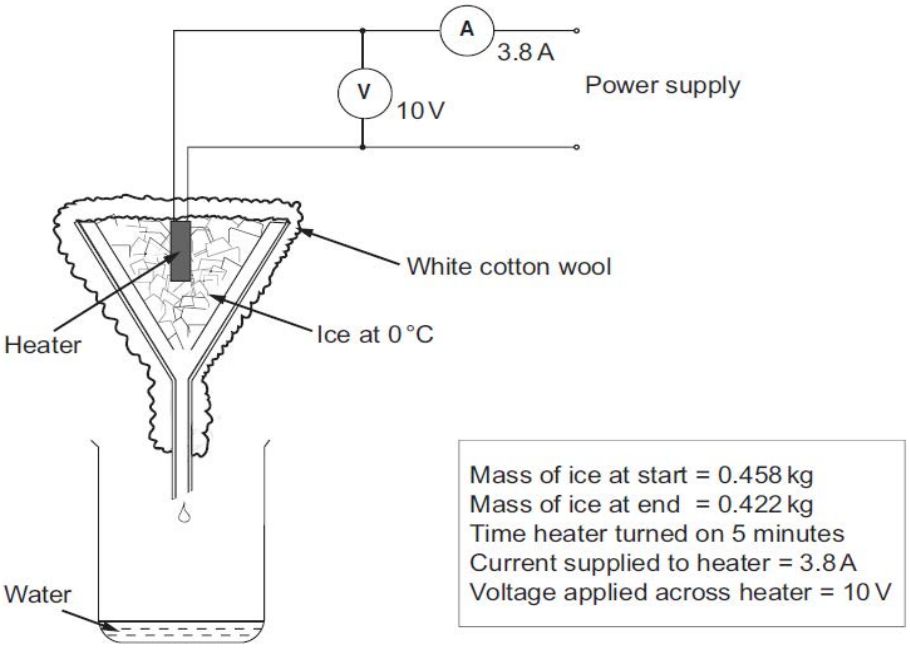
.....

(b) In the basic outline of the investigative procedure given above a number of the controlled variables have been omitted. Controlled variables are usually far more important than the dependent or independent variables. State why these must be controlled. [1]

.....

15

4. The following apparatus is used in an experiment to find the specific latent heat of fusion of ice.



(a) Explain what is meant by the phrase "the specific latent heat of fusion of ice". [3]

……...

……...

……...

(b) The density of ice is 0.92 g/cm^3. Calculate the volume of ice (in cm^3) that has melted. [3]

volume = ... cm^3

(c) (i) Calculate the energy supplied by the heater in 5 minutes. [4]

energy supplied = ... J

(ii) Use an equation from **page 2** to calculate the specific latent heat of fusion of ice. [3]

specific latent heat of fusion = ... J/kg

(iii) If the insulation was to be removed and the experiment repeated, explain the effect on the calculated value of the specific latent heat of fusion. [2]

.....

.....

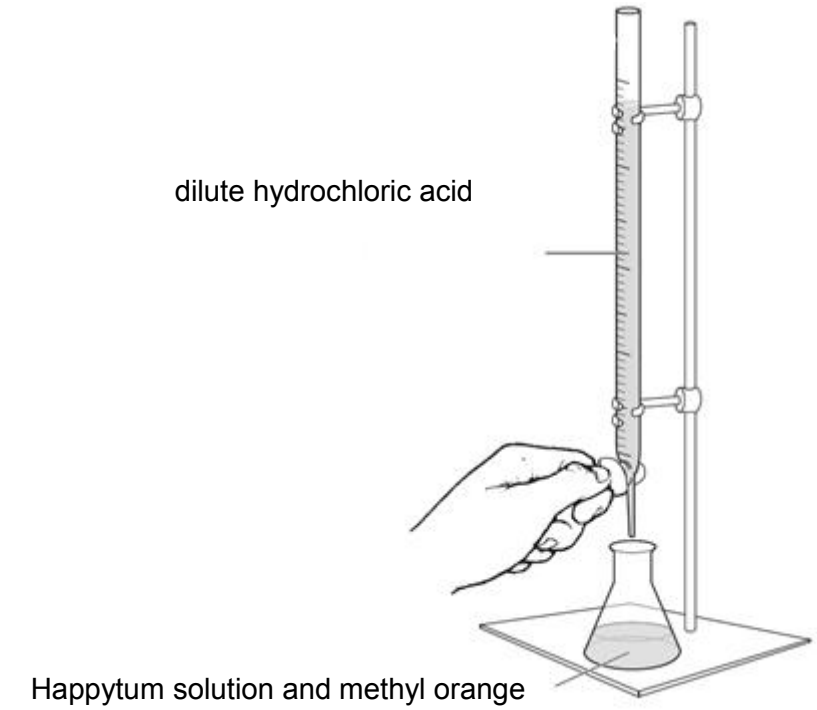
15

5. 'Happytum' is an antacid tablet used to treat indigestion which is caused by excess acid in the stomach. Antacids contain calcium carbonate.

A group of students was asked to carry out an investigation to find the percentage of calcium carbonate in a Happytum tablet. They followed the procedure below:

1. A tablet weighing 0.54 g was crushed and added to 50 cm^3 of water in a conical flask.
2. Five drops of methyl orange were added.
3. The mixture was titrated with dilute hydrochloric acid of concentration 0.25 mol/dm^3 until the methyl orange turned red.
4. This procedure was repeated using an identical tablet.

Diagram of apparatus



(a) Describe the chemical reaction that occurs between a Happytum tablet and an acid. [2]

……...

……...

……...

The results collected were as follows.

	Run 1	**Run 2**
Final volume (cm^3)	12.30	23.90
Initial volume (cm^3)	0.65	12.30
Volume added (cm^3)	.....	.....

(b) Calculate the mean volume added. [1]

mean volume added = …… cm^3

(c) In this reaction,1 mol of calcium carbonate reacts with 2 mol of hydrochloric acid.
Calculate the amount in moles of calcium carbonate in one tablet. [2]

amount of calcium carbonate = …… mol

(d) Calculate the percentage by mass of calcium carbonate in each tablet. [2]

percentage by mass = …… %

(e) Explain why the two titres above are not the same. [2]
Assume no weighing errors or spillages were made.

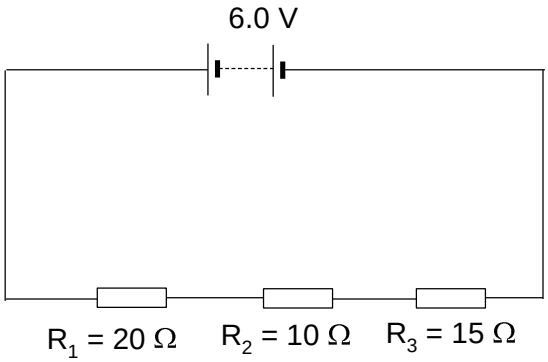
……

……

……

6. A group of pupils study electrical circuits in a physics lesson. They are given a 20 Ω resistor, a 15 Ω resistor and a 10 Ω resistor.

(a) They set up the following circuit with the aim to use it to make various measurements.



(i) Calculate the current in the circuit. [4]
Record your answer to two decimal places.

current = ...

(ii) **Add** to the circuit diagram the symbol for a voltmeter to measure the potential difference across the ends of the 15 Ω resistor. [1]

(iii) **Modify** the circuit diagram to add the symbol of an ammeter which measures the current through the 15 Ω resistor. [1]

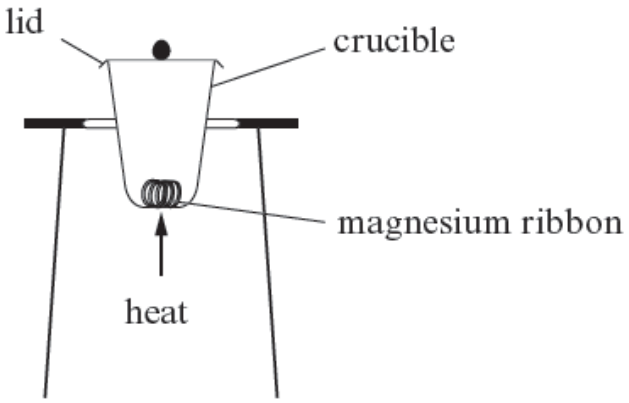
(iv) Calculate the potential difference across the 20 Ω resistor. [1]

potential difference = ... V

(b) Draw a circuit diagram below that uses the same components as the one above with a **higher** total current. Explain why your circuit has a higher current. [3]

10

7. Magnesium burns in air with a bright white flame to give a white powder called magnesium oxide. In order to work out the formula of magnesium oxide, Emily and Dwayne carried out an experiment using the apparatus shown below.



The results of their experiment are shown in the table.

Mass of crucible and lid (g)	19.80
Mass of crucible, lid and magnesium (g)	20.28
Mass of crucible, lid and product after heating (g)	20.44

(a) State what is meant by the term 'empirical formula'. [2]

……...

……...

(b) Calculate the empirical formula for magnesium oxide using Emily and Dwayne's results.
You must show your workings. [4]

A_r (Mg) = 24 A_r (O) = 16

empirical formula ……

(c) The correct empirical formula of magnesium oxide is MgO. Explain why Emily and Dwayne's results give a different value.

[Assume that they did not spill any product and correctly weighed the material in each case.] [2]

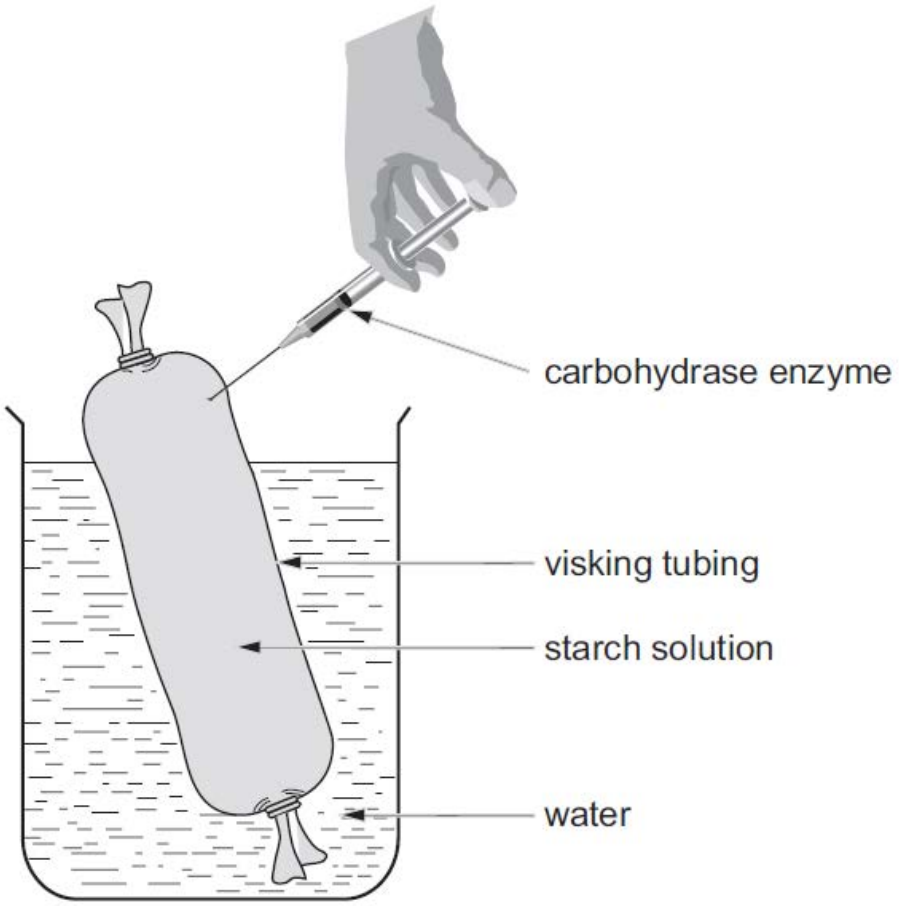
.....

.....

.....

8

8. An experiment was carried out to investigate some of the properties of visking tubing. A piece of tubing was knotted at the bottom end and then filled with starch solution. A knot was then tied at the top end. The filled visking tubing was then suspended in a beaker of water.



For the next 15 minutes the water in the beaker was sampled, at 5 minute intervals, for the presence of both starch and glucose. After 15 minutes a carbohydrase enzyme was injected into the visking tubing and further samples of water were tested.

The results are shown below:

	Time (minutes)						
	0	5	10	15	20	25	30
starch	-	-	-	-	-	-	-
glucose	-	-	-	-	+	++	+++

Key - = negative result
\+ = positive result
\+++ = increasing concentration

(a) Account for the observations made in this experiment. [6 QER]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) State how the water in the beaker was tested for both glucose and starch and how the tests confirmed the results in the table above. [4]

.....

.....

.....

.....

.....

.....

.....

.....

10

GCSE COMBINED SCIENCE

COMPONENT 4

Applications in Science

HIGHER TIER

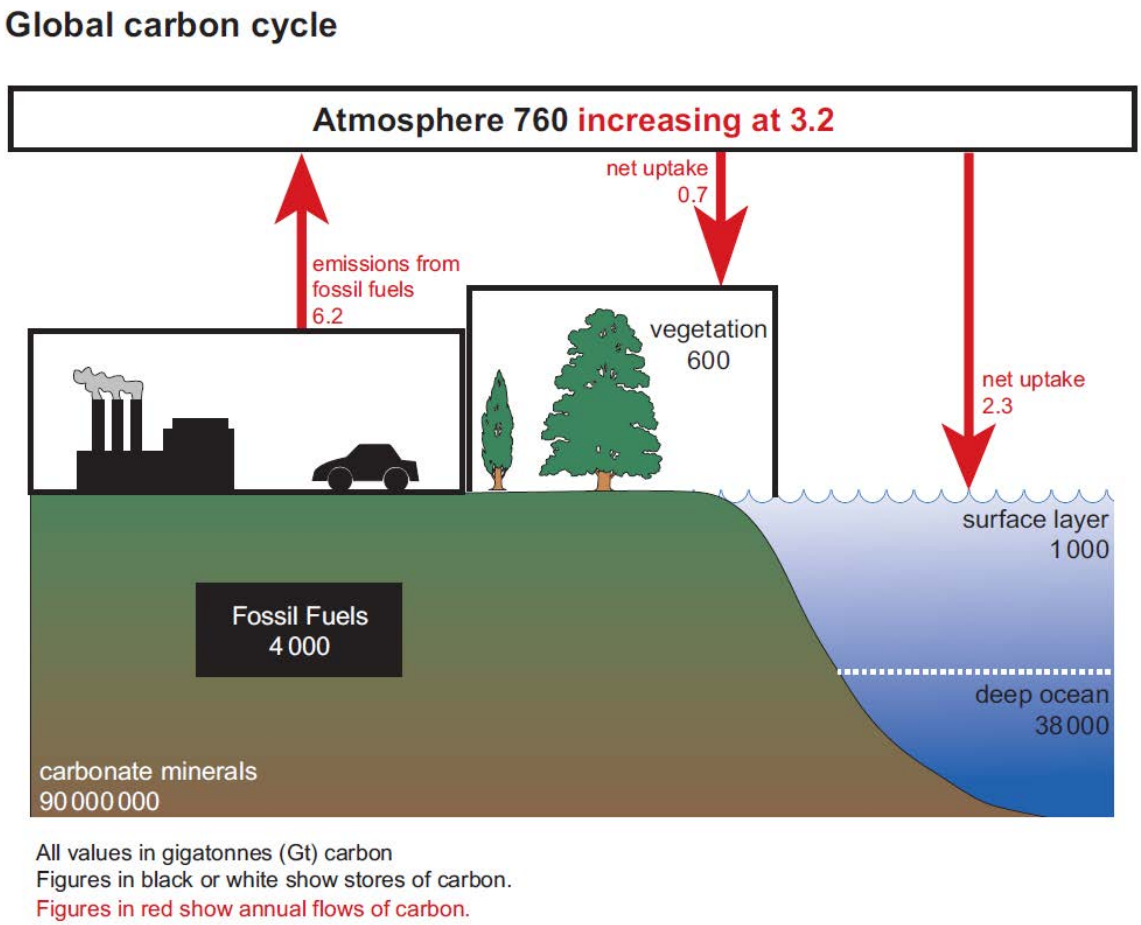
SAMPLE ASSESSMENT MATERIALS

RESOURCE BOOKLET
for use in Section A

EXPLORING THE GREENHOUSE EFFECT

On Earth, carbon is recycled as shown in **Diagram 1** below.

Diagram 1



It is claimed that global warming is caused by humans adding greenhouse gases (GHG) to the atmosphere. Two GHG are carbon dioxide (CO_2) and methane (CH_4).

Greenhouse gases can be compared using their Global Warming Potential (GWP). GWP is the ability of a GHG to trap heat in the atmosphere relative to an equal amount of carbon dioxide. **Table 1** gives the GWP of four GHG.

Table 1

Greenhouse gas	GWP
CO_2	1
CH_4	21

Equation 1

$$\text{greenhouse contribution in kg } CO_2\text{eq} = \text{mass of gas (kg)} \times \text{GWP}$$

The Government gives a grant to buyers of electric vehicles. This is intended to reduce the amount of GHG we produce.

Two such electric vehicles are the Amptec and the Voltec. The Voltec car has an electric motor only. The Amptec car has both an electric motor and a petrol engine. **Table 2** gives information about these electric vehicles and of a petrol engine car.

Table 2

	Typical petrol engine car	Amptec	Voltec
Range per charge (km)	not applicable	80	200
Range on one tank of fuel (km)	700	660	not applicable
Mean fuel used (litres per 100 km)	6.0	1.2	0
Official CO_2 produced (g/km) (Tested over 100 km)	100	27	0

COMPONENT 4 – Applications In Science

HIGHER TIER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statements.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

SECTION A

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)		2 H_2O (1) + CO_2 (1)	2			2		
		(ii)	I	100 × 21 (1) = 2 100 [kg CO_2eq] (1)		2		2	1	
			II	Carbon dioxide produced by burning has a greenhouse contribution of 275 [kg CO_2eq] (1) Which is less than that of methane (1)			2	2		
	(b)	(i)	I	Doesn't burn fossil fuels / produce CO_2		1		1		
			II	280 × 27 (1) 7 560 [g] (1)		2		2	2	
		(ii)		32 × 0.45 (1) = 14.4 [kg] (1)		2		2	2	
		(iii)		Ignores carbon dioxide produced during charging (1) Which is equivalent to 72 g/km (1)			2	2		
	(c)			They are then cheaper so encourages us to buy electric vehicles (1) Meets [government] targets on CO_2 production / decrease carbon footprint of user (1)	2			2		
				Question 1 total	**4**	**7**	**4**	**15**	**5**	**0**

SECTION B

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>2</td><td>(a)</td><td></td><td></td><td>Conical flask containing hydrochloric acid and marble chips (1)
Fitted with bung and connected by suitable tubing to gas syringe /inverted measuring cylinder over water (1)
Allow fully labelled diagram to earn marks
Measure time taken to collect 100 cm^3 using stopwatch (1)</td><td>3</td><td></td><td></td><td>3</td><td></td><td>3</td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>Construction of suitable table (1)
Correct title and units in columns 2 & 3 (1)
Correct data in columns 2 & 3. Time must be in seconds (1)

<table><tr><th>Name of student</th><th>Start temperature (^oC)</th><th>Time for reaction (seconds)</th></tr><tr><td>James</td><td>21</td><td>150</td></tr><tr><td>Abigail</td><td>30</td><td>76</td></tr><tr><td>Syra</td><td>40</td><td>38</td></tr></table>
Alternative response:

<table><tr><th>Name of student</th><th>James</th><th>Abigail</th><th>Syra</th></tr><tr><td>Start temperature (^oC)</td><td>21</td><td>30</td><td>40</td></tr><tr><td>Time for reaction (seconds)</td><td>150</td><td>76</td><td>38</td></tr></table></td><td></td><td>3</td><td></td><td>3</td><td>1</td><td>3</td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>Any time estimate between 18 and 20 seconds (1)
The reaction rate [approximately] doubles / time for the reaction [approximately] halves for every 10^oC rise [in temperature] (1)</td><td></td><td></td><td>2</td><td>2</td><td>1</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 2 total</td><td>3</td><td>3</td><td>2</td><td>8</td><td>2</td><td>8</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)	(i)		CO_2 (1) Anaerobic respiration (1) Of glucose (1) Glucose → ethanol and carbon dioxide (1)	4			4		
		(ii)		*S. cerevisiae* (1) Higher the rate of fermentation the higher the rate of CO_2 production (1) And therefore ethanol production (1)		1	1 1	3		3
		(iii)	I	To exclude air (1) And therefore prevent aerobic respiration (1)	2			2		2
			II	To prevent contamination with wild/other strains of yeasts	1			1		1
		(iv)	I	(43.2 - 41.7) (1) 60-45 =0.1 (1)		2		2	2	
			II	Yeast being poisoned by ethanol (1) Glucose becoming depleted (1)		2		2		2
	(b)			Failure to isolate controlled variables will compromise the validity of the investigation	1			1		1
				Question 3 total	**8**	**5**	**2**	**15**	**2**	**9**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	(a)			The amount of energy per kg (1) Required to change ice to water (1) Without change in temperature (1)	3			3		
	(b)			Determination that mass of melted ice = 0.036 kg (1) Conversion to 36 g (1) $\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{36}{0.92}$ = 39.1 [cm^3] (1)		3		3	3	3
	(c)	(i)		Recall of: $P = V \times I$ (1) Substitution: P = 3.8 × 10 = 38 [W] (1) Energy supplied = $P \times t$ = 38 × 300 (1-conversion of minutes) = 11 400 [J] (1)	1 1	1 1		4	3	4
		(ii)		Substitution into $Q = mL$ i.e.11 400 = 0.036 $\times L$(1) Manipulation: (1) i.e. $L = \frac{11400(\text{ecf})}{0.036(\text{ecf})}$ L = 3.2 × 10^5 [J/kg] (1)	1	1 1		3	3	3
		(iii)		Greater mass of ice melts for the same amount of heat supplied by the heater (1) L calculated from this experiment would be smaller than the actual value (1)			2	2		2
				Question 4 total	**6**	**7**	**2**	**15**	**9**	**12**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			Neutralisation reaction (1) in which salt, carbon dioxide and water are formed (1)	2			2		2
	(b)			11.65 (first box), 11.60 (second box) Do not accept 11.6 Mean = 11.63 [cm^3]		1		1		1
	(c)			moles HCl = 11.63 (**ecf**) $\times \frac{0.25}{1000}$ = 0.0029 mol (1) moles $CaCO_3$ = 2 $\times$ 0.0029 (**ecf**) = 0.0058 [mol] (1)		2		2	2	2
	(d)			mass $CaCO_3$ = 0.0058 (**ecf**) $\times$ 40 = 0.232 / 0.23 g (1) % = 0.232 (**ecf**) $\times \frac{100}{0.54}$ = 42.9/43 [%] (1)		2		2	2	2
	(e)			Reading of burette scale / parallax errors (1) Adding too much acid / passing the endpoint (1)			2	2		2
				Question 5 total	**2**	**5**	**2**	**9**	**4**	**9**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)		Total resistance = 20 + 15 + 10 = 45 (Ω) (1) Recall $V = IR$ (1) $I = V/R$ = 6/45 rearrange and substitute (1) = 0.13A (1) Both number + unit for mark (1) Allow ecf.	1	1 1 1		4	2	3
		(ii)		Correct symbol for voltmeter in parallel with the 15 Ω (or R_2) resistor	1			1		1
		(iii)		Correct symbol for ammeter in series with the 15 Ω resistor	1			1		1
		(iv)		20 × 0.13 = 2.6 [V]		1		1	1	1
	(b)			Two or three resistors must be shown in parallel in completed circuit. (1) By placing resistors in parallel there are more branches for current to flow through. (1) So decreasing total resistance. (1)		3		3	2	3
				Question 6 total	**3**	**7**	**0**	**10**	**5**	**9**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			Simplest whole number (1) Ratio of atoms/ions in compound (1)	2			2		
	(b)			Mass Mg = 20.28 - 20.04 = 0.24 [g] Mass oxygen reacted = 20.44 - 20.28 = 0.16 [g] Both correct for a mark (1) $\text{Moles} = \frac{\text{mass}}{\text{molar mass}}$ (1) Mg = $\frac{0.48}{0.24(\textbf{ecf})}$ = 0.02 [mol] **and** O = $\frac{0.16(\textbf{ecf})}{16}$ = 0.01 [mol](1) Empirical formula: i.e. Mg_2O (1) Allow **ecf** Workings must be shown to obtain marks. If the correct empirical formula is given without workings award 1 mark only	1	1 1	1	4	2	4
	(c)			Not all the magnesium reacted (1) therefore amount of oxygen underestimated (1)			2	2		2
				Question 7 total	**3**	**2**	**3**	**8**	**2**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			**Indicative content:** **AO1 allocation** - Visking tubing gives a model of selectively permeable membrane which allows diffusion of molecules based upon size. Small molecules can diffuse through but not larger ones. Starch can be thought of as a chain of glucose molecules **AO3 allocation** - Starch is too large to diffuse across the membrane and so is not detected in the beaker. In first 15 minutes there is no glucose in water but after 15 minutes glucose is detected. After 15 minutes the concentration of the glucose increases up to 30 minutes. The only source of glucose is from the digestion of starch. The enzyme carbohydrase must break down starch into glucose molecules once it is added. **5 – 6 marks** Clear understanding of the idea of selective diffusion based upon size of molecules across the Visking tubing. Clearly states similarities (structure of glucose as chain of glucose molecules) and differences (size of molecules) between starch and glucose. Clearly explains the change in glucose concentration in terms of action of enzyme and subsequent diffusion of smaller molecule across membrane. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. The information included in the response is relevant to the argument.* **3 – 4 marks** Appreciates that Visking tubing is a selective membrane which allows smaller molecules (glucose) to pass through. Starch does not pass through because of larger size. Understands that glucose is only formed after the addition of carbohydrase and so only starts diffusing after the enzyme is added. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.*	3		3	6		6

				1 – 2 marks An appreciation of the relative sizes of the molecules and that smaller molecule can diffuse across the Visking tubing. Glucose is the smaller molecule which diffuses after 15 minutes only after carbohydrase has been added. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks** *No attempt made or no response worthy of credit.*						
	(b)			Water added to iodine solution (1) Stayed brown therefore no starch present (1) Water added to Benedict's solution and heated strongly (1) Went orange/red/brick red therefore glucose present (1)	4			4		4
				Question 8 total	**7**	**0**	**3**	**10**	**0**	**10**

COMPONENT 4 – Applications in Science

HIGHER TIER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

	Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
Section A	1	4	7	4	15	5	0
Section B	2	3	3	2	8	2	8
	3	8	5	2	15	2	9
	4	6	7	2	15	9	12
	5	2	5	2	9	4	9
	6	3	7	0	10	5	9
	7	3	2	3	8	2	6
	8	7	0	3	10	0	10
	TOTAL	**36**	**36**	**18**	**90**	**29**	**63**