# COMBINED SCIENCE

**Paper 0653/11**
**Multiple Choice (Core)**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | D | 21 | A | 31 | C |
| 2 | C | 12 | B | 22 | B | 32 | D |
| 3 | C | 13 | D | 23 | D | 33 | B |
| 4 | A | 14 | B | 24 | C | 34 | A |
| 5 | B | 15 | A | 25 | D | 35 | D |
| 6 | B | 16 | D | 26 | B | 36 | C |
| 7 | A | 17 | D | 27 | B | 37 | B |
| 8 | A | 18 | A | 28 | A | 38 | B |
| 9 | C | 19 | C | 29 | D | 39 | A |
| 10 | B | 20 | C | 30 | C | 40 | D |

## General comments

Candidates performed very well on **Questions 1**, **4**, **5**, **7**, **16**, **17** and **28**. **Questions 9**, **21**, **23**, **30**, **31**, **34**, **35**, **36**, **37**, **38** and **40** proved the most challenging for candidates.

## Comments on specific questions

### Question 9

All of the options were chosen with equal frequency, indicating a lack of confidence with interpreting diagrams of plant stems and a lack of understanding of which substances are transported within a stem.

### Question 21

Options **C** and **D** were popular incorrect choices. These candidates could not recall the reactivity series.

### Question 23

Options **A** and **C** were as popular as the correct answer, option **D**, indicating that candidates were guessing. Air contains approximately 20% oxygen, so 100 $cm^3$ would contain 20 $cm^3$.

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**Question 30**

All responses were chosen with equal frequency. Candidates were unable to explain why the head of a drawing pin does not go into a thumb when pressed.

**Question 31**

Option **A** was a popular incorrect choice. These candidates had confused a property of gases with liquids.

**Question 34**

Option **D** was chosen more often than the correct answer, option **A**. Candidates confused wavelength with amplitude.

**Question 35**

Option **B** was more popular than the correct answer, option **D**. These candidates recognised the process as refraction but did not know how the light changes direction.

**Question 36**

Options **A** and **D** were more popular than the correct answer showing a lack of knowledge of the order of waves within the electromagnetic spectrum in terms of wavelength and frequency.

**Question 37**

Option **D** was chosen more frequently than the correct answer, option **B**. These candidates did not appreciate the relationship between voltage, resistance and current.

**Question 38**

Option **D** was more popular than the correct answer showing confusion about how switches can control different components within a parallel circuit depending on the position of the switch.

**Question 40**

All the other options were more popular than the correct answer showing a lack of confidence in calculating distance from speed and time. Using $\times 10^8$ may have been a challenge for some candidates.



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**Paper 0653/12**
**Multiple Choice**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | D | 21 | C | 31 | B |
| 2 | A | 12 | A | 22 | D | 32 | B |
| 3 | D | 13 | C | 23 | A | 33 | D |
| 4 | B | 14 | D | 24 | B | 34 | C |
| 5 | C | 15 | B | 25 | B | 35 | C |
| 6 | D | 16 | C | 26 | C | 36 | C |
| 7 | C | 17 | A | 27 | D | 37 | A |
| 8 | A | 18 | A | 28 | A | 38 | B |
| 9 | B | 19 | A | 29 | A | 39 | D |
| 10 | C | 20 | B | 30 | D | 40 | B |

## General comments

Candidates performed very well on **Questions 1**, **2**, **3**, **5**, **7** and **11**. **Questions 6**, **8**, **9**, **16**, **19**, **20**, **24**, **25**, **26**, **29**, **30**, **34**, **35**, **37**, **38** and **40** proved the most challenging for candidates.

## Comments on specific questions

### Question 6

Option **C** was chosen more frequently than the correct answer, option **D**. These candidates found it challenging to interpret the results of an investigation into the presence of starch in leaves left in the dark and in the light.

### Question 8

Option **B** was more popular than the correct answer, option **A**. Candidates knew that chemical digestion breaks down large molecules, but they thought these large molecules were soluble.

### Question 16

Option **A** was more popular than the correct answer, option **C**. Candidates thought that a decrease in temperature indicated an exothermic reaction.



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**Question 19**

All of the options were chosen with equal frequency, indicating guessing and a lack of confidence with interpreting the state of matter of a halogen at room temperature, given its melting point and boiling point.

**Question 20**

Option **D** was as popular as the correct answer, option **B**. Candidates incorrectly thought that brass was a compound.

**Question 24**

Option **A** was chosen more often than the correct answer, option **A**. Candidates had confused the products of incomplete combustion and complete combustion.

**Question 25**

Option **D** was more popular than the correct answer, option **B**. Candidates did not appreciate that the main constituent of natural gas is methane and that petroleum is a mixture of hydrocarbons.

**Question 26**

Option **B** was more popular than the correct answer, option **C**. Z cannot be a hydrocarbon as it contains a chlorine atom.

**Question 29**

Options **B** and **C** were as popular as the correct answer, option **A**, showing a lack of understanding of energy changes in terms of kinetic and gravitational potential energy.

**Question 30**

Option **B** was more frequently chosen than the correct answer, option **D**. These candidates thought the pressure would be halved rather than doubled.

**Question 34**

Options **A** and **D** were more popular than the correct answer, option **C**. These candidates were not confident identifying how to measure the frequency of the water wave.

**Question 35**

All the options were more commonly chosen than the correct answer, option **C**, showing a lack of understanding of how an image forms.

**Question 37**

Option **B** was as popular as the correct answer, option **A**. These candidates were not confident in their understanding of the relationship between voltage, current and resistance.

**Question 38**

Option **C** was as popular as the key and option **D** was chosen more often than the key. Candidates were not confident calculating power from voltage and current.

**Question 40**

Option **C** was more commonly chosen than the correct answer, option **B**, and option **D** was as popular. These candidates could not recall the diameter of the Milky Way.


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**Paper 0653/13**
**Multiple Choice**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | D | 21 | C | 31 | B |
| 2 | A | 12 | A | 22 | D | 32 | B |
| 3 | D | 13 | C | 23 | A | 33 | D |
| 4 | B | 14 | D | 24 | B | 34 | C |
| 5 | C | 15 | B | 25 | B | 35 | C |
| 6 | D | 16 | C | 26 | C | 36 | C |
| 7 | C | 17 | A | 27 | D | 37 | A |
| 8 | A | 18 | A | 28 | A | 38 | B |
| 9 | B | 19 | A | 29 | A | 39 | D |
| 10 | C | 20 | B | 30 | D | 40 | B |

## General comments

Candidates performed very well on **Questions 1**, **2**, **3**, **5**, **7** and **11**. **Questions 6**, **8**, **9**, **16**, **19**, **20**, **24**, **25**, **26**, **29**, **30**, **34**, **35**, **37**, **38** and **40** proved the most challenging for candidates.

## Comments on specific questions

### Question 6

Option **C** was chosen more frequently than the correct answer, option **D**. These candidates found it challenging to interpret the results of an investigation into the presence of starch in leaves left in the dark and in the light.

### Question 8

Option **B** was more popular than the correct answer, option **A**. Candidates knew that chemical digestion breaks down large molecules, but they thought these large molecules were soluble.

### Question 16

Option **A** was more popular than the correct answer, option **C**. Candidates thought that a decrease in temperature indicated an exothermic reaction.

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**Question 19**

All of the options were chosen with equal frequency, indicating guessing and a lack of confidence with interpreting the state of matter of a halogen at room temperature, given its melting point and boiling point.

**Question 20**

Option **D** was as popular as the correct answer, option **B**. Candidates incorrectly thought that brass was a compound.

**Question 24**

Option **A** was chosen more often than the correct answer, option **A**. Candidates had confused the products of incomplete combustion and complete combustion.

**Question 25**

Option **D** was more popular than the correct answer, option **B**. Candidates did not appreciate that the main constituent of natural gas is methane and that petroleum is a mixture of hydrocarbons.

**Question 26**

Option **B** was more popular than the correct answer, option **C**. Z cannot be a hydrocarbon as it contains a chlorine atom.

**Question 29**

Options **B** and **C** were as popular as the correct answer, option **A**, showing a lack of understanding of energy changes in terms of kinetic and gravitational potential energy.

**Question 30**

Option **B** was more frequently chosen than the correct answer, option **D**. These candidates thought the pressure would be halved rather than doubled.

**Question 34**

Options **A** and **D** were more popular than the correct answer, option **C**. These candidates were not confident identifying how to measure the frequency of the water wave.

**Question 35**

All the options were more commonly chosen than the correct answer, option **C**, showing a lack of understanding of how an image forms.

**Question 37**

Option **B** was as popular as the correct answer, option **A**. These candidates were not confident in their understanding of the relationship between voltage, current and resistance.

**Question 38**

Option **C** was as popular as the key and option **D** was chosen more often than the key. Candidates were not confident calculating power from voltage and current.

**Question 40**

Option **C** was more commonly chosen than the correct answer, option **B**, and option **D** was as popular. These candidates could not recall the diameter of the Milky Way.


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# COMBINED SCIENCE

**Paper 0653/21**
**Multiple Choice (Extended)**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | B | 21 | D | 31 | D |
| 2 | B | 12 | B | 22 | C | 32 | A |
| 3 | D | 13 | C | 23 | A | 33 | D |
| 4 | D | 14 | B | 24 | D | 34 | D |
| 5 | B | 15 | B | 25 | A | 35 | C |
| 6 | A | 16 | C | 26 | C | 36 | A |
| 7 | A | 17 | D | 27 | B | 37 | A |
| 8 | A | 18 | A | 28 | B | 38 | C |
| 9 | C | 19 | C | 29 | B | 39 | C |
| 10 | C | 20 | B | 30 | B | 40 | B |

## General comments

Candidates performed very well on **Questions 1**, **2**, **6**, **8**, **11**, **17**, **18**, **22** and **32**. **Questions 15**, **21**, **24**, **25**, **28**, **30**, **34** and **38** proved the most challenging for candidates.

## Comments on specific questions

### Question 15

Option **A** was a popular incorrect choice. Candidates thought thermal energy is given out as bonds break rather than as bonds form.

### Question 21

Options **A**, **B** and **C** were frequently chosen by candidates, indicating a lack of confidence in interpreting diagrams of molecules.

### Question 24

Options **B** and **C** were sometimes selected. Some candidates were not confident with the observations of the reaction of aqueous chlorine and aqueous potassium bromide.

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**Question 25**

Options **A** and **B** were chosen by candidates who were not familiar with the equations for reactions that take place in the blast furnace.

**Question 28**

Option **A** was as popular as the correct answer, option **B**. These candidates could not calculate the average speed of the cyclist from the distance and times provided.

**Question 30**

Options **A** and **C** were sometimes chosen. These candidates did not know the meaning of the term geothermal.

**Question 34**

Option **B** was chosen by candidates who thought the angle of incidence is between the ray of light and the air–glass boundary rather than the normal.

**Question 38**

Option **B** was selected by candidates who reversed what happens to the ammeter reading and the total resistance.



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# COMBINED SCIENCE

**Paper 0653/22**
**Multiple Choice (Extended)**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | D | 21 | D | 31 | A |
| 2 | A | 12 | A | 22 | B | 32 | D |
| 3 | C | 13 | D | 23 | B | 33 | A |
| 4 | B | 14 | A | 24 | D | 34 | C |
| 5 | A | 15 | A | 25 | A | 35 | A |
| 6 | B | 16 | B | 26 | D | 36 | C |
| 7 | B | 17 | C | 27 | C | 37 | C |
| 8 | C | 18 | C | 28 | A | 38 | B |
| 9 | C | 19 | B | 29 | B | 39 | D |
| 10 | A | 20 | D | 30 | C | 40 | D |

## General comments

Candidates performed very well on **Questions 1**, **3**, **9**, **12** and **15**. **Questions 4**, **10**, **11**, **14**, **21**, **26**, **30** and **33** proved the most challenging for candidates.

## Comments on specific questions

### Question 4

Option **C** was a popular incorrect choice, with candidates confusing the graph for enzyme activity and pH with temperature.

### Question 10

Option **B** was sometimes chosen by candidates who thought sex was not a risk factor for coronary heart disease.

### Question 11

Option **B** was a popular choice. Candidates may have found interpreting the Venn diagram format challenging.

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**Question 14**

All the incorrect options were frequently selected, indicating that candidates found recognising the arrangement of particles challenging. The negative numbers may have made this more difficult for some candidates.

**Question 21**

Options **A** and **B** were selected by candidates who could not recall that the number of protons is used to arrange the Periodic Table.

**Question 26**

Option **A** was more commonly chosen than the correct answer. These candidates did not appreciate that filtering was not necessary in the preparation.

**Question 30**

Option **A** was more popular than the correct answer, option **C**. Option **B** was also frequently chosen. Candidates were not confident in determining pressure from weight and area.

**Question 33**

Option **C** was commonly chosen. These candidates knew that density decreases but did not realise that volume increases.



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# COMBINED SCIENCE

**Paper 0653/23**
**Multiple Choice (Extended)**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | D | 11 | D | 21 | A | 31 | D |
| 2 | C | 12 | A | 22 | B | 32 | B |
| 3 | B | 13 | A | 23 | D | 33 | C |
| 4 | C | 14 | C | 24 | B | 34 | B |
| 5 | A | 15 | B | 25 | A | 35 | C |
| 6 | B | 16 | D | 26 | C | 36 | D |
| 7 | A | 17 | C | 27 | D | 37 | A |
| 8 | C | 18 | A | 28 | C | 38 | B |
| 9 | B | 19 | D | 29 | D | 39 | A |
| 10 | D | 20 | C | 30 | B | 40 | A |

## General comments

Candidates performed very well on **Questions 3**, **4**, **8**, **10**, **12**, **13**, **14**, **17**, **22**, **24**, **25**, **31** and **39**. **Questions 18**, **21**, **26**, **28**, **29**, **35** and **38** proved the most challenging for candidates.

## Comments on specific questions

### Question 18

Option **B** was more popular than the correct answer, option **A**. These candidates thought that ethane was reduced rather than oxidised.

### Question 21

All the options were frequently chosen, indicating a lack of confidence with the trends associated with Group VII elements.

### Question 26

All the options were frequently chosen, indicating a lack of confidence with interpreting $R_f$ value.

### Question 28

Option **D** was as popular as the correct answer, option **C**. These candidates were not able to interpret the speed-time graph to determine the height.

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**Question 29**

Option **B** was more popular than the correct answer, option **D**, with candidates who confused weight and mass.

**Question 35**

Option **A** was sometimes chosen. These candidates correctly identified the angle of incidence but did not know the direction in which the ray of light moved.

**Question 38**

Option **D** was sometimes chosen by candidates who did not know the relationship between resistors in parallel.



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# COMBINED SCIENCE

**Paper 0653/31**
**Core Theory**

## Key messages

Candidates should always show their working in numerical question as they may gain credit for a correct formula even if their calculation contains an arithmetic error. This was relevant in **Questions 4(b)(ii)**, **7(a)(iii)** and **9(b)(i**) in this paper.

Candidates should read the question carefully. See comments for **7(a)(ii)** and **7(b)**.

All candidates should make sure that they are familiar with the syllabus content. Some questions require the recall of syllabus statements and references to these questions are indicated throughout this report.

## General comments

There were some good responses from those candidates who demonstrated a thorough knowledge of all three sciences. These candidates were able to answer questions in both familiar and unfamiliar contexts. Candidates are advised to attempt every question, especially those questions where they make a choice from answers that are written on the question paper.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates successfully identified the liver.

**(ii)** Generally, well answered. A few candidates confused **F**, the mouth with **D**, the large intestine.

**(iii)** Some candidates identified the correct answer that physical digestion involves breaking large food pieces into smaller food pieces. The most common incorrect answer chosen was insoluble molecules are broken down into soluble molecules. Candidates are reminded that physical digestion does not involve any chemical changes to the food.

**(b) (i)** The higher-scoring candidates who were familiar with the syllabus answered this question well. Others struggled to gain full credit. Many answered gradient correctly with fewer stating the first response, net. The word net is used to describe the overall effect of the random movement of the particles and considers that a small number of particles will move against the concentration gradient, the vast majority will move down the concentration gradient.

**(ii)** Generally, answered well.

**(c)** Many candidates were unfamiliar with the chemical test for protein. Incorrect responses included testing for starch sugar and fat. The biological molecule stated by the candidates did not match the test solution in some cases. Candidates should be familiar with the tests for each biological molecule, the correct reagent and the colour change showing a positive result.

### Question 2

**(a) (i)** Generally, candidates were successful in identifying Y, the penis. They struggled to name X the sperm duct correctly. Incorrect responses included urethra and prostate gland. In Fig. 2.1 the


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sperms leave the testis and travel through the sperm duct before entering the urethra which goes down the centre of the penis.

**(ii)** Overall, candidates knew the position of the testis, and many labelled it correctly. Some candidates were not awarded credit for their answer because their label line either stopped at the scrotum, or just inside the scrotum, not touching the testis. Candidates are reminded that the label line must either touch the body part or finish inside it.

**(b) (i)** Candidates found this question challenging. The correct answer, eggs, was given by a few higher-scoring candidates. Most responses stated either ovule or ovary. Ovules are a part of a flower, and eggs are stored and released from the ovary in humans.

**(ii)** Oviduct, the correct answer was chosen by some candidates. Others circled either ovary or uterus. The egg is released from the ovary and travels down the oviduct before reaching the uterus. It is when the egg is in the oviduct that fertilisation can take place.

**(c) (i)** Candidates found this question challenging. There were a few correct answers, stating that antibiotics are ineffective in treating a virus infection. Unacceptable responses included ‘because it’s a virus’, ‘antibiotics make it worse’ or ‘the virus feeds on antibiotics.

**(ii)** Some candidates answered this question well, gaining full credit. Others answered the first part of the question correctly but then they could not calculate the percentage increase. The increase in the number of males, 3, has to be divided by 4, the number of affected males in the 18 to 34 age group. The percentage increase is obtained when this fraction is multiplied by 100, a result of 75 per cent.

**Question 3**

**(a) (i)** Many candidates interpreted the food web correctly. Others stated the duck as a secondary consumer instead of a primary consumer. Candidates are reminded that secondary consumers in this food web feed on herbivores, and these are the brown trout and the mink.

**(ii)** Generally, answered well. Most candidates stated the correct answer, muskrat.

**(b)** Many candidates gained full credit for this question. The main error was the first response. Candidates were unfamiliar with the term synthesise which means to create a substance by chemical reaction. Decompose and digest were the most common incorrect choices.

**(c) (i)** There were many correct responses to this question. Candidates who did not gain credit usually omitted one or more elements or stated compounds, for example carbon dioxide or water.

**(ii)** The importance of carbohydrates to release energy in the body was stated correctly by most candidates. Candidates should be aware that energy is not created by carbohydrates. Energy is transferred from the carbohydrate molecules to molecules in the cells of the body.

**(iii)** Candidates found this question challenging. Instead of plasma, the correct answer, candidates wrote red blood cells. The main role of red blood cells is to transport oxygen.

**Question 4**

**(a)** Some higher-scoring candidates successfully balanced the equation. The remaining candidates struggled with this question. There was an assortment of incorrect numbers written in the spaces of some scripts. Others wrote state symbols or symbols of elements.

**(b) (i)** The measuring cylinder was correctly named by many candidates. Incorrect responses included test-tube, beaker, or just tube or cylinder.

**(ii)** The volume of gas, 22.6 $cm^3$, had to be divided by 60 to calculate the rate of production of gas per second. What was important here was the rounding up of the answer to two decimal places. The result of the division was 0.3766 recurring. When this is rounded up to two decimal places the final answer is 0.38. Some candidates wrote 0.37 and they gained partial credit. Others did an incorrect calculation, either by dividing the time by the volume, or multiplying them both together.


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**(iii)** Most candidates gained partial credit by describing the catalyst's role in speeding up the rate of a reaction. Fewer went further with the statement that the catalyst is unchanged at the end of the reaction.

**(iv)** The term group in the question is another word for a collection of elements, in this case the transition metals. A few candidates scored credit, but many stated a group in the periodic table, for example Group I.

**(c)** Covalent bonding was correctly stated by many candidates who described the sharing of electrons between hydrogen and oxygen as the reason for their answer. The fact that the bonding is between non-metals was another acceptable reason for covalent bonding. Incorrect responses included double, ionic and chemical (bonding).

**Question 5**

**(a)** Most candidates gained some credit for this question. They could match the element with the correct box because they knew that all the atoms in the element are identical. The most common error was pairing the compound and mixture with the wrong boxes. The compound molecules have two or more different atoms joined together and the molecules are all identical. The mixture has two or more different substances.

**(b) (i)** Generally answered well.

**(ii)** Some candidates gained most of the available credit for this question. For the first answer, lithium was often seen instead of fluorine, the correct answer. Lithium forms an ion with the charge of 1+. More candidates identified beryllium correctly. For the third response, some candidates successfully stated carbon as the element used as an inert electrode, but others chose neon, an inert gas. Candidates are reminded that the electrode must be solid. The best responses were for the last element, carbon. Nitrogen was also accepted for this response.

**(iii)** All but the most able candidates found this question challenging. The metallic character of elements decreases across the period, from Li to Ne. Incorrect responses included descriptions of the number of outer shell electrons or an increase in mass number.

**Question 6**

**(a) (i)** Most candidates stated oxygen, the gas that reacts with the magnesium.

**(ii)** A few candidates circled basic to gain credit. There was no pattern to the incorrect responses. Candidates are reminded that metals form basic oxides and non-metals form acidic oxides.

**(iii)** This question was quite well answered. More candidates would have obtained the mark if they had stated that the exothermic reaction released thermal energy to the environment instead of the reaction just releasing energy. A minority of responses incorrectly described an endothermic reaction.

**(iv)** Some candidates successfully completed the word equation. Others gave hydrogen instead of water as one of the products.

**(b) (i)** A small number of candidates knew that sulfur dioxide and oxides of nitrogen both cause acid rain. Many candidates wrote global warming, and damage to the ozone layer was frequently seen too. Some scripts contained descriptions of harmful effects on the body, e.g. respiratory problems. These responses were not accepted because the question was asking for the adverse effect to the environment, not humans.

**(ii)** Candidates were not familiar with the production of sulfur dioxide by burning fossil fuels.

**(c) (i)** The removal of oxygen from iron(III) oxide is an example of a reduction reaction. A few of the higher-scoring candidates gained credit for this question. Chemical, exothermic and oxidation are examples of incorrect responses.

**(ii)** There were only a few candidates who successfully named hematite. Many stated iron ore. Those who were familiar with the syllabus knew the specific name for iron ore.


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**Question 7**

**(a) (i)** Many candidates successfully read the total distance from the graph. Some lower-scoring candidates made errors in interpreting the scale of the Y-axis. Consequently, the range of responses was from 440 m to 500 m with the correct answer being 480 m. A minority of scripts showed attempts to calculate the area under the graph to find the total distance travelled. This is only appropriate for a speed/time graph. Not a distance/time graph.

**(ii)** Many candidates related the description of the motion to correct time intervals. This required four lines to be drawn, with both of the boxes on the right-hand side having two lines leading to them. Some candidates only matched one line from the left to each box, therefore limiting their maximum mark.

**(iii)** To find the maximum speed of the candidate, candidates had to study the graph and look for the part with the steepest gradient. Then the speed = distance ÷time equation was used just for this ***section. A*** small number of candidates did this. The maximum speed occurred between 120s and 160s. The increase in distance occurred between 220 m and 480 m, which works out as 260 m When this is divided by the time taken for this change, 40 s, the answer is 6.5 m/s.

In most of the incorrect answers, candidates worked out the average time, total distance ÷ total time. Candidates did gain some credit for these answers if they gave the correct equation.

**(b) (i)** Most candidates found this question challenging. They had to circle one word on each line. Some scripts only circled one word, and all three correct words had to be circled to gain one mark. When the candidate cycles, they are releasing chemical energy from their bodies to allow the contraction of muscles as they pedal so their store of chemical energy decreases. With the acceleration the speed of the candidate increases causing an increase of kinetic energy. Since the candidate is on the level the gravitational potential energy stays the same.

**(ii)** In a similar way to **(b)(i)**, the chemical energy decreases to allow the candidate to use the pedals of the bicycle. This time the kinetic energy stays the same because the candidate is still travelling at the same speed. However, because the candidate is moving higher up their gravitational potential energy increases. Candidates also found this question challenging.

**(c)** A few candidates gained full credit by explaining that the fossil fuels are burned to produce steam, which turns the turbines and later the generators. There were many vague responses to this question reflecting insufficient knowledge of electricity generation using fossil fuels. An example of this is ‘The fossil fuels are burned to release heat energy which is then converted to electrical energy’.

**Question 8**

**(a)** This question was answered well by all candidates who showed a good understanding of the particles in a solid.

**(b)** Candidates found this question challenging. The stem of the question makes it clear that the smoke is just an indicator for the movement of the air. Therefore, the description should be all in terms of the movement of the air. The candle warms the air above it, causing the hot air to rise and leave the box. Cooler air comes in through the other chimney and so a convection current is set up.

**(c) (i)** Most candidates answered this question correctly. The most common error was a description of an electrical conductor or occasionally a conductor of heat.

**(ii)** Some candidates successfully stated that the voltmeter should be placed in parallel across the resistor. Others stated a variety of unacceptable responses, for example ‘the ammeter and voltmeter should be switched’ and ‘there is no switch.

**(iii)** The lamp had to be placed in parallel across the resistor. This was done successfully by many candidates. Partial credit was awarded for the correct symbol for the lamp.


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**Question 9**

**(a)** The diagram, Fig. 9.1, showed the distance of two wavelengths, 6.0 m. The wavelength is defined as the distance between two successive waves, so in this case it is 3.0 m. There were several correct responses given. The most frequent incorrect answers included 6.0 (m) or 2.0 (m).

**(b) (i)** This question used the equation $v = f\lambda$. In this case the frequency is calculated by dividing the speed of sound by the wavelength, 330 ÷ 0.15. Some candidates did this successfully. Others calculated 0.15 ÷ 330. The unit, Hz, was often omitted or written incorrectly.

**(ii)** The fact that particles transmit sound waves was the important concept for this question. Many candidates stated that there is no air in the vacuum of space. It was important to say there is no medium or particles to transmit the sound. Sound can travel through solids and liquids so the response needed was more general than just no air.

**(c)** The next stages in the life cycle of a small mass star were not well known by many candidates. Partial credit was obtained by candidates who named some of the stages correctly, but full credit was rarely awarded.


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# COMBINED SCIENCE

**Paper 0653/32**
**Core Theory**

## Key messages

Candidates should always show their working in numerical question as they may gain credit for a correct formula even if their calculation contains an arithmetic error. This was relevant for **Questions 7(a)(iii)**, **8(d)**, **9(a)(ii)** and **9(b)(ii)** in this paper.

Candidates should read the question carefully. See comments for **1(c)(i)** and **4(a)(i)**.

All candidates should make sure that they are familiar with the syllabus content. Some questions require the recall of syllabus statements and references to these questions are indicated throughout this report.

## General comments

There were some good responses from those candidates who demonstrated a thorough knowledge of all three sciences. These candidates were able to answer questions in both familiar and unfamiliar contexts. Candidates are advised to attempt every question, especially those questions where they make a choice from answers that are written on the question paper.

## Comments on specific questions

### Question 1

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**(ii)** Candidates had to choose which of the growth periods showed the fastest growth rate of plant X. This is shown by the steepest gradient on the graph. It occurred between 10 and 20 days. Many candidates made the correct selection.

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**(a) (i)** Many candidates successfully named the ovary. Incorrect responses included egg, ovule, uterus and urethra.


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**(ii)** Generally answered quite well by candidates of all abilities. Incorrect responses included labelling the cervix and various places in the uterus. Candidates are reminded that the label line must touch the structure intended, with no space between the end of the label line and the structure.

**(b)** Candidates were unfamiliar with the changes in the thickness of the uterus lining during the menstrual cycle. From day 1 the thickness of the lining of the uterus decreases due to menstruation, and then it increases towards day 28, preparing for a possible embryo.

**(c) (i)** Most candidates gained some credit for this question. The first and third responses, capillaries and valves respectively, were the most common correct answers. Fewer gained credit for the second response. 'Thinner walls' was the most frequent incorrect response for the second response. Arteries have thicker walls and veins have a lumen with a larger diameter.

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**(ii)** The necessity for calcium to maintain the strength of bones was stated by most candidates.

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**(a) (i)** There were several acceptable responses to this question that was generally answered well. Hunting of tigers and the loss of habitat due to human activity were the most common correct answers.

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**(ii)** The measuring cylinder was correctly named by many candidates. Incorrect responses included test-tube, beaker, or just tube or cylinder.

**(iii)** Many candidates successfully stated that magnesium atoms lose electrons to form positive ions. Fewer knew that the general name for these positive ions is cations. The most common error was anions. For the third answer, many candidates successfully stated ionic (bonds). The most common error for this question was covalent (bonds). Candidates are reminded that covalent bonds involve the sharing of electrons and do not involve attraction between positive and negative ions. Oxidation was given by most candidates to describe the gain of oxygen by magnesium.

**(b)** In their responses, candidates had to appreciate the fact that copper is much less reactive than magnesium. Therefore, predictions that little or no reaction would be expected were accepted. Candidates found this question challenging. The response required an observation, for example 'no bubbles are produced'. General statements such as 'the reaction is different' or any references to gain or loss of electrons were not accepted.


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**Question 5**

**(a) (i)** Many candidates counted the atoms in the organic compound to deduce the correct molecular formula, $C_5H_{11}Cl$. When writing formulae candidates are reminded to write the numbers as subscripts and they should be smaller than the element symbols. The correct case of letters in the symbols should be used. Therefore, C*l* is acceptable for the chlorine atom, whereas CL is not.

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**(ii)** Some higher-scoring candidates successfully balanced the equation. The remaining candidates struggled with this question. There was an assortment of incorrect numbers written in the spaces of some scripts. Others wrote state symbols or symbols of elements.

**(iii)** Generally, candidates struggled with this question and appeared to be unfamiliar with the syllabus. Candidates should be aware that polymers are very large molecules made up from monomers which join together.

**Question 6**

**(a) (i)** Many candidates scored full credit for this question. The main error occurred when candidates wrote 39 for either the number of neutrons or protons. Candidates are reminded that the top number in the box of the element in the Periodic Table shows the number of protons. The relative atomic mass, 39, shows the number of protons and neutrons in the atom. Therefore, in potassium the number of neutrons is 39 – 19 = 20.

**(ii)** This question was challenging for most candidates. Some successfully stated that the element is in Group **I** because it has one electron in its outer shell. It was insufficient to state that potassium is in Group I without any explanation of its electronic structure. The second way in which the electronic configuration of potassium relates to the number of shells in the atom. Looking at the electronic structure, there are four shells containing electrons, so that makes the potassium atom to be in Period 4.

**(iii)** Some candidates knew the (–1) negative charge on the electron. Fewer knew the relative mass of an electron, 1/1835.

**(b) (i)** The lilac colour of the flame test for potassium was given successfully by many of the higher-scoring candidates. Other candidates were not familiar with this particular flame test and they stated a variety of incorrect colours.

**(ii)** The test for hydrogen with a lighted splint was known by many candidates. Some credit was awarded to those candidates who knew the observation but omitted to mention the lighted splint needed to ignite the gas.

**(iii)** Generally answered well. Incorrect responses included endothermic and radiation.

**(iv)** Many candidates knew that the universal indicator was showing a strong alkaline solution. A range of pH values between 10 and 14 were acceptable and many candidates gained credit for their response.

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**(a) (i)** Generally answered well. Candidates read the scale of the measuring cylinder successfully to get the volume of 24 $cm^3$.

**(ii)** The mass of the liquid was determined by reading the balances. Most candidates knew to subtract the initial mass of the measuring cylinder from the final mass of both the measuring cylinder and the liquid. The most common error was failing to subtract the initial mass of the measuring cylinder from the total mass, so instead of 34 g they gave 234 g.


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**(iii)** Since the calculation used the two previous answers, any errors in **parts (i)** and **(ii)** were carried forward. Many candidates knew the formula for density and did the calculation successfully. Fewer candidates wrote the correct unit. Since the mass was in grams and the volume in $cm^3$, the unit is $g/cm^3$.

**(b)** Most candidates struggled with this question. Many of them described boiling, where an external heat source is applied to the liquid. The explanation consisted of two main points. The first is to state that some of the particles in the liquid have more kinetic energy than others. Secondly, some of these more energetic particles are able to escape from the surface of the water.

**Question 8**

**(a) (i)** The angle of incidence, X, was correctly identified by most candidates.

**(ii)** Candidates had to use two ideas to answer this question. They needed to know that the normal is at 90° to the mirror, so the value of the angle of incidence, **X**, is 60°. They also needed to know that the angle of incidence, equals the angle of reflection, so this means that angle **Y** is 60°. Some candidates struggled with this question. The most common incorrect answer was 30° where candidates did not take the 30° from 90°.

**(b)** Most candidates answered this question well, showing the ray bending away from the normal as it left the glass block. Credit was not awarded to those candidates who did not use a ruler and produced a wavy line. Also, since it was a single ray of light, it had to be continuous and with the ray travelling through the block. Any break in the path of the ray of light was not credited.

**(c) (i)** The use of microwaves to heat up food was the most common correct application given. Those candidates who wrote just 'heat' were not awarded credit. More detail was needed. The use of infra-red in television remote controls was the most popular correct application. Candidates should be aware that several applications for both of these forms of electromagnetic radiation are listed in the syllabus. The use of infrared radiation for thermal imaging was acceptable, but seeing in the dark was too vague

**(ii)** Most candidates scored at least partial credit for this question. Visible light and X-radiation were the most popular correct responses. The most common incorrect response was gamma radiation.

**(iii)** Most candidates found this question challenging. The seven colours of the spectrum had to be given in the correct order starting with red. The most frequently omitted colour was indigo. Some candidates put pink and purple in their answers. The seven colours had to be written as shown in the syllabus.

**(c)** This question involved the equation speed = distance ÷ time. The distance from the Moon to the Earth and the speed of light are both known. Therefore, the equation is rearranged to calculate the time taken for light to travel from the Moon to the Earth. Many candidates did this successfully. Others calculated the speed ÷ distance or speed x distance.

**Question 9**

**(a) (i)** This question was answered well by most candidates.

**(ii)** The equation $P = IV$ was used to calculate the current in the circuit. Most candidates succeeded in calculating that the current is 10A. Other candidates divided the voltage by the power to get a current of 0.1A.

**(iii)** The correct fuse rating for the fuse in the kettle is the one higher than the current of 10A which is 13A. Many candidates selected the 10A fuse instead of the one above. There was scope for an error carried forward from **(aii)**, so those candidates who calculated a current of 0.1A were given credit for circling the 1A fuse rating.

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**(ii)** Candidates had to know the Ohm's Law equation R = V/I. They also had to know that the total resistance is 20 + 40 = 60Ω. Therefore, the voltage = 0.1 × 60 = 6.0 V. An error carried forward was allowed for those candidates who had put the current as 0.2A in **(i)**. Some candidates found this question challenging, with many multiplying the two resistance values together instead of adding them.



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# COMBINED SCIENCE

**Paper 0653/33**
**Core Theory**

## Key messages

Candidates should always show their working in numerical question as they may gain credit for a correct formula even if their calculation contains an arithmetic error. This was relevant for **Questions 7(a)(iii)**, **8(d)**, **9(a)(ii)** and **9(b)(ii)** in this paper.

Candidates should read the question carefully. See comments for **1(c)(i)** and **4(a)(i)**.

All candidates should make sure that they are familiar with the syllabus content. Some questions require the recall of syllabus statements and references to these questions are indicated throughout this report.

## General comments

There were some good responses from those candidates who demonstrated a thorough knowledge of all three sciences. These candidates were able to answer questions in both familiar and unfamiliar contexts. Candidates are advised to attempt every question, especially those questions where they make a choice from answers that are written on the question paper.

## Comments on specific questions

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# COMBINED SCIENCE

**Paper 0653/41**
**Extended Theory**

## Key messages

Candidates who did well on this paper

- were thoroughly prepared for this type of examination and demonstrated knowledge with understanding of most of the learning objectives in the syllabus,
- used the wording given in the syllabus when stating definitions or describing scientific ideas,
- read questions carefully and used the number of marks for each question as a guide to the detail required in their answers,
- included working and relationships between variables in questions involving calculations and presented this information clearly.

## General comments

Large numbers of candidates showed excellent knowledge with understanding of all sections of the syllabus and were familiar with good examination technique. Candidates were able to complete the examination within the allotted time.

Stronger candidates set out answers to the calculations in **Questions 7, 8** and **9** clearly and logically. They started with the relationship between the relevant variables followed by the working and then wrote the result on the answer line provided. This is good practice and may allow partial credit to be awarded even when the calculation is not completed correctly. The better answers included numerical results corrected to the same number of significant figures as the lowest number of significant figures in the question data.

When stating chemical symbols consisting of two letters, candidates should make sure that the second letter is in lower case e.g. Cu and not CU. When writing chemical formulae and chemical equations, candidates should take care that numbers showing subscripts and balancing are the correct sizes in relation to the chemical symbols. e.g. $2H_2O$ and not $_2H2O$ or $H^2O$.

Candidates tended to write answers of appropriate length although some stronger candidates included much more information than was needed for full credit.

Material that seemed relatively challenging or unfamiliar to some candidates included

- **Question 2(a)(i)** recognition of plasmolysis.
- **Question 4(b)** understanding what happens when a fixed volume of air is repeatedly passed over hot copper.
- **Question 8(a)(ii)** mechanisms of thermal energy transfer through metals.
- **Question 9(d)** determining the combined effect of differences in length and diameter on the electrical resistance of two wires.
- **Question 9(e)** determining the altitude of a satellite orbiting the Earth.

## Comments on specific questions

### Question 1

**(a)** Candidates of all abilities answered this very well. The most common mistakes were to suggest **F** or **B** instead of **A**.


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**(b) (i)** Large numbers of candidates gained full or partial credit. There were two kinds of mistakes. One of these involved the incorrect conversion of units between millimetres and micrometres and the other concerned confusion over how to make use of the magnification factor.

**(ii)** The two key ideas that candidates had to include were that the mitochondria were the site of respiration and that therefore energy was released. Many answers included the suggestion that energy is produced, created or made and this is always penalised. Stronger answers use terms such as energy is released, provided, transferred or even the simpler idea of given to the sperm.

**Question 2**

**(a) (i)** The two most common mistakes were osmosis and flaccid although a very wide selection of incorrect suggestions was seen from candidates who may have been unfamiliar with this part of the syllabus.

**(ii)** This section of the syllabus was very familiar to large numbers of candidates. Many answers were very clearly expressed and gained full credit. Reasons for loss of credit included any suggestion that salt or salt solution moved in to or out of the cell, and unqualified or vague references to 'concentration' e.g. 'water moves from high concentration to low' where the candidate may have been referring to the concentration of water but has left it unclear. Candidates should be advised to avoid altogether the idea of concentration of water when answering Questions of this type. Candidates were familiar with the concept of movement of water from low to high solute concentration, but they had to make it clear that the high solute concentration was inside the cell.

**(b) (i)** Full credit was awarded for the two and only two correct answers. All the incorrect terms were suggested with glycerol being slightly more common.

**(ii)** Photosynthesis was very familiar and large numbers of candidates were awarded full credit. Common mistakes included suggesting that the raw materials were oxygen and glucose, that the energy involved was chemical, heat or simply light and stating chloroplast instead of chlorophyll.

**(c) (i)** Most candidates constructed the correct food chain. The questions required all the organisms to be included and so candidates who omitted any of them did not gain credit. The most common omission was algae. Partial credit was awarded if the only mistake was the drawing of arrows in the reverse direction.

**(ii)** Candidates who gained full credit in **part (c)(i)** usually answered this question correctly.

**Question 3**

**(a) (i)** This mark was awarded to the majority of candidates.

**(ii)** Almost all the candidates were able to describe blockage or narrowing of the coronary arteries. Some candidates stated that the blood flow through the arteries was reduced, but the mark was awarded only if they explained that this was the result of blockage.

**(iii)** The risk factors for coronary heart disease were very familiar to most candidates. Some suggestions were too brief or too vague e.g. the word 'exercise' was not enough for the idea of lack of exercise, the terms DNA or family history were not accepted as alternatives for the idea of genetic predisposition. Most references to diet were not accepted unless qualified e.g. high cholesterol in the blood. Some candidates wrote about consequences for the body or health caused by poor blood supply from a diseased heart.

**(b)** The important features of the structure of arteries and how these relate to function were familiar to many candidates. Candidates needed to refer to 'thick muscular walls' rather than just 'thick walls'. Stronger candidates always referred to 'high blood pressure' rather than just 'pressure'.

**Question 4**

**(a)** Most candidates gained full credit. Although the formula of copper oxide appeared in the question, some candidates did not make use of it and some others stated the word equation for which no credit was awarded. The mark for balancing an equation always depends on all formulae being correct.


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**(b)** Stronger candidates were familiar with this experiment and were awarded full credit. If an incorrect volume of gas remaining was stated, an error could be carried forward for the second mark. Many candidates did not fully understand what was occurring during the process. Some suggested that the residual gas volume would be zero because all the gas in the air would be used up or that there was more copper than was needed. Others believed that the volume would remain at 100 $cm^3$ because the air is simply pushed from one syringe to the other without any reaction occurring.

**(c) (i)** This was answered very well by large numbers of candidates. In their explanations, candidates had to refer to energy. It was not enough simply to state that the products were higher than the reactants. Candidates who chose to describe energy changes associated with bond breaking and making had to take care with their wording. Credit was not awarded for suggestions such as 'the energy needed for bond breaking is greater than the energy needed for bond making'. The explanation could be expressed in terms of energy taken in from the surroundings provided the term energy was used and not just the term 'heat' or references to temperature decrease.

**(ii)** Most candidates knew how to label the activation energy. The best answers included an extension of the reactant energy level to mark the lower end of the activation energy arrow with the arrow rising vertically to touch the energy maximum. A common mistake was to draw an arrow that showed an activation energy for the reverse reaction.

**(iii)** Many candidates had learned the definition of activation energy as stated in the syllabus. For full credit, it was important to state that activation energy was the minimum energy required for a reaction to occur.

**(iv)** The definition of a catalyst was very familiar to most candidates and full credit was frequently awarded. Most candidates who gained only partial credit usually omitted to make clear that the catalyst remained unchanged. Some responses suggested that candidates' experience of catalysis was limited to enzyme activity, but they could still obtain full credit.

**Question 5**

**(a) (i)** The majority of candidates correctly referred to the appearance of gas or a green/yellow colour. Some candidates missed the significance of the instruction in the question to describe an observation and described an electrode process e.g. chloride ions lose electrons. One other common mistake was to describe the formation of metallic zinc.

**(ii)** This was a challenging question for most candidates. The formula of zinc chloride was stated in the question and this could have led candidates, who were unfamiliar with the formula of zinc ions, to $Zn^{2+}$. Some stronger candidates gained at least partial credit but most missed the correct state symbols.

**(b) (i)** Many candidates produced sketches which could be awarded full or partial credit. The better answers showed neatly drawn circles with good attempts to reproduce the examples of atoms **A** and **B** given in the question. If candidates had omitted to shade in atoms of **B** then it was assumed that **B** was represented by the larger circles. There needed to be some attempt to show atoms **A** and **B** randomly mixed up and not in well-ordered layers of **A** and layers of **B**.

**(ii)** Many candidates had learned the syllabus explanation for the properties of alloys and were awarded full credit. The best answers referred to the different sizes of atoms, ions or particles rather than phrases such as different sizes or shapes of elements. Candidates needed to avoid using the term 'molecules' in their answers. Some common misconceptions included the ideas that alloys are stronger because at least one of the metals is stronger or that because there are two metals, the attractive forces between the atoms are greater.

**Question 6**

**(a)** The majority of candidates were awarded full credit for their response. The most common incorrectly ticked box was 'part of the alkane homologous series'

**(b)** The majority of candidates were very familiar with constructing dot and cross bonding diagrams and most gained full credit.


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**(c)** Stronger candidates were familiar with the conditions for this reaction, and many were awarded full credit. One common mistake was to suggest an incorrect type of catalyst, usually a transition metal or an enzyme. Some candidates suggested addition polymerisation instead of just addition, but this was not accepted. Water was accepted as an alternative for steam.

**Question 7**

**(a) (i)** Candidates who had learned the syllabus definition of acceleration gained the mark. They needed to state 'change in speed per unit time' rather than less precise suggestions such as 'speed per time' or 'speed for a given time'. The wording 'rate of change of speed per unit time' was not accepted. Many candidates of all abilities appeared to be prompted by the phrase 'moving in a straight line' to give the answer 'constant acceleration'.

**(ii)** This was very well answered. The majority of candidates stated the relationship *change in speed ÷ time* and then correctly used data from the graph in **part (i)** to work through to the value of the acceleration. Some candidates who were less familiar with this type of calculation attempted to calculate an area under the graph and others stated incorrect or no units.

**(b) (i)** The relationship KE = ½ m $v^2$, was very familiar to most candidates and the majority used it to obtain the correct numerical answer. In some cases, candidates knew the formula but were unsuccessful in working through to the velocity of the ball. A common difficulty was uncertainty in obtaining v from $v^2 = 5$. Credit was not awarded for a final answer left as $\sqrt{5}$.

**(ii)** The majority of the stronger candidates were very familiar with how to answer this question and many were awarded full credit. Candidates who were more challenged by this context often gained partial credit by stating GPE = m × g × Δh and/or that GPE = KE or referring to the complete conversion of kinetic energy to gravitational potential energy. Candidates should be advised to use the value of g = 9.8 N/kg which is stated on the front cover of the examination booklet. Candidates should state the final numerical answer using the same number of significant figures as that appearing in the question data. The final answer should be written clearly on the answer line. This means that full credit could be missed if the correct answer appears in the working (e.g. 0.255) but an over-corrected figure (e.g. 0.3) is written on the answer line.

**Question 8**

**(a) (i)** Almost all the candidates could name a poor thermal conductor, but not quite as many knew this as a thermal insulator. An incorrect suggestion frequently seen was 'resistor'.

**(ii)** Stronger candidates realised that they needed to be describing thermal conduction in metals in terms of the behaviour of particles. Many of these candidates were awarded at least partial credit for referring to the vibrations of particles (atoms, ions or the lattice as a whole) and/or the movement of delocalised electrons. The strongest candidates gained full credit for describing ways in which the energy is passed on through the metal via collisions. Candidates who did not include reference to particles tended to suggest answers such as 'conduction, convection and radiation', 'by heating one end' or 'by passing an electric current'.

**(b)** Partial credit was frequently awarded because many candidates were familiar with the use of the relationship v = f × λ. Less familiar was the need for the frequency to be converted from GHz to Hz, and/or the conversion factor 1 GHz = $1.0 \times 10^9$ Hz.

**Question 9**

**(a)** Stronger candidates usually correctly stated 'charge'. Of the many incorrect suggestions, the most common were current, volts, coulomb and mass.

**(b)** Most candidates were familiar with the two circuit symbols. The most common mistakes were to suggest resistor instead of variable resistor and fuse, battery or thermistor instead of heater.

**(c)** Most candidates realised that the fault was something to do with the LED. Some candidates suggested that the LED would not allow current to pass but they needed also to state that this was caused by the LED being connected the wrong way round. Credit was also given for stating that


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the battery needed to be reversed. Some candidates stated that an LED allows current to pass in only one direction but, on its own, this was not accepted.

**(d)** This proved to be a particularly challenging question and only the strongest candidates successfully worked through to the final answer. Most candidates found it very difficult to combine the joint effect of changing both the length and the diameter when comparing the resistances of the two wires. Candidates could gain marks by stating that resistance is proportional to the length of the wire and/or inversely proportional to the cross-sectional area. Any candidate who realised that this meant that the resistance was inversely proportional to the square of the diameter usually went on to gain full credit.

**(e)** This was a challenging question and only the strongest candidates worked through to the correct final answer. Credit was awarded if candidates stated a relationship which could be used to find the orbital radius e.g. $velocity = 2\pi r \div T$. Many candidates were awarded this mark even though most could make no further progress. Credit was also awarded to candidates who understood that the radius of the Earth needed to be subtracted from their calculated value of the orbital radius.



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# COMBINED SCIENCE

**Paper 0653/42**
**Extended Theory**

## Key messages

Candidates who performed well on this paper:

- demonstrated knowledge and understanding in all three science disciplines with good recall of scientific terms, phrases and equations
- were guided by the command words e.g. describe, explain, calculate, to structure their answers
- were guided by the number of marks available for each question to inform the detail of their answers
- recalled and rearranged equations when necessary and clearly showed the steps in their calculations
- interpreted diagrams and data by providing explanations as well as descriptions
- used data, in different forms, provided in the rubric, to explain or justify conclusions.

## General comments

Most candidates performed very well and demonstrated a comprehensive knowledge of the syllabus. They were clearly well prepared for the examination. Most candidates demonstrated strength of knowledge in all three science disciplines.

## Comments on specific questions

### Question 1

**(a)** Most candidates correctly identified the structures on this cross-section diagram of a leaf. Candidates generally identify the stomata, but they occasionally confused the spongy and palisade mesophyll cells, and the xylem and phloem cells.

**(b)** Most candidates correctly recalled the balanced symbol equation for photosynthesis.

**(c) (i)** Almost all candidates made two correct readings from the rate of photosynthesis graph to calculate the difference in the rates.

**(ii)** Candidates combined knowledge of enzymes, kinetic theory and photosynthesis to explain the shape of the graph. Many candidates gave high-level responses with good descriptions of enzyme-substrate complexes. Some candidates did not make clear reference to the quantities on the *x*-axis and *y*-axis.

### Question 2

**(a) (i)** In this question, candidates located and named the cell structure responsible for protein synthesis on a diagram of a bacterial cell. Candidates were more likely to gain a mark for identifying the structure than recalling the name (ribosome).

**(ii)** In this question, candidates needed to complete sentences about respiration and protein synthesis. A common error was that protein synthesis requires oxygen (rather than energy) from respiration. A common misconception was that respiration is a similar process to digestion where ‘large’ molecules are broken down (rather than glucose molecules).

**(iii)** Most candidates correctly selected mitochondria to complete the sentence about the location of aerobic respiration.


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**(b) (i)** Most candidates clearly described the role of platelets in preventing the entry of bacteria to the bloodstream. Most referred clearly to clot formation. A few candidates used terms such as fibrin and fibrinogen, which are beyond the scope of the syllabus. If used, these terms should be used correctly.

**(ii)** Stronger candidates gained at least one mark for clearly describing how bacteria become resistant. The idea of adaptation, expressed by some candidates, is relevant but not specific enough for the concept of resistance. A common misconception was that bacteria gain immunity to the treatment. Weaker candidates rarely identified the treatment. A few candidates referred to antibiotics and an idea of how they are misused.

**(c)** Most candidates gained at least one mark for a correct method of reducing the spread of diseases.

**Question 3**

**(a) (i) (ii)** Almost all candidates drew correct arrows to complete the food web diagram and identified one of the herbivores.

**(b) (i)** Most candidates interpreted the food web diagram correctly to explain the impact on the lion population of replacing grassland with crops. A common misconception was that the grassland is a habitat for lions to hide in rather than a food source for the lion's prey.

**(ii)** This question was about captive breeding programmes. Many candidates expressed clearly that such programs are for increasing the populations of endangered species rather than simply preventing their extinction. Some candidates needed to be more descriptive about the 'captive' environment in which the endangered species are kept e.g. a zoo or a safari park where access to food, healthcare and absence of predators increase their chances of survival.

**Question 4**

**(a) (i)** Many candidates completed the balanced symbol equation and included the correct state symbol (in bracket and lowercase). Common errors included the addition of hydrogen in the products, and identifying sodium chloride as a solid (it is dissolved in water, so is aqueous).

**(ii)** Methyl oranges changes from yellow (in the alkaline NaOH) to orange as it is neutralised by the acid. Most candidates correctly recalled at least one of these colours. A common error was that it becomes colourless.

**(iii)** Most candidates were guided by the mark allocation (2) and ticked two boxes to indicate true statements about sodium hydroxide.

**(b) (i)** Only the strongest candidates correctly described the reaction in terms of bond making and breaking. Some candidates did not refer to the bonds. Many candidates appeared to base their answers around (incorrect) recall of exothermic versus endothermic reactions, rather than address the question.

**(ii)** Most candidates gained at least two marks for drawing and labelling the reactants and products in the reaction pathway. A very few candidates did not indicate the activation energy 'hump'. A common misconception was that the arrow to indicate the overall energy change is double headed i.e. indicating both increase and decrease.

**Question 5**

**(a) (i)** Only the strongest candidates clearly described the complete process for carbon monoxide formation in a blast furnace with many stating both correct symbol equations. Candidates generally knew that carbon reacts with oxygen and/or carbon dioxide is produced. The reaction between carbon and carbon dioxide was less commonly known.

**(ii)** Many candidates correctly recalled the balanced symbol equation for iron extraction in the blast furnace. Common errors were to record some reactants and/or products as ions and to record iron as a diatomic molecule.


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**(b) (i)** Most candidates correctly completed the dot-and-cross diagram to show the bonding in a carbon dioxide molecule.

**(ii)** Most candidates described two strategies to reduce the effects of climate change.

**Question 6**

**(a) (i) (ii)** Most candidates correctly recalled the general formula for the series (alkanes) that includes ethane and they correctly recalled the series for ethene and ethane.

**(b)** Candidates completed three sentences in this question about reactions of ethene. Commonly, candidates knew that ethene reacts with hydrogen. Many also named the catalyst (nickel). Only the strongest candidates recalled that this is an addition reaction.

**(c)** Most candidates gave a temperature above –88°C (diagrams show that butane is a larger molecule than ethane). A common error in the explanation was that there are more bonds to break. Candidates must refer to intermolecular bonds when explaining the differences in boiling points between fractions.

**Question 7**

**(a) (i) (ii)** Many candidates concluded correctly that the chemical energy store (the car has a battery) decreases. A common incorrect or insufficient answer was potential energy. Many weaker candidates named friction as an energy store. The graph shows increasing speed, so most candidates identified kinetic energy as an energy store that increases. The thermal energy store also increases.

**(iii)** Most candidates gave some description of the sloping line on the graph. Candidates generally gained the second mark by stating the equation.

**(iv)** Most candidates used the distance and time data in the question and simply calculated the average speed. Candidates should be aware that when a question has sub-sections the information in previous parts may be required throughout. Here, candidates needed to make use of the speed–time graph. This shows that the car moved at $\frac{1}{2}V$ for 3 seconds and $V$ for 2 seconds. Therefore, $3.5\,V = 5.6\,\text{m}$, so $V = 1.6\,\text{m/s}$.

**(b)** Most candidates calculated the change in gravitational potential energy correctly. Most candidates gained a mark for recall of the equation. A common error was in the conversion (or not) of grams to kilograms. The question was posed so that candidates needed to select only the vertical height of the slope. Some candidates attempted to include the length of the slope in their calculation. Candidates should know that the value of $g$ used in the current syllabus series is $9.8\,\text{m/s}^2$ (or $9.8\,\text{N/kg}$) and that this value can be found printed on the front cover of the exam paper.

**Question 8**

**(a)** This question was about comparing thermal energy emission by black and white surfaces. Candidates needed to describe the controlled fair-test starting conditions, the measurements taken and the information used to make the conclusion. Most candidates gained at least one mark for the idea of taking the temperature of each container after a period of time (assumed to be the same for both). Many candidates referred to using the same volume of water in each container but neglected to mention the same starting temperature. A common error was to state a conclusion (e.g. black is a better emitter) without explaining how that is determined (e.g. largest temperature decrease (in unit time) or shortest time (for unit temperature decrease).

**(b) (i)** Many candidates knew that there are no particles in space and that it is a vacuum. Stronger candidates related the presence/absence of particles to explain why conduction and convection, or radiation is or is not possible.

**(ii)** Many weaker candidates did not recall the stages in a small mass star like the Sun. Common misconceptions were that the Red Giant stage occurs before the stable star is formed and that a supernova occurs after the stable period.


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**(iii)** Many candidates knew that a black hole and a neutron star are formed following a supernova explosion. However, this question asked what is formed from the nebula that is produced by the supernova. Very few candidates gained a mark for simply stating ‘stars’.

**Question 9**

**(a)** Many candidates recalled the circuit symbols for a generator and a fuse. Common errors included galvanometer and resistor respectively.

**(b) (i)** Only the strongest candidates defined e.m.f. correctly. Many answers referred to the circuit, a force, charge or electrons and voltage. Here, the battery provides a force to do work against the resistors in the circuit to move a charge around the complete circuit (the distance travelled in the direction of the force). Reference to moving one unit of charge e.g. 1 coulomb, gained the second mark.

**(ii)** Many candidates correctly combined parallel and series resistor equations to find the combined resistance in the circuit. Some candidates attempted to combine all three resistors in the parallel resistor equation.

**(c)** In this question, candidates needed to determine the minimum height of a mirror to make a particular observation. Many candidates gained one mark for showing some halving of a vertical length by applying the relationship between angle of incidence and angle of reflection. Some candidates gained further marks for subtracting the length of the mirror. Candidates generally gained at least one mark for some plausible combination of these steps.


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# COMBINED SCIENCE

**Paper 0653/43**
**Extended Theory**

## Key messages

Those candidates who did well on this paper:

- were familiar with the definitions of scientific terms and physics equations shown in the syllabus
- understood the different requirements of the command words 'describe' and 'explain'
- set out clear and precise answers using the correct scientific terminology
- used the number of marks for an item as a guide to the depth of answer required
- ensured that they included working and formula in questions involving calculations and that this was set out clearly enough for partial credit to be awarded even if an error was made.

## General comments

Most candidates attempted all the questions including calculations. Weaker candidates often omitted working in their calculations. They should be encouraged to do so as there may have been missed opportunities for awarding partial credit. Where a candidate knows the correct formula but cannot rearrange the formula to fit the question, they are usually given credit for stating the correct formula in any form. For example, **Question 7(c)**, candidates were given some credit for stating $I = Q/T$ even if they then go onto calculate charge incorrectly. They were also given credit for converting minutes to seconds even when there were no other credit worthy responses.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates were able to identify the parts of the digestive system. The most common error was incorrectly identifying the pancreas as the gall bladder.

**(ii)** Many candidates were unable to name the rectum and the colon. A few candidates stated the anus which had already been given in the question. Candidates should be encouraged to read the whole question and not just the part above the answer line.

**(b) (i)** Most candidates correctly identified enzyme **P**, using their knowledge of the acidity of the stomach. Enzyme **Q** was the most common incorrect answer as this enzyme worked best in neutral conditions. A few candidates named the enzyme in the stomach rather than choosing the correct letter from Fig. 1.2. As this was not the question set, no credit could be given.

**(ii)** Stronger answers included a complete explanation of the effect of pH7 on enzyme **S** using the correct terminology, such as active site and enzyme-substrate complex. Weaker answers just gave a description of the effect of pH7 without any explanation.

**(c)** Most candidates were able to state that either fats or oils were broken down. Only a few candidates successfully completed the whole sentence. Where incorrect answers were given, they were usually some other food molecule.

### Question 2

**(a) (i)** The majority of candidates were able to identify the tree as a producer.


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**(ii)** The majority of candidates were able to identify the fungi as a decomposer. A few candidates thought that fungi were producers.

**(iii)** Most candidates correctly identified the millipede. A few candidates chose the nematode, suggesting that they had misinterpreted the directions of the arrows in Fig. 2.1.

**(b) (i)** When describing transpiration, candidates should be encouraged to use the term water vapour rather than water. Many candidates have the misconception that water evaporates through the stomata. The new syllabus has removed the requirement for candidates to understand the difference between evaporation from mesophyll cells and diffusion through stomata. Therefore, they should just be encouraged to understand that transpiration is the loss of water vapour from the leaves.

**(ii)** The majority of candidates stated that the transpiration rate increased. Some candidates should be encouraged to state the full relationship between increased wind speed and increased transpiration, rather than just stating that 'wind speed increases transpiration rate'.

**(c)** Stronger answers included a complete explanation of the effect of the concentrated sugar solution. These answers included ideas about water potential, osmosis and turgor pressure. The most common misconception was that the sugar solution moved into the vacuole of the cells through the partially permeable membrane. Candidates should be encouraged to answer osmosis questions in terms of water potential and avoid using terms such as concentration gradient or higher concentration. These terms often result in confusion as to which substance - water or sugar is concentrated.

**Question 3**

**(a)** The majority of candidates gained at least one mark, usually for plasmid. The protein coat was often incorrectly identified as a cell wall.

**(b)** Although most candidates could state one body defence, a significant proportion of candidates found it difficult to name two. Candidates should be encouraged to state the body defences listed in the syllabus rather than providing vague descriptions used in everyday life such as fever. When asked to provide two body defences, candidates should make sure that their answers are distinctly different. For example, skin and white blood cells, rather than naming two functions of white blood cells.

**(c)** When asked to describe a term from the syllabus, candidates should provide an answer that closely matches the description in the syllabus. A few candidates were successful, others tended to give vague descriptions about drugs affecting the body or stated they were medication given by a doctor.

**(d)** Many strong answers were provided by candidates, these included ideas about antibodies and active immunity. Candidates should be encouraged to use ideas about antibody production rather than vague comments about the immune system fighting the infection. Many candidates referred to the vaccine containing small amounts of bacteria. The contents of a vaccine is not a requirement on this syllabus. However, if it is discussed candidates should use ideas about dead or weakened pathogens. Small amounts of bacteria is a common misconception.

**Question 4**

**(a)** Most candidates were able to use the reactants and products provided in the question to attempt a balanced symbol equation. A few candidates incorrectly assumed that hydrogen was one of the other products.

**(b) (i)** Candidates that calculated the rate usually gave a correct answer. Candidates should be encouraged to use the same number of significant figures as for the rates provided in Table 4.1.

**(ii)** Most candidates were able to describe the relationship between size and rate of reaction. Many also linked this to surface area, although some candidates had the misconception that large pieces have a larger surface area. When answering chemistry questions on rates of reaction, candidates should be encouraged to include ideas about frequency of collisions between particles rather than just stating that there are more collisions.


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**(c)** The majority of candidates gained at least one mark for this question. Candidates should use dots and crosses as shown in Fig. 4.2, rather than all crosses. Some candidates just copied the outer shell of the atoms rather than converting them to ions. When completing dot-and-cross diagrams, candidates should ensure they draw some electrons on all the outer shells. Magnesium had lost the two outer-shell elections so in the ion the outer shell should have been drawn with eight elections as the 'new outer shell' and not left blank.

**Question 5**

**(a) (i)** Many candidates correctly stated diatomic, there was no clear pattern to incorrect answers.

**(ii)** The majority of candidates attempted this question although only a few gave two correct answers. The appearance of bromine is a syllabus requirement, and candidates should be able to recall the appearance as a red-brown liquid. Many answers referred to orange or just brown.

**(b)** A few successful answers were seen that included the correct colour change and explanation. Many candidates just gave the colour of chlorine, if adding chlorine to a colourless liquid would give the yellow-green colour of chlorine gas. Common misconceptions included the idea that chlorine is more reactive than potassium iodide and that chlorine displaces iodide.

**(c) (i)** Most candidates correctly stated that chlorine is used to kill bacteria. In this context candidates should state that chlorine kills pathogens rather than just removing them.

**(ii)** The majority of candidates provided a correct answer to this question.

**Question 6**

**(a) (i)** Most candidates successfully stated the molecular formula of pentene.

**(ii)** The majority of candidates were able to complete the structure of pentene. Candidates should ensure they include all the bonds as some left out the carbon–carbon bonds.

**(iii)** Many candidates were able to provide a correct description of a homologous series. Candidates should make sure they answer in terms of trends in physical properties rather than just similar properties. Weaker answers described hydrocarbons rather than a homologous series.

**(iv)** Most candidates identified at least one description; there was no clear pattern to incorrect answers. Candidates should note the number of marks being awarded as many only drew one line rather than the two indicated by the [2] next to the question.

**(b) (i)** Although most of the candidates knew that carbon monoxide is a gas, few realised that carbon would be a solid.

**(ii)** Few candidates understood that this was incomplete combustion.

**(iii)** Candidates should be encouraged to answer similar questions in terms of respiratory problems rather than vague comments about breathing difficulties or lung damage. Some candidates mixed up this concept with the effects of carbon monoxide in the blood.

**Question 7**

**(a)** Few candidates were able to determine the p.d. across the lamp; many assumed the voltage was the same as that stated above the battery symbol.

**(b)** The majority of candidates realised they needed to use the formula $V = IR$. However, many used the incorrect voltage in their calculation. Where these candidates had stated the correct formula, they were credited. For this reason, candidates should state any formula used in their calculations.

**(c)** Strong candidates gave a complete answer showing all their calculations, including the conversion of minutes to seconds. Common errors were seen in the calculation of current, where candidates had not realised that they needed to add 0.8 to their answer from **Question 7(b)** or had not converted to seconds**.** Candidates should be careful to set out their answers clearly showing the


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steps in their calculation. When candidates did this, they were often credited with three marks even when their calculation of current was incorrect. Other candidates gained all five marks using the concept of error carried forward by clearly showing they had used their incorrect answer to **Question 7(b)**. Where a candidate just writes down an incorrect value for charge it is difficult to apply the error carried forward concept. The most common misconception was that the unit of charge is Q.

**Question 8**

**(a)** Most candidates were able to calculate the weight of the object. Candidates should be made aware that the front of the examination paper has this statement, 'Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / $s^2$)'. There was clear evidence that most candidates used 9.8 N although a few did use 10 N in their calculation.

**(b)** Most candidates gained one mark for using $F = ma$. Very few candidates then went on to calculate the resultant force by adding the weight of the object to their answer.

**(c) (i)** The majority of candidates successfully calculated the useful energy output. The most common misconception was to divide the efficiency by total energy input rather than multiply.

**(ii)** Strong candidates were able to calculate the vertical distance. There was no clear pattern to how candidates calculated incorrect answers.

**Question 9**

**(a) (i)** Most candidates gave a correct answer to this question.

**(ii)** Successful answers were seen in many cases; these included the correct idea of density and convection currents. When describing this concept candidates should answer in terms of air rather than particles. Candidates often describe particles gaining energy, expanding and becoming less dense. This is not the case for an individual particle so often answers are very confused as to whether the individual particle becomes less dense or the particles spread out making the hot air less dense.

**(iii)** Most candidates made a good attempt at answering this question. Strong answers referred to particles colliding with the walls with greater force and the idea of area. Candidates should make sure any collisions are more frequent rather than there being just more of them. Candidates that answer in terms of kinetic energy should ensure they make it clear the particles collide with the walls with greater kinetic energy or speed, rather than the particles are just moving around randomly with greater kinetic energy or speed. Although most candidates mentioned collisions very few linked the force to area.

**(b)** Although most candidates could state that the direction was parallel, few used the term vibration in the heading of Table 9.1. Wave, particle and energy were all seen as incorrect responses.

**(c)** Most candidates attempted an answer linked to the Big Bang Theory. Candidates should be encouraged to read questions carefully as this question asked about the beginning of the Universe and not just the Big Bang Theory. They should also be encouraged to use the terminology in the syllabus that refers to a single point of high density and temperature, rather than vague comments about small area that are dense or hot.


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# COMBINED SCIENCE

**Paper 0653/51**
**Practical Test**

## Key messages

Supervisors should submit a completed report for all practical tasks and all questions. This is essential in order to judge whether the candidate answers are appropriate for the apparatus and reagents provided at the centre. Some Supervisor reports had omissions.

Candidates should be familiar with the Notes for Quantitative Analysis provided both in the syllabus and in the question paper. Questions expect candidates to extract relevant information from these notes. The information in these notes supported candidates to answer questions **2 (a)**, **2 (c)** and **2 (e)**. Candidates who do not engage with these notes disadvantage themselves when answering these questions.

Some questions rely on candidates giving their answers to a specified number of decimal places or significant figures. In calculations where this is expected, candidates are always clearly instructed to do so. It is very common for candidates to miss this instruction.

In order to access all the marks in the planning questions it is important to make sure that candidates read the question and investigate the variables in the question. It is very common for candidates to choose to vary incorrect variables. Secondly, it is essential that all bullet points in the question are addressed. Omitting to address some of the bullet points prevents full marks from being awarded.

Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates do not label axes appropriately or choose appropriate scales. It is relatively common for candidates to show non-linear scales, often omitting values near the origin or using the values in the table as the main values on the major gridlines, even if such values give a non-linear scale.

The revised syllabus now has a section on the Language of Measurement. In this section words such as accuracy, precision and validity are defined in line with international accepted guidelines. It is important that candidates who choose to use these words do so appropriately according to their definitions. Vague and generic answers to questions such as ‘it is more accurate/valid/precise’ are not usually given any credit.

Generic responses when evaluating data or a procedure are not given credit. Answers such as ‘human error’ or ‘parallax error’ are often stated inappropriately. When asked to evaluate a procedure it is important that answers are specific to the apparatus and experiment.

## General comments

Candidates showed a positive attitude to the assessment. It was evident that most candidates had completed all of the practical tasks and almost all candidates attempted the planning question.

In preparation for the practical test, it is expected that candidates do a substantial amount of practical work integrated into their course. It is noticeable that some candidates appear to have had limited practical experience.

## Comments on specific questions

### Question 1

**(a)** Almost all candidates recorded five values for the height of the foam. In almost all cases candidates appeared to have carried out the instructions carefully, leading to results showing a


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consistent increase in the boiling tubes from **A** to **E**. However, a common error was to ignore the instruction to 'record the heights of the foam in mm to the nearest mm'. Most candidates recorded their values in centimetres.

**(b) (i)** The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis (in this case the vertical axis was height of foam / mm and the horizonal axis was number of pieces of potato). Where appropriate, the labels need to include units. Some candidates reversed the axes despite instructions at the start of **1 (b) (i)** stating to '… plot on the grid the height of the foam (vertical axis) against the number of pieces of potato.' Some candidates omitted units for the vertical axis and some mis-labelled the horizontal axis 'number of potatoes'.

The scale must be linear and chosen so that the plotted points occupy most of the grid. Major gridlines should have a simple scale that is straightforward to plot (for example, whole numbers, 2, 4, 5 or 10). A very common error was to start the vertical axis at a value other than zero without adding a value to the origin. This sometimes made it appear that the vertical axis was not linear if the intervals on the major gridlines were numbers such as '10, 15, 20 …' without an indication that the origin was 5 rather than 0. Another common error was to label the major gridlines on the horizontal axis with the values in the table '1, 2, 4, 8, 16'. This is a non-linear scale. A non-linear scale means that the appropriate scale mark is not awarded, and neither is the plotting mark, as plots cannot be checked.

Plots should be small crosses or dots in circles. Large 'blobs' are rejected because it is impossible to judge the accuracy of the plotting.

**(ii)** Some candidates did not draw appropriate lines of best fit. Depending on the candidate's values in **1 (a)**, the relationship may have appeared as a straight line or a curve. For straight lines, the line should be drawn with a ruler. Any points that are ignored as an outlier should be circled. Where there is a scatter of points, the line should be drawn so that the same number of points lie to each side of the line. Where the points give a pattern that is best represented by a curve. it should be noted are that the curve should be a single, smooth, fine line. It should be noted that feathered lines, dot-to-dot straight lines between points, overly thick lines or broken or double lines are not accepted. It is recommended that candidates use pencil because they can rub out and try again if their initial attempt is unsuccessful.

**(c)** This question gave instructions to describe the relationship between two variables which were stated in the question: surface area and height of foam. Most candidates answered this well stating clearly that as surface area increases, height of foam increases. However, some candidates did not emphatically state a relationship. 'They both increase' is not a description of a relationship. Secondly, some candidates did not answer in terms of the two variables they were asked about. 'Height of foam increases when the number of potato pieces increases' is a true statement but does not answer the question and was not awarded a mark.

**(d) (i)** This question was well answered. Some identified that for higher values of surface area the foam overflowed and was lost from the tube before measuring. Other answers identified that there is a level of judgement involved in deciding where to start and end the measurement. Other answers also correctly discussed the variable height of the surface of the foam. Some correctly described issues such as that the bubbles burst or that the height of the foam is either increasing or decreasing during measurement. Weaker answers were vague and stated that 'you can't see where to measure' or 'it is difficult to measure'. Again, generic answers such as parallax error and human error were not credited.

**(ii)** The main point here is that the foam does not represent all of the oxygen produced. Oxygen is lost when it escapes to the air and when foam bubbles burst. Again, the main reason that some candidates did not earn a mark is that many gave non-specific answers such as 'it's more accurate' or 'you get less human error'.

**(i)** There were two main marking points here. Firstly, the candidate needed to draw a diagram of apparatus that collects and measures the gas from the boiling tube. It was important that the apparatus was correct (either a gas syringe or a measuring cylinder over water) and that the gas would enter the apparatus and be collected. A common error was to leave gaps between the delivery tube and the collection apparatus that would allow the gas to escape. Secondly, the apparatus to collect and measure the gas needed to be correctly labelled. Common errors were to


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draw an incorrect set-up that would not be suitable to collect a gas, either with incorrect apparatus or leaks, or to omit the label. For some candidates it appeared that they were unfamiliar with gas collection apparatus. These candidates either left the question blank or drew inappropriate apparatus such as open test-tubes or condensers.

**Question 2**

**(a)** Most candidates recorded both masses in the table. It appeared that the masses had usually been correctly measured as they were in an appropriate expected range for a conical flask and contents. In most cases the mass measured in **step 9** was similar to the mass from **step 5**, as expected. It should be noted that the Supervisor value is very important here. Where conical flasks of sizes differing to that specified in the Confidential Instructions were used, it is essential that a note is made. Otherwise, where masses are unusually high or low, outside of the expected value, candidates are at risk of missing both marks.

For **step 8**, some candidates correctly recorded the observation as 'white precipitate' but there were many omissions of the word 'precipitate'. 'It goes white' and 'it goes cloudy' were not accepted.

**(b)** This question proved to be difficult for candidates because they struggled to communicate clearly. There are two distinct points to be made for the mark. Firstly, the candidates needed to state whether they agree or disagree with the teacher's statement. Secondly, they need to justify this in terms of the results in Table 2.1. Many quoted the question 'yes no mass was gained or lost' without referring to the data. Another common reason for missing this mark was to say 'masses are identical' without stating whether or not this supports the teacher's idea.

**(c)** In order to answer this question, candidates need to refer to the notes for qualitative analysis which are provided on the back of the paper. Many candidates do not routinely refer to these notes. Error carried forward from the table was allowed here, so that candidates who said 'sulfate because it goes cloudy' were awarded a mark.

**(d)** The apparatus shown in Fig. 2.1 is a sealed apparatus. Many candidates recognised the significance of this and stated that this is unsuitable for a reaction where a gas is produced because a build-up of pressure would result in the stopper being pushed out (and hence the loss of some of the products). The main shortcoming was answers in which candidates did not realise that a carbonate and acid produce a gas (again, this is stated on the qualitative analysis notes) and so gave vague or incorrect answers such as 'the reaction is too reactive' or 'it would explode'.

**Question 3**

Candidate performance in this question varied. Best practice is to consider the bullet points carefully and use these to structure answers. The most common reason for a low mark in the planning question is that the answer only addresses some, but not all, of the bullet points. For full marks it is essential that a mark is awarded against each of the bullet points. It should further be noted that it is not necessary to give hypotheses or safety precautions unless the question specifically asks for them.

It is essential that candidates engage fully with the variables that they are investigating. In this case it was to investigate the relationship between the mass of citric acid added to aqueous sodium hydrogencarbonate and the decrease in temperature. If candidates do not start by considering the plan with these two variables firmly in mind, they cannot gain full marks. It was relatively common for candidates to discuss changing the wrong variable, such as the temperature of the aqueous sodium hydrogencarbonate. Another common error was to base their results processing on the final temperature of the solution alone, rather than calculating a temperature decrease.

It is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted or the order was jumbled. Best answers mirror the way that experimental methods are set out in the rest of the paper, with each step being described one at a time. The minimum accepted method for the second bullet point was to add different masses of citric acid to aqueous sodium hydrogencarbonate and to measure the temperature. The fine details were awarded marks in the other sections.

It should be noted that to 'control' a variable means to keep that variable constant. Candidates stated often that they would 'control the mass of citric acid' (or even 'control the temperature') which is ambiguous and


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incorrect. Taken literally this means that the mass (or temperature) is kept constant. For clarity it is better if candidates state clearly which variable they change and which variables they intend to keep constant or keep the same. It is better, if they are unsure of the meaning of 'control' to avoid using the word at all.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a measuring cylinder was needed to measure the volume of aqueous sodium hydrogencarbonate, a balance to measure the mass of the citric acid and a thermometer to measure the temperature of the aqueous sodium hydrogencarbonate and the reaction mixture.

Commonly, planning questions have one variable that it is not possible to directly measure. In this case it was the temperature decrease. In order to do this, it was necessary to measure the temperature of the aqueous sodium hydrogencarbonate before adding the citric acid and to monitor the temperature during the reaction, noting the value of the lowest temperature reached. Following this, a processing mark was available for stating that the decrease can be calculated by subtraction of the two values. Very few candidates described how to do this. A common error, for example, was to state to 'measure the initial temperature' after the solid citric acid was added to the aqueous sodium hydrogencarbonate rather than before. This would not be a suitable method because the reaction would have already started. Also, most answered measured the 'final' temperature or the temperature after a fixed time. The key point of the investigation is to measure the lowest temperature reached, so the decrease could be reliably calculated.

A relatively common error was to include an external source of heating such as a water-bath or even a Bunsen burner. This would prevent the collection of any meaningful results about the temperature change caused by dissolving the citric acid. Candidates need to take care not to routinely include the use of a water-bath in planning questions unless the temperature is a controlled variable.

When stating which variables will be kept constant, candidates should take care not to state that they will 'use the same amount' of something. In this case, it would be preferable to 'use the same volume of aqueous sodium hydrogencarbonate'. In general, solids are controlled by measuring mass and solutions by measuring volume.

The bullet point that asks candidates to state how they will process their results is sometimes either ignored or candidates give vague responses that are not awarded marks. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not given credit. Stronger candidates included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice. However, candidates need to check that the variables on the axes of their graphs are the ones in the question. The two variables in this case are 'the mass of citric acid' and 'decrease in temperature'. Marks for processing were not awarded for graph axes with 'temperature' alone as this is too vague.

**Question 4**

**(a) (i)** Some Supervisor reports gave very different values of voltage and $d_0$ to those expected from practical trials of this experiment, (0.08–0.20 V and 35.0–45.0 cm). As most centre values were close to these values, where results differed it implied that the circuits provided to candidates had been incorrectly assembled. In such cases, candidates with values close to those of their Supervisor were awarded marks. It was also relatively common for candidates to include a minus sign before their values, suggesting that the circuit had been incorrectly assembled.

**(ii)** In such a question, candidates need to suggest a change to the apparatus. The question states that the crocodile clip is wide, answers stating 'use a narrower crocodile clip' were considered too close to a reverse of the question to be awarded a mark. Better answers suggested an alternative such as connecting the crocodile clip to a pointer or a pin or using a bare wire to make the connection.

**(iii)** Candidates who have carried out the procedure discussed pertinent practical difficulties, such as the difficulty in keeping the wire straight or issues with the small fluctuations of the voltmeter reading. Vague answers such as difficult to measure or difficult to see the measurement were not credited.

**(iv)** This formula is more challenging than the standard 'one number divided by another' and many candidates struggled to process the values. This may be due to candidates not knowing how to enter a subtraction as a denominator on their calculators. It was therefore very common to see a correct substitution but an incorrect answer. Secondly, there was an instruction to 'Give your answer to **two** significant figures.' This instruction was often ignored.


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**(b) (i)** This question was usually well answered. The most common issue leading to incorrect answers were incorrect numbers of zero after the point, leading to the measured values being incorrect by a factor of 10. For example, the expected range of current was in the region 0.030–0.050 A. It was common to see values of 0.3 A given.

**(ii)** Almost all candidates were able to use their values from **4 (b) (i)** to calculate a voltage. It should be noted that error carried forward was applied here, so that a correct calculation method based on incorrect values in **4 (b) (i)** was given full credit. A relatively common error was to misunderstand the symbol $V_2$. This was defined as the reading on the voltmeter just above in **4 (b) (i)**. Some candidates squared this value in their working, implying that they thought it represented $V^2$.

**(c)** Candidates found this question very challenging. It should be noted that candidates needed to both present a worked calculation to show whether the values are with 10% and make a clear statement of whether or not their calculation shows that the values are within the limits of experimental accuracy. There are a number of acceptable calculation routes. Most candidates calculate either an increase by 10% of the smaller value or a decrease by 10% of the larger**.** A small number of candidates presented their calculations without giving a final statement of whether they believed that their values were, or were not, within 10%. It should be noted that error carried forward was also applied to this question, so that a correct answer based on incorrect values in **4 (a) (iv)** and **4 (b) (ii)** was given full credit.

**(d) (i)** It was the intention of this question that the candidate should represent the pointer as it would appear on an analogue meter, starting at the central ‘dot’ and pointing to the correct value. Many candidates marked the position on the scale but did not draw a full pointer. Another difficulty was that many candidates did not calculate the value of the divisions on the scale correctly. As each division represents 0.2 V, the pointer should point to an area between the second and third division after the 1.0 V value. Many placed the pointer incorrectly.

**(ii)** Most candidates knew that it is important to avoid overheating of components in the circuit, but fewer were able to suggest a second reason, such as to prevent unnecessary draining of the charge of the battery. Common incorrect answers included references to electric shock or electrocution (not relevant when using laboratory batteries). Vague answers such as ‘to reset values to zero’ or ‘to save electricity’ were not awarded credit.


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# COMBINED SCIENCE

**Paper 0653/52**
**Practical Test**

There were too few candidates for a meaningful report to be produced.

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# COMBINED SCIENCE

**Paper 0653/61**
**Alternative to Practical**

## Key messages

Candidates should be familiar with the Notes for Quantitative Analysis provided both in the syllabus and in the question paper. Questions expect candidates to extract relevant information from these notes. The information in these notes supported candidates to answer questions **2 (d)** and **2 (e)**. Candidates who do not engage with these notes disadvantage themselves when answering these questions.

Some questions rely on candidates giving their answers to a specified number of decimal places or significant figures. In calculations where this is expected, candidates are always clearly instructed to do so. It is very common for candidates to miss this instruction.

In order to access all the marks in the planning questions it is important to make sure that candidates read the question and investigate the variables in the question. It is very common for candidates to choose to vary incorrect variables. Secondly, it is essential that all bullet points in the question are addressed. Omitting to address some of the bullet points prevents full marks from being awarded.

Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates do not label axes appropriately or choose appropriate scales. It is relatively common for candidates to show non-linear scales, often omitting values near the origin or using the values in the table as the main values on the major gridlines, even if such values give a non-linear scale.

The revised syllabus now has a section on the Language of Measurement. In this section words such as accuracy, precision and validity are defined in line with international accepted guidelines. It is important that candidates who choose to use these words do so appropriately according to their definitions. Vague and generic answers to questions such as ‘it is more accurate/valid/precise’ are not usually given any credit.

Generic responses when evaluating data or a procedure are not given credit. Answers such as ‘human error’ or ‘parallax error’ are often stated inappropriately. When asked to evaluate a procedure it is important that answers are specific to the apparatus and experiment.

## General comments

Candidates showed a positive attitude to the assessment. There were few omissions and almost all candidates attempted the planning question at some length.

Although the alternative to practical is a paper-based assessment, it is still intended that candidates do a substantial amount of practical work integrated into their course. The assessment may be designed around written questions, but it is not intended that the candidates only practise using written questions. It is noticeable that some candidates appear to have had limited practical experience.

## Comments on specific questions

### Question 1

**(a)** Almost all candidates measured the height of the foam correctly to an accuracy within $\pm 1$ mm. Those who made errors sometimes did not measure from the bottom of the foam, but rather from the bottom of the boiling tube. This implied that they had not fully followed the instructions of how to measure given in Fig. 1.1. A few candidates did not follow the instruction to measure ‘in mm to the


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nearest mm'. Some gave answers in centimetres. This made it difficult for them to process data properly later in the question.

**(b) (i)** The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis (in this case the vertical axis was height of foam / mm and the horizonal axis was number of pieces of potato). Where appropriate, the labels need to include units. Some candidates reversed the axes despite instructions at the start of **1 (b) (i)** stating to '… plot on the grid the height of the foam (vertical axis) against the number of pieces of potato.' Some candidates omitted units for the vertical axis and some mis-labelled the horizontal axis 'number of potatoes'.

The scale must be linear and chosen so that the plotted points occupy most of the grid. Major gridlines should have a simple scale that is straightforward to plot (for example, whole numbers, 2, 4, 5 or 10). A very common error was to start the vertical axis at a value other than zero without adding a value to the origin. This sometimes made it appear that the vertical axis was not linear if the intervals on the major gridlines were numbers such as '10, 15, 20 …' without an indication that the origin was 5 rather than 0. Another common error was to label the major gridlines on the horizontal axis with the values in the table '1, 2, 4, 8, 16'. This is a non-linear scale. A non-linear scale means that the appropriate scale mark is not awarded, and neither is the plotting mark, as plots cannot be checked.

Plots should be small crosses or dots in circles. Large 'blobs' are rejected because it is impossible to judge the accuracy of the plotting.

**(ii)** This data gives a pattern that is best represented by a curve. In general, this was well attempted. The common areas of improvement are that curves should be a single, smooth, fine line. It should be noted that feathered lines, dot-to-dot straight lines between points, overly thick lines or broken or double lines are not accepted. It is strongly recommended that candidates use pencil because they can rub out and try again if their initial attempt is unsuccessful.

**(iii)** This question gave instructions to describe the relationship between two variables which were stated in the question: surface area and height of foam. Most candidates answered this well stating clearly that as surface area increases, height of foam increases. However, some candidates did not emphatically state a relationship. 'They both increase' is not a description of a relationship. Secondly, some candidates did not answer in terms of the two variables they were asked about. 'Height of foam increases when the number of potato pieces increases' is a true statement but does not answer the question and was not awarded a mark.

**(iv)** Another well answered question with many candidates stating a value and drawing clear lines to meet both axes to show how they found their value. However, some omitted the instruction to 'Show your working on your graph.' and hence did not gain this mark.

**(c)** This question was poorly answered, because candidates either repeated the question or gave vague responses. Answers such as 'to control the length' or 'to make sure the length is constant' are a repeat of the question. Best answers recognised that this enables the initial mass or volume of the potato to be controlled. Some said 'to control the surface area'. This is incorrect as the independent variable for the experiment is changing surface area. Vague, generic answers such as 'to make the test reliable/accurate' were not credited.

**(d) (i)** This type of question expects candidates to relate their answers to the specific measurement they have taken. Best answers identified that there is a level of judgement involved in deciding where to start and end the measurement. Other answers also correctly discussed the variable height of the surface of the foam. Some correctly described practical 'real life' issues such as that the bubbles would be bursting, or the height of the foam would be moving in reality. Weaker answers were vague and stated that 'you can't see where to measure' or 'it is difficult to measure '. Again, generic answers such as parallax error and human error were not credited.

**(ii)** The main point here is that the foam does not represent all of the oxygen produced. Oxygen is lost when it escapes to the air and when foam bubbles burst. Again, the main reason that some candidates did not earn a mark is that many gave non-specific answers such as 'it's more accurate' or 'you get less human error'.


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**(iii)** There were two main marking points here. First, the candidate needed to draw a diagram of apparatus that collects and measures the gas from the boiling tube. It was important that the apparatus was correct (either a gas syringe or a measuring cylinder over water) and that the gas would enter the apparatus and be collected. A common error was to leave gaps between the delivery tube and the collection apparatus that would allow the gas to escape. Second, the apparatus to collect and measure the gas needed to be correctly labelled. Common errors were to draw an incorrect set-up that would not be suitable to collect a gas, either with incorrect apparatus or leaks, or to omit the label.

**Question 2**

**(a)** The question asked candidates to 'Record in Table 2.1 these masses to the nearest 0.1 g.'. The instruction to record to the nearest 0.1 g was frequently ignored. Hence, '151' was not accepted. The use of a zero as a decimal place is a source of confusion. Candidates need to recognise that a zero is a value equivalent to other numbers when placed after the decimal point.

**(b)** Most candidates correctly suggested the use of a measuring cylinder. Volumetric or graduated pipettes were also accepted. It should be noted that 'pipette' alone is not accepted as a suitable apparatus for measuring volume because many laboratory pipettes are dropping pipettes and are not graduated. Syringe is not a suitable measuring apparatus for volumes greater than 10.0 $cm^3$.

**(c)** This question proved to be difficult for candidates because they struggled to communicate clearly. There are two distinct points to be made for the mark. Firstly, the candidates needed to state whether they agree or disagree with the teacher's statement. Secondly, they need to justify this in terms of the results in Table 2.1. Many quoted the question 'yes no mass was gained or lost' without referring to the data. Another common reason for missing this mark was to say 'masses are identical' without stating whether or not this supports the teacher's idea.

**(d)** This question was answered correctly by many candidates. In order to answer it, candidates needed to refer to the notes for qualitative analysis which are provided on the back of the paper. Many candidates do not routinely refer to these notes.

**(e)** The apparatus shown in Fig. 2.1 is a sealed apparatus. Many candidates recognised the significance of this and stated that this is unsuitable for a reaction where a gas is produced because a build-up of pressure would result in the stopper being pushed out (and hence the loss of some of the products). The main shortcoming was answers in which candidates did not realise that a carbonate and acid produce a gas (again, this is stated on the qualitative analysis notes) and so gave vague or incorrect answers such as 'the reaction is too reactive' or 'it would explode'.

**Question 3**

Best practice is to consider the bullet points carefully and use these to structure answers. The most common reason for a low mark in the planning question is that the answer only addresses some, but not all, of the bullet points. For full marks it is essential that a mark is awarded against each of the bullet points. It should further be noted that it is not necessary to give hypotheses or safety precautions unless the question specifically asks for them.

It is essential that candidates engage fully with the variables that they are investigating. In this case it was to investigate the relationship between the mass of citric acid added to aqueous sodium hydrogencarbonate and the decrease in temperature. If candidates do not start by considering the plan with these two variables firmly in mind, they cannot gain full marks. It was relatively common for candidates to discuss changing the wrong variable, such as the temperature of the aqueous sodium hydrogencarbonate. Another common error was to base their results processing on the final temperature of the solution alone, rather than calculating a temperature decrease.

It is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted or the order was jumbled. Best answers mirror the way that experimental methods are set out in the rest of the paper, with each step being described one at a time. The minimum accepted method for the second bullet point was to add different masses of citric acid to aqueous sodium hydrogencarbonate and to measure the temperature. The fine details were awarded marks in the other sections.


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It should be noted that to 'control' a variable means to keep that variable constant. Candidates stated often that they would 'control the mass of citric acid' (or even 'control the temperature') which is ambiguous and incorrect. Taken literally this means that the mass (or temperature) is kept constant. For clarity it is better if candidates state clearly which variable they change and which variables they intend to keep constant or keep the same. It is better, if they are unsure of the meaning of 'control' to avoid using the word at all.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a measuring cylinder was needed to measure the volume of aqueous sodium hydrogencarbonate, a balance to measure the mass of the citric acid and a thermometer to measure the temperature of the aqueous sodium hydrogencarbonate and the reaction mixture.

Commonly, planning questions have one variable that it is not possible to directly measure. In this case it was the temperature decrease. In order to do this, it was necessary to measure the temperature of the aqueous sodium hydrogencarbonate before adding the citric acid and to monitor the temperature during the reaction, noting the value of the lowest temperature reached. Following this, a processing mark was available for stating that the decrease can be calculated by subtraction of the two values. Very few candidates described how to do this. A common error, for example, was to state to 'measure the initial temperature' after the solid citric acid was added to the aqueous sodium hydrogencarbonate rather than before. This would not be a suitable method because the reaction would have already started. Also, most answered measured the 'final' temperature or the temperature after a fixed time. The key point of the investigation is to measure the lowest temperature reached, so the decrease could be reliably calculated.

A relatively common error was to include an external source of heating such as a water-bath or even a Bunsen burner. This would prevent the collection of any meaningful results about the temperature change caused by dissolving the citric acid. Candidates need to take care not to routinely include the use of a water-bath in planning questions unless the temperature is a controlled variable.

When stating which variables will be kept constant, note that candidates should take care not to state only that they will 'use the same amount' of something. In this case, it would be preferable to 'use the same volume of aqueous sodium hydrogencarbonate'. In general, solids are controlled by measuring mass and solutions by measuring volume.

The bullet point that asks candidates to state how they will process their results is sometimes either ignored or candidates give vague responses that are not awarded marks. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not given credit. Stronger candidates included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice. However, candidates need to check that the variables on the axes of their graphs are the ones in the question. The two variables in this case are 'the mass of citric acid' and 'decrease in temperature'. Marks for processing were not awarded for graph axes with 'temperature' alone as this is too vague.

**Question 4**

**(a) (i)** There was an instruction to 'Record your value to the nearest 0.1 cm.'. For this question, most candidates followed this instruction and recorded their value correctly.

**(ii)** Some candidates mis-used the language of measurement and often gave vague answers that could not be awarded any marks. The main advantage of the apparatus in Fig. 4.3 is that it has a sharp point, and this enables the reading on the ruler to be seen without it being hidden, as it is when the wider crocodile clip (which hides a section of the scale) is used. Vague, generic answers referencing 'it is more accurate / reliable / precise' or 'it avoids human / parallax error' were not credited.

**(iii)** This formula is more challenging than the standard 'one number divided by another' and many candidates struggled to process the values. This may be due to candidates not knowing how to enter a subtraction as a denominator on their calculators. It was therefore very common to see a correct substitution but an incorrect answer. Secondly, there was an instruction to 'Give your answer to **two** significant figures.' This instruction was often ignored.

**(b) (i)** Reading analogue scales can be challenging because the first step is to work out the scale and hence the values represented by each mark on the scale. Most read the voltmeter correctly as 1.20 V, but fewer were able to work out that the smallest division on the ammeter is 0.02 A. Hence incorrect answers such as 0.8 A or 0.04 A were commonly seen.


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**(ii)** In common with other questions, generic answers such as 'more accurate' were not credited. Best answers referred to the idea that a digital device does not rely on human judgement or processing to decide the value. Some very high-level answers referred to practical issues of using analogue equipment, such as the minor fluctuations of the needle.

**(iii)** The format of the equation was familiar to candidates, and almost all were able to use their values from **4 (b) (i)** correctly to calculate a voltage. It should be noted that error carried forward was applied here, so that a correct calculation method based on incorrect values in **4 (b) (i)** was given full credit.

**(c)** Many candidates completed this calculation without a problem. It should be noted that candidates needed to both present a worked calculation to show whether the values are with 10% and make a clear statement of whether or not their calculation shows that the values are within the limits of experimental accuracy. There are a number of acceptable calculation routes. Most candidates calculate either an increase by 10% of the smaller value or a decrease by 10% of the larger. A small number of candidates presented their calculations without giving a final statement of whether they believed that their values were, or were not, within 10%. It should be noted that error carried forward was also applied to this question, so that a correct answer based on incorrect values in **4 (a) (iv)** and **4 (b) (ii)** was given full credit.

**(d)** Most candidates knew that it is important to avoid overheating of components in the circuit, but fewer were able to suggest a second reason, such as to prevent unnecessary draining of the charge of the battery. Common incorrect answers included references to electric shock or electrocution (not relevant when using laboratory batteries). Vague answers such as 'to reset values to zero' or 'to save electricity' were not awarded credit.



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# COMBINED SCIENCE

**Paper 0653/62**
**Alternative to Practical**

## Key messages

Some questions rely on candidates giving their answers to a specified number of decimal places or significant figures. It is very common for candidates to miss this instruction. Similarly, when data is entered into a table, the recorded data should match the presentation of numbers already printed in the table. E.g. In **1(a)(i)** the answers needed were 115 and 119 and not 115.0 and 119.0.

To access all the marks in the planning questions it is important that candidates read the question and investigate the specific variables in the question. It is common for candidates to investigate incorrect variables. Secondly, it is essential that all bullet points in the question are addressed. Omitting to address some of the bullet points prevents full marks from being awarded.

Candidates should follow the guidance in Section 4 of the syllabus when constructing graphs. Many candidates do not label axes appropriately or draw an inaccurate line of best fit.

The revised syllabus now has a section on the Language of Measurement. In this section, words such as accuracy, precision and validity are defined in line with international accepted guidelines. It is important that candidates who choose to use these words do so appropriately. Vague and generic answers to questions such as 'it is more accurate/valid/precise' are not usually given any credit. These words are often used incorrectly by candidates, for example, accuracy and precision relate to the quality of a reading. Hence a procedure or a piece of apparatus cannot be described as 'accurate' or 'precise'.

Generic responses when evaluating data or a procedure are not given credit. Answers such as 'human error' or 'parallax error' are often stated inappropriately. When asked to evaluate a procedure it is important that answers are specific to the apparatus and experiment.

## General comments

Candidates showed a positive attitude to the assessment. There were few omissions, and almost all candidates attempted the planning question at some length.

## Comments on specific questions

### Question 1

**(a) (i)** The majority of candidates correctly entered the numbers 115 and 119 into the correct places in the table. The most common error was writing 115.0 and 119.0, which does not match the level of precision of the other numbers in the table. A very small number of candidates did not realise the measuring cylinders were upside down and so wrote 125 and 121.

**(ii)** Most candidates wrote the correct answers, 9 and 4, in the table. Error carried forward was applied to those candidates that obtained incorrect numbers in the previous question.

**(b)** In their answer, candidates had to link light intensity and rate of photosynthesis. Candidates who did not gain the mark tended to write about the distance of the lamp rather than the light intensity, or the volume of gas rather than the rate of photosynthesis. Some candidates described proportion and since the data is neither directly or indirectly proportional, candidates were not awarded the mark. A small number of candidates tried to explain how light intensity causes a change in photosynthesis.


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**(c)** This question proved to be very demanding for candidates. The idea was to wait for 5 minutes to allow the plant to generate oxygen at a constant rate. Most candidates wrote about the plant starting to photosynthesise rather than photosynthesising at a steady rate. Some candidates used the word equilibration, and this was awarded credit.

**(d) (i)** This question required the reading to be recorded to the nearest 0.5°C and so the answer was 26.0°C. A large number of candidates incorrectly recorded it as 26°C.

**(ii)** Many candidates had the basic idea of what to do to improve the apparatus, but they struggled to put it into words. Many candidates said to use a 'heat shield' without specifying what this meant. Candidates who went further and described what form this would take, for example, a sheet of glass or Perspex or container of water were awarded the mark.
Some candidates gave vague answers about changing the lamp but those who said change the lamp to one that releases less heat e.g. an LED received the mark. Other candidates suggested using a water-bath or moving the lamp further away which would have changed the experiment too much from what was originally given in the procedure.

**Question 2**

Many candidates were awarded at least half of the available marks. Best practice is to consider the bullet points carefully and use these to structure answers. The most common reason for a low mark in the planning question is that the answer only addresses some, but not all, of the bullet points. For full marks it is essential that a mark is awarded against each of the bullet points.

It is essential that candidates engage fully with the variables that they are investigating. In this case it was to investigate the relationship between the colour of the leaves and the rate of water loss. The question prompted candidates to consider measuring the mass of the leaves. Many candidates tried to use other methods that would not have worked. If the candidates do not start by considering the plan with these two variables firmly in mind, they cannot gain full marks. Another common shortcoming was to base their results processing on the just the change in mass of the leaf rather than the rate of change of mass.

It is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted, or the order was jumbled. The best answers mirror the way that experimental methods are set out in the rest of the paper, with each step being described one at a time rather than paragraphs of continuous prose.

The minimum accepted method for the second bullet point was to measure the mass of different coloured leaves before and after leaving them for a specified time. The fine details were awarded marks in the other sections.

Most candidates chose to use a balance to measure the mass of the leaves and some type of laboratory timer to measure the time that they were left for – with most candidates scoring the marks for the apparatus.

As mentioned above, the basic method is to measure the mass of at least two different coloured leaves before and after leaving them to lose water. Some candidates tried to use a potometer and so had obviously seen this and tried to link it to the experiment, but this would not work as a method. Other candidates suggested soaking leaves in water and then finding their mass, which again would not produce results that answer the question. Candidates needed to use the term 'mass rather than 'weight' of the leaves.

For the candidates who had a workable method, the majority picked up some marks in the measurement section by describing how to measure the mass of the leaves before and/or after. Many candidates made the excellent suggestion to use at least five different colours of leaf.

Candidates made good suggestions about the control variables, with temperature and something to do with the air condition, e.g. humidity, as common answers. Some suggestions were too vague, such as the same location. The candidates were told that the leaves came from the same type of plant so this was not awarded credit.

The processing section proved to be challenging for many candidates with the most common mark awarded being for finding the difference in mass before and after. Very few candidates linked their processing back to the original statement about rate at the start of the question. To gain this mark candidates needed to describe how to calculate the rate of water loss or write a formula that would allow this to be done.


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Many candidates sketched a set of graph axes and if these had rate and colour as the labels this was awarded the mark, but most candidates did not include the word rate and only considered the loss in mass. The final processing mark must always link to the variables investigated in the question, be these measured or derived – in this case colour and rate of water loss.

**Question 3**

**(a) (i)** This question asked candidates to record the readings on the balances to two decimal places. Many candidates either gave the full reading from the balance or gave the readings to two significant figures i.e. 5.4, 6.8, and 6.5. Neither of these misunderstandings were worthy of credit.

**(ii)** Most candidates correctly calculated the mass of copper oxide using the readings from step 3 and step 1. Some candidates subtracted the wrong combination of numbers from their table e.g. step 9 minus step 3 or step 9 minus step 1. Error carried forward was applied here so as not to disadvantage candidates who got the previous answers wrong.

**(iii)** Some candidates tried to calculate the mass by doing the wrong subtraction.

**(iv)** Most candidates were able to calculate the percentage by mass to two significant figures getting the answer of 80. Some candidates then negated the correct answer by writing 80.0 and so only scored one mark. Other common errors including doing the division upside down and getting an answer over 100% but this could still gain the second mark if it was given to two significant figures. Candidates are reminded that they should show their working out and not just write the final answer. Some candidates would have got some credit had they shown where their incorrect answer came from, provided they had rounded it to two significant figures. An incorrect answer to two significant figures with no working to show where this number came from cannot be awarded marks.

**(v)** Very few candidates were awarded the mark for this question. Candidates were told in the procedure that the methane is burned, so no credit was awarded just for repeating that information. Candidates needed to add to it and state that the methane is flammable and then link this to the idea of it being a safety risk by causing an unintended fire. Most candidates went down the route of it being a greenhouse gas or somehow toxic.

**(vi)** Candidates needed to state the idea of the flame being hotter or that the yellow flame causes soot to coat the test-tube.

**(vii)** The idea of burning their fingers or damaging the balance were the required answers. Many candidates thought we were looking for some experimental reason about the reaction not being finished or that the temperature would somehow affect the mass of the contents of the test-tube. Some candidates went down the safety route but gave vague answers about it being ‘dangerous’ or ‘unsafe’ without explaining why.

**(b)** This question proved demanding for most candidates. One mark was commonly awarded for ‘heat to constant mass’ but the second mark for linking this to how we would know if the reaction was finished was comparatively rare. Candidates should not use standard phrases without linking them to the specific experiment or procedure being asked about.

**(c)** This question proved to be very demanding with candidates generally only saying that there would be a larger mass of copper formed. This answer does not explain why the larger mass is a good thing experimentally. Some candidates wrote about reducing the percentage error and this was accepted.

**Question 4**

**(a) (i)** Most candidates were able to correctly state 44.8 as the reading.

**(ii)** Virtually all candidates were able to subtract their previous answer from 50 and get 5.2. Error carried forward was applied from the previous question.

**(b) (i)** The majority of candidates were able to correctly plot all the points but labelling the axes with the headings from the table was a problem for many candidates. It was common for the units to be


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missing. Data should be plotted correctly using either small crosses or dots in circles. Large 'blobs' are not credited because it is impossible to judge the accuracy of the plotting.

**(ii)** Many candidates made the mistake of joining the first and last points with a straight line. In this case, that made three of the points fall below the line (assuming they were correctly plotted). A line of best fit should have an even spread of points on either side of the line and does not need to touch any of the points at all. It is strongly recommended that candidates attempt the graph and line of best fit questions in pencil so that they can rub out any mistakes and try again if their initial attempt is not successful. It is very difficult to do this in pen. It should be noted that feathered lines, dot-to-dot straight lines between the points, overly thick lines, broken lines and double lines are not accepted.

**(iii)** Extrapolation appears to be a skill with which some candidates are unfamiliar. Some candidates joined the first plotted point to the origin rather than continuing their line of best fit until it intercepted the vertical axis. Many candidates correctly extrapolated the line but then incorrectly read the value where the line crossed the axis. Other candidates did not extrapolate the line but then estimated a value. This was not awarded marks because candidates had not shown that they arrived at their value by doing the extrapolation.

**(iv)** Most candidates were able to calculate a value of *M*. A minimum of two significant figures were required, and it was necessary to correctly round their answer rather than truncate it.

**(c) (i)** Most candidates were able to determine the position of the centre of the mass and get the answer 67. Some candidates misinterpreted the question and gave the answer as 3, probably indicating that they had found the width of the mass rather than the position of its centre. Where candidates did not get the correct answer, it was common to give them one mark for reading 65.5 or 68.5.

**(ii)** Many candidates did not realise they had to subtract their previous answer from 100. Information needed in later questions is sometimes given in earlier parts of the question. Those who looked back to Fig. 4.1 will have seen what needed to be done.

**(d)** This question proved demanding for candidates. For the advantage, it was common for candidates to refer to being 'easier to read' or 'easier to see the number' without stating why i.e. the string does not cover the reading as much as the mass would have done. Candidates seemed more familiar with the disadvantage. The idea of the string affecting the mass of the object or the string being able to slip or slide along the rule being common correct answers. Some candidates wrote about the string snapping or masses landing on fingers, and this was not credited as it us a safety concern, not a disadvantage.


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# COMBINED SCIENCE

**Paper 0653/63**
**Alternative to Practical**

## Key messages

It is very important that candidates are familiar with the Notes for Quantitative Analysis provided both in the syllabus and with every practical question paper (see page 20 of this paper). Questions expect candidates to be able to extract relevant information from these notes. The information in these notes supported candidates to answer **Question 1(d)**. Candidates who do not engage with these notes disadvantage themselves when answering these questions.

To access all the marks in the planning question, it is important that candidates read the question and investigate the variables in the question. It is very common for candidates to choose to vary incorrect variables. Secondly, it is essential that all bullet points in the question are addressed. Omitting to address some of the bullet points prevents full marks from being awarded.

Candidates should follow the guidance in Section 4 of the syllabus when constructing graphs. Many candidates do not label axes appropriately or choose appropriate scales. It is relatively common for candidates to show non-linear scales, often omitting values near the origin or using the values in the table as the main values on the major gridlines, even if such values give a non-linear scale.

The revised syllabus now has a section on the Language of Measurement. In this section, words such as accuracy, precision and validity are defined in line with international accepted guidelines. It is important that candidates who choose to use these words do so appropriately. Vague and generic answers to questions such as ‘it is more accurate/valid/precise’ are not usually given any credit. These words are often used incorrectly by candidates, for example, accuracy and precision relate to the quality of a reading. Hence a procedure or a piece of apparatus cannot be described as ‘accurate’ or ‘precise’.

## General comments

Candidates showed a positive attitude to the assessment. There were few omissions, and almost all candidates attempted the planning question at some length.

## Comments on specific questions

### Question 1

**(a) (i)** Almost all candidates gave the heart rate to three significant figures for lifting block **E** as 134.

**(ii)** Some candidates correctly stated that it was more accurate to count the beats for three minutes rather than one minute because people recover at different rates. A common error was to suggest that this would allow them to calculate the average. Few candidates stated that counting over three minutes would reduce the impact of errors, for example, the human error when using a stopwatch.

**(iii)** This question was well answered with most candidates stating that the heart needed time to return to its normal, resting rate.

**(b) (i)** Most candidates were able to read the values from the balances and correctly round to two decimal places. Candidates were directed to record these values in Table 1.1. Some candidates wrote their answers in the squares drawn on the balance images. If the correct answers were recorded in this way, credit was given.


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**(ii)** This question gave instructions to describe the relationship between two variables which were stated in the question: mass of the block and heart rate after exercise. Most candidates answered this well, stating clearly that as the mass lifted increases, heart rate after exercise increases. However, some candidates did not emphatically state a relationship. 'They both increase' is not a description of a relationship.

**(c) (i)** Most candidates correctly calculated the percentage increase in heart rate using the equation provided.

**(ii)** There were two marking points available for explaining why the percentage increase in heart rate was calculated rather than the increase. Many candidates gained one mark for stating that the heart rates at rest were all different. Few went on to say that using a percentage allowed the increases to be compared. Vague, generic answers such as 'to make the test reliable/accurate' were not credited.

**(d)** Many candidates correctly described the appearance of the limewater in test-tubes **P** and **Q**. However, the Notes for Use in Quantitative Analysis state that carbon dioxide 'turns limewater milky'. It was rare for a candidate to quote this for test-tube **Q**, instead relying on their knowledge to state 'milky' or 'cloudy'. Credit was given in these cases. A common error was to describe test-tube **P** as being 'clear' rather than 'colourless'. Credit was given if a candidate correctly compared the test-tubes, e.g. '**Q** is more milky than **P**'. Some explanations lacked detail and did not link the idea that **Q** contained the air that was being breathed out, and so contained more carbon dioxide. A common error was to simply state that 'carbon dioxide turns limewater milky' and not explain where this carbon dioxide comes from.

**Question 2**

**(a)** This question was well answered with most candidates correctly recording the values from the thermometers to the nearest 0.5 °C

**(b) (i)** Many candidates were awarded both marks. However, some candidates did not follow the expected conventions:

- The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis (in this case the vertical axis was given as boiling point / °C) and the independent variable on the horizonal axis. Some candidates mislabelled the horizontal axis 'Spatulas of **H**'.
- The scale must be linear and chosen so that the plotted points occupy most of the grid. Major gridlines should be a simple scale that is straightforward to plot (for example, whole numbers, 2, 4, 5 or 10). A non-linear scale means that the appropriate scale mark is not awarded, and neither is the plotting mark, as plots cannot be checked.
- Data should be plotted correctly using either small crosses or dots in circles. Large 'blobs' are rejected because it is impossible to judge the accuracy of the plotting.

**(ii)** This question was well answered with nearly all candidates correctly circling the point they had plotted for 5 spatulas.

**(iii)** This data gives a pattern that is best represented by a straight line. In general, this was not well attempted, with many candidates simply joining the first and last points. This leads to an uneven distribution of points in relation to the line of best fit and so is not awarded credit. It is recommended that candidates use pencil because they can rub out and try again if their initial attempt is not successful. It should be noted that feathered lines, dot-to-dot straight lines between points, overly thick lines, broken lines or double lines are not accepted.

**(iv)** Candidates were required to describe the relationship between the boiling point of the water and the number of spatulas of **H** dissolved in the water. This question was well answered.

**(v)** Many candidates extended their line of best fit to 8 spatulas, but some omitted the instruction to 'Show your working on your graph' by drawing clear lines from the *x*-axis to their line and then across to the *y*-axis.

**(c)** This question required candidates to use clear scientific language to describe improvements to two of the steps in the method. Correct answers used words such as 'volume' and 'mass' rather than


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'amount'. Some candidates gave apparatus, such as a 'measuring cylinder to measure the water' and 'balance to measure **H**' and these were given credit. A few candidates stated a volume or mass, such as '100 ml' or '5 g' and these were also awarded marks.

**(d)** Candidates found this question demanding as few realised the method given would result in the volume of water in the beaker decreasing. Changes to the method that were awarded credit included 'topping the water up to the same volume' or 'covering the beaker'. The change mark was linked to the error mark.

**Question 3**

**(a)** In common with other questions, generic answers such as 'more accurate' etc. were not credited. Strong answers described to the idea that there were smaller divisions on voltmeter **P** or that it had a smaller range.

**(b)** This question was very well answered with nearly all candidates recording the values to the nearest mA in the table.

**(c) (i)** Most candidates correctly used Fig. 3.4 to read off the value of the intercept.

**(ii)** Most candidates used their value from **3(c)(i)** to calculate the resistance **X**. Error carried forward was applied here.

**(d) (i)** Few candidates were able to state that the type of error was a 'zero' or 'systematic' error. Many candidates simply stated that the ammeter was 'broken' or 'human error'.

**(ii)** Some candidates realised that they would obtain the correct value by subtracting 2 mA from the values in Table 3.1. A common error was misreading Fig. 3.5 and writing '20 mA' or '0.2 mA'.

**Question 4**

Many candidates gained at least half of the available marks. Best practice is to consider the bullet points carefully and use these to structure answers. The most common reason for a low mark in the planning question is that the answer only addresses some, but not all, of the bullet points. For full marks it is essential that a mark is awarded against each of the bullet points.

It is essential that candidates investigate the variable that is required by the question. In this case it was to investigate the relationship between the distance *h* and the width of the beam. If the candidates do not start by considering the plan with these two variables firmly in mind, they cannot gain full marks. It was relatively common for candidates to describe changing the wrong variable, such as the length of the beam or the mass placed on the end. Another common error was to base their results processing on their measurements alone, rather than calculating a change in distance, *h*.

It is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted, or the order was jumbled. Best answers mirror the way that experimental methods are set out in the rest of the paper, with each step being described one at a time. The minimum accepted method for the second bullet point was to add a mass to the end of the beam and measure *h* for different widths. The fine details were awarded marks in the other sections.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a ruler was needed to measure the distance, a clamp to secure the beam to the bench and some tape to secure the mass to the beam. Credit was not given for other ways of securing the beam, such as 'hammer and nails'.

It should be noted that to 'control' a variable means to keep that variable constant. For clarity it is better if candidates state clearly which variable they change and which variables they intend to keep constant or keep the same. It is better, if they are unsure of the meaning of 'control' to avoid using the word at all.

Commonly, planning questions have one variable that it is not possible to directly measure. In this case it was the distance *h*. To do this, it was necessary to measure the height of the beam from the floor before and after adding the mass. Following this, a processing mark was available for stating that the decrease can be calculated by subtraction of the two values. Very few candidates described how to do this. A common error


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was to state to ‘measure the height of the beam’ after the mass was added. This would not be a suitable method because the beam would have already moved.

The bullet point that asks candidates to state how they will process their results is sometimes ignored or candidates give vague responses that are not awarded marks. Vague, generic answers such as ‘repeat and take an average’ or ‘draw a graph of the results’ are not given credit.

Marks could be gained from drawing a table. For example, a measurement mark was given if a candidate drew a table that included five different widths for the beam.

The space on page 17 was for candidates to draw a table. Some candidates ignored this space and then ran out of lines for their answer.



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