Principal examiner reports for teachers

Principal examiner reports for teachers summarise what candidates did well and what candidates needed to improve for this examination series only.

This report is to be used in conjunction with the question paper and mark scheme.

For guidance on teaching and learning we provide resources for many of our syllabuses.

Resource	Where to find it
Grade descriptions – Grade descriptions describe the level of performance typically demonstrated by candidates achieving the different grades awarded for a qualification.	School support hub Select: Subject > Resource finder > Syllabus and specimen materials
Schemes of work – Schemes of work are designed to support you in your teaching and lesson planning.	School support hub Select: Subject > Resource finder > Teaching and learning
Lesson planning – Guidance on how to plan a lesson.	Lesson planning
Resource plus – There may be additional resources such as teaching packs containing lesson plans, resources and worksheets and videos for aspects of your syllabus.	School support hub Select: Subject > Resource finder > Teaching and learning
Teaching tools	Teaching Tools
Exemplar candidate responses	School support hub Select: Subject > Resource finder > Teaching and learning
Learner guide – A guide for students to help them understand what the course involves.	School support hub Select: Subject > Resource finder > Teaching and learning
Community forums – Do you have a question or something to share? Our online forums are great way to keep up to date with your subject and the global Cambridge community.	Community forum on the school support hub
Access to scripts for this series.	Access to scripts service
Results analysis is available for some syllabuses.	Results analysis
Test maker is available for some subjects.	Test maker

Other services from Cambridge International Education

- **Digital mocks service**
- **Insight assessments**
- **Professional development**
  - Focus on assessment
  - Online marking workshops

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/11
Multiple Choice (Core)

Key messages

Candidates performed well on **Questions 1**, **3**, **4**, **5**, **6**, **7**, **8**, **11**, **12**, **13**, **14**, **15**, **17**, **18**, **21**, **22**, **23**, **27**, **28**, **29, 32**, **33**, **35**, **36**, **38**, **39** and **40**.

Candidates performed less well on **Questions 2**, **9**, **10**, **16**, **19**, **20**, **24**, **25**, **26**, **30**, **31**, **34** and **37**.

Candidates showed the strongest understanding on **Question 13**, while **Question 9** required greater application of knowledge. In general, candidates responded positively to questions assessing Biology.

Comments on specific questions

Question 2

- All options were popular.
- Some candidates needed to pay careful attention to the 'not' aspect of thquestion on how cells are made up.

Question 9

- Options **C** and **D** were more popular than the key.
- Some candidates could not identify option **B** as the structure that secretes the fluid in which sperm swim in the human male reproductive system.

Question 10

- Option **C** was as popular as the key.
- Some candidates incorrectly thought that there is an X chromosome in all sperm cells.

Question 16

- Option **B** was more popular than the key.
- Some candidates recognised that hydrogen is produced during the electrolysis of dilute sulfuric acid and thought that sulfur dioxide was produced instead of oxygen.

Question 19

- Option **C** was as popular as the key and option **D** was more popular.
- Some candidates did not recognise that the transfer of oxygen from one substance to another is a redox reaction.

Question 20

- Option **C** was more popular than the key.
- Some candidates needed to recognise that X was a basic oxide.

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Question 24

- Option **C** was a popular incorrect answer.
- Some candidates reversed the first two steps in the treatment of a domestic water supply.

Question 25

- Option **A** was more popular than the key.
- Some candidates were not familiar with the formation of nitric acid in the atmosphere following the reaction of nitrogen and oxygen in a car engine.

Question 26

- Option **C** was more popular than the key.
- Some candidates did not recognise that B was ethene and matched the information given.

Question 30

- Option **B** was more popular than the key.
- Some candidates recognised that the area of contact with the ground was part of the expression but confused weight with mass of block.

Question 31

- Option **A** was more popular than the key.
- Some candidates thought that liquids can be compressed easily.

Question 34

- Option **A** was more popular than the key.
- Some candidates were not familiar with the colours of each wavelength of visible light based on relative order.

Question 37

- Option **A** was as popular as the key and option **C** was more popular.
- Some candidates needed to recall that an electric circuit transfers energy from the cell to its components and then into the surroundings.

Question 40

- Option **D** was more popular than the key.
- Some candidates were not able to recall the approximate diameter of the Milky Way galaxy.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/12
Multiple Choice (Core)

Key messages

Candidates performed well on **Questions 1**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **11**, **13, 14**, **15, 16**, **18**, **21**, **22**, **24**, **25**, **26**, **27**, **28**, **35**, **36**, **38** and **39**.

Candidates performed less well on **Questions 2**, **10**, **12**, **17**, **19**, **20**, **23**, **29**, **30**, **31**, **32**, **33**, **34**, **37** and **40**.

Candidates responded most successfully to **Question 4** and less successfully to **Question 34**. In general, candidates demonstrated secure knowledge and understanding of Biology.

Comments on specific questions

Question 2

- Option **C** was a common incorrect answer.
- Some candidates recognised that active transport requires energy from respiration and thought that diffusion also requires energy from respiration.

Question 10

- Option **D** was a common incorrect answer.
- Some candidates confused alleles with genotypes.

Question 12

- Option **C** was equally as popular as the key.
- Some candidates were not able to recognise that the capelin is a carnivore.

Question 17

- Option **A** was as popular as the key and option **C** was more popular.
- Some candidates did not recognise that decomposition of electrolytes occurs during electrolysis.

Question 19

- Option **B** was more popular than the key.
- Some candidates thought that iron rusting was a physical change.

Question 20

- Option **D** was as popular as the key.
- Some candidates recognised that methyl orange is yellow when sodium hydroxide is added to litmus. They were not able to recall the colour of litmus in sodium hydroxide.

Question 23

- Options **B** and **C** were more popular than the key.

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- Some candidates were not familiar with the reactions of the metals listed in the syllabus with hot water and with the methods of their extraction from their oxide.

Question 29

- Option **A** was more popular than the key.
- Some candidates recognised that weight is affected by gravitational field strength and incorrectly thought that mass is also affected.

Question 31

- Option **B** was equally as popular as the key.
- Some candidates incorrectly thought that the rapid and random motion of each dust particle was evidence that the particles were molecules, as opposed to evidence for the kinetic particle model of matter.

Question 33

- Options **A** and **B** were popular incorrect answers.
- Some candidates were not familiar with the path of the dispersion of white light though a glass prism.

Question 34

- Options **B** and **C** were more popular than the key.
- Some candidates were not familiar with the relative wavelength and region of ionising radiation for radio waves and X-rays.

Question 37

- Options **A** and **C** were more popular than the key.
- Some candidates were not able to interpret the circuit diagram correctly and did not recognise that only statement 1, that there is a separate switch to control each lamp, was correct.

Question 40

- Options **B** and **C** were common incorrect answers.
- Some candidates were not familiar with the meaning of a light-year.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/13
Multiple Choice (Core)

Key messages

Candidates performed well on **Questions 1**, **2**, **3**, **4**, **5**, **7**, **9**, **11**, **12**, **13**, **16**, **17**, **18**, **19**, **21**, **23**, **25**, **27**, **28**, **29**, **32**, **33**, **34**, **35**, **37** and **38**.

Candidates performed less well on **Questions 6**, **8**, **10**, **14**, **15**, **20**, **22**, **24**, **26**, **30**, **31**, **36**, **39** and **40**.

Candidates found **Question 13** the easiest and **Question 14** the most challenging. There was evidence of guessing on Questions **24** and **31**.

Comments on specific questions

Question 6
- Option **B** was more popular than the key.
- The candidates knew the rate of breathing would increase although they incorrectly thought that the depth of breathing decreases with exercise.

Question 8
- Option **D** was more popular than the key.
- Candidates knew that some of the pathogens show resistance to the antibiotic although they incorrectly thought the pathogen was a virus.

Question 10
- Option **B** was more popular than the key.
- Candidates could not determine the phenotypes of the offspring given the provided information.

Question 14
- All the other options were more popular than the key.
- Candidates found this the most challenging question on the paper, showing a lack of familiarity with the bonding in magnesium chloride.

Question 15
- Option **B** was a common incorrect answer.
- Candidates did not use the Periodic Table to check the formula of fluorine so gave the formula of sodium fluoride as NaF*l*.

Question 20
- Option **A** was a common incorrect answer.
- The colour of universal indicator in acidic, neutral and alkaline solutions was not known.

Question 22
- Options **A** and **B** were common incorrect answers.
- Transition elements have a high melting point and high density and do not form colourless compounds.

Question 24
- There was evidence of guessing for this question, as all options were chosen.
- This indicates that candidates are not familiar with what happens in a blast furnace.

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Question 26

- Options **B** and **C** were common incorrect answers.
- Candidates confused complete and incomplete combustion and also did not recognise that water is a product of combustion.

Question 30

- Option **D** was more popular than the key.
- Candidates may have been tempted by the fact that the weight and total area in contact with the ground is the lowest for the mouse, without determining the density for each animal.

Question 31

- There was evidence of guessing on this question, as each option was chosen.
- Candidates may have found the ‘not’ aspect of the question on energy transfer an additional challenge.

Question 36

- Option **A** was equally as popular as the key.
- Candidates knew that electrons were involved although they incorrectly thought that the cloth gained electrons.

Question 39

- Option **B** was more popular than the key.
- Candidates were not confident in selecting a suitable safety precaution for using a radioactive source that emits gamma radiation.

Question 40

- Options **A**, **B** and **C** were all popular choices.
- This shows a lack of familiarity with the order of planets from the Sun.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/21
Multiple Choice (Extended)

Key messages

Candidates performed well on **Questions 1, 2**, **3**, **4**, **5**, **6**, **7**, **9**, **10**, **12**, **13**, **14**, **16**, **18**, **19**, **21**, **22**, **24**, **25**, **26**, **29**, **30**, **31**, **35**, **36**, **38**, **39** and **40**.

Candidates performed less well on **Questions 8**, **11**, **15**, **17**, **20**, **23**, **27**, **28**, **32**, **33**, **34** and **37**.

Candidates found **Questions 4**, **13** and **39** particularly easy. They found **Question 11** the most difficult. There was evidence of guessing on **Question 27**. In general, candidates found the questions on Biology the most straightforward. Overall, they performed well on this paper.

Comments on specific questions

Question 8
- Option **B** was more popular than the key.
- Candidates were not able to interpret the graph to determine an explanation for its shape.

Question 11
- Option **A** was more popular than the key.
- Candidates were not able to interpret the number of new HIV infections and AIDS deaths from the graph.

Question 15
- Options **B** and **C** were common incorrect answers.
- Candidates could not determine the volume of oxygen.

Question 17
- Options **A** and **D** were common incorrect answers.
- The formation of hydrogen at the cathode during the electrolysis of dilute sulfuric acid using carbon electrodes was not known.

Question 20
- Option **D** was a popular incorrect option.
- Candidates knew the oxide was basic but thought element Q was a non-metal.

Question 23
- Option **D** was a popular incorrect option.
- Candidates had confused the colour change with the result using anhydrous copper(II) sulfate.

Question 27
- There was evidence of guessing as all the options were equally chosen.
- The tests for iron(III) ions and sulfate ions were not well known.

Question 32
- Option **B** was a common incorrect answer.
- Candidates knew a solid metal transfers energy through thermal conduction via atomic lattice vibrations although they did not know that the movement of delocalised electrons is also involved.

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Question 33

- Option **B** was a common incorrect answer.
- The direction of refracted light was not known.

Question 34

- Option **A** was a common incorrect answer.
- Candidates did not know the position of the virtual image formed by the thin converging lens.

Question 37

- Option **B** was more popular than the key.
- Candidates knew the number of turns but not the height.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/22
Multiple Choice (Extended)

Key messages

Candidates performed well on **Questions 1**, **2**, **3**, **4**, **5**, **6**, **8**, **9**, **12**, **13**, **14**, **15**, **17**, **21**, **22**, **24**, **26**, **27**, **29**, **31**, **32**, **33**, **36**, **37**, **38**, **39** and **40**.

Candidates performed less well on **Questions 7**, **10**, **11**, **16**, **18**, **19**, **20**, **23**, **25**, **28**, **30**, **34** and **35**.

Candidates found **Questions 4**, **29** and **37** the easiest and **Questions 11** and **34** the most difficult.

Comments on specific questions

Question 7
- Option **A** was as popular as the key.
- Candidates were not able to recognise the xylem from the micrograph.

Question 10
- Option **C** was a common incorrect answer.
- Candidates reversed mitosis and meiosis.

Question 11
- Option **C** was more popular than the key.
- Candidates did not recognise that increased use of antibiotics kills non-resistant bacteria, reducing competition for resources

Question 16
- Option **D** was a common incorrect answer.
- 56 g of N_2 contain more molecules than 64 g of SO_2.

Question 18
- Option **B** was a common incorrect answer.
- Candidates did not correctly interpret the reaction pathway diagram to determine the effect of a catalyst on an energy change.

Question 19
- Option **D** was a common incorrect answer.
- Candidates did not know that molecules of a substance separating from each other is a physical change.

Question 20
- Option **C** was a common incorrect answer.
- Candidates knew the volume of gas produced would be lower although they incorrectly thought the rate of reaction was lower than the initial rate.

Question 23
- Option **C** was a common incorrect answer.
- The halogens become less reactive down the group.

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Question 25
- Options **A**, **B** and **C** were all popular incorrect choices.
- Candidates were not familiar with the chemical test for water and the correct colour change.

Question 28
- Option **C** was a common incorrect answer.
- Candidates did not appreciate that the speed and time are directly proportional.

Question 30
- Option **C** was a common incorrect answer.
- Candidates could not determine the weight of the object from the graph.

Question 34
- Option **B** was as popular as the key and option **C** was more popular.
- Candidates were not able to describe what happens to the frequency and wavelength of the wave as it passes from medium 1 into medium 2.

Question 35
- Options **A** and **B** were common incorrect answers.
- Candidates did not correctly identify the values for the wavelength and width of the gap that produce the greatest diffraction.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/23
Multiple Choice (Extended)

Key messages

Candidates performed well on **Questions 1**, **3**, **4**, **5**, **6**, **7**, **8**, **10**, **11**, **12**, **13**, **14**, **15**, **18**, **21**, **22**, **24**, **26**, **28**, **29**, **30**, **31**, **32**, **36**, **37**, **38** and **39**.

Candidates performed less well on **Questions 2**, **9**, **16**, **17**, **19**, **20**, **23**, **25**, **27**, **33**, **34**, **35** and **40**.

Candidates found **Question 1** the easiest and **Question 27** the hardest.

Comments on specific questions

Question 2
- Option **B** was more popular than the key.
- Candidates knew that osmosis is the diffusion of water molecules although they confused the direction as from a concentrated solution to a dilute solution.

Question 9
- Option **A** was more popular than the key.
- Candidates did not know that during anaerobic respiration, less energy per glucose molecule is released than aerobic respiration.

Question 16
- Option **B** was more popular than the key.
- Candidates were not able to calculate the mass of CO_2 produced from the given volume.

Question 17
- Option **A** was more popular than the key.
- Candidates knew the products of electrolysis of molten lead(II) bromide although they did not know them for aqueous copper(II) sulfate.

Question 19
- Option **B** was a common incorrect answer.
- Candidates knew the white tile should be placed underneath the conical flask but reversed the expected colour change.

Question 20
- Options **A** and **B** were common incorrect answers.
- Candidates did not realise a burette and pipette were also needed for the salt preparation.

Question 23
- Options **B** and **D** were as popular as the key.
- Candidates had incomplete understanding on the reactivity of the metals.

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Question 25

- Option **C** was more popular than the key.
- Candidates were not familiar with the structure of methane and thought it contains a single-single carbon to carbon bond.

Question 27

- Options **A** and **B** were more popular than the key. Candidates found this the hardest question.
- Candidates did not correctly interpret the test for a barium ion and a nitrate ion.

Question 33

- Option **A** was equally as popular as the key.
- Candidates could not recall the range of sound in air audible to humans as 17 mm to 17 m.

Question 34

- Option **B** was as popular as the key and option **C** was more popular.
- Candidates did not correctly identify a suitable distance for the lens to be placed when the focal length of the lens is 15 cm.

Question 35

- Options **A** and **B** were as popular as the key.
- They did not recall that the speed of sound waves in water is greater than the speed of sound waves in air.

Question 40

- Options **A** and **B** were common incorrect answers.
- They did not recall that the type of nuclear reaction that powers the star is fusion and that the composition of hydrogen decreases and helium increases over time.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/31
Theory (Core)

Key messages

What candidates did well
- Candidates were able to select appropriate words and phrases to show knowledge and understanding.
- Candidates were able to identify the properties of reflex arcs and the use of drugs to affect reactions in the body.
- Candidates defined elements and compounds using the words provided.
- Candidates showed clear knowledge of states of matter and the associated changes of state.

What candidates needed to improve
- Candidates need to show their working, including the relevant equation where applicable, in mathematical questions.
- Candidates would benefit from further study of respiration and its role in organisms.
- Candidates need to be able to recall all the chemical tests and food tests required by the syllabus.
- Candidates need to be able to use all the symbols for circuit components accurately in context.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Most candidates knew the parts of the central nervous system and identified the brain.

Limited responses
- Some candidates offered answers related to nerves or a specific nerve. Other candidates selected the muscle from the diagram.
- Candidates need to be able to apply knowledge to the information provided in the question.

(ii) Comprehensive responses
- Candidates were able to apply their knowledge of a reflex arc to select the correct three letters in the correct order.
- It was more common for P and Q to be identified correctly, with R selected instead of S.

Limited responses
- All letters were seen in each space. Some candidates also suggested names of neurones, and many included the spinal cord in their reflex arc.

(iii) Comprehensive responses
- Candidates included two uses of energy from the list given in the syllabus. This list provides candidates with a number of uses from which to draw.
- The most common example was growth.

Limited responses
- Some candidates repeated movement, which was given in the question.
- Many candidates also gave respiration, which is the process that releases energy rather than how energy is used.

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- Some candidates gave processes such as breathing and digestion, which are whole-system processes rather than specific uses of energy within those systems.

(b) (i) Comprehensive responses

- Most candidates correctly identified the properties of reflex actions and ticked the correct two boxes.

Limited responses

- Some candidates added a third tick in the 'uses hormones' box or ticked this instead of one of the two correct answers.

(ii) Comprehensive responses

- Most candidates applied their understanding of the role of drugs in the body to correctly identify the drug.

Limited responses

- Enzyme and bacteria were occasionally seen where candidates selected terms they knew influenced the body.

(c) Comprehensive responses

- Candidates gave two characteristics of living organisms and were able to recall the descriptions given in the syllabus.
- Successful descriptions often involved reproduction, excretion or movement.

Limited responses

- Many candidates gave descriptions that did not use the appropriate scientific vocabulary from the syllabus. For example, describing growth as 'getting bigger' and nutrition as 'taking in food'.
- Respiration was often described as breathing rather than as the reaction that takes place in cells.
- Candidates often described egestion (the removal of undigested food waste) rather than excretion.

Question 2

(a) Comprehensive responses

- Some candidates described the two aspects of a balanced diet: the need for all food groups and the need for appropriate amounts of these food groups.

Limited responses

- Candidates often gave examples of some food groups rather than including all seven. Candidates who give named food groups need to include all seven.
- It was common for candidates to suggest equal amounts of all food groups, which does not constitute a healthy diet.
- Some candidates gave general comments about not eating too much of specific food groups, most commonly fats and oils.

(b) (i) Comprehensive responses

- Candidates knew sources of fibre and selected two of the correct food types from the table.

Limited responses

- Candidates often gave one correct source and then suggested dairy, meat or fish as the second.

(ii) Comprehensive responses

- Many candidates calculated the difference between the values and gave a detailed comparison of the intake in country B being higher.

Limited responses

- Candidates often did not include units when using data.

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- Some candidates compared country A and country B rather than referring to the comparison required in the question.

(iii) Comprehensive responses

- A few candidates linked a lower intake of a relevant food type to lower vitamin C intake and the development of scurvy.

Limited responses

- Candidates often identified meat as the food type lacking.
- Some candidates linked vitamin D to scurvy.
- Many candidates just suggested that country A lacked nutrients generally without specifically addressing the question posed.

(c) Comprehensive responses

- All four elements in proteins were listed, sometimes as C, H, O and N.

Limited responses

- Nitrogen was often omitted by candidates.
- Other candidates gave biological molecules such as glucose, amino acids and starch rather than the elements required by the question.

(d) Comprehensive responses

- Egestion was given in a few cases.

Limited responses

- The most common answer was excretion. Candidates often confuse the processes of egestion and excretion and would benefit from using these terms and explaining the difference between the two processes.

Question 3

(a) Comprehensive responses

- Candidates identified the adaptation as a large surface area and explained that this allowed more sunlight to be absorbed for photosynthesis.
- In a few cases, candidates discussed the leaf being thin, giving short diffusion distances.

Limited responses

- Candidates often had the idea of light absorption and photosynthesis. It was very common for this not to be linked to the correct adaptation.
- Alternatively, some candidates stated an adaptation without explaining how this helped the leaf in terms of photosynthesis.
- Some candidates did not refer to the shape of the leaf as instructed by the question and discussed the amount of chlorophyll or chloroplasts present.

(b) Comprehensive responses

- Candidates gave the correct term for each part of the leaf labelled in the diagram, selecting from the words provided.
- Chloroplast was most often identified correctly.

Limited responses

- Candidates often selected the terms xylem and osmosis. In some cases, these were the wrong way around.
- Some candidates confused the stomata with the guard cell or the cuticle with the epidermis.

(c) Comprehensive responses

- The sentences were correctly completed by a few candidates who knew the process of photosynthesis and how gases move into and out of leaves.

Limited responses

- Often only the first sentence was completed correctly.
- Candidates often gave carbon dioxide as the gas produced or, in fewer cases, water.

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- The process was often given as photosynthesis, with occasional active transport or osmosis. Osmosis was often linked to water for the first gap.

Question 4

(a) Comprehensive responses

- Only a few candidates identified body length as continuous variation. It was more common for candidates to give genetic variation, which was a reasonable description.

Limited responses

- A wide range of answers were offered. Some of the more common responses included different and independent.

(b) (i) Comprehensive responses

- Many candidates knew the process that leads to genetic change and the term for an alternative form of a gene that is produced.

Limited responses

- Candidates sometimes used the term heterozygous in either box and the term monohybrids was often used in the second gap. Candidates would benefit from practising the use of genetic terms and understanding their definitions.

(ii) Comprehensive responses

- Candidates were able to give a detailed description of enzymes that included their structure as proteins and their function as catalysts.
- A few candidates described the role of enzymes in metabolic reactions.

Limited responses

- Often only the idea of enzymes speeding up reactions was given by candidates.
- Many candidates described enzymes as cells.
- Some candidates described enzymes in terms of their inability to function at extremes of temperature or pH rather than describing what they are and what they do. For example, they discussed enzymes denaturing at high temperatures. While this is a characteristic of enzymes, it does not address the question of what an enzyme is.

(c) (i) Comprehensive responses

- Candidates often linked habitat destruction to pollution or climate change. In many cases, a specific type of pollution was described.

Limited responses

- Candidates often described different types of pollution. Candidates would benefit from considering a variety of ways rather than focusing solely on pollution.
- Candidates often discussed fishing, which would potentially endanger the pupfish without necessarily harming the habitat.
- In a similar way, candidates described humans killing or hunting the fish. This question was specifically about habitat destruction. Candidates would benefit from considering separately the causes of habitat destruction and the reasons why organisms become endangered or extinct. There is some overlap, although this is not the case in all situations.

(ii) Comprehensive responses

- Candidates applied their knowledge of adaptation and natural selection. They explained how the pupfish is adapted to the conditions and that the non-native fish are less likely to survive because they are not adapted to these conditions.
- Some candidates specifically discussed the adaptation in terms of enzymes being able to function at high temperatures and extreme pH.

Limited responses

- Candidates were often not specific in their responses, referring only to fish without qualifying whether they were referring to the pupfish or the non-native fish.
- Often candidates did not include the comparison between the two species of fish, stating that the pupfish is adapted or that the non-native fish die without linking this to lack of adaptation.

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(iii) Comprehensive responses

- Few candidates recognised that there was a decrease in the number of species, which would reduce biodiversity.

Limited responses

- Candidates often referred in detail to disruption of food chains and food webs and the resulting changes in populations without discussing biodiversity. Candidates would benefit from identifying the key words in the question that need to be addressed rather than assuming what the question is asking.
- In some cases, candidates referred to the extinction of other species.

Question 5

(a) Comprehensive responses

- Many candidates showed their knowledge of the different chemical processes by linking them to the correct descriptions.
- Clear responses used straight lines and linked each box to only one other box.

Limited responses

- Candidates often knew the description of filtration.
- The description of diffusion was often confused with either chromatography or titration.

(b) (i) Comprehensive responses

- Most candidates applied their knowledge of how surface area affects reaction rates to identify the correct reactions.

Limited responses

- Candidates reversed the order, not recognising that a shorter time resulted from a faster reaction.
- Some candidates gave the number of pieces in the reverse order.

(ii) Comprehensive responses

- Most candidates successfully performed the rate calculation using the data provided.

Limited responses

- A variety of methods were seen. These included multiplying the data or selecting the wrong data from the table. Some candidates tried to average the data before calculating the rate.

(iii) Comprehensive responses

- Candidates showed understanding that increasing concentration would reduce the time taken for the reaction. Candidates showed that they understood the time would be shorter or the reaction would finish faster.

Limited responses

- Candidates gave responses that described an increase in reaction rate rather than referring to time, as required by the question.
- Some candidates thought concentration had no effect on reaction rate and that temperature would need to be changed to alter the rate of reaction.

(c) Comprehensive responses

- A few candidates explained that carbon dioxide is an acidic oxide because carbon is a non-metal or because non-metals form acidic oxides.
- In some cases, candidates gave the reverse argument that basic oxides are formed from metals and carbon is a non-metal.

Limited responses

- Many responses stated that it is an acidic oxide because it has a low pH or because it turns an indicator red, which did not fully explain why it is acidic.

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- Some candidates were not precise in their descriptions and suggested it was an acidic oxide because carbon dioxide is a non-metal rather than recognising that carbon is the non-metal element.

(d) (i) Comprehensive responses

- Some candidates stated the correct trend in metallic properties across the Periodic Table, describing the change from metallic to non-metallic.

Limited responses

- In many cases, candidates answered in terms of reactivity down a group or across the Periodic Table. This did not address the question asked.

(ii) Comprehensive responses

- Many candidates used their knowledge of the Periodic Table to state the number of electrons correctly.

Limited responses

- A wide range of different numbers were suggested.
- Common incorrect responses were 20, the atomic number of calcium, and 8, the number associated with a full electron shell.

Question 6

(a) Comprehensive responses

- Most candidates were able to use the molecular formula to show the displayed formula, clearly showing the four bonds using lines and the appropriate atoms using letters.

Limited responses

- It was common for candidates to attempt a dot-and-cross diagram instead of the displayed formula. Candidates would benefit from practising displayed formula for a range of organic compounds.
- Candidates sometimes did not use the correct numbers of atoms, drawing a molecule of ethane. Candidates would benefit from using the information provided in the question to check their answers.

(b) Comprehensive responses

- Candidates stated that the type of bonding in methane is covalent.

Limited responses

- Ionic was often seen, as were attempts to describe the bonding as single or double.
- Candidates need to be clear about the differences between ionic and covalent bonding.

(c) Comprehensive responses

- Candidates were able to clearly link saturated compounds with having no C=C double bonds or having only C–C single bonds.
- In many cases, the reverse argument was given, with unsaturated compounds described as having double bonds.

Limited responses

- In a number of responses, the link was the wrong way around. For example, saturated compounds have double bonds.
- Candidates often repeated information from the question, for example stating that saturated compounds are fully saturated, or discussed one type of compound being more reactive than the other.

(d) (i) Comprehensive responses

- Some candidates correctly completed the symbol equation using the correct symbol for a gas.

Limited responses

- Candidates generally were able to recall that oxygen and carbon dioxide were gases. Methane was often presented as aqueous or solid.

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(ii) Comprehensive responses

- Many candidates were able to recognise that the transfer of thermal energy to the surroundings signified an exothermic reaction.

Limited responses

- Candidates suggested a range of reaction types, including endothermic, displacement and cracking.
- Candidates need to understand the identifying features of different reactions.

(e) (i) Comprehensive responses

- Candidates recalled the influence of methane in relation to global warming or climate change.
- In a number of cases, candidates described this in terms of the enhanced greenhouse effect or increased global temperatures.

Limited responses

- Many candidates suggested that methane would cause breathing problems, damage to the ozone layer or made general comments about reducing air quality.
- In some cases, candidates referred to increased carbon dioxide, another greenhouse gas. This showed some misunderstanding that methane itself is not a greenhouse gas and showed that candidates thought methane causes more carbon dioxide to be released into the atmosphere.

(e) (ii) Comprehensive responses

- Few candidates recognised that methane is released by livestock farming and therefore suggested reducing livestock farming.
- This idea was expressed in a range of ways, for example by suggesting that less meat should be consumed.

Limited responses

- Many candidates suggested reducing the use of fossil fuels or the storage of methane.
- In some cases, specific suggestions for reducing the use of fossil fuels were given, including the use of electric vehicles.

(f) Comprehensive responses

- Most candidates used the words provided to describe elements and compounds.

Limited responses

- Candidates rarely confused elements and compounds, placing them the wrong way around at the start of the sentences.

Question 7

(a) Comprehensive responses

- In most cases, candidates gave all four changes of state in the correct order. Evaporation and freezing were more commonly seen than boiling and solidifying.

Limited responses

- There was occasional confusion regarding process C, with suggestions including combustion, distillation and liquidation.

(b) Comprehensive responses

- Many candidates identified that the water was not pure or clearly explained that it contained salt or other impurities.

Limited responses

- Some candidates mentioned salt without any indication that it was dissolved in the water.
- A few candidates thought the water would be frozen and therefore would not melt.

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(c) **Comprehensive responses**

- Few candidates clearly described the purpose of the three processes in the treatment of water.
- Sedimentation was linked to the removal of large particles in the form of solids or insoluble material. Some candidates included a description of allowing these particles to settle or fall to the bottom of the tank.
- A few candidates identified that carbon was used to remove odours and tastes. Some candidates instead linked it to the filtering of chlorine or organic pollutants.
- Most candidates knew that chlorine killed pathogens in the water and described this clearly.

Limited responses

- Sedimentation was often described as involving some sort of filtering of particles. This was a common misunderstanding of the process, and candidates would benefit from comparing the different stages to note the differences in what is removed from the water and how.
- The description of the use of carbon was often general, for example removing chemicals, filtering harmful pollutants or cleaning the water.
- Candidates often did not specifically refer to killing microbes, instead discussing their removal.

(d) **Comprehensive responses**

- A few candidates were able to recall the colour change from blue to pink on the addition of water.
- Candidates need to be able to give both the test and the result for all the chemical tests required by the syllabus and be confident in identifying the result for each reagent.

Limited responses

- Quite a few candidates suggested the observation for testing for anhydrous copper(II) sulfate, from white to blue.
- Other common suggestions were from brown to colourless, or vice versa, possibly thinking of bromine, or colourless to cloudy, possibly thinking of limewater.

(e) **Comprehensive responses**

- Candidates stated oxygen as the gaseous element.

Limited responses

- Carbon dioxide was a common suggestion. Methane was occasionally suggested.

(f) **Comprehensive responses**

- Candidates gave both hydrogen and oxygen.

Limited responses

- Candidates often identified only one of the gases, more commonly oxygen.
- A wide range of gases were suggested, including nitrogen and carbon dioxide.
- Many candidates also suggested carbon or a metal such as calcium or magnesium. Candidates would benefit from checking that their suggestion meets the requirements of the question, in this case a gaseous element.

Question 8

(a) **Comprehensive responses**

- Candidates gave the correct calculated answer and showed how they had completed the calculation using the formula given. For example, candidates clearly showed the relative atomic masses multiplied by the number of atoms in the formula. They showed the addition of these three numbers to give the resulting relative formula mass.

Limited responses

- Candidates often did not multiply the relative atomic mass by the number of atoms and just added the three together.
- Some candidates did not multiply the hydrogen and obtained an answer that was one lower than required.

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- Candidates would benefit from opportunities to practise these calculations for a range of chemical formula and from showing their working, so that the steps in their method are clear even if an error is made.

(b) (i) Comprehensive responses

- A few candidates correctly identified the gas produced at each electrode.

Limited responses

- Oxygen was often given for X. It was less common to see hydrogen for Y.
- On some occasions, the correct gases were formed at the wrong electrode.
- Carbon dioxide was given in many responses.
- Some candidates thought that because sulfuric acid was being electrolysed, sulfur or sulfur dioxide would be released.

(ii) Comprehensive responses

- Many candidates identified the name of the negative electrode as the cathode.
- It was evident that some candidates had used the PANIC memory aid effectively to assist them.

Limited responses

- Some candidates suggested the anode, and others suggested anion or neutron.

(iii) Comprehensive responses

- Few candidates suggested graphite as a suitable material. Carbon and platinum were both seen rarely.

Limited responses

- Candidates were familiar with the use of copper as an electrode, and this was a common suggestion.
- Some candidates suggested a generic metal, while others suggested iron or more reactive metals such as magnesium and zinc, without recognising the requirement for an inert electrode.
- In many cases, candidates did not attempt a response to this question.

(c) (i) Comprehensive responses

- Most candidates gave a suitable pH value for sulfuric acid within the specified range.

Limited responses

- Many candidates suggested a neutral pH or a pH above 7.
- Candidates need to be familiar with the pH scale and be able to relate pH values to acids and bases, including the colours produced with universal indicator.

(ii) Comprehensive responses

- Candidates gave the correct reactants and products, including applying knowledge of chemical tests to identify hydrogen.
- Most candidates were able to insert the correct reactants and the given product.

Limited responses

- Candidates often suggested an alternative to hydrogen, such as oxygen, or entered the word gas in the final gap. The chemical test for hydrogen was not always linked to the gas identified.
- In some cases, candidates split the magnesium and sulfate across the last two gaps in an attempt to fill the gaps with the chemical names given.

(iii) Comprehensive responses

- Few candidates selected a suitable metal and then explained its use in relation to the metal's position relative to hydrogen in the reactivity series. For example, gold is below hydrogen in the reactivity series.

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Limited responses

- Where a correct metal was suggested, it was common for the explanation to be in terms of the metal being generally unreactive.
- A range of materials were suggested, including reactive metals.
- Candidates would benefit from opportunities to compare the reactivity of metals and consider how this affects their use.

Question 9

(a) (i) Comprehensive responses

- Almost all candidates were able to suggest two types of power station that use renewable energy sources. It was equally common for candidates to give their answers as letters from the list or as the names of the power stations.

Limited responses

- Very occasionally, candidates included fossil fuels.

(ii) Comprehensive responses

- Most candidates knew that fossil fuel power stations produce carbon dioxide.

Limited responses

- Geothermal and hydroelectric power stations were occasionally seen.

(b) Comprehensive responses

- Few candidates gave the answer nuclear fission.

Limited responses

- Candidates often suggested fusion instead of fission. Candidates would benefit from being careful in their use of terminology in contexts such as this.

(c) (i) Comprehensive responses

- Some candidates were able to complete this calculation by determining that there were 4 half-lives and multiplying 2.0 by ½ four times. This method was seen in many successful answers.

Limited responses

- Many candidates were able to deduce that there were 4 half-lives in 116 years and showed this in their working.
- Candidates did not know how to use this half-life to complete the calculation and often multiplied or divided 2.0 by 4.

(ii) Comprehensive responses

- Candidates were able to state the charge as negative.
- Some candidates showed the symbol for the high-energy electron.

Limited responses

- Many candidates selected positive or neutral as the charge.

(iii) Comprehensive responses

- Candidates placed the correct sub-atomic particle in the correct gap to describe what happens in the nucleus.

Limited responses

- Many candidates did not place the words in the correct order, with both proton and electron given in the first gap.
- Candidates need to be able to recall the changes that happen during β-emission.

(iv) Comprehensive responses

- Some candidates gave gamma and alpha as the other types of radiation resulting from radioactive decay.

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Limited responses

- Candidates often gave a region of the electromagnetic spectrum, such as infrared, ultraviolet or X-rays.
- Some candidates also gave other Greek letters, such as sigma or omega, alongside one of the correct responses.
- Candidates need to be familiar with the different forms of radiation and be able to distinguish between radiation in the contexts of electromagnetic waves, thermal changes and isotope decay.

(d) Comprehensive responses

- Candidates gave detailed descriptions of specific storage solutions. For example, they referred to storage in lead-lined boxes with thick concrete walls.
- Other candidates described storage deep underground.

Limited responses

- Candidates would benefit from being specific in their responses. Some candidates referred to storage away from people, which was not a full answer, or stated that it was stored in a thick container.
- A few candidates thought radioactive materials needed to be stored in a way that would prevent them from reacting.

Question 10

(a) (i) Comprehensive responses

- Candidates identified R as the weight in most cases.

Limited responses

- Occasionally, P was given.
- Candidates would benefit from practice using this type of force diagram and identifying the different forces acting in the context.

(ii) Comprehensive responses

- A few candidates understood the importance of resultant force in determining acceleration.
- These candidates stated that a resultant force is needed for acceleration.

Limited responses

- Candidates often limited their description to the difference in forces, repeating that force Q is greater than S.
- It was clear that many candidates thought that the difference in forces caused the plane to move forward rather than causing a change in speed. Candidates would benefit from practice explaining how differences in forces affect objects in a range of contexts.

(iii) Comprehensive responses

- Candidates used the value for g provided on the front of the paper and recalled the equation for weight in order to complete this calculation, showing their working through both the equation and substitution. Most candidates gave their answer to 6 significant figures (the nearest whole number).
- Candidates would benefit from using the value for g provided. In a few responses, candidates used a value of g = 10. Where g = 10 was used, candidates needed to show that this was the value of g being used. In many cases, candidates did not make this clear and divided the weight by 10 without reference to g.

Limited responses

- Candidates often did not show their working or the equation they were using.
- It was common for candidates to multiply the numbers or divide by 10 without any explanation or working.

(iv) Comprehensive responses

- Candidates recognised the need to calculate the total area in contact with the ground and then substituted this into the correct equation for pressure to calculate the answer.

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- They showed their working in a clear way, first calculating the total area, then giving the equation they were using, followed by substitution and the full answer. A rounded answer was then given on the answer line.

Limited responses

- Candidates often calculated the total area and then completed the wrong substitution.
- Incorrect substitutions often involved using the mass rather than the weight or completing a multiplication rather than a division.
- Candidates rarely gave the equation they were using and just showed manipulation of the numbers provided. Candidates would benefit from stating the relevant equation as the first step in answering this type of question.

(b) (i) Comprehensive responses

- Candidates completed the unit conversions necessary, showing their working and obtaining an answer of 702. The candidates then showed, using symbols or words, that this was approximately 700 km/h.

Limited responses

- The requirement to complete unit conversions for distance and time was often missed. Candidates often tried to use the equation for speed, which did not help them in this context.
- Some candidates tried to manipulate the numbers and work backwards, dividing 700 by 195. This did not show how the two numbers were related other than numerically.

(ii) Comprehensive responses

- Some candidates were able to show the equation for speed and correctly substitute to give the answer in hours.

Limited responses

- Candidates often did not use the correct value for speed, selecting 195 m/s from the previous question instead of 700 km/h (or 702 km/h).
- Other candidates rearranged the equation incorrectly and multiplied the distance by the speed or completed the division the wrong way around.

Question 11

(a) (i) Comprehensive responses

- Few candidates were able to show the correct symbols and arrange them correctly in the circuit.
- Candidates need to be able to recall all the symbols for electrical components and be familiar with their use within circuits.

Limited responses

- Most candidates needed to improve by using the correct symbol for an a.c. power supply and a heater. In most cases, a battery was used for the a.c. power supply, and a range of thermistors, fuses and resistors were seen for the heater. In a number of cases, candidates attempted to designate a heater using a circle with an H inside. It was often the case that only the switch was correct.
- Without knowing the symbols, candidates found it difficult to position the components correctly. Recall of the symbols is an important underpinning skill and candidates would benefit from further practice.
- Candidates often had the correct idea of a parallel circuit. The positioning of the switches was often with one in parallel and the other in the series part of the circuit. Candidates would benefit from further practice drawing parallel circuits with switches in different positions and linking this to practical work, where they can observe the impact of different positions.
- Candidates would benefit from further practice drawing circuits with clear wires and symbols and without gaps.

(ii) Comprehensive responses

- Few candidates selected the correct value and gave a clear explanation in terms of the resistance in parallel being less than that of one of the hotplates.
- A few candidates showed a calculation to support their decision.

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Limited responses

- Candidates selected all the options, with 50 Ω and 100 Ω being the most common responses.
- Where candidates selected 50 Ω, their explanation was that it would be the same at all points around a circuit.
- Where candidates selected 100 Ω, their explanation involved adding the resistance of the hotplates together.

(b) (i) Comprehensive responses

- Some candidates applied their knowledge of methods of thermal energy transfer to identify those involved in the system described.

Limited responses

- Candidates often tried to describe what was happening in terms of heating rather than stating the method and did not use the correct terminology in their response.
- Other candidates suggested exothermic and endothermic as terms related to the transfer of heat, which did not apply in this context.

(ii) Comprehensive responses

- Most candidates knew the boiling point of water.

Limited responses

- Some candidates suggested lower boiling points.

(iii) Comprehensive responses

- Most candidates could identify the diagrams for liquid water and gaseous steam.

Limited responses

- Very occasionally, candidates suggested A for liquid water.

(c) Comprehensive responses

- A few candidates were able to describe how steel and iron differ in terms of acquiring magnetism. This was often expressed in terms of steel forming permanent magnets and iron forming temporary magnets.

Limited responses

- In some responses, the difference was the wrong way around, for example iron magnets last longer than steel.
- In other cases, general differences between steel and iron were expressed in the context of magnets. For example, magnets made from steel are harder or steel forms magnets that resist corrosion.
- Other candidates discussed the strength of the magnet or simply described one as better.

(d) Comprehensive responses

- The density was calculated, and working, including the equation and corresponding substitution, was shown.

Limited responses

- Many candidates need to improve their use of standard form in calculations.
- The equation was rarely seen, and in many cases the numbers were manipulated incorrectly.

Question 12

(a) (i) Comprehensive responses

- The two other regions of the electromagnetic spectrum were given by some candidates.

Limited responses

- Gamma rays and microwaves were also commonly seen. Candidates seemed to give two regions of the electromagnetic spectrum without selecting those most radiated by the Sun.

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(ii) Comprehensive responses

- Most candidates were able to describe a harmful effect.
- The most common answer seen was cancer. A wide range of other effects were also seen.

Limited responses

- Candidates gave general answers relating to harm or irritation without specifying the type of harm or where it occurred.

(iii) Comprehensive responses

- Candidates gave a wide range of responses relating to medical and forensic use.

Limited responses

- Candidates suggested solar panels or uses related to infrared or microwaves (heating) or X-rays (viewing internal body structures).
- Many candidates thought that it was used in sunscreen.

(iv) Comprehensive responses

- Most candidates correctly positioned ultraviolet.

Limited responses

- Candidates need to be able to recall the position of electromagnetic waves in the spectrum. Ultraviolet was often placed on the right-hand side or centrally.

(b) (i) Comprehensive responses

- Candidates correctly identified the amplitude and wavelength from the graph provided.

Limited responses

- Often wavelength was given for amplitude and amplitude for wavelength.
- Other candidates suggested 2 m or 6 m for the wavelength.

(ii) Comprehensive responses

- Candidates completed the sentence to describe both the particles and where they escape from.

Limited responses

- A wide range of suggestions were seen for the first gap, including gas, loose and water.
- In the second gap, fewer correct responses were seen. Candidates often suggested boiling or particles.
- Candidates need to be familiar with the definitions given in the syllabus.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/32
Theory (Core)

Key messages

What candidates did well

- When given appropriate prompts, candidates were able to select the correct terms to answer the questions.
- Candidates were familiar with pathogens and their transmission.
- Candidates were able to balance symbol equations and give word equations.
- Candidates were able to interpret speed-time graphs.

What candidates needed to improve

- Candidates need to improve their understanding of reproduction in humans, including the different stages of the menstrual cycle and the process of fertilisation.
- Candidates would benefit from further study of chemical tests and food tests.
- Candidates need to be able to use all the symbols for circuit components accurately in context.
- Candidates need to improve their layout of calculations, including showing the relevant equation used and their working before giving an answer to an appropriate number of significant figures.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Many candidates identified the specialised cell.

Limited responses

- Some candidates gave vague answers, for example specialised cell or root cell.

(b) (i) Comprehensive responses

- Candidates were able to show the equation for magnification and correctly substitute the values. The calculation was then completed and an answer given.

Limited responses

- Many candidates had the division the wrong way around. Some candidates just multiplied the numbers.
- Other candidates did not show any working.

(ii) Comprehensive responses

- Few candidates were able to describe that new cells are formed by the division of existing cells. Mitosis was seen more often.

Limited responses

- Many candidates suggested photosynthesis. This is the most well-known process in plants. A few candidates suggested respiration.
- Other candidates suggested mechanisms for reproducing the whole organism rather than individual cells.
- Candidates would benefit from further study of cell division.

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(c) **Comprehensive responses**

- Many candidates correctly completed the sentence describing the movement of water into cells.

Limited responses

- Some candidates put cell wall in one or both of the gaps. Plant was a common response in the second gap.
- Candidates often did not attempt to suggest other processes by which substances enter cells.

(d) **Comprehensive responses**

- Some candidates identified the adaptation and gave clear explanations of how it allows increased water uptake. Candidates rarely mentioned increased mineral ion uptake.
- Answers were clear and concise, giving the relevant points.

Limited responses

- Many candidates had the idea of a large surface area without linking this to increased uptake.
- Other candidates described the shape as long or having a hair, without specific reference to the adaptation.

(e) **Comprehensive responses**

- Many candidates identified both the pigment and the part of the cell.

Limited responses

- On some occasions, the answers were the wrong way around.
- Chlorophyll was more often identified correctly.
- Candidates often put the leaf for the part of the cell, presumably not realising a part of a cell was required.

(f) **Comprehensive responses**

- Candidates completed the table with both the colour of the iodine solution and whether starch was present.
- Candidates chose a range of ways to show whether starch was present, all of which were accepted.

Limited responses

- Few candidates could give the correct colours of iodine. More candidates could suggest whether starch was present.
- Candidates would benefit from improving their knowledge of the various food tests, including the positive and negative results.

Question 2

(a) **Comprehensive responses**

- Candidates applied their knowledge to identify the diagram as a method of preventing sexually transmitted disease.

Limited responses

- Candidates suggested the answer AIDS or gave a type of pathogen.

(b) (i) **Comprehensive responses**

- Most candidates circled the correct type of pathogen.

Limited responses

- Candidates occasionally indicated bacteria.

(ii) **Comprehensive responses**

- Many candidates ticked the correct two boxes to show the methods of transmission of HIV.

Limited responses

- Most candidates identified one correct method. Alternative suggestions included infected mosquitoes and coughing and sneezing.

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(c) **Comprehensive responses**

- Candidates gave responses specific to the stage of fertilisation. For example, they described the fusion of the nuclei of the egg and sperm and could describe where fertilisation takes place. The inclusion of nuclei was rarely seen.

Limited responses

- Candidates often gave answers relating to sexual reproduction in general, describing sexual intercourse and the introduction of sperm into the vagina, the movement of sperm, or the formation of the embryo and implantation in the uterus.
- Candidates who discussed the stage of fertilisation often did so in vague terms. For example, they discussed the meeting of sex cells rather than their fusion or combination.
- There was significant confusion about where fertilisation takes place. Many candidates discussed sperm entering the ovaries to fertilise the eggs, and others described the process as taking place in the uterus.
- Candidates would benefit from further study of the processes involved and the distinction between the different stages of human reproduction.

(d) **Comprehensive responses**

- Few candidates were able to explain what occurred in the ovaries and uterus at this point in the menstrual cycle. Those that did described both ovulation and the thickening of the uterus lining occurring.

Limited responses

- Most candidates described the process of menstruation. It was clear that this process was not well understood, and many candidates did not use appropriate scientific language.
- When describing what took place in the ovaries, candidates referred to the production of eggs rather than accurately describing ovulation as the release of eggs.
- Many candidates gave responses referring to the opening of the uterus to allow access for sperm or discussed the uterus expanding.
- Candidates need to use appropriate scientific language to describe the specific stage addressed in the question. Candidates would also benefit from further study of the changes that happen during the menstrual cycle.

Question 3

(a) **Comprehensive responses**

- Candidates correctly completed the sentences with the words provided to describe an ecosystem using the definition in the syllabus.

Limited responses

- Candidates sometimes got the answers the wrong way around.

(b) **Comprehensive responses**

- Most candidates applied their knowledge of the roles of organisms to identify both a carnivore and a tertiary consumer.

Limited responses

- The carnivore was more often identified correctly. Many candidates could not identify a tertiary consumer. In a number of cases, the leopard or locust was suggested as the tertiary consumer.
- Instead of selecting from the food web, a few candidates tried to define the terms given.

(c) **Comprehensive responses**

- Most candidates could identify the arrows as representing feeding and circled this answer. This required candidates to link food chains with the carbon cycle, which most were able to do.

Limited responses

- Candidates occasionally circled decomposition.

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(d) **Comprehensive responses**

- Candidates generally stated the source of energy as the Sun and then described the feeding relationships between the grass, the impala and the leopard. Some candidates identified the grass as the producer as an alternative point.

Limited responses

- Candidates often only described the feeding relationships. In a number of cases, they did not specifically refer to the food chain, including the impala.
- When candidates tried to discuss energy loss in the food chain, they were often too vague and discussed different percentages of energy at different levels without the idea of energy being lost to the environment causing this reduction.

(e) **Comprehensive responses**

- Most candidates could describe the effect on the food chain, including the immediate effect on primary consumers and the subsequent impact on animals higher up in the food chain.
- Some candidates gave excellent answers, using scientific terminology and referring to habitat loss or decreased biodiversity.
- Other candidates described the loss of soil or increased carbon dioxide in the atmosphere.

Limited responses

- Candidates did not use specific scientific terms such as habitat to describe the impacts.
- Candidates were also not specific in terms of the effects on different organisms, for example discussing loss of food for animals.

Question 4

(a) **Comprehensive responses**

- Most candidates linked the words to their definition.

Limited responses

- Candidates occasionally suggested only one correct link, usually genotype or phenotype.

(b) (i) **Comprehensive responses**

- Some candidates were able to give this definition.
- A full answer included both the idea of genetic information being transmitted and the idea that it is passed from generation to generation.

Limited responses

- Candidates generally had the idea of inheritance being from parent to offspring. Candidates were less clear that it is genetic information that is passed on.

(ii) **Comprehensive responses**

- Few candidates were able to complete the boxes to show how sex is inherited.

Limited responses

- Candidates generally entered X and Y in the boxes. Sometimes 4 letters were entered in each row, for example XX or XY, and in other cases the X and Y chromosomes were entered in the wrong rows.

(c) (i) **Comprehensive responses**

- Most candidates were able to correctly determine the number of males with beta thalassaemia.

Limited responses

- Candidates occasionally suggested 4 or 3.

(ii) **Comprehensive responses**

- Few candidates were able to define homozygous. These candidates correctly used the term allele in their definition.

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Limited responses

- Candidates often used the term genes instead of allele.
- Some candidates thought that the term specifically related to not having beta thalassaemia.
- Other candidates gave vague descriptions and implied that it involved having only one allele rather than two copies of the same allele.

(iii) Comprehensive responses

- A few candidates linked a lack of haemoglobin to an inability to transport oxygen in the blood. Even fewer linked this to reduced respiration and the release of less energy.

Limited responses

- Many candidates were not clear on the role of haemoglobin and thought it directly provided energy.
- Other candidates used the idea of anaemia to suggest that a lack of haemoglobin caused a lack of iron, which caused the tiredness.

Question 5

(a) (i) Comprehensive responses

- Some candidates gave both metals.

Limited responses

- Many candidates gave copper, with iron forming the other part of the alloy.

(ii) Comprehensive responses

- Most candidates were able to identify the Group II metals.

Limited responses

- A few candidates gave potassium or zinc in addition to magnesium.

(iii) Comprehensive responses

- Few candidates gave aluminium, which is the example given in the syllabus. The Group I and Group II metals were seen in similar amounts.

Limited responses

- Copper and zinc were common suggestions. Candidates are familiar with the use of these metals in electrolysis and were not aware that this did not involve extraction from their ores.

(iv) Comprehensive responses

- Some candidates identified the alkali metals from the list.

Limited responses

- Candidates often suggested calcium, magnesium or aluminium.

(v) Comprehensive responses

- Some candidates were aware of the role of transition metals as catalysts and selected a transition metal from the list.
- Copper and iron were the most commonly seen, although zinc was also common.

Limited responses

- Candidates suggested aluminium or magnesium.

(b) Comprehensive responses

- Most candidates were able to use ratios to calculate the mass of oxygen.

Limited responses

- A wide range of numerical responses were seen. 20 was one of the more common responses. As candidates generally did not show their working, it was not clear why this or other answers were selected.

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(c) **Comprehensive responses**

- Some candidates knew the gas that turned limewater milky.

Limited responses

- Hydrogen was a very common suggestion. Oxygen was occasionally suggested.
- Candidates would benefit from further study of chemical tests.

(d) **Comprehensive responses**

- Some candidates were able to explain how a calcium ion is formed by the loss of 2 electrons.

Limited responses

- In many cases, candidates discussed both the gain and loss of electrons, with confusion between the formation of the ion and the atom.
- Some candidates discussed loss of ions rather than electrons.
- Candidates would benefit from improving their use of terms such as ion and electron, particularly in this type of context.

Question 6

(a) **Comprehensive responses**

- Many candidates completed all the sentences about air using the words provided.

Limited responses

- Candidates often put compound in the first gap.
- Oxygen was a common choice for the second gap.
- A range of gases were seen in the third gap, including oxygen and methane.
- In the last gap, nitrogen and argon were occasionally given.
- Candidates often correctly completed two or three gaps. There was no clear pattern in which gaps candidates answered correctly.

(b) (i) **Comprehensive responses**

- Most candidates determined the number of neutrons from the information provided.

Limited responses

- Some candidates added the numbers to give an answer of 24. Others stated the mass number as 16.
- Candidates need to be more familiar with using the proton number and mass number to deduce the number of protons, neutrons and electrons in an atom.

(ii) **Comprehensive responses**

- Most candidates were able to give the number of electrons in the oxygen atom.

Limited responses

- Candidates occasionally suggested the mass number.

(iii) **Comprehensive responses**

- Few candidates completed the electron configuration, using either a dot or a comma to separate the electron shells.

Limited responses

- A common suggestion was 2, 8, 6.
- The response given in this part was often based on a different number of electrons to **Question 6(b)(ii)**. 8, 16 and 24 were all common suggestions.

(c) (i) **Comprehensive responses**

- Most candidates were able to complete the word equation using the reactants and products given.

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Limited responses

- Candidates occasionally attempted a symbol equation, which was often incorrect. The construction of a symbol equation is a more difficult skill, and candidates should only attempt it when instructed to do so by the question.

(ii) Comprehensive responses

- A few candidates were able to explain that the reaction involved both oxidation and reduction.
- Some candidates explained in terms of oxidation of magnesium and reduction of copper oxide.

Limited responses

- Some candidates suggested that copper lost oxygen rather than copper oxide.
- Often candidates discussed the movement of oxygen in vague terms. For example, oxygen moves from copper.

(d) Comprehensive responses

- Few candidates were able to give two properties of ionic compounds.
- Some candidates gave high melting points or boiling points. Candidates needed to specify whether the compound was aqueous, molten or solid when discussing electrical conductivity.

Limited responses

- Properties of metals were most commonly given.
- Candidates would benefit from further study of the properties of ionic compounds, particularly the differences in electrical conductivity when molten, aqueous or solid.
- Many candidates named metals or ionic compounds rather than referring to properties.

Question 7

(a) (i) Comprehensive responses

- Most candidates were able to determine the number of atoms.

Limited responses

- Occasionally, candidates gave the number of elements, 2.

(ii) Comprehensive responses

- Candidates gave the correct calculated answer and showed how they had completed the calculation using the chemical formula given. For example, candidates clearly showed the relative atomic masses multiplied by the number of atoms in the formula. They showed the addition of these two numbers to give the resulting relative molecular mass.

Limited responses

- Candidates often did not multiply the relative atomic mass by the number of atoms and just added them together.
- Some candidates did not multiply the hydrogen and so obtained an answer lower than that required.
- Candidates would benefit from opportunities to practise these calculations for a range of chemical formula and to show their working.

(iii) Comprehensive responses

- Candidates described unsaturated compounds as compounds which contain one or more C=C double bonds.
- Candidates described hydrocarbons as compounds containing only carbon and hydrogen atoms.

Limited responses

- Candidates occasionally described a saturated compound instead of an unsaturated compound.
- Other candidates thought saturation in this context was related to dissolving in water and therefore described unsaturated as not fully dissolved.
- A common omission was to state ‘double bond’ without the idea of a compound that contains double bonds.

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- Candidates often had the idea that carbon and hydrogen were present. Sometimes candidates did not explicitly state that no other types of atom were present.
- Candidates were also not precise in their use of language. For example, they described a hydrocarbon as a mixture of carbon and oxygen or as containing carbon and hydrogen molecules.

(iv) Comprehensive responses

- Few candidates identified the test and the observation. The observation should include both the initial colour and the colour formed when a positive result is obtained.

Limited responses

- Candidates commonly suggested food tests including Benedict's, Biuret and iodine.
- Many candidates suggested the test for hydrogen.

(b) (i) Comprehensive responses

- Some candidates gave the name of the polymer.

Limited responses

- A wide range of suggestions were given, including polymerisation, carbon dioxide and polymethane.

(ii) Comprehensive responses

- Few candidates could identify the type of polymerisation as addition.

Limited responses

- A wide range of suggestions were given, most of which had no relation to polymerisation. For example, gas, distillation, cracking, heating and melting.

(c) Comprehensive responses

- Most candidates were able to describe the motion of particles in gases as either random or fast. These candidates gave simple descriptions that related to particles rather than the bulk properties of gases.
- Some candidates were able to describe the separation of particles in a gas in terms of being far apart.

Limited responses

- Candidates occasionally discussed motion in terms of moving freely, which is too vague, or vibrating, which is incorrect. Other candidates discussed the frequency of collisions, which was not relevant to the question asked.
- Candidates often described the separation of particles too vaguely. For example, as free, not tightly packed or not touching. Candidates would benefit from describing what the property is rather than what property is absent.

Question 8

(a) (i) Comprehensive responses

- Candidates identified the solid fossil fuel, coal.

Limited responses

- Candidates suggested liquid fossil fuels, such as diesel or petroleum, or fossil-related answers, such as carbon or fossils.

(ii) Comprehensive responses

- Few candidates gave clear explanations recognising that fossil fuels contain sulfur and that burning combines it with oxygen to produce sulfur dioxide.

Limited responses

- Some candidates suggested that fossil fuels contain sulfur dioxide, which is released on burning.
- Other candidates gave vague answers about toxic gases being produced when fossil fuels are burnt.

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(b) (i) Comprehensive responses

- Most candidates were able to suggest a suitable acidic pH.
- A few of these candidates gave the pH of a weak acid.

Limited responses

- Numbers from across the pH range were suggested.

(ii) Comprehensive responses

- Most candidates described in detail the use of universal indicator. Few of these candidates went on to compare the colour observed with a colour chart.

Limited responses

- Candidates often suggested litmus as a suitable indicator or repeated the use of a pH meter given in the question.
- Other candidates used general terms such as pH paper or pH strips.
- Some candidates described what the different colours signified. Candidates need to know how to test for pH, including the reagent used and how the result is determined.

(c) Comprehensive responses

- Most candidates balanced the equation correctly by filling in the gaps.

Limited responses

- A few candidates tried to add chemical symbols, and others suggested 4 in one of the gaps.

(d) Comprehensive responses

- Most candidates were able to state the specific boiling point of pure water.

Limited responses

- Some candidates gave vague responses, for example by stating that water has a lower boiling point.

Question 9

(a) Comprehensive responses

- Some candidates understood that resultant force is the difference between the two forces and calculated the resultant force in this case.
- Some candidates expressed this in standard form.

Limited responses

- Many candidates multiplied the two forces, added them together or divided them.
- Candidates would benefit from further study of the concept of resultant force.

(b) (i) Comprehensive responses

- Few candidates gave a different source of ionising radiation. More common responses included radon, rocks, and food and drink.

Limited responses

- Most candidates gave a source associated with cosmic rays or stated the Sun or sunlight.
- Candidates would benefit from considering the example given and providing an alternative suggestion.

(ii) Comprehensive responses

- Most candidates gave cancer.
- In some cases, cell damage and mutations were given.

Limited responses

- Some candidates gave vague responses, stating sickness, burns or damage.

(iii) Comprehensive responses

- Few candidates were able to complete the sentence about α-particles.

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Limited responses

- Oxygen was a common suggestion.
- Candidates need to be able to recall the different types of radioactive emissions and their nature.

(c) Comprehensive responses

- Candidates gave clear descriptions of the Sun forming a red giant followed by a white dwarf and planetary nebula.
- Few candidates described both the stages and the correct sequence.

Limited responses

- Some candidates gave a range of other stages, including black dwarf, red supergiant and black hole.
- The sequence was often in the wrong order or included additional stages.
- Candidates would benefit from further study of the lifecycle of stars.

(d)(i) Comprehensive responses

- Some candidates showed concisely that sound waves need a medium or that space is a vacuum.
- Candidates sometimes described a vacuum to show that sound waves need particles.

Limited responses

- Many candidates thought that sound could not travel from the Sun to the Earth because it was too far away. They had the idea that sound waves could not travel such a large distance.
- Other candidates discussed the lack of air in space. This implied that sound waves need air to travel rather than a medium.
- There was also some confusion between the terms medium and median. Candidates need to be careful in their use of technical terms so that they can convey the appropriate ideas.

(ii) Comprehensive responses

- Most candidates were able to use standard form to calculate the distance.
- Some candidates gave their answer in standard form, while others wrote out the entire number.

Limited responses

- Candidates often made an error either with the standard form or with the number of zeros.
- Some candidates divided the number to get a value of 600 km. In questions such as this, based on actual situations, candidates need to check their answers as a sense check. This would allow candidates to recognise that 600 km is far too small a distance from the Sun to the Earth.

(iii) Comprehensive responses

- Some candidates entered visible light in the appropriate box.

Limited responses

- Many candidates did not enter visible light in the correct box.
- Sometimes candidates did not enter visible light at all. They attempted to enter all the waves in the electromagnetic spectrum, omitting visible light.
- Candidates need to make sure that their response addresses the specific question.

Question 10

(a) Comprehensive responses

- Few candidates were able to explain that the constant speed is due to there being no resultant force.
- Some candidates were able to explain that the horizontal forces were balanced, often using the named horizontal forces from the diagram.

Limited responses

- Candidates would benefit from further study of the concept of resultant force and the impact on speed of balanced and unequal forces.

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- Most candidates thought the driving force was greater as the bike was moving forward and that the size of the forces was not changing, causing constant speed.
- Other candidates explained the constant speed in terms of travelling on a level surface, for example not uphill or downhill.

(b) (i) Comprehensive responses

- Few candidates were able to show the correct symbols and arrange them appropriately in the circuit.
- Candidates need to be able to recall all the symbols for electrical components and be familiar with their use within circuits.

Limited responses

- Candidates sometimes placed two lamps in parallel. Many circuits were seen with two switches and two lamps in series.
- The correct placement of the switches was seen in some responses, with many placing one switch in parallel and the other in the first part of the circuit before the branching, where it would control both lamps.
- Candidates rarely used a fuse in their circuit diagram.
- In many cases, incorrect symbols were used for all components. Without knowing the symbols, it was difficult for candidates to go on to position the components correctly. Recall of the symbols is an important underpinning skill, and candidates would benefit from further practice.

(ii) Comprehensive responses

- Few candidates were able to link the fuse melting to a high current, which then stops the flow of current or electrons.

Limited responses

- Candidates often had the idea that the current could no longer flow. They did not explain this in terms of a high current and the subsequent melting of the fuse.
- Candidates sometimes discussed heating and the fuse acting to stop ‘overheating’.
- Other candidates described circuit breakers and discussed them ‘tripping’ when the current was too high.

(c) (i) Comprehensive responses

- Candidates stated electrons in their response.

Limited responses

- A range of particles were seen, including protons and neutrons. Other candidates gave the charge, either positive or negative, rather than the type of particle.
- Many candidates suggested a positively charged electron.

(ii) Comprehensive responses

- Some candidates knew that particles move faster when air heats up and gave a comparative answer.
- This was expressed in a range of ways, including particles speeding up or gaining kinetic energy.

Limited responses

- Candidates sometimes had an incorrect impression of the movement of particles in a gas and described the particles as vibrating more.
- Some candidates described a change in pressure by describing the particles hitting the walls more often or colliding more frequently.

Question 11

(a) Comprehensive responses

- Few candidates were able to complete all the steps in this calculation.
- Candidates who gave comprehensive responses completed both unit conversions and stated and applied the equation for energy to multiply the current, voltage and time. The answer was then clearly written on the answer line.

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Limited responses

- It was common for candidates not to complete the unit conversion for current, and in many cases the time was given in minutes rather than seconds.
- Many candidates did not state the equation they were using. Their multiplication suggested that they were using only current and voltage, with no inclusion of time.
- Candidates needed to give the equation or show complete substitution as evidence of working.

(b) (i) Comprehensive responses

- Few candidates showed the equations they were using for weight and work done and then showed how substitution of the values gave the answer of 588 J.
- In a few cases, candidates used the equation for change in gravitational potential energy from the extension content and completed the correct substitution.

Limited responses

- Candidates often did not show any equation, instead showing multiplication of the figures without showing why.
- Candidates need to include the equation they are using in questions that require them to 'show that…'.

(ii) Comprehensive responses

- Few candidates showed the equation they were using and correctly substituted the values to produce an answer.

Limited responses

- Most candidates were not able to provide the correct equation for power and therefore did not complete the correct calculation.

(iii) Comprehensive responses

- Some candidates stated the energy store.

Limited responses

- Kinetic energy was the most common answer given.

(c) (i) Comprehensive responses

- Most candidates gave the maximum speed of the drone.

Limited responses

- Candidates occasionally gave 20 as their answer.

(ii) Comprehensive responses

- Some candidates showed clearly that they used the area under the graph to calculate distance and showed the appropriate numerical working.
- Candidates showed their use of area by stating that the distance was the area under the graph, giving the equation for the area of a triangle, or by labelling the appropriate area under the graph.

Limited responses

- Many candidates attempted to use the equation for speed to answer this question. This was generally unsuccessful.
- Candidates need to be more familiar with the use of speed-time graphs to calculate distance and would benefit from further experience with this type of calculation.

Question 12

(a) (i) Comprehensive responses

- Few candidates stated a definition for ultrasound that included frequencies above 20 kHz.

Limited responses

- Many candidates described how ultrasound is used or gave vague answers about it being high frequency.

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(ii) Comprehensive responses

- Few candidates gave a clear definition of frequency. The definition needed to include reference to the number of peaks, waves, oscillations or vibrations per unit time.

Limited responses

- Many candidates discussed pitch or gave vague answers relating to the amount of waves or how fast the waves are.
- Candidates would benefit from further study of this definition.

(iii) Comprehensive responses

- Some candidates gave a value less than 20 Hz and gave an explanation linked to this being the bottom of the audible range for humans.

Limited responses

- Candidates gave values in the ultrasonic range, which are above the audible range for humans.

(b) Comprehensive responses

- Candidates appreciated that they needed to calculate the total area in contact with the ground and then substituted this into the correct equation for pressure, calculating the answer.
- They showed their working in a clear way, first calculating the total area, then giving the equation they were using, followed by substitution and the full answer. A rounded answer was then given on the answer line.

Limited responses

- Candidates often completed the calculation using the equation without calculating the total area first.
- Candidates sometimes calculated the total area, which was then used in the wrong substitution.
- Incorrect substitutions often involved completing a multiplication rather than a division.
- Candidates rarely gave the equation they were using and just showed manipulation of the numbers provided. Candidates would benefit from stating the relevant equation as the first step in answering this type of question.

(c) (i) Comprehensive responses

- Candidates completed the sentences, selecting appropriate words.

Limited responses

- Most candidates identified the change of state to a gas.
- Few candidates could describe the process of evaporation, with water being a common suggestion.

(ii) Comprehensive responses

- Most candidates suggested that cooling was the reason for elephants spraying themselves with water.

Limited responses

- A few candidates suggested that it was for cleaning purposes.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/33
Theory (Core)

Key messages

What candidates did well
- Candidates were able to select appropriate words and phrases to show their knowledge and understanding.
- Candidates were able to describe the human defences against pathogens.
- Candidates used the information provided to determine the reactivity of metals.
- Candidates were able to interpret force diagrams to identify the different forces acting in a situation.

What candidates needed to improve
- Candidates need to show their working, including the relevant equation where applicable, in mathematical questions.
- Candidates need to recall the reagents and observations for the full range of chemical and biological tests.
- Candidates would benefit from further study of the properties of metals and ionic compounds.
- Candidates need to improve their written responses when an explanation is required. Candidates often gave vague responses or did not use the correct scientific terminology. For example, when explaining how a fuse works and resultant force.

Comments on specific questions

Question 1

(a) Comprehensive responses
- Some candidates were able to identify three differences between the cells from the diagram.
- Candidates were clear about which cell they were referring to and how it was different.
- Most commonly, they referred to the nucleus in the neurone and the circular DNA and cell wall in the bacterial cell.

Limited responses
- Some candidates were not clear about which cell they were referring to.
- Other candidates did not consider the diagram and stated that neurones had myelin sheaths, which a relay neurone does not.
- Some candidates tried to describe the difference in shape with limited success. For example, describing the bacterial cell as having a solid shape.

(b) Comprehensive responses
- Some candidates correctly identified the type of neurone shown.
- Candidates would benefit from further study of the different types of neurone, their structure and role.

Limited responses
- A common incorrect suggestion was brain neurone.

(c) Comprehensive responses
- Many candidates knew that neurones conduct electrical impulses.

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Limited responses
- Candidates often gave vague terms such as control or repeated the idea of nervous impulses.

(d) Comprehensive responses
- Most candidates knew the definition of a pathogen.

Limited responses
- Some candidates thought that decomposers or antibiotics were disease-causing organisms.

(e) Comprehensive responses
- Candidates gave two defences in most cases.
- The most common were white blood cells, mucus and antibodies.

Limited responses
- There was some confusion as some candidates suggested antibiotics rather than antibodies.
- Candidates need to refer to the list of defence mechanisms in the syllabus. Some tried to rely on other knowledge and often expressed these ideas too vaguely. For example, changing temperature.

(f) Comprehensive responses
- Most candidates were able to identify both characteristics using the definitions given.

Limited responses
- Few candidates suggested absorption instead of nutrition, and the idea of defaecation was seen instead of excretion. Excretion and egestion are commonly confused terms, and candidates would benefit from further study of these terms.

Question 2

(a) (i) Comprehensive responses
- Most candidates were able to interpret the information in order to sketch an appropriate graph.
- Almost all candidates showed the increase initially. Some then showed the decrease from 5 minutes. This was completed as a smooth curve or with straight lines. Some candidates placed a flat top at the peak of the curve, which was a reasonable assumption given the information.

Limited responses
- Some candidates showed the decrease from 4 minutes, having incorrectly interpreted the information provided. Others did not show any decrease and had a curve that levelled off.

(ii) Comprehensive responses
- Few candidates were able to perform this percentage change calculation.
- Comprehensive responses showed their working, calculating the difference between the volumes and dividing by the initial volume. This was then multiplied by 100 and the correct answer written on the answer line.

Limited responses
- 600% was a very common answer, where candidates just divided the final volume by the initial volume and multiplied by 100.
- Other candidates divided 0.5 by 3 or did not multiply by 100 to convert to a percentage.
- Candidates would benefit from further practice performing percentage change calculations in different contexts. Candidates would also benefit from checking their answer to make sure it shows the approximate relationship. For example, if the value has doubled, they should expect a 100% increase, and if it has more than doubled (as in this case), the answer they calculate should be more than 100%.

(b) (i) Comprehensive responses
- Few candidates could identify limewater in this context.
- Candidates would benefit from further practical experience using limewater to test expired air.

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Limited responses
- A wide range of food tests were suggested, with the ethanol emulsion test being the most common. This was presumably because of the reference to turning milky in the next part.
- Water was also a common suggestion.

(ii) Comprehensive responses
- Candidates were able to explain that there was more carbon dioxide in expired air, which causes solution Y to go milky. Candidates were clear that there was more carbon dioxide, not just the presence of carbon dioxide, and understood that the expired air was exhaled through the liquid in test-tube B.

Limited responses
- Many candidates gave general responses about air going into test-tube B, or thought the change was due to oxygen entering.
- Some candidates thought the change was due to the presence of fats.

(c) (i) Comprehensive responses
- Some candidates identified the reaction that releases energy as respiration.

Limited responses
- A wide range of suggestions were seen, including digestion, exercising and breathing.

(ii) Comprehensive responses
- Some candidates were able to state a use for the energy released, using the list provided in the syllabus.
- Growth was very frequently given.

Limited responses
- Respiration was more commonly seen as a use of energy than in **Question 2(c)(i)**, as the process that releases energy.
- Candidates need to give a process that directly uses the energy released rather than a system-wide process such as breathing or reproduction.
- Candidates sometimes gave the same idea that had already been provided in the question, namely movement or muscle contraction.

Question 3

(a) (i) Comprehensive responses
- Candidates used the letters from the diagram to identify the correct parts of the flower. The filament and sepal were most commonly correct.

Limited responses
- Candidates often confused the stigma and the style.
- A wide range of suggestions were given, with every part of the flower being suggested.

(ii) Comprehensive responses
- Some candidates were able to state two ways the flower is adapted for pollination.
- The most common answers were colourful petals, sticky pollen and a scent. Occasionally, the production of nectar was mentioned.

Limited responses
- Candidates sometimes used vague references to flowers having colour, without linking this to the petals.
- They also suggested the idea of having lots of pollen, which is more generally a characteristic of wind-pollinated flowers.

(b) Comprehensive responses
- Most candidates were able to link each word to the corresponding definition.

Limited responses
- Occasionally, pollination and fertilisation were the wrong way around.

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- Other candidates thought that pollination contains pollen.

(c) Comprehensive responses

- Some candidates were able to give very detailed descriptions. These candidates included the uptake of water by the roots and the cells through which the water moves.
- Most candidates were aware of the role of root hair cells and/or xylem.

Limited responses

- Some candidates described the movement of water by active transport.
- Other candidates were not specific in their description of the cells. For example, describing water uptake in root cells and movement through cells in the leaf.

Question 4

(a) Comprehensive responses

- Most candidates were able to identify the tiger as a consumer and carnivore.

Limited responses

- Few candidates thought it was also either a producer or a decomposer.
- Candidates would benefit from further study of the terms used to describe organisms in a food web.

(b) Comprehensive responses

- Few candidates could clearly explain what a food web is using appropriate language, such as that used in the syllabus.
- Candidates were able to communicate how a food web relates to food chains and the interconnected nature of the web.

Limited responses

- Candidates often had vague ideas about many food chains, with no idea of the inter-linking.
- Some candidates had the idea that it showed an organism's role in the ecosystem.
- Others did not distinguish between a web and a chain in their description. For example, describing it as showing what animal eats what.

(c) (i) Comprehensive responses

- Many candidates were able to suggest reasons why the tiger might be endangered.
- Common suggestions included hunting, pollution and climate change. The idea of a lack of prey was also often seen.

Limited responses

- Candidates sometimes repeated the idea of habitat destruction that was given in the question.

(ii) Comprehensive responses

- Few candidates referred to two relevant effects of deforestation.
- The full range of responses was seen, with the idea of extinction given most often.

Limited responses

- Some candidates repeated the loss of habitat from the question or described an effect on the population of tigers.

(iii) Comprehensive responses

- Many candidates were able to identify the example as using the area for crop production.

Limited responses

- Candidates sometimes suggested that the area was used for livestock production.

(d) Comprehensive responses

- Candidates completed all the gaps using appropriate scientific language.
- The second gap was most often completed correctly.

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Limited responses

- Some candidates suggested adaptation or selection for the first gap.
- The final gap required candidates to use the appropriate scientific term, allele, but many used vague terms such as genetic information, DNA or genes.
- Candidates would benefit from further study of the role of alleles and genetic variation in natural selection.

Question 5

(a) Comprehensive responses

- Most candidates were able to link the chemical terms to their descriptions.
- Candidates used clear, straight lines to show the links.

Limited responses

- Candidates sometimes put all the joining lines through a central point, which makes it difficult to determine the path of each line.
- There was no clear pattern in the definitions that candidates identified, with most combinations seen.

(b) (i) Comprehensive responses

- Few candidates were able to identify experiment A and give both reasons why, in terms of temperature and concentration.

Limited responses

- Candidates often identified A but only gave an explanation in terms of temperature rather than referring to all the data.
- Some candidates suggested C because it also had a low temperature and did not appreciate the effect of concentration.

(ii) Comprehensive responses

- Most candidates provided a suitable pH for the acid.

Limited responses

- Candidates suggested values above and including pH 7.
- Candidates need to be familiar with the typical pH of acids and bases and the associated colour changes when tested with universal indicator and litmus.

(iii) Comprehensive responses

- Most candidates provided an appropriate colour for the universal indicator.

Limited responses

- Few candidates suggested either blue, green or purple.

(iv) Comprehensive responses

- Few candidates were able to explain that this was not a suitable indicator, as it does not differentiate between acidic pHs.
- Some explained this by the idea that the colour change was the same for all acids or that it only shows whether the liquid is an acid or a base.

Limited responses

- Many candidates gave vague explanations. For example, that it does not show the exact pH.
- Others suggested that because it was already orange there would be no further change when added to an acid.

(v) Comprehensive responses

- Few candidates knew that carbon dioxide was the gas produced.

Limited responses

- Many candidates suggested noble gases.
- Many candidates attempted to name a gas based on the reactants. For example, hydrocarbonate chloride or calcium hydrochloride.

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Question 6

(a) (i) Comprehensive responses

- Most candidates deduced the number of atoms.

Limited responses

- A range of numbers between four and eight were suggested as possible answers.

(ii) Comprehensive responses

- Some candidates finished the displayed formula by adding the ethanol group to one of the carbons and completing the bonds with hydrogen.
- Candidates used simple lines to show the bonds and were careful to ensure that the number of each atom was consistent with the formula given.

Limited responses

- Sometimes candidates linked the alcohol group through the hydrogen rather than the oxygen.
- A wide range of ring structures were seen.
- Some candidates added extra carbon atoms to the backbone carbon chain.
- Candidates would benefit from further study of simple displayed formula, including understanding the different numbers of bonds made by carbon, hydrogen and oxygen.

(iii) Comprehensive responses

- Some candidates knew that the bonds in ethanol were covalent.

Limited responses

- Many candidates suggested ionic bonding.
- Others suggested double bonds or single bonds without specifying that the bonds are covalent.
- Candidates would benefit from further study of the different types of bond.

(iv) Comprehensive responses

- Candidates gave the correct calculated answer and clearly showed how they completed the calculation using the formula provided. For example, responses showed the relative atomic masses multiplied by the number of atoms in the formula and the addition of these values to obtain the relative formula mass.

Limited responses

- Candidates often did not multiply the relative atomic mass by the number of atoms and instead added the three values together.
- Some candidates did not multiply the hydrogen.
- Candidates would benefit from the opportunity to practice these calculations for a range of chemical formula, with the encouragement to show their working so that they can demonstrate their method even if they make a mistake.

(b) Comprehensive responses

- Few candidates were able to describe both motion and separation.
- Candidates provided clear explanations of how particles move randomly or slide over each other.
- Candidates more commonly describe the particles as being close together. This was sometimes expressed as the particles touching.
- Clear responses understood the difference between motion and separation and addressed these two points independently.

Limited responses

- There were many vague answers. For example, particles being separated or particles moving. Candidates needed to be more specific when describing how the particles move and how they are separated.
- A small number of candidates described bulk properties, discussing the flow of the liquid or that it takes the shape of the container.

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(c) **Comprehensive responses**

- Some candidates were aware of the composition of hydrocarbons and could explain why alcohol was not a hydrocarbon.
- This was generally phrased as ethanol containing oxygen as well as hydrogen and carbon.

Limited responses

- Candidates offered a range of incorrect explanations, including that it does not contain double bonds, that it contains a hydroxide, or because it is a liquid.
- Candidates would benefit from further study of organic compounds, including hydrocarbons and alcohols.

(d) **Comprehensive responses**

- A wide range of uses were given, and most candidates were able to make a suitable suggestion.
- The most common suggestions were as a disinfectant, antiseptic, or in perfumes and cosmetics. Some candidates also applied their knowledge of food tests to suggest testing for fats or oils.

Limited responses

- Many candidates gave vague answers, for example medical use or as a reactant.
- Some candidates repeated the idea of fuel given in the question.

(e) **Comprehensive responses**

- Few candidates were able to complete the word equation.
- Candidates showed that combustion needs oxygen and the correct products for complete conduction.

Limited responses

- Some candidates suggested reactants or products that are not involved in this reaction. For example, carbon was a common reactant and hydrogen was a commonly suggested product.
- Other candidates knew carbon dioxide was involved, although it was sometimes given as the product.
- With no reactants or products provided in the question, some candidates did not attempt the question.
- Candidates need to be familiar with complete combustion and be able to write word equations for a range of fuels

Question 7

(a) **Comprehensive responses**

- Many candidates were able to give two properties of metals.
- The most commonly seen properties were a high melting point, a high boiling point, or malleability.

Limited responses

- Many candidates only gave one correct property.
- Often the description was too vague, for example good conductors.
- Properties of specific metals were given in some cases, for example hard or catalyst, rather than general properties of metals.

(b) **Comprehensive responses**

- Most candidates were able to put the metals in the correct order using the information given.

Limited responses

- Occasionally, candidates gave the reverse order of the metals.

(c) **Comprehensive responses**

- Most candidates were able to balance the symbol equation.

Limited responses

- A small number of candidates tried to insert chemical symbols.

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- Candidates would benefit from further practice balancing a range of symbol equations.

(d) (i) Comprehensive responses

- Few candidates gave both the metals used to make brass.

Limited responses

- Some candidates suggested copper and iron. Aluminium, steel, magnesium and nickel were also commonly seen suggestions.
- Candidates needed to recall the metals used to make brass.

(ii) Comprehensive responses

- Some candidates explained the use of steel for cutlery by clearly comparing the physical properties of steel and iron.
- Both the idea of steel resisting corrosion and steel being harder were given by candidates.

Limited responses

- Candidates sometimes gave properties that were not relevant or were not correct. For example, ability to conduct heat, toxicity or ability to shape.
- Other candidates gave vague descriptions by stating that it is resistant or stays shiny.

(e) (i) Comprehensive responses

- Most candidates could identify the number of elements in copper(II) sulfate.

Limited responses

- Some candidates suggested 2, presumably thinking of copper and sulfate.

(ii) Comprehensive responses

- Some candidates identified the oxidation state.

Limited responses

- A range of incorrect responses were seen. 4 was a common incorrect answer.

Question 8

(a) Comprehensive responses

- Some candidates gave a clear description of the relationship.
- Candidates recognised that the two numbers would be the same and expressed this in a range of ways.

Limited responses

- Some candidates tried to describe the relationship in terms of the number of protons and neutrons, although these responses were generally not clear.
- Other candidates described the relationship in terms of the number of shells rather than the number of electrons in a shell.

(b) Comprehensive responses

- Some candidates were able to clearly show the position of the electrons and the correct charge on the ion.
- Candidates used clear marks for the electrons, and the single negative charge was shown in the correct position.

Limited responses

- Many candidates showed the electronic configuration of the atom rather than the ion.
- Candidates also commonly gave the ion a positive charge.
- Candidates need to improve on their completion of electronic configurations for atoms and ions.

(c) Comprehensive responses

- Few candidates could describe the test for chloride ions.
- Candidates need to name the specific test and the colour of the observed precipitate.

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Limited responses
- Some candidates did not state that the silver nitrate needed to be acidified.
- A wide range of incorrect tests were suggested, including various food tests.

(d) Comprehensive responses
- Few candidates described two properties of solid ionic compounds.
- Occasionally, candidates referred to high melting points or boiling points.

Limited responses
- Candidates often described the properties of a solid without reference to the ionic compound.
- Candidates sometimes gave properties of metals.

(e) (i) Comprehensive responses
- Some candidates completed the sentences to describe electrolysis.
- Candidates often used alternative wording to describe decomposition, for example break down.

Limited responses
- Candidates suggested vague terms for the first gap, such as process or change.
- Candidates would benefit from further study of electrolysis.

(ii) Comprehensive responses
- Few candidates were able to state the electrode at which each gas is made.

Limited responses
- Many candidates stated the electrodes the wrong way around.

Question 9

(a) (i) Comprehensive responses
- Most candidates stated the boiling point of water.

Limited responses
- Some candidates suggested temperatures lower than the boiling point. Temperatures in the range of 37 to 60 °C were seen.

(ii) Comprehensive responses
- Most candidates were able to identify both changes of state.

Limited responses
- Condensation was given by fewer candidates. Some suggested alternatives included sublimation, water vapour and boiling.

(b) Comprehensive responses
- Few candidates were able to explain the position of the heating element.
- Candidates needed to recognise that convection was taking place and that this involved the movement of water of different densities due to the heating effect of the element.
- Candidates gave clear explanations and a complete narrative of the process.

Limited responses
- Candidates often gave vague answers. For example, thermal energy transferred from down to up or boiling starts at the bottom of the kettle.
- Candidates need to improve their understanding of thermal energy transfer and be able to apply this to different contexts.

(c) (i) Comprehensive responses
- Some candidates were able to complete the calculation of the energy transferred by the kettle.
- Candidates completed the correct unit conversion, stated the equation for energy, and correctly substituted the values.

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Limited responses
- Candidates often did not complete the initial unit conversion.
- Many candidates did not show working to support their answers.
- Some candidates divided the power by the time instead of multiplying.

(ii) Comprehensive responses
- Some candidates were able to identify the 13A fuse and give an explanation in terms of comparison with the current.

Limited responses
- Candidates who selected the 13A fuse often were not clear in their explanation. For example, it was not too high or too low.
- Other candidates repeated the information given in the question that it protects the circuit.
- All the options for the value of the fuse were seen. 10A because it is closest to the value of the current, 30A because it is the biggest and allows the most current, and 5A because it will protect it more.

(iii) Comprehensive responses
- Few candidates were able to explain how the fuse protects the kettle.
- Clear explanations included the melting of the fuse due to a high current and the subsequent breaking of the circuit. The idea of breaking the circuit was given in a range of ways, including stopping the current and stopping the flow of electrons.

Limited responses
- Candidates often did not discuss the fuse melting. Some used terminology associated with circuit breakers, such as blowing a fuse.
- Candidates also commonly referred to the fuse stopping the flow of electricity or preventing the kettle from exploding or getting too hot.

Question 10

(a) Comprehensive responses
- Some candidates correctly calculated the density.
- Candidates used the dimensions to calculate the volume and then gave the equation for density and substituted the values.

Limited responses
- Many candidates did not show any working and just wrote an incorrect answer on the answer line. Candidates could improve by being clear about how they calculated their answer.
- The equation for density was often given incorrectly.

(b) (i) Comprehensive responses
- Most candidates showed the correct reflected ray.
- Candidates used a ruler to draw the line at the correct angle.

Limited responses
- Some candidates showed refraction or drew multiple lines.

(ii) Comprehensive responses
- Most candidates stated that the line was the normal.

Limited responses
- Suggestions from candidates included imaginary line, reflected line, or just the middle line.
- Candidates could benefit from further study of the scientific terms associated with light and its behaviour at mirrors and lenses.

(iii) Comprehensive responses
- Candidates clearly indicated the angles using an arc between the appropriate light ray and the normal.

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Limited responses

- Candidates sometimes extended the arc beyond the ray to the mirror.
- Other candidates placed the letters around the diagram without clearly indicating the angle they were trying to label. An arc is an appropriate method for doing this.

(c) (i) Comprehensive responses

- Candidates need to describe the change in terms of neutrons changing into protons and electrons.

Limited responses

- Candidates occasionally discussed the appropriate sub-atomic particles in their answers. When they did, the wrong change was described. For example, neutrons being gained or, more commonly, protons leaving the nucleus.

(ii) Comprehensive responses

- Some candidates were able to complete this calculation by determining that there were 4 half-lives and multiplying 0.1 by ½ four times. This method was seen in most successful answers.

Limited responses

- A significant proportion of candidates were able to deduce that there were 4 half-lives and showed this in their working.
- Candidates did not know how to use this half-life to complete the calculation and often multiplied or divided 0.1 by 4.

Question 11

(a) (i) Comprehensive responses

- Most candidates applied their knowledge of forces to identify the arrow representing weight.

Limited responses

- A and D were also given.

(ii) Comprehensive responses

- Many candidates correctly selected D as friction.

Limited responses

- B was sometimes given as a suggestion.

(iii) Comprehensive responses

- Few candidates appreciated that there was no acceleration because there was zero resultant force.
- Candidates need to recognise that a constant speed is a consequence of there being no resultant force and show this in their answer and explanation.
- Correct explanations often referred to the forces being balanced.

Limited responses

- Most candidates gave a value above zero for the resultant force and explained this in terms of the wheelbarrow being pushed forwards.
- Candidates would benefit from further study of the concept of resultant force.

(iv) Comprehensive responses

- Most candidates were able to calculate the work done.
- Candidates gave the equation for work done and showed the substituted values before giving the answer.

Limited responses

- Many candidates just wrote 3.75 on the answer line without showing any working. This is a result of dividing the force by the distance rather than multiplying.

(b) Comprehensive responses

- Most candidates were able to calculate the moment, and fewer were able to state the units.

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- Candidates gave the equation for the moment, substituted the values for force and perpendicular distance, and calculated the moment with the unit.

Limited responses
- Occasionally, candidates divided the force by the distance.
- Candidates often gave N/m as the unit, even when the correct calculation was completed. J was also sometimes given.

Question 12

(a) Comprehensive responses
- Some candidates gave all three regions of the electromagnetic spectrum.

Limited responses
- Candidates often identified one electromagnetic radiation emitted by the Sun, generally either ultraviolet or infrared.
- Gamma rays were often given, and X-rays was occasionally suggested.

(b)(i) Comprehensive responses
- Most candidates placed the letter A correctly on the graph.

Limited responses
- Candidates sometimes placed the letter at the point at which the descent started at 60 seconds. This was sometimes ambiguous, and candidates could improve by positioning the letter more clearly on the downward slope.

(ii) Comprehensive responses
- Candidates showed how they used the graph to calculate the area and therefore the distance.
- Some candidates labelled the area of the graph they were calculating.
- Candidates most commonly used the equation for speed rearranged.

Limited responses
- Some candidates completed the incorrect calculation, and often no working was shown to support the answer given.

(c) Comprehensive responses
- Some candidates identified the charged particles as electrons.

Limited responses
- Some candidates suggested protons or positively charged particles.
- Candidates could improve their understanding of the transfer of charged particles.

(d)(i) Comprehensive responses
- Some candidates correctly calculated the current.
- Candidates showed their working, stating the equation and substituting the appropriate values.

Limited responses
- A few candidates multiplied the current and resistance.

(ii) Comprehensive responses
- Candidates were able to suggest that one lamp would continue to work if the other lamp was broken.
- In some cases, candidates explained that there was potential to switch the lamps on and off independently. This idea was less commonly seen.

Limited responses
- Some candidates thought it would allow all lamps to have the same energy, which was too vague.
- Others thought the reverse, that they would have different energy.
- Some candidates described the properties of lamps in a series circuit.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/41
Theory (Extended)

Key messages

What candidates did well
- Many candidates used appropriate scientific terminology to describe phenomena.
- Few questions were left unanswered, and most candidates attempted every question.
- There was evidence that many candidates are being exposed to a good breadth of subject knowledge and can demonstrate strengths across a full range of topics.

What candidates needed to improve
- Some candidates did not follow the command words in the stem of the question.
- Some candidates provided limited descriptions when describing phenomena and did not include units or identify trends, instead repeating the information already in the stem of the question.
- During calculation, questions some candidates did not state the formula used and did not show their working.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Most candidates correctly identified the tassel as the male part of the plant that made pollen.

Limited responses
- All three incorrect options were seen with a similar frequency.

(ii) Comprehensive responses
- Many candidates identified that a specific named structure was outside the flower, for example anthers are exposed to wind.
- Some candidates linked a feature of a structure to a function.

Limited responses
- Some candidates gave a description regarding the gametes (pollen) rather than the plant structure.
- Some candidates identified a feature of a structure without linking it to a function.

(iii) Comprehensive responses
- Many candidates calculated the correct number of chromosomes in a diploid cell, realising it would be 2*n.*
- Some candidates stated that a diploid cell has a pair/two of each chromosome.

Limited responses
- Some candidates suggested that the chromosomes were duplicates, copies or clones.

(iv) Comprehensive responses
- Many candidates recognised the type of cell division that creates gametes as meiosis.

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Limited responses
- Mitosis was commonly seen.

(b) (i) Comprehensive responses
- Most candidates correctly deduced the gametes for the parents and produced a correct cross for the offspring.

Limited responses
- Some candidates gave the incorrect parental gametes although they went on to produce a correct cross for the gametes they had given.

(ii) Comprehensive responses
- Most candidates correctly predicted the percentage outcome from the cross given.

Limited responses
- The most commonly seen incorrect response was 50.

Question 2

(a) Comprehensive responses
- Some candidates explained the role of enzymes in digestion using the key terms molecules and absorption.

Limited responses
- Many candidates did not use key terminology and instead referred to pieces or particles of food.
- The idea of absorption was less commonly seen.

(b) Comprehensive responses
- Most candidates identified glycerol as the other product of the breakdown of fats.

Limited responses
- Some candidates suggested it was glucose or glycogen.

(c) (i) Comprehensive responses
- Some candidates identified that lipase digests fats into fatty acids because it is specific and has a complementary active site.

Limited responses
- Some candidates used inaccurate language to describe the action of enzymes.
- Some candidates described the active site as being on the substrate.
- A few candidates described the enzymes as being broken down.
- Some candidates suggested that the fatty acids were the substrate and that only lipase reacted with them.
- Some candidates suggested that the results were due to lipase not being denatured and the other two enzymes being denatured.
- Some candidates suggested that the enzyme was reacting with sodium carbonate.

(ii) Comprehensive responses
- Some candidates correctly named a part of the digestive system that secreted amylase and where it acts. Salivary glands linked to mouth was the most commonly seen response.

Limited responses
- Some candidates did not link the site of secretion to the relevant site of action. For example, amylase secreted in the pancreas acts in the mouth.

(d) Comprehensive responses
- Many candidates stated the mixture was bile.

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Limited responses

- A wide variety of alternatives such as hydrochloric acid, fatty acids, amylase, lipase, gastric juice or saliva were seen.

(e) Comprehensive responses

- Many candidates stated that stomach acid kills pathogens.
- Some candidates recognised that it created optimum pH conditions for protease enzyme to work in.

Limited responses

- Many responses suggested that stomach acid broke down food molecules.
- Some candidates suggested that the acid was there to neutralise.

Question 3

(a) Comprehensive responses

- Some candidates identified the four terms that applied to perch and its position in the food web.

Limited responses

- Most candidates recognised that perch was a carnivore.
- Many candidates recognised that perch was in the 3rd trophic level.
- Some candidates suggested that perch was a herbivore and at the 2nd trophic level.

(b) (i) Comprehensive responses

- Most candidates used the food web to form a food chain with five trophic levels.

Limited responses

- Some candidates omitted the arrows in the construction of the food chain.

(ii) Comprehensive responses

- Some candidates explained that energy is lost during the transfer between trophic levels, and gave examples of how energy is lost, recognising that the longer the food chain, the more times this energy loss would occur, resulting in insufficient energy for more trophic levels.

Limited responses

- Many candidates were able to give an example of a type of energy loss.
- Most candidates referred to energy being lost during the transfer between trophic levels.

(c) (i) Comprehensive responses

- Most candidates correctly named another structure that was found in algae cells but not animal cells as either vacuole or cell wall.

Limited responses

- Some candidates restated the structure given as the example in the question stem.
- Cell membrane was the most seen incorrect response.

(ii) Comprehensive responses

- Many candidates were able to state the correct balanced formula for photosynthesis.

Limited responses

- Some candidates were able to correctly state the left-hand side of the equation only.
- A few candidates gave the equation for respiration.

Question 4

(a) Comprehensive responses

- Nearly all candidates correctly identified the term as transmissible.

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Limited responses
- There were too few incorrect responses to comment.

(b) Comprehensive responses
- Some candidates identified that the virus was made of genetic material.

Limited responses
- Many candidates suggested that the polio virus was surrounded by a jelly coat, presumably confusing it with an ovum.

(c) Comprehensive responses
- Many candidates identified either the brain or spinal cord as being a part of the central nervous system.

Limited responses
- Many candidates used just the term ‘spine’ or gave an example from the peripheral nervous system.

(d) (i) Comprehensive responses
- Most candidates were able to correctly apply the terms lymphocytes and memory cells to describe how the body responds to a vaccine.
- Some candidates also correctly applied the terms immune and complementary.

Limited responses
- Some candidates used more generic terms such as white blood cell, rather than naming a specific type of WBC.

(ii) Comprehensive responses
- Some candidates explained clearly the role of vaccination in controlling the spread of polio in a country, using the data provided as evidence.

Limited responses
- Many candidates did not follow the command words in the stem of the question and did not use the data provided.
- Many candidates considered the role of vaccination in an individual body, as opposed to its effect within an entire population.

(iii) Comprehensive responses
- Some candidates were able to use the data given to calculate the number of births in 2022 and then multiply this figure by four to obtain the total number of doses needed.

Limited responses
- Many candidates were able to use the data given to calculate the number of births in 2022.
- Some candidates gained ECF for recognising that their incorrect number of births needed to be multiplied by four to reach a value for the number of doses required.
- Some candidates made power of ten errors in the calculation.
- A few candidates showed no workings.

Question 5

(a) (i) Comprehensive responses
- Most candidates recognised the atomic number of the element shown as 13.

Limited responses
- A few candidates confused the atomic number and the mass number.

(ii) Comprehensive responses
- Most candidates recognised the mass number of the element shown as 27.

Limited responses
- A few candidates confused the atomic number and the mass number.

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(iii) **Comprehensive responses**

- Some candidates showed a good understanding of the properties that define which period an element is in.

Limited responses

- Many candidates offered the idea of 3 electrons in the outer shell rather than 3 electron shells – in other words they considered the group rather than the period.
- Electron shells were not always described as being occupied.

(b) **Comprehensive responses**

- Some candidates were able to explain how the presence of delocalised electrons allows metals to conduct electricity.

Limited responses

- Many candidates just identified the presence of delocalised electrons in a metal structure.
- Some candidates only referred to metal in a molten state.

(c) **Comprehensive responses**

- Many candidates correctly linked the relative position of a metal in the reactivity table to the method of extraction.

Limited responses

- Some candidates incorrectly linked the two, with no obvious pattern to incorrect responses.

(d) **Comprehensive responses**

- Many candidates identified the other product as being hydrogen.

Limited responses

- Some candidates gave water or oxygen as the product.

(e) **Comprehensive responses**

- Some candidates correctly used stoichiometric calculations to calculate the mass of iron produced, demonstrating a good understanding of the relationship between moles, mass and molar mass.
- Some of the candidates used the ratio approach to calculate the correct mass of iron.

Limited responses

- Some candidates inverted the molar ratio.
- Some candidates omitted this question.

Question 6

(a) **Comprehensive responses**

- Some candidates identified that this was the minimum amount of energy required for a reaction to occur.

Limited responses

- Many candidates just identified it as the energy required to start a reaction.

(b) **Comprehensive responses**

- Some candidates deduced the correct products.
- Some candidates constructed balanced equations.

Limited responses

- Some candidates did not balance the equation correctly.
- Some candidates suggested alternative products.

(c) **Comprehensive responses**

- Many candidates displayed the covalent bonding in a molecule of chlorine using appropriate dots and crosses.

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Limited responses

- Some candidates suggested that chlorine contained a double bond of two pairs of shared electrons.

(d) Comprehensive responses

- Some candidates demonstrated a good understanding of attractive forces in covalent molecules and ionic compounds, relating these to differences in melting points.

Limited responses

- Some candidates were able to link differences in strength of attractive forces to differences in boiling point although they did not link this to differences in energy needed to overcome them.
- Some candidates used insufficient terminology to correctly describe the attractive forces in chlorine and sodium iodide.

Question 7

(a) Comprehensive responses

- Many candidates stated the test for carbon dioxide.

Limited responses

- Some candidates stated the test as being the limestone test.
- Some candidates suggested the test for hydrogen or oxygen.

(b) Comprehensive responses

- Some candidates correctly constructed a tangent to the curve at point 0.95 g.
- Some candidates then used the formula; rate = Δ y step/Δ x step, using values from their constructed tangent to derive the rate of reaction.

Limited responses

- Many candidates took readings from the axis intercepts from point 0.95 g rather than constructing a tangent.
- Many candidates read the figure on the x-axis intercept as 77.
- Some candidates left their final answer in fraction form rather than evaluating.

(c) Comprehensive responses

- A small number of candidates described the graph as having a shallower gradient that still finished at 1.00 g and then levelled off.
- Some candidates recognised that the gradient of the curve would be shallower.

Limited responses

- Some candidates recognised that the shape of the curve would be less steep.
- Some candidates thought that the curve would end sooner.

(d) Comprehensive responses

- Many candidates used moles = mass/Mr to find the moles of carbon dioxide, then multiplied this value by 24 to find the volume.

Limited responses

- Some candidates left their final answer in fraction form rather than evaluating.
- Some candidates omitted the primary calculation to find the moles of carbon dioxide.
- Some candidates omitted this question.

Question 8

(a) Comprehensive responses

- Many candidates identified coal or petroleum as fossil fuels.

Limited responses

- Some candidates gave an insufficient response of just ‘oil’.
- Some candidates repeated the type of fossil fuel, or a derivative of, the one given in the stem of the question.

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(b) **Comprehensive responses**

- Many candidates drew the correct displayed formula for methane.

Limited responses

- Some candidates included a double bond.

(c) (i) **Comprehensive responses**

- Many candidates correctly identified the other product of cracking.

Limited responses

- A few candidates gave the carbon and hydrogen as two separate products.

(ii) **Comprehensive responses**

- Some candidates correctly completed the figure to show the display formula for but-1-ene.

Limited responses

- Some candidates were not able to complete the figure although they correctly identified the position of the C=C.

(iii) **Comprehensive responses**

- Most candidates correctly selected covalent as the type of bond in a molecule of but-1-ene.

Limited responses

- Intermolecular was the most commonly seen incorrect response.

(d) **Comprehensive responses**

- Many candidates correctly understood that waste gases from digestion in animals are another source of methane.

Limited responses

- Complete combustion of carbon containing fuels was the most commonly selected incorrect response.

(e) **Comprehensive responses**

- Many candidates demonstrated good knowledge of the effects of climate change and suggested appropriate methods for reducing its effects.
- Many candidates suggested afforestation.

Limited responses

- Some candidates suggested switching to electric vehicles, without consideration of how the electricity would be generated.

Question 9

(a) (i) **Comprehensive responses**

- Almost all candidates correctly identified a stopwatch (or stop clock) as the instrument used to measure the time taken for the car to travel along the track.

Limited responses

- A few candidates named an instrument for measuring distance, such as a ruler or metre rule, or a light gate, confusing an instrument for measuring time with one used to measure length or trigger timing electronically.

(ii) **Comprehensive responses**

- Most candidates correctly applied $v = s/t$, substituting 2.4 m and 4.4 s, and evaluated this to give 0.55 m / s.

Limited responses

- Some candidates set up the correct formula and substitution without fully evaluating the division, leaving the answer as a fraction (for example, 2.4/4.4) rather than a decimal value.

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- Some candidates inverted or misapplied the formula, writing expressions like 4.4./2.4 or 4.4 × 2.4, showing confusion between division and multiplication.

(iii) Comprehensive responses

- Some candidates correctly used a = Δv/Δt, rearranging to Δv = a × t (0.85 × 2.0), to reach a velocity of 1.7 m / s.

Limited responses

- Some candidates left their final answer in fraction form rather than evaluating.
- Most of the candidates substituted the given values into an equation of motion for distance or used v = s/t instead of the acceleration equation, which did not lead to the correct final answer.
- Some candidates used the wrong formula such as $F = ma$, or performed incorrect operations (for example, dividing or multiplying unrelated values), or simply stated a wrong answer without showing any working.

(iv) Comprehensive responses

- Most candidates sketched a straight line of constant, non-zero gradient passing through the origin, correctly representing the constant acceleration of the car from rest.

Limited responses

- Some candidates drew a curve rather than a straight line, which incorrectly implied a changing acceleration rather than the constant acceleration described in the question.

(b) (i) Comprehensive responses

- Some candidates correctly stated the vertical acceleration as 9.8 m / s², recognising the value of the acceleration of free fall given on the front page of the paper.

Limited responses

- Several candidates gave 0 m /s ², incorrectly assuming that because the horizontal velocity was zero at the edge of the table, there was also no vertical acceleration.
- Some candidates gave irrelevant or incorrect responses such as ‘North,’ ‘constant speed,’ ‘gravity,’ ‘increase,’ ‘downwards,’ ‘negative,’ ‘vector,’ or left the answer blank. These reflected confusion between direction, concepts of motion, or incomplete knowledge.

(ii) Comprehensive responses

- Most candidates equated the loss in gravitational potential energy to the gain in kinetic energy ($mgh = \frac{1}{2}mv^2$), a few cancelled the mass m from both sides, and rearranged correctly to find v = 3.8 m/s.

Limited responses

- Most candidates were unable to cancel m from both sides of the equation, or substituted values incorrectly, and so could not reach the correct final answer even when the correct starting equation was identified.
- Some candidates left their final answer in fraction form rather than evaluating.
- Most candidates were able to quote either the correct equation for GPE or KE.
- Some candidates mixed up energy and force relations.

Question 10

(a) (i) Comprehensive responses

- Many candidates correctly substituted into density = mass ÷ volume (1.4 ÷ 900) to obtain 0.0016 g / cm³.

Limited responses

- Some candidates used the inverted formula, density = volume ÷ mass, so despite correctly substituting the given values, the final answer was incorrect.
- Some candidates left their final answer in fraction form rather than evaluating.

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(ii) Comprehensive responses

- Most of the responses explained that gas particles collide with the walls of the container and that this exerts a force on the walls.

Limited responses

- Many candidates described the particles as moving and hitting the walls of the bottle without going on to state that the collisions exert a force, or to link this force to pressure through the idea of force per unit area.

(b) (i) Comprehensive responses

- Most candidates correctly substituted into P = IV (2.5 × 12) to obtain a power of 30 W.

Limited responses

- A small number of candidates used an incorrect relationship, such as P = V/I.

(ii) Comprehensive responses

- The most successful responses stated that boiling occurs throughout the liquid whereas evaporation occurs only at the surface, and that boiling occurs only at the boiling point whereas evaporation can occur at any temperature below it.

Limited responses

- Many candidates instead compared the rate of the two processes (for example, stating that evaporation is slower than boiling) or referred to bubble formation.

(iii) Comprehensive responses

- Most candidates sketched a straight line of constant, non-zero gradient passing through the origin, correctly showing that current is directly proportional to voltage for a resistor of constant resistance.

Limited responses

- Some of the lines drawn did not pass through the origin or were curved.

Question 11

(a) (i) Comprehensive responses

- Some candidates described the vibration/oscillation of particles and stated that this occurred parallel to the direction of energy transfer.

Limited responses

- Most candidates were able to describe the vibration/oscillation of particles without stating that this vibration occurs in the same direction as the direction of energy transfer.
- Some candidates suggested the vibration occurred perpendicular to the direction of energy transfer.

(ii) Comprehensive responses

- Most candidates correctly identified sound as an example of a longitudinal wave.

Limited responses

- Some candidates only wrote ‘seismic waves’ rather than specifying seismic P-waves.
- Some candidates gave radio waves or microwaves as an example.

(b) Comprehensive responses

- Most candidates recognised that the waves produced by diffraction would be curved.
- Some candidates drew three curved wavefronts spreading out beyond the gap, with spacing consistent with the wavelength of the original waves, correctly showing diffraction.

Limited responses

- Some candidates drew straight rather than curved lines.
- Many candidates did not take into consideration the spacing between the wavefronts.

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(c) Comprehensive responses

- Where the full calculation was completed, candidates used n = sin i / sin r to find r = 30°, then correctly subtracted this from 90° to give θ = 60°, recognising that θ was measured from the surface rather than the normal.

Limited responses

- Some candidates substituted θ directly into the refraction equation in place of r, overlooking that θ was defined from the boundary rather than the normal, which led to an incorrect final answer despite an otherwise correct method.
- Many candidates who correctly found the angle of r did not subtract the value from 90 to find the value of θ.

Question 12

(a) (i) Comprehensive responses

- Most candidates correctly named gravitational attraction (or gravitational force/pull) as the force that keeps the Earth in orbit around the Sun.

Limited responses

- Some candidates confused the force with related quantities, giving answers such as 'gravitational field strength' or 'gravitational potential energy' instead of naming the force itself.

(ii) Comprehensive responses

- Almost all candidates correctly stated that the strength of the gravitational force decreases/weakens as distance from the Sun increases.

Limited responses

- A small number of candidates stated that the force increases or stays the same with distance.

(iii) Comprehensive responses

- Many candidates identified the reaction as fusion.
- Some candidates were able to specifically describe the combination of hydrogen nuclei to form helium.

Limited responses

- Some candidates omitted to use the term nuclear.
- Many candidates omitted to describe the elements involved.
- A few candidates stated nuclear fission as the reaction.
- A small number of candidates referred to radioactive decay.

(iv) Comprehensive responses

- Many candidates were able to recall a correct formula for orbital speed ($v = 2\pi r/T$).
- Some candidates were able to substitute some values into the formula.
- Some candidates were able to convert the radius into metres and the time into seconds.

Limited responses

- Some candidates incorrectly converted, or forgot to convert, the orbital period into seconds.
- Some candidates did not convert the orbital distance from km to m.
- Many candidates attempted to use an unrelated equation of motion, and so could not make further progress even when the unit conversion was correct. A good number directly divided the distance in km by the time in days.

(b) Comprehensive responses

- A few candidates correctly determined that 28 500 years corresponds to 5 half-lives (28 500 ÷ 5700) and went on to halve the count rate five times to reach approximately 9.6 counts/minute.

Limited responses

- Most candidates correctly identified the number of half-lives without completing the repeated halving of the count rate or carried out only a single halving.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/42
Theory (Extended)

Key messages

What candidates did well
- Many candidates used appropriate scientific terminology to describe phenomena.
- Few questions were left unanswered, and most candidates attempted all questions.
- There was evidence that many candidates were exposed to a good breadth of subject knowledge and could demonstrate strengths across a full range of topics.

What candidates needed to improve
- Some candidates did not follow the command words in the stem of the question. Occasionally, candidates attempted to explain phenomena when they were asked to describe them.
- Some candidates provided limited descriptions of phenomena and did not include units or identify trends, instead repeating information already provided in the stem of the question.
- In calculation questions, some candidates did not state the formula used and did not show their working.

Comments on specific questions

Question 1

(a) Comprehensive responses
- Many candidates identified the guard cell.

Limited responses
- Some candidates stated the cell as stomata instead of a guard cell.

(b) Comprehensive responses
- Many candidates stated chlorophyll.

Limited responses
- Some candidates identified the cell structure as a chloroplast rather than the pigment chlorophyll.

(c) Comprehensive responses
- Many candidates identified the spongy mesophyll as having air spaces for gas exchange.
- Many candidates recognised that the palisade mesophyll was situated at the top of the leaf for maximum light absorption or that it possessed many chloroplasts for light absorption.

Limited responses
- Some candidates used inaccurate language to describe the air spaces.
- Some candidates identified a large number of chloroplasts and did not link this to light absorption.
- A few candidates confused the spongy mesophyll and palisade layers.
- A few candidates described the palisade mesophyll layer as tightly packed rather than explaining that the cells within the layer were tightly packed.

(d) (i) Comprehensive responses
- Many candidates stated the test for carbon dioxide.

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Limited responses
- Some candidates stated the test as the limestone test.

(ii) Comprehensive responses
- Some candidates identified differences in the concentration of carbon dioxide in human airways and lungs.

Limited responses
- Many candidates suggested that the air spaces in plant leaves during the day would have the same concentration of carbon dioxide as atmospheric air.
- Many candidates suggested that inspired air in plant leaves during the day would have the same concentration of carbon dioxide as atmospheric air.
- A few candidates suggested that inspired air in the human airways would have a higher concentration of carbon dioxide than atmospheric air.
- A few candidates suggested that expired air from the human lungs would have a lower concentration of carbon dioxide than atmospheric air.

(e) Comprehensive responses
- Most candidates were able to divide their area by 10 to calculate the density of stomata.
- Some candidates were able to use a formula to calculate the area.
- Some candidates were able to round their value to the nearest whole number.

Limited responses
- Some candidates did not calculate the area accurately.
- Some candidates did not round their value to the nearest whole number.

Question 2

(a) Comprehensive responses
- Most candidates identified the hormone insulin.

Limited responses
- Some candidates identified alternative hormones, including testosterone, adrenaline or enzymes such as amylase.

(b) Comprehensive responses
- Many candidates stated that glucose was stored as glycogen.
- Some candidates stated that glycogen was stored in the liver.

Limited responses
- Some candidates stated that glucose was stored as sucrose or starch.
- Some candidates stated that glycogen was stored in the kidney or stomach.

(c) Comprehensive responses
- Many candidates stated that the organ that secretes glucagon was the pancreas.

Limited responses
- Some candidates stated the kidney or the stomach as the organ that secretes glucagon.

(d) Comprehensive responses
- Many candidates understood the principle of negative feedback.
- Many candidates were able to describe the principle of negative feedback with specific reference to controlling blood glucose concentration.
- Many candidates were able to use the correct terminology and the hormones insulin and glucagon and described their effects in the control of blood glucose concentration.

Limited responses
- Some candidates did not specify the direction in which the hormones regulated the blood glucose concentration.
- Some candidates referred to blood sugar levels or blood sugar concentration instead of blood glucose concentration.

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Question 3

(a) **Comprehensive responses**

- Many candidates identified the types of chicken in B and D.
- Many candidates were able to identify that chickens with the desirable features were selected and then bred.
- A few candidates were able to explain that this continued with their offspring for many generations.

Limited responses

- Some candidates identified the chicken in type A instead of B.
- Some candidates tried to explain this in terms of genetic engineering or genetic modification instead of selective breeding.

(b) **Comprehensive responses**

- Some candidates were able to describe the use of antibiotics as killing bacteria.
- A few candidates were able to explain that the use of antibiotics when not necessary can result in antibiotic resistance in bacteria.

Limited responses

- Many candidates identified that chicken Z had a bacterial infection and did not state what the antibiotics were used for or the risk of antibiotic resistance.

(c) (i) **Comprehensive responses**

- Many candidates identified the function of the different bacterial cell structures.

Limited responses

- Some candidates identified the plasmid as the site of protein synthesis.
- Some candidates identified the ribosome as containing extra genes.

(ii) **Comprehensive responses**

- Many candidates stated that the process was decomposition.
- Some candidates recognised the role of decomposition in releasing carbon dioxide back to the atmosphere or nutrients to the soil.
- A few candidates recognised the importance of the release of carbon dioxide for photosynthesis.

Limited responses

- Some candidates stated alternative processes including diffusion and respiration.
- Many candidates did not link the process with the provision of materials for photosynthesis and the beginning of the food chain.

Question 4

(a) **Comprehensive responses**

- Many candidates could describe fertilisation using the correct scientific terminology.

Limited responses

- Some candidates used the term foetus instead of zygote.
- Some candidates used the term diploid instead of haploid.

(b) (i) **Comprehensive responses**

- Many candidates were able to describe at least one adaptive feature of egg cells.
- Some candidates described the egg cells as having a haploid nucleus, preventing the doubling of chromosome number at fertilisation.

Limited responses

- Some candidates referred to the jelly coat as the cell membrane.
- Some candidates referred to the egg as having a yolk rather than having a nutrient store or energy store.

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(ii) Comprehensive responses

- Most candidates were able to describe female gametes as being larger and that fewer female gametes were produced during one event.
- Some candidates were able to describe the features of male gametes including the possession of an acrosome, flagellum or lots of mitochondria.
- Some candidates described sperm cells as being motile.

Limited responses

- A few candidates stated values from the table and did not give a descriptive difference between the male and female gametes.

(c) (i) Comprehensive responses

- Many candidates recognised that only one parent was required for asexual reproduction.
- Some candidates stated that the offspring produced would be genetically identical.

Limited responses

- Some candidates stated that the offspring would be similar and not genetically identical.

(ii) Comprehensive responses

- Some candidates were able to explain that, due to the lack of genetic variation, organisms would be unable to adapt to a change in the environment.
- Some candidates gave an example of a change in the environment such as disease.

Limited responses

- Some candidates gave a limited explanation and did not describe the lack of genetic variation.
- Some candidates suggested a lack of adaptation to their environment rather than a change in their environment.

Question 5

(a) Comprehensive responses

- Many candidates described the molecules as being close together and vibrating.

Limited responses

- Some candidates described the molecules as being unable to move.

(b) Comprehensive responses

- Some candidates could describe that the hydrogen molecules are moving faster due to their smaller molecular mass.

Limited responses

- Some candidates referred to hydrogen as being lighter.
- Some candidates referred to hydrogen and not hydrogen molecules.
- Some candidates repeated the question and stated that hydrogen diffused faster than nitrogen.

(c) Comprehensive responses

- Many candidates stated the value 21%.

Limited responses

- Some candidates gave the value 22%.

(d) (i) Comprehensive responses

- Some candidates were able to describe the formation of nitrous oxides.

Limited responses

- Some candidates did not refer to the high temperatures involved.

(ii) Comprehensive responses

- Some candidates constructed balanced equations.

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Limited responses
- A few candidates did not attempt this question.
- Some candidates did not balance the equation.
- Some candidates suggested alternative products or reactants.

(e) Comprehensive responses
- Many candidates displayed the covalent bonding in a molecule of nitrogen using appropriate dots and crosses.

Limited responses
- Some candidates suggested that nitrogen contained a single bond of one pair of shared electrons.

Question 6

(a) Comprehensive responses
- Many candidates identified the differences between copper and potassium.

Limited responses
- Some candidates identified that copper had a lower melting point.
- Some candidates identified that copper was softer than potassium.

(b) Comprehensive responses
- Most candidates were able to describe neon as having a full outer shell of electrons.
- A few candidates were able to explain that, due to the full outer shell of electrons, neon did not need to gain, lose or share electrons.

Limited responses
- Some candidates recognised that neon had a full outer shell of electrons and did not include that neon did not need to gain, lose or share electrons.

(c) Comprehensive responses
- Most candidates identified the section of the periodic table as D.

Limited responses
- Some candidates identified the section of the periodic table as B.

(d) Comprehensive responses
- Most candidates drew the correct electronic configuration of a magnesium atom.

Limited responses
- Some candidates included 4 electrons on the second shell of the magnesium atom.

(e) Comprehensive responses
- Some candidates described magnesium as having layers which were able to slide over each other.

Limited responses
- Some candidates described the atoms as being able to slide over each other.
- Some candidates tried to explain this in terms of delocalised electrons.

(f) (i) Comprehensive responses
- Most candidates identified ionic bonding.

Limited responses
- A few candidates stated covalent bonding instead of ionic bonding.

(ii) Comprehensive responses
- Many candidates identified that magnesium atoms would lose electrons and that oxygen atoms would gain electrons.
- Many candidates also identified that the number of atoms lost and gained was 2.

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Limited responses
- A few candidates suggested that magnesium and oxygen atoms shared electrons.
- A few candidates suggested that oxygen atoms transferred electrons to magnesium atoms.

Question 7

(a) Comprehensive responses
- Many candidates gave the correct state symbol.

Limited responses
- A few candidates gave the state symbol for an aqueous solution or for a liquid.

(b) (i) Comprehensive responses
- Most candidates gave the concentration A.

Limited responses
- There were too few incorrect responses to comment.

(ii) Comprehensive responses
- Most candidates identified concentration C and explained that this took the longest time or was the slowest reaction.

Limited responses
- A few candidates identified concentration C and did not explain this in terms of the length of time of the reaction.
- A few candidates tried to explain this in terms of particle density and did not refer to the time of the reaction.

(c) Comprehensive responses
- Many candidates identified that distilled water was pure or contained fewer impurities than tap water.

Limited responses
- Some candidates used inaccurate terminology and described tap water as containing chemicals or substances.

(d) (i) Comprehensive responses
- Most candidates gave a time of less than 124 seconds.

Limited responses
- A few candidates gave a time of more than 124 seconds.

(ii) Comprehensive responses
- Many candidates were able to describe the molecules as having a higher kinetic energy when the temperature was increased.
- Many candidates explained that an increase in temperature would result in a higher frequency of collisions and more successful collisions.
- A few candidates were able to explain this in terms of more molecules having the necessary activation energy.

Limited responses
- Some candidates referred to the molecules as having more energy and did not refer specifically to kinetic energy.
- Some candidates described an increase in the number of collisions instead of an increase in the frequency of collisions.

(e) Comprehensive responses
- Most candidates were able to describe sulfur dioxide as being produced from the burning or combustion of fossil fuels.
- Some candidates were able to describe these fossil fuels as containing sulfur compounds.

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Limited responses
- Many candidates described fossil fuels as containing other compounds including toxic, dangerous or carbon compounds.

Question 8

(a) (i) Comprehensive responses
- Some candidates identified the reactant as water or steam.

Limited responses
- Many candidates gave alternative reactants including alcohol and acid.
- Some candidates omitted this question.

(ii) Comprehensive responses
- Some candidates drew the correct repeating unit including brackets.

Limited responses
- Some candidates included a double bond.
- Some candidates drew ethane.
- Some candidates did not include the continuation bonds.

(iii) Comprehensive responses
- Many candidates identified decolourisation.

Limited responses
- A few candidates stated a colour change to orange.

(b) Comprehensive responses
- Some candidates were able to construct a fully balanced equation for the combustion of ethene.

Limited responses
- Some candidates suggested that hydrogen was a product.
- Some candidates suggested that water was a reactant.

(c) (i) Comprehensive responses
- Most candidates described the chain length as decreasing.

Limited responses
- A few candidates described the chain length as increasing.

(ii) Comprehensive responses
- Some candidates described the use as a chemical feedstock.
- Some candidates described the use for making chemicals or plastics.

Limited responses
- Some candidates gave alternative uses including fuel, heating and road building.

Question 9

(a) Comprehensive responses
- Many candidates were able to describe speed as a scalar quantity and velocity as a vector quantity.
- Some candidates described speed as having magnitude only and velocity as having magnitude and direction.

Limited responses
- Some candidates suggested that speed was a vector quantity and velocity was a scalar quantity.
- Some candidates gave the formula for speed and the formula for velocity.

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(b) (i) Comprehensive responses

- Some candidates described the non-constant acceleration.

Limited responses

- Most candidates described the motion as acceleration and did not describe this as non-constant acceleration.

(ii) Comprehensive responses

- Many candidates used the correct formula and calculated acceleration.

Limited responses

- Some candidates did not state the formula that they used.
- Some candidates used an alternative formula, for example the formula for speed, to give a different value.

(c) (i) Comprehensive responses

- Many candidates used the formula to calculate the resultant force of 6 N.
- Some candidates used the resultant force to calculate the resistive force.

Limited responses

- Some candidates did not use the correct formula and calculated a different resultant force.
- Some candidates calculated the resultant force and did not use this to calculate the resistive force.

(ii) Comprehensive responses

- Many candidates could recall the formula to calculate kinetic energy.
- Some candidates were able to use the formula to calculate the correct value.

Limited responses

- Some candidates did not square the velocity.
- Some candidates omitted to half their value.
- Some candidates did not round their value appropriately.

Question 10

(a) (i) Comprehensive responses

- Detecting fake banknotes, tanning and sterilisation were common correct answers.

Limited responses

- Some candidates suggested that the use was for X-rays.
- Some candidates suggested the use in the medical field and did not provide further details.

(ii) Comprehensive responses

- Many candidates gave the effects of UV radiation.

Limited responses

- A few candidates described damage and did not specify whether this was to cells, skin or eyes.

(b) (i) Comprehensive responses

- Many candidates were able to state that the direction was parallel to the direction of propagation.
- Some candidates specified that it was the direction of vibrations or oscillations that were parallel.

Limited responses

- Some candidates suggested that it was the direction of energy transfer instead of vibrations or oscillations.
- A few candidates suggested that the direction was perpendicular to the direction of propagation.

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(ii) Comprehensive responses

- Many candidates were able to state the lowest frequency of ultrasound and included the unit of hertz or kHz.

Limited responses

- Some candidates suggested the speed of sound.
- Some candidates confused the units hertz and kHz.
- A few candidates omitted the units.

(iii) Comprehensive responses

- Most candidates described compressions as having higher pressure and rarefactions as having lower pressure.
- Some candidates explained this in terms of particle density.

Limited responses

- A few candidates suggested that compressions were waves that were closer together and did not refer to particles.

(c) Comprehensive responses

- Many candidates were able to draw at least one correct line from the object through the lens.
- Some candidates drew the object on the other side of the lens in the correct position.

Limited responses

- Some candidates did not draw their line through the centre of the lens.
- Some candidates did not draw a line through one of the focal points.

Question 11

(a) (i) Comprehensive responses

- Many candidates stated that resistance also doubles when the length of the wire doubles.

Limited responses

- Some candidates suggested that the resistance increases and did not specify the magnitude of its increase.
- A few candidates suggested that the resistance halves.
- A few candidates suggested that the resistance stays the same.

(ii) Comprehensive responses

- Many candidates gave the correct resistance of 6.3 ohms.

Limited responses

- Some candidates gave the resistance of 25.2 ohms.

(b) (i) Comprehensive responses

- Some candidates were able to use the formula to give a total resistance of 50 ohms.
- Some candidates showed the formula they used and the relevant working.

Limited responses

- Many candidates did not show the formula they used or their working.
- Some candidates calculated the combined resistance as 0.1 instead of 10 ohms.
- Some candidates added the values of all the resistors to give a total resistance of 80 ohms.

(ii) Comprehensive responses

- Many candidates were able to recall the correct formula.

Limited responses

- Many candidates omitted to divide their value by 2 to give the correct value for current.

(c) Comprehensive responses

- Many candidates recalled the correct formula.
- Many candidates were able to substitute the values to give the energy in joules.

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Limited responses
- Some candidates did not convert between minutes and seconds.

Question 12

(a) (i) Comprehensive responses
- Many candidates were able to state the number of protons and neutrons.

Limited responses
- Some candidates stated the correct number of protons and did not state the correct number of neutrons.
- Some candidates stated the number of neutrons as 235.

(ii) Comprehensive responses
- Few candidates stated the relative charge of 92.

Limited responses
- Most candidates stated that the charge was positive.
- Many candidates omitted this question.

(iii) Comprehensive responses
- Many candidates described the process of nuclear fission as the division or splitting of nuclei.

Limited responses
- Some candidates described the process of nuclear fission as the division or splitting of an atom.

(b) Comprehensive responses
- Most candidates stated the source of background radiation as the Sun.
- A few candidates stated the source as cosmic rays.

Limited responses
- Many candidates suggested different parts of the electromagnetic spectrum.

(c) Comprehensive responses
- Many candidates identified the most common nuclear reaction as nuclear fusion.
- A few candidates were able to describe the combination of hydrogen nuclei to form helium.

Limited responses
- Many candidates omitted to describe the elements involved.
- A few candidates stated nuclear fission.

(d) Comprehensive responses
- Most candidates were able to recall the correct formula.
- Most candidates were able to substitute some values into the formula.
- A few candidates were able to calculate that the radius is 382 000 kilometres.

Limited responses
- Many candidates did not rearrange the formula appropriately.
- Many candidates did not calculate a correct distance.

(e) Comprehensive responses
- Most candidates could describe at least part of the Big Bang Theory.
- Many candidates described the universe as expanding from a single point of high density or temperature and included that the universe is still expanding.
- A few candidates stated the universe as being 13.8 billion years old.

Limited responses
- Some candidates omitted the term universe.
- Some candidates described the universe as expanding from a single point of high pressure.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/43
Theory (Extended)

Key messages

What candidates did well

- A small number of candidates highlighted or underlined key words in the question, which proved helpful in ensuring that the answer related to the question being asked.
- Some candidates articulated their ideas well and gave clear and concise responses.
- Most candidates showed their full working in calculation questions.
- The photosynthesis equation, structure of the heart, components of blood, atomic structure, enthalpy in reactions, covalent bonding, order of reactivity, constant velocity and acceleration were well known.

What candidates needed to improve

- Questions requiring more free-response style answers, particularly those in Biology, often lacked the required detail. It is advisable for candidates to practise these styles of question.
- Ensuring that all aspects of a question are answered, using both the mark allocation and the number of lines provided as a guide, can help with this.
- Candidates need to learn definitions and terms.
- Candidates needed to learn how to write correct formula and practise balancing equations.
- Biodiversity, mitosis, the role of capillaries, the route of water absorption by plants, stages in an enzyme-catalysed reaction, catabolic reactions, electrons and chemical properties, the hydrogen-oxygen fuel cell, constructing balanced equations, oxidation and reduction, products of electrolysis, electrical components and their effect on current in a circuit, step-up transformers, associated equations, the origin of beta decay, how stars release energy and critical angle were not well known.

Comments on specific questions

Section A

Question 1

(a) Comprehensive responses

- A small number of candidates drew all five lines correctly.
- Algae and mosquito larvae were well known.

Limited responses

- Many candidates drew two or three lines correctly, recognising the terms for two or three organisms, usually algae, mosquito larvae and fish.
- Very few candidates drew two lines from the dragonfly larva.

(b) (i) Comprehensive responses

- Some candidates knew the term biodiversity.

Limited responses

- Common incorrect responses included community, ecosystem and kingdom.

(ii) Comprehensive responses

- Most candidates calculated the average correctly.
- Most candidates gave a valid conclusion to the scientist's experiment.

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Limited responses
- A small number of candidates made an arithmetic error when calculating the average.

(c) (i) Comprehensive responses
- A very small number of candidates knew that mitosis is the division of the nucleus.
- A small number of candidates recognised that the cells produced were genetically identical.

Limited responses
- Most candidates referred to cell division.
- Many candidates knew that identical cells were formed, and few referred to them as genetically identical.

(ii) Comprehensive responses
- The word equation for photosynthesis was well known.

Limited responses
- The most common incorrect response had the equation reversed, giving the aerobic respiration equation.
- Some candidates swapped glucose and water.

Question 2

(a) Comprehensive responses
- Many candidates chose the correct letters.

Limited responses
- The left ventricle was often given as A or D.
- The pulmonary artery was often given as B.
- All letter options were seen quite often.

(b) (i) Comprehensive responses
- Many candidates discussed the difference in pressure between arteries and veins; this was well known.
- Some candidates discussed the differences in the walls and lumen.
- A small number of candidates discussed valves in veins and not arteries.

Limited responses
- Some candidates discussed the pressure in either the artery or the vein without comparing the two.
- Some candidates stated that the artery was thicker, with no reference to the walls.
- Many candidates referred to tubes or thinness without naming the lumen.
- Many candidates did not mention valves.

(ii) Comprehensive responses
- Some candidates knew what was transferred and explained how this could occur.
- Gas exchange was a common response.

Limited responses
- The most common answer was to transport blood around the body.
- Many candidates discussed transporting oxygen around the body.
- Many candidates stated that the cell walls were one cell thick rather than that the walls of the capillaries were one cell thick.
- Some candidates omitted the question.

(c) Comprehensive responses
- The parts of the blood were well known.

Limited responses
- Lymphocyte was sometimes identified as J.
- A cell which engulfs pathogens was sometimes identified as H.
- All combinations were seen.

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Question 3

(a) **Comprehensive responses**
- The differential water potential was well known.
- Some candidates described the movement of water through a partially permeable membrane.

Limited responses
- Some candidates had water moving from a low to high water potential.
- Some candidates had water moving either from high to low concentration or from low to high concentration.
- A small number of candidates had substances moving.
- Few candidates mentioned the need for a partially permeable membrane.

(b) **Comprehensive responses**
- A small number of candidates identified all three cells correctly.

Limited responses
- Xylem was the better known of the three cells.
- Incorrect responses for the first box included leaf, stomata, guard cells, branch, vacuole and xylem.
- Incorrect responses for the second box included stem and mesophyll cells.
- Incorrect responses for the third box included xylem, root hair and root cell.
- Some candidates omitted the question.

(c) (i) **Comprehensive responses**
- Many candidates calculated the rate correctly.

Limited responses
- Incorrect responses included 5.2, 5.8 and 6.

(ii) **Comprehensive responses**
- Many candidates concluded that increased wind speed increased the rate of water uptake.
- Some candidates appreciated that there would be more evaporation.
- Some candidates knew that there would be more movement of water through the leaf.
- A very small number of candidates considered the reduced humidity around the leaf or the greater concentration gradient caused by the wind.

Limited responses
- Many candidates described it bubbling more because it transpired more.
- Many candidates only repeated the data from the table or cited their argument multiple times.

(iii) **Comprehensive responses**
- Many candidates appreciated that the water intake would increase.
- Some candidates related this to the increased evaporation of water.

Limited responses
- Incorrect explanations included to cool itself down, to photosynthesise more, to transpire more and because the water particles move faster.

Question 4

(a) **Comprehensive responses**
- Glucose and energy were quite well known.

Limited responses
- Incorrect responses for glucose included protein, glycogen and lactic acid.
- Incorrect responses for energy included lactic acid, protein and glucose.

(b) **Comprehensive responses**
- Many candidates knew the products made during either or both aerobic and anaerobic respiration.

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- Some candidates appreciated the difference in energy released.

Limited responses
- Some candidates thought that energy was needed for both aerobic and anaerobic respiration.
- Some candidates thought that aerobic respiration uses glucose and anaerobic respiration does not.
- Many candidates thought that both aerobic and anaerobic respiration produce an oxygen debt.

(c) (i) Comprehensive responses
- A small number of candidates described a substrate binding to the active site of the enzyme, with some forming an enzyme-substrate complex.

Limited responses
- The stages of an enzyme-catalysed reaction were not well known.
- Many candidates discussed the enzyme mixing with or reacting with a substrate or food.
- The active site was not well known.
- A very small number of candidates included an enzyme-substrate complex.
- Few candidates mentioned the products being released from the enzyme.
- A significant number of candidates omitted the question.

(ii) Comprehensive responses
- Specificity of the enzyme was well known.

Limited responses
- Many candidates discussed the enzymes working best at different temperatures or pH values, or discussed the denaturation of enzymes.

(iii) Comprehensive responses
- A small number of candidates gave two correct rows and a similar number gave one correct row.

Limited responses
- Many of the expected substances were present, with at least one and usually two not matching.
- Many candidates left at least one blank space in the rows.
- There were also many incorrect substances included in the rows.
- Many candidates confused substrate and product.
- A significant number of candidates omitted the question.

Question 5

(a) (i) Comprehensive responses
- Blue was well known.

Limited responses
- Common errors included green and brown.

(ii) Comprehensive responses
- Many candidates calculated x correctly.

Limited responses
- Some candidates calculated x correctly from an incorrect Mr of water, which was often given as 8.
- The most common error was 90 – 18.
- Some candidates omitted the question.

(b) Comprehensive responses
- Some candidates gave all three treatments correctly.
- Filtration was well known.

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Limited responses

- Many candidates did not know the purpose of carbon. Incorrect responses included bacteria, germs, metals, non-metals and ions.
- The purpose of chlorine was known by some candidates. Incorrect responses included boiling, chemicals and heating.

(c) **Comprehensive responses**

- The atomic structure of the two isotopes was well known by many candidates.

Limited responses

- Some candidates discussed same protons instead of the same number of protons.
- Number was also omitted from neutrons.
- Incorrect responses included a different number of electrons and a different number of protons.
- A small number of candidates thought that the isotopes had the same mass.

(d) **Comprehensive responses**

- Some candidates knew that the number of electrons must be the same, and a very small number appreciated that the electronic structure was the same.

Limited responses

- Many candidates thought that the same number of protons explained the same chemical properties.
- Some candidates defined isotopes.

Question 6

(a) **Comprehensive responses**

- Most candidates knew the term exothermic.

Limited responses

- Incorrect responses included fire and radiation.

(b) **Comprehensive responses**

- A small number of candidates gave two correct mistakes.
- The relative energies of the reactants and products were the better known of the two.

Limited responses

- Incorrect responses included no ΔH, activation energy is incorrect without explaining how, the equation is not balanced, the reactant and product are not marked, there are no units and the activation energy should go downwards.

(c) **Comprehensive responses**

- A small number of candidates gave either an advantage or a disadvantage, and a very small number gave both.

Limited responses

- Many advantages were too vague, such as no pollution, eco-friendly, green and better for the environment.
- Disadvantages could refer to gasoline or hydrogen, such as explosive and combustible. Another common disadvantage was that it was expensive.

(d) **Comprehensive responses**

- A small number of candidates calculated the volume correctly.
- Many candidates showed all of their working.

Limited responses

- Incorrect responses included 6.6, where the unit had not been converted from kg to g; 13 200, where the stoichiometry had been omitted; and 13.2, where both the unit conversion and stoichiometry had been omitted.
- Some candidates divided by 24 instead of multiplying by 24.

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- Some candidates used 1 as the M_r of hydrogen.
- Some candidates omitted the question.

(e) Comprehensive responses

- Some candidates increased the pressure, and more candidates decreased the temperature.

Limited responses

- The most common incorrect response was to put it in a smaller box.

(f) Comprehensive responses

- The bonding in the oxygen molecule was well known.

Limited responses

- Some candidates only showed the bonding electrons.
- The most common incorrect response was a single bond between the two oxygen atoms and each oxygen atom having six non-bonding electrons.

Question 7

(a) Comprehensive responses

- A very small number of candidates gave a balanced symbol equation.

Limited responses

- Most candidates gave an incorrect formula for zinc chloride, including ZnC*l* and ZnHC*l*.
- Many candidates gave an incorrect formula for hydrochloric acid, including H_2C*l* and HCl_2.
- H was also seen frequently for hydrogen.

(b) (i) Comprehensive responses

- Many candidates read the correct value from the graph and then divided it by 60.

Limited responses

- Incorrect responses included 35 ÷ 3, 60 ÷ 35, adding lots of volumes together and then dividing by 3 or 4.

(ii) Comprehensive responses

- Some candidates drew a steeper curve which levelled at 35 cm^3.

Limited responses

- Many candidates drew a curve with a steeper gradient which levelled off at either a higher or lower volume than 35 cm^3.
- Some candidates drew a less steep curve.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- Some candidates appreciated the larger surface area giving rise to more frequent collisions.

Limited responses

- Incorrect responses included the smaller pieces of zinc having a smaller surface area, they would move faster, or they would have more kinetic energy and more collisions, with no reference to their frequency increasing.

(d) (i) Comprehensive responses

- High density was well known.

Limited responses

- Non-malleable and low boiling point were common incorrect responses.

(ii) Comprehensive responses

- Some candidates defined a catalyst correctly.

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Limited responses

- Whilst many candidates appreciated that a catalyst changes the rate of a reaction, few knew that it can be recovered unchanged at the end of the reaction or that it is not used up during the reaction.
- A significant number of candidates thought that the catalyst did not take part in the reaction.

Question 8

(a) (i) Comprehensive responses

- Colour change was well known.

Limited responses

- No bubbling and metal sinks were common incorrect reposes.

(ii) Comprehensive responses

- Most candidates gave the metals in the correct order.

Limited responses

- A small number of candidates reversed the order.

(b) Comprehensive responses

- A very small number of candidates described the oxidation and reduction reactions correctly.

Limited responses

- Some candidates described the loss of electrons by magnesium as oxidation.
- Very few candidates appreciated that it was the copper ion gaining electrons rather than the copper atom.
- Many candidates reversed the gain and loss of electrons.

(c) Comprehensive responses

- A very small number of candidates named the correct products at both electrodes.
- Some candidates named the product at the cathode correctly.

Limited responses

- Incorrect responses at the anode included sulfate, copper, sulfur, hydrogen, anion and water.
- Incorrect responses at the cathode included cation, sulfur and sulfate.

Question 9

(a) (i) Comprehensive responses

- Many candidates knew that mobile electrons were responsible for the conduction.

Limited responses

- Incorrect responses included because it has a regular lattice, electrons, moving particles and vibrating particles.

(ii) Comprehensive responses

- Some candidates drew a clockwise arrow.

Limited responses

- Many candidates drew an arrow in the incorrect direction or drew several arrows in different directions.
- Many candidates omitted the question.

(iii) Comprehensive responses

- Some candidates calculated the value correctly.

Limited responses

- Some candidates did not convert the minutes into seconds.
- Many candidates did not multiply 60 by 2 for the two minutes.
- Incorrect equations included $Q = IVt$, $L = 2R$ and $R = I \div V$.

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(iv) Comprehensive responses

- A very small number of candidates knew that the current increases because there is a lower combined resistance.

Limited responses

- Most candidates thought that the current would decrease because the resistance increased or because the current split into two.
- A significant number of candidates omitted the question.

(b) (i) Comprehensive responses

- A very small number of candidates described the construction of the step-up transformer completely.
- A small number of candidates knew that there were two coils of wire, and some of these named them as primary and secondary.

Limited responses

- Few candidates included a soft iron core in their description. Some candidates wrapped wires around without specifying around what.
- Very few candidates knew that there were more turns on the secondary coil.
- Many candidates described a generator.
- Many candidates omitted the question.

(ii) Comprehensive responses

- Very few candidates knew the correct equation to use.

Limited responses

- Many answers just had a scatter of numbers.
- Some candidates used number of turns and had 10 000 ÷ 80 as the sum.
- A common incorrect response was (80 × 230) ÷ 10 000 = 1.84.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- A very small number knew where a step-down transformer would be used.

Limited responses

- Incorrect responses included power station, in wires, in cables, in plugs and in wall sockets.
- Many candidates omitted the question.

Question 10

(a) Comprehensive responses

- Some candidates gave the ionising effects in the correct order.

Limited responses

- Many confused ionising effects with penetrating ability and so reversed the order.
- Many discussed the power of the radiations or the charge on the radiations.
- A significant number of candidates omitted the question.

(b) (i) Comprehensive responses

- A very small number knew that a neutron becomes a proton and an electron.

Limited responses

- Very few candidates knew that it was the neutron that transformed.
- Some candidates had loss of protons from the nucleus or gain of electrons into the nucleus.
- Many candidates described alpha decay.
- Some candidates discussed a loss of energy or the nucleus becoming unstable.
- A significant number of candidates omitted the question.

(ii) Comprehensive responses

- A small number of candidates explained why beta was the most useful.

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Limited responses

- Candidates did not understand that the level of radiation which would pass through the material would depend on the thickness of that material, and so many discussed the use of paper, aluminium and lead to stop the various radiations.
- Many candidates discussed the penetrating ability of beta with no reference to alpha or gamma or the use in the question.
- Some candidates discussed how dangerous the radiations were or their ionising effects, or stated that some were stronger than others or more harmful.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- Some candidates knew the formula of the alpha particle and balanced the equation correctly.
- Many candidates balanced the equation when the alpha particle was incorrect.

Limited responses

- Incorrect responses for the alpha particle included $\frac{1}{1}\alpha$, $\frac{1}{0}\alpha$, $\frac{0}{-1}\alpha$, $\frac{-4}{2}\alpha$ and $\frac{2}{4}\alpha$.
- The numbers on the Np were often found by adding the alpha particle numbers to those on the Am rather than subtracting them.
- Many candidates omitted the question.

(d) (i) Comprehensive responses

- A few candidates knew that hydrogen forms helium.
- Very few candidates knew it was nuclear fusion.

Limited responses

- Incorrect responses included fusion, fission, nuclear fission, collisions of atoms, solar winds, gamma radiation, radiation waves, heat, light, solar flares and decomposing.
- Most candidates did not mention any gases, and those that did often had helium splitting into hydrogen
- Many candidates omitted the question.

(ii) Comprehensive responses

- Some candidates defined a light year correctly.

Limited responses

- Incorrect responses included time light travels, distance to the Sun, distance between stars, distance per second and how many years light takes to travel.

Question 11

(a) (i) Comprehensive responses

- Most candidates described the motion correctly.

Limited responses

- Incorrect responses included no movement and stationary.

(ii) Comprehensive responses

- A small number of candidates described the motion correctly.

Limited responses

- Whilst most candidates appreciated that the car was decelerating, few candidates described this as constant.

(iii) Comprehensive responses

- Most candidates calculated the acceleration correctly.

Limited responses

- Incorrect responses included 2 ÷ 5 = 0.4 and 2 × 5 = 10.

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(b) **Comprehensive responses**

- Many candidates calculated the mass correctly.

Limited responses

- Some candidates gave an incorrect equation for kinetic energy, often ½ mv.
- Some candidates knew the equation and could not rearrange it correctly or made arithmetical errors.

(c) (i) **Comprehensive responses**

- Some candidates knew that air resistance was responsible, and a few candidates described the motion as slowing down or decelerating.

Limited responses

- Many candidates described the object either moving forward or dropping to the ground because of its weight or gravity.
- Some candidates omitted the question.

(ii) **Comprehensive responses**

- Many candidates knew that weight or gravity was acting on the object, and a very small number of candidates had the object accelerating.

Limited responses

- Many candidates described the object falling without appreciating that it would be accelerating as it fell.

Question 12

(a) **Comprehensive responses**

- Many candidates showed the amplitude correctly.

Limited responses

- Many candidates drew careless arrows that were too short.
- Some candidates thought that the distance from peak to trough was the amplitude.

(b) **Comprehensive responses**

- A small number of candidates gave three correct characteristics of the image.
- Same size and upright were the best-known characteristics.

Limited responses

- Incorrect characteristics included enlarged, real, reflected and inverted (unqualified).
- Some candidates described the diagram, including dissipation of waves going to the mirror, light bouncing off and going to the eye, and light bouncing off the normal.

(c) (i) **Comprehensive responses**

- Many candidates recalled the equation for refractive index and calculated the value correctly.

Limited responses

- Common incorrect answers were (sin 38 ÷ sin 60), 60 – 38 and (60 ÷ 38).
- Some candidates omitted the question.

(ii) **Comprehensive responses**

- A small number of candidates recalled that the angle would need to increase to be larger than the critical angle.

Limited responses

- The most common incorrect response was to increase the angle of refraction.
- Other incorrect responses included making the glass thicker, making the glass thinner and making the angle of incidence equal to the angle of refraction.
- Many candidates omitted the question.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/51
Practical Test

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates drew detailed diagrams of the flower.
- Candidates selected apparatus and described its use.
- The experimental procedures were followed carefully, and full sets of results were obtained.

What candidates needed to improve
- The diagram of the flower needed to contain sufficient detail of the male and female parts in the centre and have no shading.
- All parts of a question needed to be answered, such as drawing the width line in **Question 1(b)(ii)**.
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and then excluded.

Plan experiments and investigations

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to undertake the same investigation.
- Candidates recognised a control variable.
- The repetition of results was well known, and some candidates could explain why.
- Candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they could be easily followed by someone else.
- Candidates needed to state the range of control variables in an investigation.
- Candidates needed to know that results should be repeated and explain why repetition is necessary.
- Candidates needed to be able to explain how the results obtained from an investigation contribute to the formation of a conclusion.

Make and record observations, measurements and estimates

What candidates did well
- Candidates recorded measurements to match the precision requested in the question.
- Candidates recorded the expected observations of the experiments.
- Candidates drew results tables with appropriate headings and units.
- Candidates recorded all the results from the qualitative analysis experiment.

What candidates needed to improve
- Candidates should check the precision required by the question. Where measurements are to be made to the nearest 0.5 of the unit, values should end either in .0 or .5.
- Candidates should check the number of significant figures or decimal places in data already present in tables as a guide to the level of precision to which their values should be recorded.

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- Candidates needed to round values correctly.
- When carrying out qualitative analysis experiments, the contents of the reaction vessels needed to be observed carefully and all observations recorded.
- The results of qualitative analysis needed to be made more carefully and thoroughly.

Interpret and evaluate experimental observations and data

What candidates did well
- Candidates processed data from experiments correctly and gave answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Many candidates labelled the axes of their graphs with both quantities and units.
- Candidates showed their working on the graph to obtain estimates of a specific quantity.
- Lines of best fit were drawn well.

What candidates needed to improve
- Graphs needed to have the axes fully labelled, and the scales chosen needed to be appropriate and linear, with the plotted points covering at least half of the grid.
- Candidates needed to give answers specific to the experiment rather than generic responses.
- Candidates needed to use the Qualitative Analysis notes at the end of the paper to interpret their results.

Evaluate methods and suggest possible improvements

What candidates did well
- Candidates identified control variables.
- Candidates recognised random and systematic errors and suggested improvements.
- Many candidates explained why certain steps in a procedure were necessary.

What candidates needed to improve
- Sources of systematic and random error needed to be identified.
- Improvements to reduce the effects of error needed to be suggested.
- Candidates needed to be able to evaluate methods and explain why techniques and apparatus were used.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Many candidates used a clear, continuous line to draw their flower and made good use of the available space.
- Many candidates included the required detail, and their drawings closely resembled that of the supervisor.

Limited responses
- Some candidates used multiple sketchy lines, often with gaps in the outline.
- A small number of drawings were too small and did not use at least half of the space provided, or were too large and extended beyond the box.
- Some candidates drew flowers that did not resemble the supervisor's drawing and appeared to be pre-learnt diagrams. These diagrams also contained features that were not visible in the supervisor's drawing.

(ii) Comprehensive responses
- Many candidates correctly identified the location of the anther.

Limited responses
- Some candidates drew lines that did not touch the anther and instead indicated a petal. Some candidates labelled the filament.
- A small number of candidates omitted the question.

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(b)(i) Comprehensive responses

- Most candidates recorded an appropriate width in mm.

Limited responses

- Some candidates gave their measurements in cm rather than mm. Some candidates attempted unnecessary conversions, and common incorrect widths included values that were 10 or 100 times too large or too small.

(ii) Comprehensive responses

- Many candidates drew a line and measured the width correctly, sometimes using the same unit or conversion used in **Question 1(b)(i)**.

Limited responses

- A significant number of candidates did not draw a line as required by the question.

(iii) Comprehensive responses

- Most candidates calculated the magnification correctly and recorded their value to two significant figures.

Limited responses

- A small number of candidates inverted the calculation. Some candidates did not give their answer to the required two significant figures or did not round their value correctly.

Question 2

(a)(i) Comprehensive responses

- Most candidates drew an appropriate table, and many included suitable headings and units for the columns.

Limited responses

- Some candidates used amount of juice rather than volume and gave incorrect units. Some candidates gave only the units as the column headings.

(ii) Comprehensive responses

- Most candidates followed the procedure correctly and obtained a complete set of results.
- The volume recorded in the final minute was smaller than that recorded in the first minute.
- Volumes were recorded to the nearest 0.5 cm^3.

Limited responses

- Some candidates did not include a value at 0 minutes.
- Some measurements were recorded to the nearest cm^3 rather than to the nearest 0.5 cm^3.

(iii) Comprehensive responses

- Many candidates described their results accurately.

Limited responses

- Some candidates only considered the total amount of juice collected rather than the amount collected each minute, and an increase was a common incorrect response.

(b)(i) Comprehensive responses

- Many candidates repeated the experiment without the enzyme present.

Limited responses

- Some candidates repeated the experiment without describing any changes made. Common incorrect responses included heating and using different enzymes.

(ii) Comprehensive responses

- Some candidates gave an explanation of mixing, such as even distribution.

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Limited responses

- Some candidates repeated the question and gave mixing as their answer, which was insufficient. Some candidates answered a different question and thought it was to ensure an even temperature throughout the beaker. Other incorrect responses included increasing the rate of reaction and ensuring a complete reaction.

(iii) Comprehensive responses

- A small number of candidates explained the purpose of pureeing the apple, usually in terms of increasing surface area.

Limited responses

- Many candidates thought that it was not possible to filter large pieces of apple. Other incorrect responses included that the enzyme could not act on a solid or that pureeing would ensure a complete reaction.

(iv) Comprehensive responses

- Many candidates recognised the need to allow time for the enzyme to react.

Limited responses

- Many candidates thought that allowing more time would ensure a complete reaction.

Question 3

(a) Comprehensive responses

- Most candidates obtained a complete set of temperature readings.
- Values were often recorded to the nearest 0.5 °C.

Limited responses

- Values were sometimes recorded to the nearest °C rather than to the nearest 0.5 °C

(b) (i) Comprehensive responses

- In general, both axes were labelled with the quantity and the unit.
- Scales were linear, with the plotted points covering at least half of the grid.

Limited responses

- Some candidates omitted to label at least one of the axes with the appropriate units, and in some cases both axes.
- The instruction not to start the vertical axis from 0 was often not followed, and the plotted points did not cover at least half of the available grid. Those who did not start the vertical axis from 0 often tried to use all of the grid, and the scales were not easy to read. Scales should be straightforward, with large squares usually worth 1, 2, 4, 5, 10 or 20 units. Where awkward scales were used, candidates were often unable to read them accurately, and the points plotted were incorrect.
- A small number of candidates reversed the axes.

(ii) Comprehensive responses

- Some candidates drew a smooth curve with either a hump between the two maximum values or an extrapolation of a line continuing to ascend.

Limited responses

- Some candidates drew sketchy or multiple lines or used a ruler to draw the curve.
- Where two maximum values were obtained, many candidates did not recognise that the temperature would likely rise between the two maximum values and joined these two points with a straight line rather than a curve.

(iii) Comprehensive responses

- Many candidates drew a line from the maximum on their curve to the y-axis and read the temperature correctly.

Limited responses

- Some candidates did not draw a line on their graph to show the maximum temperature.

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- Candidates who used awkward scales almost always read the temperature incorrectly.

(iv) Comprehensive responses

- Most candidates used their results to calculate both values correctly.

Limited responses

- Some candidates did not subtract the temperature at 0 s from their maximum temperature or did not use their value from the first calculation in the second calculation.

(c) Comprehensive responses

- Some candidates correctly linked the contents of the cup to the reagent in excess.

Limited responses

- Many candidates thought that zinc was in excess because a pink solid was formed or could still be seen in the cup.
- Some candidates explained that the pink solid was copper and thought that copper or copper(II) sulfate was in excess.

(d)(i) Comprehensive responses

- A small number of candidates appreciated that the systematic error was the thermal energy given out to the surroundings.

Limited responses

- A range of incorrect responses was seen, including rounding, stirring, mass reading, volume reading and parallax.

(ii) Comprehensive responses

- Candidates who answered **Question 3(c)** correctly usually answered a method of reduction correctly as well.

Limited responses

- Systematic error was not well understood, and repetition of the procedure was the most common response.
- A small number of candidates omitted the question.

(iii) Comprehensive responses

- Random error was slightly better understood than systematic error, and some candidates discussed reading the temperature and how this could be improved.

Limited responses

- Where parallax error was discussed, candidates suggested reading the temperature directly or parallel or perpendicular to the thermometer, rather than perpendicular to the reading on the thermometer.
- Some candidates stated human error with no explanation.
- A small number of candidates omitted the question.

Question 4

(a) Comprehensive responses

- Some candidates followed the instructions carefully and obtained a complete set of results.

Limited responses

- Often only one result was given for the addition of sodium hydroxide rather than one for a few drops and one for excess.
- The colour of the bromide precipitate varied considerably, including pale white, milky, yellow and off-white. Many candidates gave only the colour and did not indicate that a precipitate was formed.

(b) Comprehensive responses

- Some candidates gave the correct identity of all three ions, dependent on the results obtained in **Question 4(a)**.

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Limited responses

- The most important thing to remember when answering qualitative analysis questions such as this is that the Qualitative Analysis sheet is printed at the back of the examination paper. It was clear from the responses that some candidates did not use this sheet.
- Some responses appeared unrelated to the results given, such as anion, cation, bromine and chloride, or only one ion being identified.
- The identity could be given in words of formula. The formula for the sulfate ion was often incorrect. The (II) was needed for iron(II), since iron(III) gives different results.

(c) Comprehensive responses

- A few candidates recognised the role of nitric acid.

Limited responses

- The most common response was to acidify it, with no further explanation. Other incorrect responses included neutralising it and diluting it.
- A significant number of candidates omitted the question.

Question 5

(a) (i) Comprehensive responses

- Most candidates obtained a complete set of results, many to one decimal place.
- The masses increased as the number of strands increased.

Limited responses

- Some gave their values to zero, two or three decimal places.

(ii) Comprehensive responses

- Most candidates described the relationship between the variables correctly.

Limited responses

- Many candidates thought that because the mass increases as the number of strips increases, the relationship must be proportional. For two variables to be proportional, the ratio between them must be constant, which was not the case here.

(iii) Comprehensive responses

- Some candidates described a genuine difficulty and suggested a strategy to overcome it. The most common were the bag not being in the centre of the strip and marking the centre, and the strips moving off the stand and so taping the ends so they could not move.

Limited responses

- Some candidates described a difficulty and did not suggest how it could be overcome.
- Some difficulties were examples of poor experimental technique and could not be described as difficulties, such as throwing the marbles into the bag.

(iv) Comprehensive responses

- Some candidates made the connection that a smaller diameter indicated that the marbles had a smaller mass and so the breaking mass of the spaghetti could be found more accurately.

Limited responses

- Many candidates used incorrect terms such as lighter or smaller weight rather than mass.
- There was also confusion regarding the terms accuracy and precision.
- A common response was that the smaller marbles would fit into the bag more easily and that more marbles would fit into the bag, with no further explanation.

(v) Comprehensive responses

- Most candidates recorded a value for the weight.

Limited responses

- Some candidates gave an integer value or a value to two decimal places.

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(b) (i) Comprehensive responses

- Many candidates chose the incorrect value and explained the error made by the student.

Limited responses

- Some candidates chose 1.91 because the calculation was incorrect. A significant number of candidates chose 1.57 despite the question stating that this value was correct.

(ii) Comprehensive responses

- Many candidates calculated the value correctly.

Limited responses

- Some candidates calculated the value correctly and then did not follow the pattern of two decimal places used in the table, giving the answer as 2.6.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- Some candidates suggested a correct value for F.

Limited responses

- Many candidates gave a suggested value for 1/F.

Question 6

Comprehensive responses

- Many candidates chose apparatus which they then used in their method.
- Some candidates gave a workable method in a logical order so that someone else could carry out the investigation using their plan.
- The measurements to be taken were clear, there were a minimum of five distances, and the need to repeat each distance was explained.
- Some candidates gave a control variable, usually the light intensity of either the lamp or the background.
- Some candidates suggested plotting a graph and gave the variables for each axis.
- A small number of candidates explained how they would use the results to reach a conclusion.

Limited responses

- Some candidates listed apparatus and did not use it in the method. Metre was a common term used instead of metre rule or ruler. Ammeter was sometimes used to measure voltage.
- Many candidates did not connect the voltmeter in a circuit with the solar cell and so did not have a workable method.
- Many candidates discussed measuring a distance without specifying between which points the distance was measured.
- Repeating the distances without explaining why this was necessary was common.
- Keeping the lamp the same was a common insufficient control.
- Plotting a graph was common, and few candidates stated the variables to be plotted on each axis.
- Using a table of results as a conclusion was common.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion.
- Some candidates changed the length of the wires and altered the connections in the circuit.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/52
Practical Test

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates selected apparatus and described its use.
- Candidates selected reagents and explained their use.
- The experimental procedures were followed carefully, and complete sets of results were obtained.

What candidates needed to improve
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and excluded.
- Candidates needed to know how to produce crystals from a solution.
- Candidates needed to know tests for water.

Plan experiments and investigations:

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to undertake the same investigation.
- Candidates recognised a control variable.
- The repetition of results was well known, and some candidates could explain why.
- Candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they could be followed by someone else.
- Candidates needed to state the control variables in an investigation.
- Candidates needed to know that results should be repeated and explain why repetition is necessary.
- Candidates needed to be able to explain how the results obtained from an investigation contribute to a conclusion.

Make and record observations, measurements and estimates:

What candidates did well
- Candidates recorded measurements to the precision requested in the question.
- Candidates recorded the expected observations of the experiments.

What candidates needed to improve
- Candidates should check the precision required by the question. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.
- Candidates should check the number of significant figures or decimal places in data already present in tables as a guide to the level of precision to which their values should be recorded.
- Candidates needed to check the precision to which measurements were requested to be recorded.
- Candidates needed to round values correctly.
- The results of qualitative analysis needed to be made more carefully and thoroughly.

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Interpret and evaluate experimental observations and data:

What candidates did well
- Candidates processed data from experiments correctly, giving answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Candidates labelled the axes of their graphs with both the quantities and the units.
- Lines of best fit were drawn well.
- Candidates showed the working on their graph to obtain the gradient of a line.

What candidates needed to improve
- Graphs needed to have fully labelled axes with quantity and unit.
- The scales chosen for the axes of the graph needed to be appropriate and linear, with the plotted points covering at least half of the grid and all of the points able to be plotted.
- Candidates needed to give answers specific to the experiment rather than generic responses.
- Candidates needed to use the Qualitative Analysis notes at the end of the paper.

Evaluate methods and suggest possible improvements:

What candidates did well
- Candidates identified control variables.
- Many candidates explained why certain steps in a procedure were necessary.
- Candidates were able to explain the range of measurements needed.

What candidates needed to improve
- Causes of error in experiments needed to be recognised.
- Improvements to reduce the effects of error needed to be suggested.
- Candidates needed to be able to evaluate methods, explaining why some techniques and apparatus were used.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Almost all candidates obtained a complete set of results.
- Almost all candidates recorded the values in mm and recorded a higher value for the greater volume of celery puree.

Limited responses
- A small number of candidates gave the volumes in cm or gave the height in mm but stated that it was in cm.
- Some candidates recorded the values to 0.1 mm.

(ii) Comprehensive responses
- Most candidates calculated the mean correctly.

Limited responses
- Some candidates gave the mean values to different numbers of significant figures.

(iii) Comprehensive responses
- Many candidates stated the relationship between the variables in the question correctly.

Limited responses
- Volume was often omitted from the relationship.
- More foam was often used instead of greater height.
- Many candidates thought that because the height increased as the volume increased, the relationship must be proportional. For two variables to be proportional, the ratio between them must be constant, which was not the case here.
- Positive relationship or correlation was insufficient.

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(iv) Comprehensive responses

- Many candidates recognised the relationship between time and rate and gave a correct relationship.

Limited responses

- Some candidates confused time with rate and so inverted the relationship.

(v) Comprehensive responses

- Many candidates suggested a lower height.

Limited responses

- Some candidates gave the generic answer of smaller results rather than using the specific outcome of height from this investigation.
- Since the question asked for a change, low was insufficient.
- A small number of candidates discussed rate rather than height. Incorrect responses also included less reactive and slower.

(b) (i) Comprehensive responses

- Some candidates gave an explanation of mixing, such as even distribution.

Limited responses

- Many candidates repeated the question and gave mixing as their answer, which was insufficient.
- Some candidates answered a different question and thought it was to give an even temperature throughout the beaker.
- Dissolving the celery puree was quite a common incorrect response.
- Other incorrect responses included increasing the rate of reaction and ensuring a complete reaction.

(ii) Comprehensive responses

- Some candidates explained the purpose of pureeing the celery, usually in terms of increasing the surface area.

Limited responses

- Many candidates thought that it was not possible to filter large pieces of solid celery.
- Other incorrect responses included the enzyme not being able to act on a solid, ensuring a complete reaction, making it soluble and dissolving it more quickly.
- A small number of candidates omitted the question.

(iii) Comprehensive responses

- A source of error was identified and an improvement suggested by many candidates. This was usually either the top of the foam being uneven and measuring the amount of gas given off in a gas syringe, the bottom of the boiling tube being rounded and changing to a piece of apparatus with a flat base, or the blank space at the end of the ruler and measuring just the foam.

Limited responses

- Parallax error was often used to describe any form of measurement error. Good experimental technique would not include parallax error.
- Incorrect improvements included levelling the foam with a ruler, waiting until the foam stopped increasing, taking lots of measurements and averaging them, and using different unspecified equipment.

Question 2

(a) Comprehensive responses

- Many candidates chose apparatus which they then used in their method.
- Some candidates gave a workable method in a logical order so that someone else could carry out the investigation using their plan.

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- The measurements to be taken were clear, there were a minimum of five different heights, and the need to repeat each height was explained.
- Some candidates gave a control variable, usually the time or intensity of the exercise.
- Some candidates suggested plotting a graph and gave the variables for each axis.
- A small number of candidates explained how they would use the results to reach a conclusion.

Limited responses

- Some candidates listed apparatus and did not use it in the method. Metre was seen instead of metre rule or tape measure. Some candidates did not know the name of the apparatus used to measure pulse, and blood pressure machine was seen quite often.
- Measuring the resting pulse was omitted by some candidates.
- Repeating the measurement without explaining why this was necessary was quite common.
- Plotting a graph was common, and some candidates stated the variables to be plotted on each axis.
- Making a table of results was sometimes used as a conclusion.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion.
- Some candidates carried out a different investigation and measured the pulse after different exercises to find the fittest.

Question 3

(a) Comprehensive responses

- Almost all candidates obtained a complete set of results.
- The masses were recorded to the same number of decimal places, with the value of M_3 between those of M_1 and M_2.

Limited responses

- A small number of candidates recorded the masses to different numbers of decimal places.
- A very small number of candidates did not have the value of M_3 between those of M_1 and M_2.

(b) (i) Comprehensive responses

- Almost all candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error or subtracted the incorrect values.

(ii) Comprehensive responses

- Almost all candidates calculated the value correctly.

Limited responses

- A small number of candidates made an arithmetical error or gave the answer to only one significant figure. Answers to calculations need to be given to at least two significant figures.

(iii) Comprehensive responses

- Almost all candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error or subtracted the incorrect values.

(iv) Comprehensive responses

- Almost all candidates calculated the value correctly.

Limited responses

- A small number of candidates made an arithmetical error or gave the answer to only one significant figure.

(v) Comprehensive responses

- Most candidates calculated the value correctly using their answers to the earlier parts of the question and gave x to one significant figure.

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Limited responses

- Some candidates either did not give the value of x to one significant figure or rounded their answer incorrectly.

(c) Comprehensive responses

- A small number of candidates appreciated that the powder must still contain some water and so should be further heated, preferably to constant mass.

Limited responses

- Incorrect responses included too much powder/crystals added, too little powder/crystals added, not cleaning the balance, not subtracting the mass of the evaporating basin, not resetting the balance, inaccurate mass measurements and a different starting mass.
- Some candidates omitted the question.

(d) Comprehensive responses

- Candidates gave a detailed description in the correct order.

Limited responses

- Many candidates heated or evaporated to dryness or left the solution to dry, thus forming a powder rather than crystals.
- Some candidates stated crystallisation with no details of how this would be done and so this was insufficient.
- Some candidates omitted the question.

(e) Comprehensive responses

- Some candidates knew both the test for water and the correct colour change.

Limited responses

- Those candidates who gave copper sulfate or cobalt chloride either did not state that they should be anhydrous or gave the incorrect starting colour for the reagent, often reversing the colour change.
- Many candidates mixed the reagents, so copper chloride and cobalt sulfate were common responses.
- Other incorrect responses included universal indicator, litmus, sodium hydroxide and methyl orange. Some candidates omitted the question.

(f) Comprehensive responses

- A small number of candidates compared the two equations and recognised that carbon dioxide was also given off in the reaction and that this contributed to the mass.

Limited responses

- Those candidates who recognised that carbon dioxide was also formed did not appreciate that it would leave the evaporating basin.
- Incorrect responses included that they were different experiments, they produced different products, they had different reactions, it decomposed and only formed the oxide.
- Some candidates omitted the question.

Question 4

(a) Comprehensive responses

- Some candidates followed the instructions carefully and obtained a complete set of results.

Limited responses

- Often only one result was given for the addition of sodium hydroxide rather than one for a few drops and one for excess.
- The colour of the iodide precipitate varied considerably, including pale white, milky and off-white. Many candidates gave only the colour and did not indicate that a precipitate was formed.
- The colour of the sulfate precipitate was sometimes cream.

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(b) **Comprehensive responses**

- Some candidates gave the correct identity of all three ions, dependent on the results obtained in **Question 4(a)**.

Limited responses

- The most important thing to remember when answering qualitative analysis questions such as this is that the Qualitative Analysis sheet is printed at the back of the examination paper. It was clear from the responses that some candidates did not use this sheet.
- Some responses bore no resemblance to the results given, such as anion, cation, bromine, iodine and chloride, or only one ion being identified.
- The identity could be given in words or formula. The formula for the sulfate ion was often incorrect.

Question 5

(a) (i) **Comprehensive responses**

- Almost all candidates obtained a complete set of results, with t increasing as m increased.

Limited responses

- A small number of candidates did not record the times to the nearest 0.1 s.

(ii) **Comprehensive responses**

- Almost all candidates divided by 10 successfully.

Limited responses

- A small number of candidates divided by 100.

(iii) **Comprehensive responses**

- Most candidates squared the number correctly.

Limited responses

- A small number of candidates rounded their values incorrectly.

(b) (i) **Comprehensive responses**

- In general, both axes were labelled with the quantity and the unit.
- Scales were linear, with the plotted points covering at least half of the grid.
- The plotted points were accurate.

Limited responses

- Some candidates omitted the appropriate units from at least one axis, and in some cases both axes. The unit for T^2 was often given as s.
- Plotted points did not always cover at least half of the available grid.
- Scales should be straightforward, with large squares usually worth 1, 2, 4, 5, 10 or 20 units. Where awkward scales were used, candidates were often unable to read them accurately, and the points plotted were incorrect.
- Scales were sometimes chosen such that not all of the points could be plotted.
- A small number of candidates reversed the axes.

(ii) **Comprehensive responses**

- A straight line of best fit was drawn well by many candidates, with points on both sides of the line.

Limited responses

- Some candidates drew multiple lines or drew a line that was not close to most of the points.
- Some candidates drew a curve.

(iii) **Comprehensive responses**

- Some candidates drew a suitable triangle that covered at least half of the line.
- The gradient from the triangle was calculated correctly.

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Limited responses

- Many candidates did not draw a triangle on the line or drew one that was too small.
- The gradient was often left as a fraction, the calculation inverted or the decimal point placed incorrectly.
- A significant number of candidates omitted the question.

(iv) Comprehensive responses

- Many candidates calculated the value of k correctly using their gradient from **Question 5(b)(iii)**.

Limited responses

- Some candidates inverted the division or gave an incorrect answer with no working shown.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- A very small number of candidates appreciated that the error in timing would be over a longer time and so would be less significant for the longer time of 20 oscillations.

Limited responses

- The most popular incorrect response assumed that the 20 oscillations meant 20 different measurements and so either anomalies could be identified more easily or a better average could be calculated.
- Other incorrect responses included 10 oscillations being too fast to measure, too inaccurate or too unreliable.
- A significant number of candidates omitted the question.

Question 6

(a) Comprehensive responses

- Almost all candidates obtained a complete set of results, with temperatures recorded to the nearest 0.5 °C.

Limited responses

- Some candidates recorded their values as whole numbers. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.

(b) Comprehensive responses

- Most candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error.

(c) Comprehensive responses

- Some candidates appreciated that the temperature was not double and showed this using a calculation from the data.

Limited responses

- Whilst many candidates appreciated that the temperature was not double, most did not explain their answer.

(d) Comprehensive responses

- Some candidates gave the two mistakes in the diagram.

Limited responses

- Many candidates gave one correct mistake and one incorrect mistake, while some candidates did not give any correct mistakes.
- Many candidates did not consider the bulb and discussed the thermometer as a whole.
- Incorrect responses included the thermometer being upside down, the thermometer being near the edge of the beaker, the thermometer not touching the bottom of the beaker, the beaker not being insulated or not having a lid, and there not being enough water in the beaker.

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(e) **Comprehensive responses**

- A very small number of candidates appreciated that the thermometer would take time to fall to the temperature of the water and so gave a temperature between 4 °C and 19 °C.

Limited responses

- The most common responses were 4, 4.5, 5 and 6, with the reason that the cold water would start warming up.
- Some candidates gave temperatures higher than room temperature, usually with no explanation.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/53
Practical Test

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates selected apparatus and described its use.
- Candidates selected reagents and explained their use.
- The experimental procedures were followed carefully, and complete sets of results were obtained.

What candidates needed to improve
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and excluded.
- Candidates needed to know how to produce crystals from a solution.
- Candidates needed to know tests for water.

Plan experiments and investigations:

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to undertake the same investigation.
- Candidates recognised a control variable.
- The repetition of results was well known, and some candidates could explain why.
- Candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they could be followed by someone else.
- Candidates needed to state the control variables in an investigation.
- Candidates needed to know that results should be repeated and explain why repetition is necessary.
- Candidates needed to be able to explain how the results obtained from an investigation contribute to a conclusion.

Make and record observations, measurements and estimates:

What candidates did well
- Candidates recorded measurements to the precision requested in the question.
- Candidates recorded the expected observations of the experiments.

What candidates needed to improve
- Candidates should check the precision required by the question. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.
- Candidates should check the number of significant figures or decimal places in data already present in tables as a guide to the level of precision to which their values should be recorded.
- Candidates needed to check the precision to which measurements were requested to be recorded.
- Candidates needed to round values correctly.
- The results of qualitative analysis needed to be made more carefully and thoroughly.

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Interpret and evaluate experimental observations and data:

What candidates did well
- Candidates processed data from experiments correctly, giving answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Candidates labelled the axes of their graphs with both the quantities and the units.
- Lines of best fit were drawn well.
- Candidates showed the working on their graph to obtain the gradient of a line.

What candidates needed to improve
- Graphs needed to have fully labelled axes with quantity and unit.
- The scales chosen for the axes of the graph needed to be appropriate and linear, with the plotted points covering at least half of the grid and all of the points able to be plotted.
- Candidates needed to give answers specific to the experiment rather than generic responses.
- Candidates needed to use the Qualitative Analysis notes at the end of the paper.

Evaluate methods and suggest possible improvements:

What candidates did well
- Candidates identified control variables.
- Many candidates explained why certain steps in a procedure were necessary.
- Candidates were able to explain the range of measurements needed.

What candidates needed to improve
- Causes of error in experiments needed to be recognised.
- Improvements to reduce the effects of error needed to be suggested.
- Candidates needed to be able to evaluate methods, explaining why some techniques and apparatus were used.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Almost all candidates obtained a complete set of results.
- Almost all candidates recorded the values in mm and recorded a higher value for the greater volume of celery puree.

Limited responses
- A small number of candidates gave the volumes in cm or gave the height in mm but stated that it was in cm.
- Some candidates recorded the values to 0.1 mm.

(ii) Comprehensive responses
- Most candidates calculated the mean correctly.

Limited responses
- Some candidates gave the mean values to different numbers of significant figures.

(iii) Comprehensive responses
- Many candidates stated the relationship between the variables in the question correctly.

Limited responses
- Volume was often omitted from the relationship.
- More foam was often used instead of greater height.
- Many candidates thought that because the height increased as the volume increased, the relationship must be proportional. For two variables to be proportional, the ratio between them must be constant, which was not the case here.
- Positive relationship or correlation was insufficient.

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(iv) Comprehensive responses

- Many candidates recognised the relationship between time and rate and gave a correct relationship.

Limited responses

- Some candidates confused time with rate and so inverted the relationship.

(v) Comprehensive responses

- Many candidates suggested a lower height.

Limited responses

- Some candidates gave the generic answer of smaller results rather than using the specific outcome of height from this investigation.
- Since the question asked for a change, low was insufficient.
- A small number of candidates discussed rate rather than height. Incorrect responses also included less reactive and slower.

(b) (i) Comprehensive responses

- Some candidates gave an explanation of mixing, such as even distribution.

Limited responses

- Many candidates repeated the question and gave mixing as their answer, which was insufficient.
- Some candidates answered a different question and thought it was to give an even temperature throughout the beaker.
- Dissolving the celery puree was quite a common incorrect response.
- Other incorrect responses included increasing the rate of reaction and ensuring a complete reaction.

(ii) Comprehensive responses

- Some candidates explained the purpose of pureeing the celery, usually in terms of increasing the surface area.

Limited responses

- Many candidates thought that it was not possible to filter large pieces of solid celery.
- Other incorrect responses included the enzyme not being able to act on a solid, ensuring a complete reaction, making it soluble and dissolving it more quickly.
- A small number of candidates omitted the question.

(iii) Comprehensive responses

- A source of error was identified and an improvement suggested by many candidates. This was usually either the top of the foam being uneven and measuring the amount of gas given off in a gas syringe, the bottom of the boiling tube being rounded and changing to a piece of apparatus with a flat base, or the blank space at the end of the ruler and measuring just the foam.

Limited responses

- Parallax error was often used to describe any form of measurement error. Good experimental technique would not include parallax error.
- Incorrect improvements included levelling the foam with a ruler, waiting until the foam stopped increasing, taking lots of measurements and averaging them, and using different unspecified equipment.

Question 2

(a) Comprehensive responses

- Many candidates chose apparatus which they then used in their method.
- Some candidates gave a workable method in a logical order so that someone else could carry out the investigation using their plan.

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- The measurements to be taken were clear, there were a minimum of five different heights, and the need to repeat each height was explained.
- Some candidates gave a control variable, usually the time or intensity of the exercise.
- Some candidates suggested plotting a graph and gave the variables for each axis.
- A small number of candidates explained how they would use the results to reach a conclusion.

Limited responses

- Some candidates listed apparatus and did not use it in the method. Metre was seen instead of metre rule or tape measure. Some candidates did not know the name of the apparatus used to measure pulse, and blood pressure machine was seen quite often.
- Measuring the resting pulse was omitted by some candidates.
- Repeating the measurement without explaining why this was necessary was quite common.
- Plotting a graph was common, and some candidates stated the variables to be plotted on each axis.
- Making a table of results was sometimes used as a conclusion.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion.
- Some candidates carried out a different investigation and measured the pulse after different exercises to find the fittest.

Question 3

(a) Comprehensive responses

- Almost all candidates obtained a complete set of results.
- The masses were recorded to the same number of decimal places, with the value of M_3 between those of M_1 and M_2.

Limited responses

- A small number of candidates recorded the masses to different numbers of decimal places.
- A very small number of candidates did not have the value of M_3 between those of M_1 and M_2.

(b) (i) Comprehensive responses

- Almost all candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error or subtracted the incorrect values.

(ii) Comprehensive responses

- Almost all candidates calculated the value correctly.

Limited responses

- A small number of candidates made an arithmetical error or gave the answer to only one significant figure. Answers to calculations need to be given to at least two significant figures.

(iii) Comprehensive responses

- Almost all candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error or subtracted the incorrect values.

(iv) Comprehensive responses

- Almost all candidates calculated the value correctly.

Limited responses

- A small number of candidates made an arithmetical error or gave the answer to only one significant figure.

(v) Comprehensive responses

- Most candidates calculated the value correctly using their answers to the earlier parts of the question and gave x to one significant figure.

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Limited responses

- Some candidates either did not give the value of x to one significant figure or rounded their answer incorrectly.

(c) Comprehensive responses

- A small number of candidates appreciated that the powder must still contain some water and so should be further heated, preferably to constant mass.

Limited responses

- Incorrect responses included too much powder/crystals added, too little powder/crystals added, not cleaning the balance, not subtracting the mass of the evaporating basin, not resetting the balance, inaccurate mass measurements and a different starting mass.
- Some candidates omitted the question.

(d) Comprehensive responses

- Candidates gave a detailed description in the correct order.

Limited responses

- Many candidates heated or evaporated to dryness or left the solution to dry, thus forming a powder rather than crystals.
- Some candidates stated crystallisation with no details of how this would be done and so this was insufficient.
- Some candidates omitted the question.

(e) Comprehensive responses

- Some candidates knew both the test for water and the correct colour change.

Limited responses

- Those candidates who gave copper sulfate or cobalt chloride either did not state that they should be anhydrous or gave the incorrect starting colour for the reagent, often reversing the colour change.
- Many candidates mixed the reagents, so copper chloride and cobalt sulfate were common responses.
- Other incorrect responses included universal indicator, litmus, sodium hydroxide and methyl orange. Some candidates omitted the question.

(f) Comprehensive responses

- A small number of candidates compared the two equations and recognised that carbon dioxide was also given off in the reaction and that this contributed to the mass.

Limited responses

- Those candidates who recognised that carbon dioxide was also formed did not appreciate that it would leave the evaporating basin.
- Incorrect responses included that they were different experiments, they produced different products, they had different reactions, it decomposed and only formed the oxide.
- Some candidates omitted the question.

Question 4

(a) Comprehensive responses

- Some candidates followed the instructions carefully and obtained a complete set of results.

Limited responses

- Often only one result was given for the addition of sodium hydroxide rather than one for a few drops and one for excess.
- The colour of the iodide precipitate varied considerably, including pale white, milky and off-white. Many candidates gave only the colour and did not indicate that a precipitate was formed.
- The colour of the sulfate precipitate was sometimes cream.

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(b) **Comprehensive responses**

- Some candidates gave the correct identity of all three ions, dependent on the results obtained in **Question 4(a)**.

Limited responses

- The most important thing to remember when answering qualitative analysis questions such as this is that the Qualitative Analysis sheet is printed at the back of the examination paper. It was clear from the responses that some candidates did not use this sheet.
- Some responses bore no resemblance to the results given, such as anion, cation, bromine, iodine and chloride, or only one ion being identified.
- The identity could be given in words or formula. The formula for the sulfate ion was often incorrect.

Question 5

(a) (i) **Comprehensive responses**

- Almost all candidates obtained a complete set of results, with t increasing as m increased.

Limited responses

- A small number of candidates did not record the times to the nearest 0.1 s.

(ii) **Comprehensive responses**

- Almost all candidates divided by 10 successfully.

Limited responses

- A small number of candidates divided by 100.

(iii) **Comprehensive responses**

- Most candidates squared the number correctly.

Limited responses

- A small number of candidates rounded their values incorrectly.

(b) (i) **Comprehensive responses**

- In general, both axes were labelled with the quantity and the unit.
- Scales were linear, with the plotted points covering at least half of the grid.
- The plotted points were accurate.

Limited responses

- Some candidates omitted the appropriate units from at least one axis, and in some cases both axes. The unit for T^2 was often given as s.
- Plotted points did not always cover at least half of the available grid.
- Scales should be straightforward, with large squares usually worth 1, 2, 4, 5, 10 or 20 units. Where awkward scales were used, candidates were often unable to read them accurately, and the points plotted were incorrect.
- Scales were sometimes chosen such that not all of the points could be plotted.
- A small number of candidates reversed the axes.

(ii) **Comprehensive responses**

- A straight line of best fit was drawn well by many candidates, with points on both sides of the line.

Limited responses

- Some candidates drew multiple lines or drew a line that was not close to most of the points.
- Some candidates drew a curve.

(iii) **Comprehensive responses**

- Some candidates drew a suitable triangle that covered at least half of the line.
- The gradient from the triangle was calculated correctly.

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Limited responses

- Many candidates did not draw a triangle on the line or drew one that was too small.
- The gradient was often left as a fraction, the calculation inverted or the decimal point placed incorrectly.
- A significant number of candidates omitted the question.

(iv) Comprehensive responses

- Many candidates calculated the value of k correctly using their gradient from **Question 5(b)(iii)**.

Limited responses

- Some candidates inverted the division or gave an incorrect answer with no working shown.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- A very small number of candidates appreciated that the error in timing would be over a longer time and so would be less significant for the longer time of 20 oscillations.

Limited responses

- The most popular incorrect response assumed that the 20 oscillations meant 20 different measurements and so either anomalies could be identified more easily or a better average could be calculated.
- Other incorrect responses included 10 oscillations being too fast to measure, too inaccurate or too unreliable.
- A significant number of candidates omitted the question.

Question 6

(a) Comprehensive responses

- Almost all candidates obtained a complete set of results, with temperatures recorded to the nearest 0.5 °C.

Limited responses

- Some candidates recorded their values as whole numbers. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.

(b) Comprehensive responses

- Most candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error.

(c) Comprehensive responses

- Some candidates appreciated that the temperature was not double and showed this using a calculation from the data.

Limited responses

- Whilst many candidates appreciated that the temperature was not double, most did not explain their answer.

(d) Comprehensive responses

- Some candidates gave the two mistakes in the diagram.

Limited responses

- Many candidates gave one correct mistake and one incorrect mistake, while some candidates did not give any correct mistakes.
- Many candidates did not consider the bulb and discussed the thermometer as a whole.
- Incorrect responses included the thermometer being upside down, the thermometer being near the edge of the beaker, the thermometer not touching the bottom of the beaker, the beaker not being insulated or not having a lid, and there not being enough water in the beaker.

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(e) **Comprehensive responses**

- A very small number of candidates appreciated that the thermometer would take time to fall to the temperature of the water and so gave a temperature between 4 °C and 19 °C.

Limited responses

- The most common responses were 4, 4.5, 5 and 6, with the reason that the cold water would start warming up.
- Some candidates gave temperatures higher than room temperature, usually with no explanation.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/61
Alternative to Practical

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates drew a detailed diagram of the flower.
- Candidates selected apparatus and described its use.

What candidates needed to improve
- The diagram of the flower needed to contain sufficient detail of the male and female parts in the centre and have no shading.
- All parts of a question needed to be answered, such as drawing the width line in **Question 1(b)(ii)**.
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and then excluded.
- Candidates needed to know why reagents are added in qualitative analysis.
- A safe flame test method needed to be given.

Plan experiments and investigations:

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to undertake the same investigation.
- Candidates recognised a control variable.
- The repetition of results was well known, and some candidates could explain why.
- Candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they could be followed by someone else.
- Candidates needed to state the control variables in an investigation.
- Candidates needed to know that results should be repeated and explain why repetition is necessary.
- Candidates needed to be able to explain how the results obtained from an investigation contribute to a conclusion.

Make and record observations, measurements and estimates:

What candidates did well
- Candidates recorded measurements to the precision requested in the question.
- Candidates recorded the expected observations of the experiments.
- Candidates drew results tables with appropriate headings and units.

What candidates needed to improve
- Candidates should check the precision required by the question. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.
- Candidates should check the number of significant figures or decimal places in data already present in tables as a guide to the level of precision to which their values should be recorded.

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- Candidates needed to round values correctly.

Interpret and evaluate experimental observations and data:

What candidates did well
- Candidates processed data from experiments correctly, giving answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Many candidates labelled the axes of their graphs with both the quantities and the units.
- Candidates showed the working on their graph to obtain estimates for a specific quantity.
- Lines of best fit were drawn well.

What candidates needed to improve
- Graphs needed to have fully labelled axes, and the scales chosen needed to be appropriate and linear, with the plotted points covering at least half of the grid.
- Candidates needed to give answers specific to the experiment rather than generic responses.
- Candidates needed to use the Qualitative Analysis notes at the end of the paper.

Evaluate methods and suggest possible improvements:

What candidates did well
- Candidates identified control variables.
- Candidates recognised random and systematic errors and suggested improvements.
- Many candidates explained why certain steps in a procedure were necessary.

What candidates needed to improve
- Sources of systematic and random error needed to be identified.
- Improvements to reduce the effects of error needed to be suggested.
- Candidates needed to be able to evaluate methods, explaining why some techniques and apparatus were used.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Many candidates used a clear, continuous line to draw the flower in the figure, making good use of the available space.
- The required detail was shown by many candidates, and the drawing closely resembled that of the figure.

Limited responses
- Some candidates used multiple sketchy lines, often with gaps in the outline.
- A small number of drawings were too small and did not use at least half of the box provided.
- Some candidates drew flowers which did not resemble the one in the Figure and appeared to be pre-learnt diagrams. These diagrams also contained features which were not visible in the figure.

(ii) Comprehensive responses
- Many candidates correctly identified the location of the anther.

Limited responses
- Some candidates drew lines that did not touch the anther and so indicated a petal. Some candidates labelled the filament.
- A significant number of candidates omitted the question.

(b) (i) Comprehensive responses
- Most candidates recorded the width correctly.

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Limited responses

- Some candidates gave their measurements in cm rather than mm. Some candidates attempted unnecessary conversions, and common incorrect widths included 0.47, 4.7, 470 and 4 700.

(ii) Comprehensive responses

- Many candidates drew a line and measured the width correctly, sometimes using the same incorrect unit or conversion seen in **Question 1(b)(i)**.

Limited responses

- A significant number of candidates did not draw a line, which was required by the question.

(iii) Comprehensive responses

- Most candidates calculated the magnification correctly and recorded their value to two significant figures.

Limited responses

- A small number of candidates inverted the calculation. Some candidates did not give their answer to the required two significant figures or did not round their value correctly.

Question 2

(a) (i) Comprehensive responses

- The apparatus required was well known, and all possibilities were seen.

Limited responses

- Some candidates used a pipette without qualifying the type of pipette. Other incorrect responses included beaker, test-tube, dropping pipette and ruler.

(ii) Comprehensive responses

- Some candidates gave an explanation of mixing, such as even distribution.

Limited responses

- Many candidates repeated the question and gave mixing as their answer, this was insufficient.
- Some candidates answered a different question and thought it was to give an even temperature throughout the beaker.
- Other incorrect responses included increasing the rate of reaction and ensuring a complete reaction.

(iii) Comprehensive responses

- A small number of candidates explained the purpose of pureeing the apple, usually in terms of increasing surface area.

Limited responses

- Many candidates thought that it was not possible to filter large pieces of solid apple.
- Other incorrect responses included the enzyme not being able to act on a solid or ensuring a complete reaction.

(iv) Comprehensive responses

- Allowing the enzyme time to react was well known.

Limited responses

- Many thought that the time would allow the reaction to go to completion.

(b) (i) Comprehensive responses

- Most candidates drew an appropriate table, many with suitable headings for the columns.

Limited responses

- Some candidates used amount of juice rather than volume and had inappropriate units.
- Some candidates only had the units as the headings for the columns.

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(ii) Comprehensive responses

- Most candidates recorded the given volumes correctly.

Limited responses

- Some candidates did not copy the values from the table accurately, recording 5 instead of 5.0.

(iii) Comprehensive responses

- Most candidates read and recorded the values correctly.

Limited responses

- Some candidates omitted the .0 from 9.0 or read the values to the nearest cm^3 instead of the nearest 0.5 cm^3.

(iv) Comprehensive responses

- Some candidates appreciated that although the overall amount of juice collected was increasing, the amount collected per minute was actually decreasing.
- Some candidates expressed this as the rate of collection decreasing or that the amount collected at the start was the greatest.
- Many candidates appreciated that juice collection stopped and used data to illustrate this.

Limited responses

- Many candidates only considered the total amount of juice collected rather than the amount collected each minute, and an increase was a common incorrect response.

(v) Comprehensive responses

- Many candidates repeated the experiment without the enzyme present.

Limited responses

- Some candidates repeated the experiment without any changes mentioned. Common incorrect responses included heating, without giving a temperature, and using different enzymes.
- A small number of candidates omitted the question.

Question 3

(a) (i) Comprehensive responses

- A few candidates appreciated that all of the cylinders could be used and the 50 cm^3 measuring cylinder would have the least error if used correctly, because only one measurement would need to be taken rather than several if the smaller measuring cylinders were used.

Limited responses

- Most candidates argued that the smaller measuring cylinders could not be used because they were too small and the contents would spill. Some stated that the 50 cm^3 measuring cylinder was the only one larger than the 30 cm^3 to be measured, without explaining why this was preferable.

(ii) Comprehensive responses

- Some candidates appreciated that the solution remained blue and therefore that copper(II) sulfate had to be in excess.

Limited responses

- Some candidates thought copper(II) sulfate formed a blue precipitate or a pink precipitate and hence was in excess, or that the blue solution was made during the reaction. Many thought zinc was in excess because a pink solid was formed. The colours of the reagents were given at the start of the experiment, and highlighting or underlining these when the question is read would help in this type of question.
- A small number of candidates omitted the question.

(iii) Comprehensive responses

- Most candidates recorded the two temperatures correctly.

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Limited responses

- Some candidates did not record the temperatures to the nearest 0.5 °C, and 37 and 36 were common incorrect responses.

(b) (i) Comprehensive responses

- In general, both axes were labelled with the quantity and the unit, scales were linear, with the plotted points covering at least half of the grid. The plots were accurate.

Limited responses

- Some candidates omitted to label at least one of the axes with the appropriate units, and in some cases both axes.
- The instruction not to start the vertical axis from 0 was often not followed, and so the plotted points did not cover at least half of the available grid. Those who did not start the vertical axis from 0 often tried to use all of the grid, and so the scales were not easy to read. Scales should be straightforward, with large squares usually worth 1, 2, 4, 5, 10 or 20 units. Where awkward scales were used, candidates were often unable to read them accurately, and so the points plotted were incorrect.
- A small number of candidates reversed the axes.

(ii) Comprehensive responses

- Some candidates drew a smooth curve with a hump between the two maximum values.

Limited responses

- Some candidates drew sketchy or multiple lines or used a ruler to draw the curve.
- Many candidates did not appreciate that the temperature would likely rise between the two maximum values and so joined these two points with a straight line.

(iii) Comprehensive responses

- Many drew a line from the top of the hump on their curve to the y-axis and read the temperature there correctly.

Limited responses

- Some candidates did not draw the line on their graph to show the maximum temperature.
- Candidates who had awkward scales almost always read the temperature incorrectly.

(iv) Comprehensive responses

- A very small number of candidates suggested taking extra readings between the two maximum values so that the true maximum could be determined.

Limited responses

- Many candidates suggested taking more readings, for example every 10 seconds, across the whole temperature range without appreciating that this was only needed between the two maxima.
- A small number of candidates omitted the question.

(v) Comprehensive responses

- Most candidates used their results to calculate both values correctly.

Limited responses

- Some candidates did not subtract the temperature at 0 s from their maximum temperature or did not use their value from the first calculation in the second calculation.

(c) (i) Comprehensive responses

- A very small number of candidates appreciated that the systematic error was the thermal energy given out to the surroundings.

Limited responses

- A range of incorrect responses was seen, including rounding, leaving it for too long, stirring, mass reading, volume reading and parallax.

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(ii) Comprehensive responses

- Candidates who answered **Question 3(c)(i)** correctly usually answered a method of reduction correctly as well.
- A significant number omitted the question.

Limited responses

- Systematic error was not well understood, and the most common response was repetition of the procedure.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- Random error was slightly better understood than systematic error, and some candidates discussed reading the temperature and how this could be improved.

Limited responses

- Where parallax error was discussed, candidates suggested reading the temperature directly or parallel or perpendicular to the thermometer rather than perpendicular to the reading on the thermometer. Many stated human error with no explanation.
- Many candidates stated human error with no explanation.

Question 4

(a) (i) Comprehensive responses

- Some candidates gave the identity of all three ions.

Limited responses

- The most important thing to remember when answering qualitative analysis questions such as this is that the Qualitative Analysis sheet is printed at the back of the examination paper. It was clear from the responses that many candidates did not use this sheet.
- Many answers were clearly guesses and bore no resemblance to the results given such as anion, cation, bromine and chloride or only one ion was identified.
- The identity could be in words of formula. The formula for the sulfate ion was frequently incorrect. The (II) was needed for iron(II), since iron(III) gives different results.
- A significant number of candidates omitted the question.

(ii) Comprehensive responses

- A few candidates recognised the role of nitric acid.

Limited responses

- The most common response was to acidify it with no further explanation.
- Other incorrect responses included neutralising it and diluting it.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- Some candidates gave a detailed and safe method for conducting a flame test, including the use of a blue Bunsen burner flame.

Limited responses

- Candidates tended to put the solution into a container and heat it or use an unsafe method such as spraying the solution into a flame. Some suggested solidifying the solution and then burning it.
- Many candidates put the splint/wire into a Bunsen burner, with no mention of a flame.
- Few candidates recognised that a blue Bunsen burner flame was required.
- A significant number of candidates omitted the question.

(b) Comprehensive responses

- A few candidates recognised that either the splint/wire or the solution was contaminated with sodium ions.

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Limited responses

- Many candidates discussed either the flame being yellow or the yellow flame masking the flame colour.
- Many candidates thought that sulfur or sulfate made the flame yellow.
- Some candidates identified the flame as being due to the presence of sodium, with no further explanation.
- Some candidates omitted the question.

Question 5

(a) (i) Comprehensive responses

- Most candidates recorded the masses to 0.1 g correctly.

Limited responses

- The readings were copied in full, with no rounding to the nearest 0.1 g. Other common incorrect responses were 68.1, 68.3 and 75.6.

(ii) Comprehensive responses

- Some candidates described the relationship of mass increasing as the number of strips increased, and a small number appreciated that the increase in mass became smaller as the number of strips increased.

Limited responses

- Many candidates thought that because the mass increased as the number of strips increased, the relationship must be proportional. For two variables to be proportional, the ratio between them must be constant, and here it was not.
- The size of the increase decreasing as the number of strips increased was missed by most candidates.

(iii) Comprehensive responses

- Some candidates made the connection that a smaller diameter must indicate that the marbles had a smaller mass and so the breaking mass of the spaghetti could be found more accurately.

Limited responses

- Many candidates used incorrect terms such as lighter or smaller weight rather than the mass in question.
- There was also confusion regarding the terms accuracy and precision.
- A common response was that the smaller marbles would fit into the bag more easily and that more marbles would fit in the bag, with no further explanation.

(iv) Comprehensive responses

- A small number of candidates ensured that either the clamps were at the same height above the bench or used a spirit level, ensuring that the air bubble was at the centre.

Limited responses

- There were many incorrect responses, including checking by eye, using a protractor without explaining what was being measured, aligning the strands with the stands, putting the strands across the stands and holding the strands vertically.

(b) (i) Comprehensive responses

- Many candidates chose the incorrect value and explained the error made by the candidate.

Limited responses

- Some candidates chose 1.91 because the calculation was incorrect.
- A significant number of candidates chose 1.57 despite the question stating that this value was correct.

(ii) Comprehensive responses

- Many candidates calculated the value correctly.

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Limited responses

- Some candidates calculated the value correctly and then did not follow the pattern of two decimal places used in the table, giving the answer 2.6.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- Some candidates suggested a correct value for F.

Limited responses

- Many candidates gave a suggested value for 1/F.
- A significant number of candidates omitted the question.

(iv) Comprehensive responses

- A small number of candidates appreciated that the variables were not proportional, usually because the ratio between them was not constant or by showing that as one doubled, the other did not.

Limited responses

- Many candidates believed that because as one variable increased in value, so did the other, then they must be proportional.
- A significant number of candidates omitted the question.

Question 6

Comprehensive responses

- Many candidates chose apparatus which they then used in their method.
- Some candidates gave a workable method in a logical order such that someone else could carry out the investigation using their plan.
- The measurements to be taken were clear, there were a minimum of five distances, and the need to repeat each distance was explained.
- Some gave a control variable, usually the light intensity of either the lamp or the background.
- Some suggested plotting a graph and gave the variables for each axis.
- A small number explained how they would use the results to reach a conclusion.

Limited responses

- Some candidates listed apparatus and did not use it in the method. Metre was common for metre rule or ruler. Ammeter was sometimes used to measure voltage.
- Many did not connect the voltmeter in a circuit with the solar cell and so did not have a workable method.
- Many discussed measuring a distance whilst not specifying what the distance was between.
- Repeating the distances without explaining why this was necessary was common.
- Keeping the lamp the same was a common insufficient control.
- Plotting a graph was common and few candidates stated the variables to be plotted on each axis.
- Many candidates used a table of results as a conclusion.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion
- Some candidates changed the length of the wires and altered the connections in the circuit.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/62
Alternative to Practical

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates selected apparatus and described its use.
- Candidates selected reagents and explained their use.
- Candidates knew the reagent used to test for reducing sugars.
- Candidates recognised safety hazards.

What candidates needed to improve
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and then excluded.
- Candidates needed to be able to describe how to carry out a test for reducing sugars.
- Candidates needed to know how to use a balance, including the taring function.
- Candidates needed to know how to produce crystals from a solution.
- Candidates needed to know why reagents are added in qualitative analysis.
- A safe flame test method needed to be given.
- Candidates needed to know why precautions are taken for safety hazards.

Plan experiments and investigations:

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to undertake the same investigation.
- Candidates recognised a control variable.
- The repetition of results was well known, and some candidates could explain why.
- Candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they could be followed by someone else.
- Candidates needed to state the range of control variables in an investigation.
- Candidates needed to know that results should be repeated and explain why repetition is necessary.
- Candidates needed to be able to explain how the results obtained from an investigation contribute to a conclusion.

Make and record observations, measurements and estimates:

What candidates did well
- Candidates recorded measurements to the precision requested in the question.
- Candidates recorded the expected observations of the experiments.

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What candidates needed to improve

- Candidates should check the precision required by the question. Where measurements are to be made to the nearest 0.5 unit, values should end in .0 or .5.
- Candidates should check the number of significant figures or decimal places in data already present in tables as a guide to the level of precision to which their values should be recorded.
- Candidates needed to check the precision to which measurements needed to be recorded.
- Candidates needed to round values correctly.

Interpret and evaluate experimental observations and data:

What candidates did well

- Candidates processed data from experiments correctly, giving answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Many candidates labelled the axes of their graphs with both the quantities and the units.
- Lines of best fit were drawn well.
- Candidates showed the working on their graph to obtain the gradient of a line.

What candidates needed to improve

- Graphs needed to have fully labelled axes with quantity and unit.
- The scales chosen for the axes of the graph needed to be appropriate and linear, with the plotted points covering at least half of the grid.
- Candidates needed to give answers specific to the experiment rather than generic responses.
- Candidates needed to use the Qualitative Analysis notes at the end of the paper.

Evaluate methods and suggest possible improvements:

What candidates did well

- Candidates identified control variables.
- Many candidates explained why certain steps in a procedure were necessary.
- Candidates were able to explain the range of measurements needed.

What candidates needed to improve

- Improvements to reduce the effects of error needed to be suggested.
- Candidates needed to be able to evaluate methods, explaining why some techniques and apparatus were used.

Comments on specific questions

Question 1

(a)(i) Comprehensive responses

- Most candidates measured the distances correctly and recorded them to one decimal place.

Limited responses

- A small number of candidates measured the height of the foam rather than the height of the mixture and the foam.
- Some candidates recorded at least one of the values as an integer, usually 5.

(ii) Comprehensive responses

- Most candidates calculated the mean correctly.

Limited responses

- Some candidates gave the mean values to different numbers of significant figures.

(iii) Comprehensive responses

- Many candidates stated the relationship between the variables in the question correctly.

Limited responses

- Volume was often omitted from the relationship.

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- More foam was used instead of greater height.
- Many candidates thought that because the height increased as the volume increased, then the relationship must be proportional. For two variables to be proportional, the ratio between them should be constant, and here it was not.
- Positive relationship or correlation was insufficient.

(iv) Comprehensive responses

- Many candidates recognised the relationship between time and rate and so gave a correct relationship.

Limited responses

- Some candidates confused time with rate and so inverted the relationship.

(v) Comprehensive responses

- Many candidates suggested a lower height.

Limited responses

- Some candidates gave the generic answer of smaller results rather than using the specific height values from this investigation.
- Since the question asked for a change, low was insufficient.
- A small number of candidates discussed rate rather than height. Incorrect responses also included less reactive and slower.

(b) (i) Comprehensive responses

- Some candidates gave an explanation of mixing, such as even distribution.

Limited responses

- Many candidates repeated the question and gave mixing as their answer, which was insufficient.
- Some answered a different question and thought it was to give an even temperature throughout the beaker.
- Dissolving the celery puree was quite a common incorrect response.
- Other incorrect responses included increasing the rate of reaction and ensuring a complete reaction.

(ii) Comprehensive responses

- Some candidates explained the purpose of pureeing the celery, usually in terms of increasing the surface area.

Limited responses

- Many candidates thought that it was not possible to filter large pieces of solid celery.
- Other incorrect responses included the enzyme not being able to act on a solid, ensuring a complete reaction, making it soluble and dissolving it more quickly.
- A small number of candidates omitted the question.

(iii) Comprehensive responses

- A source of error was identified and an improvement suggested by some candidates. This was usually either the top of the foam being uneven and measuring the amount of gas given off in a gas syringe or the bottom of the boiling tube being rounded and changing to a piece of apparatus with a flat base.

Limited responses

- Parallax error was most commonly used to describe any form of measurement error. Good experimental technique would not include parallax error.
- Common incorrect responses included the boiling tube not being fixed, the ruler not being parallel to the boiling tube and the irregular shape of the foam.
- Incorrect improvements included levelling off the foam with a ruler, waiting until the foam stopped increasing, taking lots of measurements and averaging them, and using different unspecified equipment.

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(iv) Comprehensive responses

- The apparatus required was well known, and all possibilities were seen.

Limited responses

- Some candidates used a pipette without qualifying the appropriate type of pipette.
- Other incorrect responses included test-tube, beaker, dropping pipette, measuring tube and ruler.
- A small number of candidates omitted the question.

(v) Comprehensive responses

- Some candidates stated Benedict's solution and appreciated that heat was also needed.

Limited responses

- Although Benedict's solution was well known, most candidates did not describe the test needing heating.
- Some candidates used Biuret solution or iodine solution.

Question 2

Comprehensive responses

- Many candidates chose apparatus which they then used in their method.
- Some candidates gave a workable method in a logical order such that someone else could carry out the investigation using their plan.
- The measurements to be taken were clear, there were a minimum of five different heights, and the need to repeat each height was explained.
- Some candidates gave a control variable, usually the time or intensity of the exercise.
- Some candidates suggested plotting a graph and gave the variables for each axis.
- A small number of candidates explained how they would use the results to reach a conclusion.

Limited responses

- Some candidates listed apparatus and did not use it in the method. Metre was common for metre rule or tape measure. Some did not know the name of the apparatus used to measure pulse; blood pressure machine was quite common.
- Measuring the resting pulse was omitted by some candidates.
- Repeating the measurement without explaining why this was necessary was common.
- Plotting a graph was common and few candidates stated the variables to be plotted on each axis.
- Many candidates used a table of results as a conclusion.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion.
- Some candidates did a different investigation and measured the pulse after different exercises to find the fittest.

Question 3

(a)(i) Comprehensive responses

- Some candidates tared the balance or reset it to zero.

Limited responses

- Many candidates thought that the balance needed to be cleaned each time it was used.
- Other incorrect responses included taking off the mass of the basin, using a digital balance, using a different balance, weighing multiple times and taking an average, and placing the balance on a flat surface.

(ii) Comprehensive responses

- A very small number of candidates appreciated that a yellow flame would leave soot on the basin, which would alter its mass.

Limited responses

- Many candidates repeated the question, stating that the flame was hotter.
- Some answered a different question about flame tests and stated that a yellow flame would mask the colour change.

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- Other incorrect responses included it being safer and giving a faster reaction.

(iii) Comprehensive responses

- Most candidates recorded the masses correctly to three significant figures.

Limited responses

- Some candidates either copied the entire mass readings or rounded incorrectly. Common incorrect responses included 51.2, 51.17, 46 and 45.6.

(b) (i) Comprehensive responses

- Most candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error.

(ii) Comprehensive responses

- Most candidates calculated the value correctly.

Limited responses

- A small number of candidates made an arithmetical error or gave 5.40.

(iii) Comprehensive responses

- Almost all candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error or subtracted the incorrect values.

(iv) Comprehensive responses

- Many candidates calculated the value correctly.

Limited responses

- The main error was giving the answer to one significant figure. Answers to calculations need to be given to at least two significant figures.

(v) Comprehensive responses

- Most candidates calculated the value correctly using their answers to the earlier parts of the question and gave x to one significant figure.

Limited responses

- Some candidates either did not give the value of x to one significant figure or rounded their answer incorrectly.

(c) Comprehensive responses

- A small number of candidates appreciated that the powder must still contain some water and so should be further heated, preferably to constant mass.

Limited responses

- Incorrect responses included too much powder/crystals added, too little powder/crystals added, did not clean the balance, did not subtract the mass of the evaporating basin, did not reset the balance, should measure more accurately and used a different evaporating basin.
- Some candidates omitted the question.

(d) Comprehensive responses

- Candidates gave a detailed description in the correct order.

Limited responses

- Many candidates heated or evaporated to dryness or left the solution to dry, thus forming a powder rather than crystals.
- Some candidates stated crystallisation with no details of how this would be done and so this was insufficient.
- A significant number of candidates omitted the question.

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(e) **Comprehensive responses**

- Some candidates knew both the test for water and the correct colour change.

Limited responses

- Those candidates who gave copper sulfate or cobalt chloride either did not state that they should be anhydrous or gave the incorrect starting colour for the reagent, often reversing the colour change.
- Many candidates mixed the reagents, so copper chloride and cobalt sulfate were seen quite often.
- Other incorrect responses included universal indicator, iodine, ethanol, litmus, water, cobalt hydroxide, copper hydroxide, sodium hydroxide, methyl orange, chlorine and sodium carbonate.
- A significant number of candidates omitted the question.

(f) **Comprehensive responses**

- A small number of candidates compared the two equations and recognised that carbon dioxide was also given off from the reaction and that this had mass.

Limited responses

- Those candidates who recognised that carbon dioxide was also formed did not appreciate that it would leave the evaporating basin.
- Incorrect responses included that they were different experiments, they produced different products, it decomposed and only formed the oxide.
- A significant number of candidates omitted the question.

Question 4

(a) **Comprehensive responses**

- Some candidates gave the identity of all three ions.

Limited responses

- The most important thing to remember when answering a qualitative analysis question such as this is that the Qualitative Analysis sheet is printed at the back of the examination paper. It was clear from the responses that some candidates did not use this sheet.
- Incorrect responses included iodine, anions and cations.
- The identity could be given in words or formula. The formula for the sulfate ion was often incorrect.
- A small number of candidates omitted the question.

(b) **Comprehensive responses**

- A few candidates recognised the role of nitric acid.

Limited responses

- The most common response was to acidify it with no further explanation. Other incorrect responses included neutralising it, it being more reactive, giving it colour and diluting it.
- A significant number omitted the question.

(c) **Comprehensive responses**

- A small number of candidates recognised that since hydrochloric acid contains the chloride ion, the white precipitate formed would mask the colour of the iodide precipitate.

Limited responses

- Those that appreciated that the acid contained the chloride ion usually did not explain why this was a problem.
- Many candidates thought that the hydrochloric acid was too reactive or too strong, that it increased the rate of reaction, removed impurities or that it did not react with the silver nitrate.
- A significant number of candidates omitted the question.

(d) **Comprehensive responses**

- Some candidates gave a detailed and safe method for conducting a flame test, including the use of a blue Bunsen burner flame.

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Limited responses

- Candidates tended to put the solution into a container and heat it or use an unsafe method such as spraying the solution into a flame. Some suggested solidifying the solution and then burning it.
- Many candidates put the splint/wire into a Bunsen burner, with no mention of a flame.
- Few candidates recognised that a blue Bunsen burner flame was required.
- A significant number of candidates omitted the question.

Question 5

(a) (i) Comprehensive responses

- Most candidates recorded the times correctly.

Limited responses

- A small number of candidates either copied the whole stopwatch display, rounded the values incorrectly or did not record the values to the nearest 0.1 s. Incorrect responses included 58, 5.57, 7.04 and, most commonly, 7.

(ii) Comprehensive responses

- Most candidates divided by 10 successfully.

Limited responses

- A small number of candidates divided by 100.

(iii) Comprehensive responses

- Most candidates squared the number correctly.

Limited responses

- A small number of candidates rounded their values incorrectly.

(b) (i) Comprehensive responses

- In general, both axes were labelled with the quantity and the unit.
- Scales were linear, with the plotted points covering at least half of the grid.
- The plotted points were accurate.

Limited responses

- Some candidates omitted to label at least one of the axes with the appropriate units, and in some cases both axes. The unit for T^2 was often given as s.
- Plotted points did not always cover at least half of the available grid.
- Scales should be straightforward, with large squares usually worth 1, 2, 4, 5, 10 or 20 units. Where awkward scales were used, candidates were often unable to read them accurately and so the points plotted were incorrect.
- A small number of candidates reversed the axes.

(ii) Comprehensive responses

- A straight line of best fit was drawn well by many candidates, with points on both sides of the line.

Limited responses

- Some candidates drew multiple lines or drew a line that was not close to most of the points.

(iii) Comprehensive responses

- Some candidates drew a suitable triangle that covered at least half of the line.
- The gradient from the triangle was calculated correctly.

Limited responses

- Many candidates did not draw a triangle to the line or drew it too small.
- The gradient was often left as a fraction, the calculation inverted or the placement of the decimal point was incorrect.
- A significant number of candidates omitted the question.

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(iv) Comprehensive responses

- Many candidates calculated the value of k correctly using their gradient from **Question 5(b)(iii)**.

Limited responses

- Some candidates inverted the division or gave an incorrect answer with no working shown.
- A significant number of candidates omitted the question.

(v) Comprehensive responses

- A small number of candidates used the values to show that the variables either were or were not proportional, or discussed the straight line either going through or not going through the origin.

Limited responses

- Many candidates thought that because the mass increased as the value of T^2 increased, then the relationship must be proportional. For two variables to be proportional, the ratio between them should be shown to be constant.
- Some candidates drew a straight line which did not go through the origin and stated that the variables were proportional. Some candidates thought that as the gradient was positive, the variables had to be proportional.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- A very small number of candidates appreciated that the error in timing would be over a longer time and so would be less significant for the longer time of 20 oscillations.

Limited responses

- The most popular incorrect response assumed that the 20 oscillations meant 20 different measurements and so either anomalies could be identified more easily or a better average could be calculated.
- Other incorrect responses included 10 oscillations being too fast to measure, too inaccurate or too unreliable.
- A significant number of candidates omitted the question.

Question 6

(a) Comprehensive responses

- Most candidates recorded the two temperatures correctly to 0.5 °C.

Limited responses

- Some candidates recorded their values as whole numbers, for example 70 and 30. 0.8 was also seen.

(b) Comprehensive responses

- Most candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetical error.

(c) Comprehensive responses

- Some candidates appreciated that the temperature was not double and showed this with a calculation using the data.

Limited responses

- Whilst many appreciated that the temperature was not double, most did not explain their answer.
- A small number of candidates omitted the question.

(d) Comprehensive responses

- Some candidates gave a full response detailing the hazard, what it would harm, and how the risk of the hazard could be reduced.
- A small number of candidates omitted the question.

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Limited responses

- Many answers did not include sufficient detail, usually about what the precaution was protecting.

(e) **Comprehensive responses**

- Some candidates gave the two mistakes in the diagram.

Limited responses

- Many candidates gave one correct mistake and one incorrect mistake. Some candidates did not give any correct mistakes.
- Many candidates did not consider the bulb and discussed the thermometer as a whole.
- Incorrect responses included that the thermometer is upside down, the thermometer is near the edge of the beaker, the thermometer is not touching the bottom of the beaker, the beaker is not insulated or does not have a lid, and there is not enough water in the beaker.

(f) **Comprehensive responses**

- A very small number of candidates appreciated that the thermometer would take time to fall to the temperature of the water and therefore gave a temperature between 4 and 19.

Limited responses

- The most common responses were 4, 4.5, 5 and 6, with the reason that the cold water would start warming up.
- Some candidates gave temperatures higher than room temperature, usually with no explanation.
- A small number of candidates omitted the question.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/63
Alternative to Practical

Key messages

Demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

What candidates did well
- Candidates selected apparatus and described its use.
- Candidates drew a diagram of assembled apparatus from a procedure.
- Candidates describe techniques used to ensure the accuracy of observations and data.

What candidates needed to improve
- Candidates needed to recognise that repeating a procedure allows anomalous results to be identified and excluded.
- Candidates needed to learn how to use a protractor to obtain accurate results.
- Candidates needed to read a volume measurement accurately from a measuring cylinder.
- Candidates needed to explain the techniques used to ensure the accuracy of observations and data.

Plan experiments and investigations:

What candidates did well
- Candidates chose suitable apparatus for an investigation and described its use.
- Many candidates gave a method in a detailed and logical order that would enable another candidate to carry out the same investigation.
- Candidates identified a control variable.
- Candidates recognised the importance of repeating results and some could explain why this was necessary.
- Candidates identified the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates needed to write methods in a detailed and logical order so that they would be easy for another candidate to follow.
- Candidates needed to identify a range of control variables in an investigation.
- Candidates needed to recognise the importance of repeating results and explain why repetition is necessary.
- Candidates needed to explain how the results obtained from an investigation contribute to the formation of a conclusion.

Make and record observations, measurements and estimates:

What candidates did well
- Candidates recorded measurements to the precision specified in the question.
- Candidates recorded the expected observations for the experiments.
- Candidates recorded observations and measurements in a systematic manner.

What candidates needed to improve
- Candidates needed to check the precision required by the question. Where measurements were to be made to the nearest 0.5 of a unit, values needed to end in .0 or .5.

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- Candidates needed to check the number of significant figures or decimal places in data already presented in tables as a guide to the precision to which values should be recorded.
- Candidates needed to check the precision to which measurements should be recorded.
- Candidates needed to round values correctly.

Interpret and evaluate experimental observations and data:

What candidates did well
- Candidates processed experimental data correctly and gave answers to at least two significant figures.
- Candidates selected consistent and regular scales for their graph axes.
- Many candidates labelled the axes of their graphs with both quantities and units.
- Lines of best fit were drawn accurately.
- Candidates showed their working on the graph when determining the gradient of a line.
- Candidates explained whether results were equal within the limits of experimental accuracy.

What candidates needed to improve
- Graphs needed to have axes fully labelled with both quantity and unit.
- The scales chosen for graph axes needed to be appropriate and linear, with the plotted points covering at least half of the grid.
- Candidates needed to give answers specific to the experiments rather than generic responses.
- Candidates needed to make use of the Qualitative Analysis notes provided at the end of the paper.

Evaluate methods and suggest possible improvements:

What candidates did well
- Candidates identified control variables in an investigation.
- Many candidates explained why specific steps in a procedure were necessary.
- Candidates explained the range of measurements needed for an investigation.

What candidates needed to improve
- Candidates needed to suggest improvements to reduce the effects of experimental error.
- Candidates needed to evaluate methods and explain why particular techniques and apparatus were used.
- Candidates needed to suggest improvements to experimental arrangements, methods and techniques.

Comments on specific questions

Question 1

(a) Comprehensive responses
- Many candidates measured the positions accurately and recorded them to the nearest 0.1 cm.

Limited responses
- A small number of candidates measured the left-hand side of the bubble rather than the right.
- Incorrect responses included 1.1, 1.2 and 1, 4.9, 5, 5.0 and 5.2.

(b) (i) Comprehensive responses
- Generally, candidates labelled both axes with the quantity and unit.
- Candidates selected linear scales, with the plotted points covering at least half of the grid.
- The plotted points were accurate.

Limited responses
- Some candidates omitted the unit from one or both axis labels. When units were included, minutes was sometimes recorded as m.
- Plotted points did not always cover at least half of the available grid.
- Candidates needed to select straightforward scales, with large squares usually representing 1, 2, 4, 5, 10 or 20 units. Some candidates selected awkward scales, which resulted in inaccurate plotting or graph readings.
- A small number of candidates reversed the axes.

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(ii) Comprehensive responses

- Many candidates drew accurate straight lines of best fit, with points distributed on both sides of the line.

Limited responses

- Some candidates drew multiple lines or drew a line that was not close to most of the plotted points.
- Points considered anomalous should be circled and labelled as anomalous.

(iii) Comprehensive responses

- Many candidates drew a vertical line from 35 minutes to the plotted line and then a horizontal line to the vertical axis, reading the position correctly.

Limited responses

- Many candidates did not show on their graph how they obtained their estimate.
- Some candidates misread the axes when obtaining the estimate for 35 minutes and, more commonly, when reading the position of the bubble, particularly when awkward scales were used.

(c) (i) Comprehensive responses

- Most candidates subtracted the values correctly.

Limited responses

- A small number of candidates made an arithmetic error or subtracted the wrong numbers.

(ii) Comprehensive responses

- Many candidates calculated the rate correctly and gave the correct unit.

Limited responses

- Some candidates used the distance moved at 60 minutes from **Table 1.1** instead of the value calculated in **Question 1(c)(i)**.
- A small number of candidates gave the correct units. Incorrect responses included cm, min, per min, cm/hr, cm/s, mm/s and cm/m.

(d) Comprehensive responses

- A very small number of candidates recognised that the liquid in the capillary tube moved to replace the oxygen used by the peas.

Limited responses

- Some candidates repeated the question.
- Incorrect responses included peas need oxygen, carbon dioxide is given out, the peas suck the liquid towards them, and the water is sucked up.
- Few candidates correctly discussed pressure.
- A significant number of candidates omitted the question.

(e) Comprehensive responses

- Some candidates recognised that the drop would not move.

Limited responses

- Many candidates discussed the drop moving, including that it would move towards the peas, be pushed further away, or not move much.

Question 2

(a) (i) Comprehensive responses

- Most candidates transferred the results to **Table 2.1** correctly.

Limited responses

- A very small number of candidates either miscounted one of the tallies, recorded the tallies in the incorrect places, or transferred the tallies incorrectly to the table.

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(ii) Comprehensive responses

- Most candidates counted the small animals correctly.

Limited responses

- A very small number of candidates recorded tallies in the table rather than numbers.

(iii) Comprehensive responses

- Most candidates calculated the averages correctly.

Limited responses

- Some candidates added the values without dividing by the number of trials.

(b) (i) Comprehensive responses

- Most candidates selected the preferred chamber.

Limited responses

- A very small number of candidates selected a different chamber, and all options were seen.

(ii) Comprehensive responses

- Some candidates selected the centre, usually to prevent bias.

Limited responses

- Some candidates selected the centre as this gave the animals a choice of where to go.
- Many candidates selected damp and light or dry and light, as these contained the fewest animals.
- Fair testing was the reason most often given.

(iii) Comprehensive responses

- A small number of candidates recognised that it was not possible to determine which of the two trials was correct because the results were so different, or that two of the averages were very close.

Limited responses

- Many candidates referred to identifying anomalies without relating their answer to this experiment or the trial results.
- Incorrect responses included suggestions that the animals did not have enough time to choose and that a third trial would make the results more accurate.

Question 3

(a) (i) Comprehensive responses

- Some candidates drew a boiling tube containing a liquid.
- The thermometer bulb was in the centre of the liquid and did not touch any part of the boiling tube.

Limited responses

- Many candidates drew boiling tubes which were empty.
- Diagrams frequently omitted the thermometer, or the thermometer bulb was touching either the side or the bottom of the boiling tube.
- Some diagrams also contained a Bunsen burner.

(ii) Comprehensive responses

- A very small number of candidates drew a meniscus on the liquid, with the bottom of the meniscus at 25.0 cm^3.

Limited responses

- Most candidates drew a straight horizontal line at 25.0 cm^3.

(iii) Comprehensive responses

- Many candidates recorded three correct temperatures.

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Limited responses

- For potassium carbonate, the most popular incorrect response was 46. Other incorrect responses were 40.6 and 40.5.
- For magnesium chloride, incorrect responses included 70 and 72.
- For ammonium nitrate, incorrect responses included –5.5, –0.5 and 15.5.

(iv) Comprehensive responses

- Most candidates calculated the temperature changes correctly.

Limited responses

- Some candidates omitted the + and – signs.
- Some candidates did not appreciate that the thermometer reading fell from 21.0 to –4,5, which was a temperature decrease of 25.5.

(v) Comprehensive responses

- A small number of candidates appreciated that the masses of each substance were different.

Limited responses

- Incorrect responses included not measuring the time, not insulating the boiling tube and not having the same starting temperature despite these being very close to each other.

(b)(i) Comprehensive responses

- A very small number of candidates realised that there was thermal energy transferred to the surroundings.

Limited responses

- Many candidates answered in terms of not stirring, not leaving the boiling tube long enough, not enough solid added and not taking the time.
- A significant number of candidates omitted the question.

(ii) Comprehensive responses

- A very small number of candidates appreciated that thermal energy was being gained by the solution.

Limited responses

- Most candidates gave the same incorrect reasons in **Question 3(b)(ii)** as in **Question 3(b)(i)**.
- A significant number of candidates omitted the question.

(iii) Comprehensive responses

- A small number of candidates either insulated the boiling tube or added a lid.

Limited responses

- Incorrect responses included cooling the water at the start, using higher concentrations, using a volumetric pipette to measure the water, crushing the solid, heating the solutions, adding a greater mass, adding more water, and using a beaker.
- A significant number of candidates omitted the question.

(c) Comprehensive responses

- Some candidates recognised that when the temperature fell below freezing, the water on the outside of the tube would freeze, causing the tube to stick to the test-tube rack.

Limited responses

- Incorrect responses included the ammonium nitrate on the outside making the tube sticky, the tubes being magnetically attracted, water making the tubes stick, and the difference in temperature making the tubes stick.
- A significant number of candidates omitted the question.

Question 4

Comprehensive responses

- Many candidates chose apparatus which they then used in their method.

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- Some candidates gave a workable method in a logical order that would enable another candidate to carry out the investigation using their plan.
- The measurements to be taken were clear, there were at least five different sensible temperatures, and the need to repeat measurements at each temperature was explained.
- Some candidates gave a control variable, usually the mass of manganese(IV) oxide or the volume of hydrogen peroxide or both.
- Some candidates suggested plotting a graph and identified the variables for each axis.
- A small number of candidates explained how they would use the results to reach a conclusion.

Limited responses
- Some candidates did not use a thermometer, despite carrying out the investigation at different temperatures.
- Some candidates thought that the stopwatch would measure the rate.
- Many candidates timed the reaction without referring to the volume of gas evolved in that time or to the time taken for the reaction to be completed. Some candidates measured the volume of gas produced without referring to the time taken.
- Repeating the measurement without explaining why this was necessary was a common response.
- Some candidates controlled the temperature.
- Plotting a graph was a common response, with few candidates stating the variables to be plotted on each axis.
- Making a table of results was often used as a conclusion.
- Many candidates stated a conclusion instead of explaining how the results obtained would be used to reach a conclusion.
- Many candidates confused rate with time.
- A significant number of candidates omitted the question.

Question 5

(a) (i) Comprehensive responses
- Most candidates measured the angle correctly.

Limited responses
- Incorrect responses included 19, 20, 21, 22 and 12.

(ii) Comprehensive responses
- Most candidates recorded the times correctly.

Limited responses
- Incorrect responses included 4.0 and recoding the full stopwatch display.

(iii) Comprehensive responses
- Many candidates transferred the candidates results to **Table 5.1** accurately.

Limited responses
- The most common error was recording 2.0 as 2. Some candidates did not record the other values to the nearest 0.1 s.

(iv) Comprehensive responses
- Candidates described the relationship correctly using the variables given in the question.

Limited responses
- Some candidates confused time with rate and gave the relationship between angle and rate.
- Proportional and inversely proportional were also common responses.

(b) (i) Comprehensive responses
- A small number of candidates described the use of a protractor correctly.

Limited responses
- A small number of candidates ensured that the horizontal was at 0 °.
- Most candidates did not describe measuring the angle by reading the protractor perpendicularly.

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(ii) Comprehensive responses

- A very small number of candidates recognised that reaction time error would be less significant when measuring a longer time for the longer ramp.

Limited responses

- A very small number of candidates recognised that reaction time error would be less significant when measuring a longer time for the longer ramp.
- Other incorrect responses included that the longer time is easier to measure, a larger time is always more accurate, and it will be more precise.

(iii) Comprehensive responses

- Some candidates recognised that pushing the car would vary from trial to trial and suggested letting go, using string, or using gates.

Limited responses

- Incorrect responses included reading the protractor incorrectly, misusing the stopwatch, the ramp being unstable, unequal angle spacings, the ramp being too thick, and no supports on the ramp.
- Some candidates omitted the question.

Question 6

(a) (i) Comprehensive responses

- Most candidates measured the distance correctly.

Limited responses

- Incorrect responses included 0.9 and 9.2

(ii) Comprehensive responses

- Most candidates calculated the radius using their distance in **Question 6(a)(i)** correctly.

Limited responses

- A small number of candidates made an arithmetic error.

(iii) Comprehensive responses

- Many candidates calculated the volume correctly and gave the value to three significant figures.

Limited responses

- The most common error was not giving the value to three significant figures.
- Some used 3r in place of r^3.

(iv) Comprehensive responses

- Most candidates recorded the mass to the nearest 0.1 g correctly.

Limited responses

- Incorrect responses included the full balance display, 7.3, 7.37 and 7.0.

(v) Comprehensive responses

- Most candidates calculated the value of density correctly using their earlier answers.

Limited responses

- A small number of candidates inverted the division or gave their answer to one significant figure. Calculation should always be given to a minimum of two significant figures unless otherwise specified in the question.

(b) (i) Comprehensive responses

- Some candidates calculated 10% of their calculated density and added it to their density to show it was less than 2.8, or calculated 10% of 2.8 and subtracted it from 2.8 to show that their value was less than 2.8.

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Limited responses

- Many candidates stated yes or no and gave no calculation or explanation.

(ii) Comprehensive responses

- A very small number of candidates appreciated that parallel blocks were equidistant along their length.

Limited responses

- Most candidates thought that the blocks would stop the marble from rolling. More accurate and more precise were also common responses.

(c) (i) Comprehensive responses

- Some candidates recognised that the ball was floating, so not all of its volume was being measured. This would make the calculated value of density larger.

Limited responses

- Many candidates stated that the ball floated, that the calculated density would be inaccurate, that the ball was less dense than water, or that the density could not be calculated.
- Some candidates omitted the question.

(ii) Comprehensive responses

- A few candidates recognised that the ball would need to be fully submerged and suggested how this could be achieved.

Limited responses

- Many candidates thought the volume should be calculated a different way, such as by using a ruler.
- The ball needing to be submerged was recognised by some candidates, who then either did not explain how this could be done or added a heavy object, not realising that the measured volume would also include the object's volume.

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