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

COMBINED SCIENCE

Paper 0653/12
Multiple choice Core

Key messages

Candidates performed well on **Questions 7**, **9**, **10**, **11**, **12**, **19**, **20**, **21** and **22**.

Candidates performed less well on **Questions 8**, **13**, **14**, **16**, **17**, **23**, **25**, **27**, **34**, **36**, **37** and **40**.

Candidates should take care to read the full question before answering. Some options may provide answers that are either correct statements which do not address the question, or statements that are only partially correct.

Comments on specific questions

Question 8

- The correct option was chosen by the majority of candidates.
- The incorrect options were equally chosen indicating guessing.

Question 13

- Option **C** was a common incorrect answer.
- Many candidates recognised the chipmunk as a primary consumer. Some responses showed confusion when identifying the owl's position in the food web, with candidates often selecting an incorrect role for the owl.

Question 14

- Option **C** was a common incorrect answer.
- Many candidates needed to show a clearer understanding of how lower temperature and higher pressure affect the movement and spacing of oxygen molecules.

Question 16

- Option **B** was a common incorrect answer.
- Candidates recognised that chlorine was produced. Some responses indicated confusion between the products at the electrodes, with sodium often selected instead of hydrogen.

Question 17

- Option **C** was more popular than the key.
- Candidates who take part in regular practical chemistry are more likely to be familiar with practical contexts. In this question, rate of reaction by decreasing mass is being assessed. The cotton wool prevents spitting of chemicals and does not prevent the gas escaping.

Question 23

- Option **C** was a common incorrect answer.
- Candidates correctly recognised that gasoline is a fuel. In this context, it is not used in diesel engines.

Question 25

- Option **C** was more popular than the key.
- A measuring cylinder can be used to measure a volume of a liquid. It will not measure exactly 25.0 cm^3.
- Option **A** was also a common incorrect answer.
- A beaker is not suitable for measuring an exact volume.
- Candidates who take part in practical chemistry are more likely to be familiar with suitable apparatus.

Question 27

- Option **B** was a common incorrect answer.
- Candidates recognised that when aqueous sodium hydroxide is added to calcium ions, a white precipitate is produced. This precipitate is insoluble rather than soluble in excess.

Question 34

- Option **B** was a common incorrect answer.
- These candidates could not recall the equation for wave speed.

Question 36

- Option **B** was more popular than the key.
- These candidates recognised that P was louder. They did not appreciate that P had a lower pitch.

Question 37

- Option **C** was a common incorrect answer.
- These candidates did not appreciate the effect of the position of a resister in parallel and series on current.

Question 40

- Option **B** was a common incorrect choice.
- Candidates selecting this option could not identify all of the astronomical objects that are smaller in size than the Solar System.

COMBINED SCIENCE

Paper 0653/22
Multiple choice (Extended)

Key messages

Candidates performed well on **Questions 1**, **2**, **4**, **5**, **6**, **11**, **12**, **13**, **15**, **19**, **23**, **25**, **30**, **33** and **39**.

Candidates performed less well on **Questions 3**, **7**, **9**, **14**, **16**, **18**, **20**, **21**, **22**, **24**, **35**, **36** and **38**.

Overall, candidates performed well on this paper.

Comments on specific questions

Question 3

- Option **C** was as popular as the key.
- Candidates recognised that at point X the greatest number of enzyme-substrate complexes form. They did not appreciate that kinetic energy also increases.

Question 7

- Option **B** was a common incorrect answer.
- These candidates had reversed the description of that happens in the atria and ventricles.

Question 9

- All options were equally popular, indicating guessing.
- Many candidates needed to describe the effect of increasing the depth and rate of breathing on gas exchange.

Question 14

- Option **B** was as popular as the key.
- These candidates were not able to interpret the state of matter of nitrogen and oxygen.

Question 16

- Options **A** and **C** were common incorrect answers.
- Electrode Y is the anode and so the gas formed at Y is oxygen rather than sulfur dioxide.

Question 18

- Option **D** was a common incorrect answer.
- These candidates were able to determine which measurements are sued to put metals in order of reactivity. Candidates who regularly take part in practical science are more likely to be able to answer this type of question.

Question 20

- Option **D** was a common incorrect answer.
- Sodium will form a basic oxide and not an acidic oxide.

Question 21

- Options **B** and **D** were common incorrect answers.
- These candidates were not familiar with the colour of aqueous iodine. Candidates who take part in regular practical science are more likely to perform well on this type of question.

Question 22

- Option **A** was a common incorrect answer.
- These candidates incorrectly thought that brass is an alloy of copper and iron, rather than of copper and zinc.

Question 24

- Option **C** was a common incorrect answer.
- The fraction at the top of the fractionating column has the smallest molecules.

Question 35

- Option **A** was a common incorrect answer.
- These candidates recognised that a sound wave is longitudinal and thought the speed would be greater in air than in a metal.

Question 36

- Options **A** and **C** were common incorrect answers.
- These candidates were not familiar with the key concept that an electric current is a flow of electrons towards the positive terminal of a battery.

Question 38

- Option **D** was a common incorrect answer.
- Many candidates needed to determine the resistance of a wire when given information.

COMBINED SCIENCE

Paper 0653/32
Core Theory

Key messages

What candidates did well
- Generally, candidates had prepared well for the examination and they attempted all questions.
- Candidates did well in most of the calculations.

What candidates needed to improve
- Candidates should make sure that they read the question correctly and give letters, not names, for their response if requested.
- They should also give word equations and not use symbols of the participating chemicals.
- Candidates should provide comparative responses to show a difference.
- Candidates should understand the meaning of a trend.
- Working should be shown in calculations.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- Most candidates successfully identified the parts of the cell.

Limited responses
- Some candidates gave answer **D**, the cell wall, instead of **E**, the membrane enclosing the vacuole that contains the cell sap. Candidates should be aware that the sap in the vacuole provides support to the cell from inside the cell.

(ii) Comprehensive responses
- Many candidates identified the cell wall as present in bacterial cells.

Limited responses
- The letters of all the other parts of the cell were given by several candidates. Candidates should be aware that bacterial cells do not contain many of the cell parts that are contained in animal cells.

(iii) Comprehensive responses
- The equation for respiration was completed successfully by most candidates.

Limited responses
- Incorrect responses included writing glucose as a product. Candidates are reminded that glucose is a product of photosynthesis. In the case of respiration, chemical energy is released from glucose, a reactant.

(b) (i) Comprehensive responses
- Candidates who did well in this question included a correct organism and an explanation that it causes disease.

Limited responses

- Some responses correctly stated that a pathogen is an organism. It was also important for them to say that it causes disease. Several candidates stated that the pathogen causes harm. This was too vague a term to use in this case. The full definition of a pathogen from the syllabus was required to answer this question.

(ii) Comprehensive responses

- Many candidates answered this question correctly.

Limited responses

- Some candidates confused the correct answer, antibiotics, with antibodies. Candidates are reminded to use the correct word for the type of drug that kills bacteria. Responses such as medicine are too vague.

(iii) Comprehensive responses

- Most candidates stated two correct body defences.

Limited responses

- Some candidates did not give the complete answer, Nose instead of nose hairs and stomach instead of stomach acid were incomplete answers.

Question 2

(a) (i) Comprehensive responses

- Most candidates stated the correct temperature of the highest enzyme activity.

Limited responses

- A few responses showed an incorrect reading from the graph. Some of these candidates stated 30.6(°C) instead of 36(°C). Others wrote 50(°C), which is the temperature of no activity, not the highest enzyme activity.

(ii) Comprehensive responses

- A few candidates understood that both enzymes are active only between 40(°C) and 50(°C).

Limited responses

- Most candidates misunderstood what was required of the question. Some gave the range of temperatures between 35(°C) and 75(°C), the maximum activity of both enzymes. They should be aware that enzyme **A** and enzyme **B** are not both active for the complete range of these temperatures.

(b) (i) Comprehensive responses

- Some candidates gave the correct two answers, amino acids, and glucose.

Limited responses

- Many responses gave reducing sugars for the smaller molecules that make up starch. This term is not specific enough. Candidates should be aware that during digestion starch is broken down to reducing sugars, and these reducing sugars are further broken down to produce glucose, the correct answer.

(ii) Comprehensive responses

- Some candidates listed the four chemical elements correctly.

Limited responses

- The incorrect answers ranged from one incorrect element out of the four to stating four compounds, for example, glycerol and ethanol. Candidates are reminded that elements identify the atoms in proteins and can be written as the symbols or names. Compounds consist of two or more different atoms which are chemically bonded to each other.

(c) (i) Comprehensive responses

- Some candidates correctly described the role of carbohydrates to release energy in the body.

Limited responses

- There was a wide range of incorrect answers. Some of these stated a role of keeping the body hydrated. Others described the wrong nutrient, for example the role of proteins. Some responses were vague, for example, stating that they are needed for chemical reactions in the body.

(ii) Comprehensive responses

- Many candidates successfully named two other nutrients in a balanced diet.

Limited responses

- Several candidates repeated the nutrients already given in the introduction to the question, fats, proteins and carbohydrates. Careful reading of the stem of the question excluded these nutrients. Also, single nutrients written on their own did not answer the question which was asking for types of nutrients. Therefore, instead of calcium the type of nutrient is mineral ions, and instead of vitamin C the type of nutrient is vitamins.

Question 3

(a) (i) Comprehensive responses

- The definition of biodiversity was successfully stated by some candidates.

Limited responses

- Many responses showed partial recollection of the definition. Some candidates confused the definition with that of an ecosystem. Candidates are reminded to learn and understand the ecological definitions contained in the syllabus.

(ii) Comprehensive responses

- Most candidates gave a valid reason for the destruction of habitats.

Limited responses

- Some candidates wrote deforestation as their answer. Deforestation was given in the stem of the question as an example of habitat destruction, so this was excluded as a possible answer unless a reason was given for the deforestation, for example to use the land for building.

(iii) Comprehensive responses

- Many candidates gave two other undesirable effects of deforestation.

Limited responses

- Some candidates wrote loss of habitat for one of their responses. The introduction to the question stated that deforestation is an example of habitat destruction, so that response was excluded as an answer. Candidates are reminded to read the question carefully.

(b) Comprehensive responses

- Some candidates filled all necessary tick boxes.

Limited responses

- Many candidates ticked only three boxes. The question asked to show all the terms used to describe each organism. With the cactus, rat and hawk only one box was needed, and the hawk was a tertiary consumer which had no available box. The snake is both a secondary consumer and a carnivore. Candidates should be aware that the secondary consumer shows the trophic level of the snake and the term carnivore shows that it eats other animals. Therefore, both terms apply to the snake.

Question 4

(a) (i) Comprehensive responses

- Those candidates who were familiar with the reaction knew that a gas is given off. So, the observation is the appearance of bubbles.
- Also, since it is an exothermic reaction, the beaker would feel warm.
- Some candidates stated a correct observation.

Limited responses

- Although many candidates stated that a gas is formed, they did not say how they knew this. The observation in this case is to state what our senses can detect. So, the bubbles will be seen.
- In a similar way, the candidates did not say which observation they could make to show that heat was given out. They could feel the beaker or use a thermometer.

(ii) Comprehensive responses

- Some candidates completed the word equation successfully. The reactants were given in the question, and the products had to be supplied by the candidates. Most responses gave the correct reactants.

Limited responses

- While most candidates wrote the correct reactants, fewer gave the correct products. Candidates should be aware that the products of the reaction of a carbonate and a dilute acid produce a salt, in this case copper chloride, carbon dioxide and water. Some candidates gave copper chloride, and some gave carbon dioxide. Relatively few stated water. Candidates are advised to learn the reaction of a dilute acid and a metal carbonate using different examples.

(iii) Comprehensive responses

- Many candidates stated two ways in which the rate of reaction could be reduced. The main ways stated were to decrease the concentration of acid and the temperature.

Limited responses

- Some candidates suggested doing the reaction more slowly, using different apparatus or changing the amounts of the reactants. Candidates are reminded that all these things should remain the same.
- Other candidates just stated temperature and concentration in their responses, without stating how these would be changed. More detail was needed in these responses.

(iv) Comprehensive responses

- Some candidates identified the correct colour of the universal indicator in the two environments.

Limited responses

- Many candidates were unfamiliar with the colours of universal indicator in the two environments. Candidates should be aware that they need to know the colour changes that relate to the pH values of solutions.

(b) Comprehensive responses

- Most candidates drew the two bonding electrons in the right place and many also completed the lone pairs (non-bonding electrons) correctly.

Limited responses

- Some candidates were unfamiliar with dot-and-cross diagrams and the rules for bonding. They are reminded that a covalent bond, as in hydrogen chloride, shares one electron from each atom. Hydrogen does not have any more outer-shell electrons, while chlorine has six other electrons in the outer shell which must be shown.

Question 5

(a) (i) Comprehensive responses

- Many candidates gave a correct electronic configuration of an atom of sodium. They were aware of the notation which reflects the number of electrons in the shells of the atom.
- The calculation of the number of neutrons was equally successful.

Limited responses

- Some of the incorrect responses were 11 and 23. Candidates should be aware that the number of electrons in a sodium atom is equal to the number of protons, 11. To give the electronic configuration, two electrons are in the first shell, then eight in the second shell and one electron in the third shell, giving an electron configuration of 2, 8, 1.

- The most frequent incorrect response for the number of neutrons was 19. These candidates used the atomic number, 19, to state the number of neutrons. Candidates should be aware that be aware that the number of neutrons is calculated by subtracting the atomic number, the number of protons, from the mass number.

(ii) Comprehensive responses

- A few candidates successfully answered this question. Some stated that the number of protons equals the number of electrons. Further information about the proton's positive charge and electron's negative charge would have completed their correct answer. Few candidates stated this fact.

Limited responses

- Many of the incorrect responses referred to there being more neutrons than protons in the nucleus and therefore giving it a neutral charge. Other candidates did not understand that this question is about the charges on the subatomic particles that make up the atom, not the gain and loss of electrons during reactions.

(b) Comprehensive responses

- Candidates who were successful understood the meaning of the word trend. In this question the trend was to describe how some of the properties gradually changed going down Group I. Several candidates described the trends successfully, for example, increased reactivity with water.

Limited responses

- Many candidates did not describe trends. Instead, they stated properties. Therefore, density and reactivity with water were stated in some responses, without an indication of how these properties changed down the group.

(c) Comprehensive responses

- There were several possible correct answers, and most candidates answered this correctly, with the most common responses stating that the transition elements have high melting points and high densities.

Limited responses

- Incorrect responses stated that transition metals are good conductors of heat and electricity. Although these properties are true, they are not different from the properties of Group I.

(d) Comprehensive responses

- This question was well answered by a few candidates.

Limited responses

- A considerable number of candidates did not recall the metals in the alloys stated. Candidates are reminded to learn the combinations of metals in brass and stainless steel.

Question 6

(a) (i) Comprehensive responses

- Most candidates successfully deduced the molecular formula for ethane.

Limited responses

- Some candidates who were not successful did not count the atoms correctly, which led to an inaccurate formula. Others gave the general formula, C_nH_{2n+2}. Candidates are advised to understand the difference between molecular formula and general formula.
- In writing formulae, candidates should take care to use the correct symbols and make sure that the numbers of atoms are written as subscripts. Therefore, C_2H_6 is correct. C2H6 and C^2H^6 are incorrect.

(ii) Comprehensive responses

- Some candidates answered this correctly. Since the boiling point of ethane is -89 °C, at any temperature higher than this ethane will be a gas.

Limited responses

- The incorrect responses included the state symbol (aq). This cannot be correct because (aq) describes a substance which is dissolved in water. This is clearly not the case with ethane. The boiling point of ethane is too low for it to exist as anything other than a gas.

(iii) Comprehensive responses

- Many candidates ticked the two boxes correctly. They understood that ethane contains covalent bonds and that it is saturated.

Limited responses

- Candidates who ticked the first box are reminded that methane is the main constituent of natural gas. Also, ethane does not react with aqueous bromine because it is saturated, so a tick in the last box was also incorrect.

(b) Comprehensive responses

- Many candidates succeeded in balancing the equation.

Limited responses

- Many of the unsuccessful candidates did not manage to balance the numbers of atoms on each side of the equation. Care should be taken to look at the numbers of the different atoms on each side of the equation to make sure they match.
- Candidates are reminded that it is only the numbers of reacting molecules that are needed to fil the spaces of the equation and there should not be any extra atoms written in the spaces.

(c) (i) Comprehensive responses

- A few candidates successfully stated the correct answer, incomplete combustion.

Limited responses

- Many candidates were not familiar with the term incomplete combustion. Incorrect answers included oxidation, aerobic, complete combustion, spontaneous combustion. Candidates should be aware that be aware that incomplete combustion of methane leads to carbon monoxide and particulates.

(ii) Comprehensive responses

- A few candidates answered this question correctly. They recognised that carbon monoxide is a toxic gas, and that particulates cause respiratory problems.

Limited responses

- Many candidates were not familiar with the adverse effects of both carbon monoxide and particulates. Candidates should learn the adverse effects of carbon monoxide and particulates

Question 7

(a) (i) Comprehensive responses

- Many candidates calculated the speed correctly.

Limited responses

- The most common incorrect answer was 2 (m / s). This was obtained by candidates using 30 s instead of 20 s as the time. Candidates should read the question carefully to make sure that the correct time interval is used for the calculation. If a response just said 2 (m / s) with no working, there is no evidence of use of the correct equation. The working in calculations is very important.

(ii) Comprehensive responses

- Some candidates described the motion of the car correctly.

Limited responses

- Many candidates stated that the car was moving at a constant speed. A plateau on a speed-time graph would show a constant speed. This was a distance-time graph, so it showed that no distance was covered during the time stated. Candidates are reminded to learn what the distance-time and the speed-time graphs show.

(b) (i) Comprehensive responses

- A few candidates described the motion correctly.

Limited responses

- Many candidates stated that the car was stationary. They saw the balanced forces and assumed that the car was at rest. It states in the stem of the question that the car is moving forwards. Candidates should be aware that balanced forces can also act on a moving object causing it to go at a constant speed.
- Some candidates just wrote constant. They are reminded that they must complete the term constant speed.

(ii) Comprehensive responses

- Some candidates named a correct force, for example, air resistance.

Limited responses

- Many candidates were unfamiliar with the term for force **Y**. Pulling force, backward force and back force were all seen. Candidates should be aware that be aware that an object moving through a gas has a frictional force, in this case air resistance.

(c) (i) Comprehensive responses

- Most candidates calculated the correct pressure exerted by the car on the ground.

Limited responses

- There were only a few incorrect answers from those candidates who multiplied the weight by the area instead of dividing the weight by the area.

(ii) Comprehensive responses

- The increase in temperature causes the air particles inside the car to move faster. Some candidates expressed this correctly.

Limited responses

- Many candidates did not write about the motion of the air particles. Some responses stated that the tyre expands, the air particles expand, or the tyres melt, which do not address the required explanation. Candidates are reminded that an increase in temperature in a gas gives the particles more kinetic energy so they can move faster.

Question 8

(a) (i) Comprehensive responses

- Many candidates identified the parts of the wave correctly.

Limited responses

- The main misconception was labelling **P** for the wavelength. The wavelength is the distance between the same point on successive waves. **P** is only half a wavelength.

(ii) Comprehensive responses

- Many candidates did the calculation successfully.

Limited responses

- Some candidates either wrote the wrong unit or omitted it. They are reminded that the correct unit for frequency is Hz.
- Other candidates multiplied the speed of the waves instead of dividing the speed by the wavelength.

(b) (i) Comprehensive responses

- Many candidates did the calculation correctly.

Limited responses

- Some candidates did not use all of the necessary information. An example of this is 0.25×6. Another example is 2.0×6.0.
- Other candidates misread the question as 6.0 hours a day, so their answers were too big.

(ii) Comprehensive responses

- Most candidates answered this question correctly.

Limited responses

- The main confusion was between conduction and convection. Candidates are reminded that thermal energy is transferred through solids mainly by conduction. In liquids and gases thermal energy is transferred by convection.

Question 9

(a) (i) Comprehensive responses

- Many candidates answered this question correctly.

Limited responses

- The main incorrect answer given was electricity. Candidates are reminded that an electric current results from the flow of charge, or in the case of metals, the flow of electrons.

(ii) Comprehensive responses

- A small number of candidates answered this question correctly.

Limited responses

- Some candidates entered a correct reading. However, they did not follow this up with an explanation stating that it is a series circuit and the current is the same around the circuit. Several responses stated that ammeter readings are always the same, without stating that it is a series circuit. Candidates are advised to explain the reasons for their answers.

(iii) Comprehensive responses

- Most candidates did a correct equation for resistance.

Limited responses

- A few candidates used an incorrect current to answer this question. Instead of using 1.5 A, they used 3 A.

(b) Comprehensive responses

- Many candidates circled the correct gases.

Limited responses

- The most common incorrect answer was nitrogen. Candidates should be aware that the Sun mainly consists of hydrogen and helium.

(c) Comprehensive responses

- Some candidates completed the whole calculation successfully.

Limited responses

- The calculation was in two stages. The mass of the object on the moon had to be calculated first, then this mass had to be used to calculate the weight on Earth. Some candidates calculated the mass on the moon correctly, then did not continue the rest of the calculation, to find the weight on Earth. Candidates should be aware that the weight of an object depends on the gravitational field strength, and the mass is the same everywhere.

COMBINED SCIENCE

Paper 0653/42
Extended Theory

Key messages

What candidates did well

- Many candidates were familiar with the factual material in the syllabus and could use appropriate scientific terms to express relevant ideas.
- Many candidates used the wording shown in the syllabus for definitions and processes.
- Candidates could use data from graphs in calculations.
- In calculations, candidates used relevant relationships between variables and processed data accurately. They set out working clearly and in a logical order and stated final numerical answers to an appropriate number of significant figures.

What candidates needed to improve

- Candidates should learn scientific definitions as they appear in the syllabus.
- Candidates should include details that are relevant to the context of the question and avoid answers that are too general.
- Reaction profile diagrams in Chemistry should be drawn carefully.
- Candidates should always include working in calculations. This should state the relevant relationships between variables and clearly set out the steps which lead to the final answer. Candidates should make sure the data they are processing has the correct units. This means that the units given in the question may need to be converted.

Comments on specific questions

Question 1

(a) **Comprehensive responses**

- Most candidates were able to identify where absorption and egestion occur.

Limited responses

- A few candidates stated the names of parts of the alimentary canal rather than using the labels.

(b) **Comprehensive responses**

- Some candidates selected only those parts shown on the diagram that are part of the alimentary canal.

Limited responses

- Many candidates suggested several parts that are not in the alimentary canal.
- A common incorrect suggestion was part **A**.

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

- Most candidates described the role of hydrochloric acid in killing microorganisms.
- Some candidates gave responses such as bacteria and pathogens.

Limited responses

- Some candidates described details of chemical digestion. The question included a reference to providing optimum pH for enzymes and asked for the other function of hydrochloric acid.
- A few candidates used the term ‘germs’ rather than microorganisms.

(ii) Comprehensive responses

- Many candidates completed three or four of the sentences correctly.

Limited responses

- Some candidates identified active site and/or denaturation.
- Incorrect suggestions for starch included denaturing, a named sugar such as glucose or the general term carbohydrate.

(iii) Comprehensive responses

- Some candidates stated high or increased temperature. Other responses described temperature above the optimum.

Limited responses

- Instead of a clear reference to high temperature, some candidates stated ‘temperature’, ‘extremes of temperature’, ‘temperatures that are too hot or too cold’ or ‘changes in temperature’.
- Some candidates used the term ‘heat’ instead of high temperature.
- A few candidates suggested climatic environmental condition such as global warming.

Question 2

(a) (i) Comprehensive responses

- Many candidates identified the features on the diagram that are evidence for wind pollination. Some candidates used alternative terms to describe ‘feathery’.

Limited responses

- Incorrect answers included references to anthers hanging out of the flower and pollen exposed on the outside of the flower.
- Some candidates referred to 'sticky' rather than 'feathery' when describing evidence visible in the diagram.
- Some candidates suggested that the stigma was not enclosed or covered, rather than describing it as hanging outside.
- Some candidates described pollination.

(ii) Comprehensive responses

- Most candidates stated 'ovule'. Some candidates gave 'ovary' as their response.

Limited responses

- Common incorrect suggestions were stigma and anther,

(iii) Comprehensive responses

- Most candidates stated the position of grass in a food chain correctly. Responses included terms such as 'producer' or 'first trophic level', or other wording that suggested the idea of the beginning of the chain.

Limited responses

- A few candidates suggested the terms ‘primary’ or ‘at the bottom’.

(b) (i) Comprehensive responses

- Most candidates wrote fully correct balanced equations for photosynthesis. Candidates usually made sure that chemical symbols were written correctly and that subscripts and stoichiometry were shown properly.

Limited responses

- A few candidates wrote a word rather than the balanced equation.
- A few candidates wrote the equation for respiration or made mistakes in their recall of the formula of glucose.

(ii) Comprehensive responses

- Comprehensive answers referred to the four key ideas (1) protection or monitoring of plants and/or habitats, (2) legislation to promote protection, (3) education to increase awareness and (4) preservation of seeds in, for example, seed banks. Some candidates included at least three of the key ideas and many referred to two of them.

Limited responses

- Many candidates wrote detailed answers that focused on only the key idea of protection, listing different ways this could be achieved.
- Some candidates suggested captive breeding programmes or artificial insemination drawn from an animal rather than plant context.

Question 3

(a) (i) Comprehensive responses

- Many candidates completed the calculation correctly. Responses included numerical answers close to 2.3, as well as 230%.

Limited responses

- Many candidates calculated the difference between the two cross-sectional areas.
- A few candidates corrected the answer to one significant figure.

(ii) Comprehensive responses

- Many candidates related the different cross-sectional areas of the aorta and vena cava to the relative difference in the pressure of blood carried in these vessels. Some candidates stated that the larger area in the vena cava reduced resistance to blood flow rate. Some candidates stated that the smaller area in the aorta maintained the higher blood flow rate needed to transport blood around the body.

Limited responses

- Some candidates repeated their answers to part **(a)(i)**.
- Some candidates described the general functions of arteries and veins.
- Some candidates described structural features of arteries and veins other than cross-sectional area.

(b) (i) Comprehensive responses

- Most candidates identified haemoglobin.

Limited responses

- Common incorrect suggestions made by a few candidates included plasma, carbon dioxide, glucose and oxygen.

(ii) Comprehensive responses

- Many candidates described the movement of oxygen through the cell membrane by diffusion down the oxygen concentration gradient. A few candidates also stated that diffusion occurs through the random or net movement of oxygen molecules through a partially permeable membrane.

Limited responses

- Some candidates referred only to diffusion.
- Some candidates described general features of gas exchange through the alveoli.
- A few candidates described general features of respiration.

(iii) Comprehensive responses

- Some candidates described at least two factors that are linked to an increased rate of oxygen diffusion into the cell.

Limited responses

- Many candidates identified important variables without making the link to an increased rate of diffusion of oxygen into the cell. Examples include suggesting ‘temperature’ rather ‘increased or high temperature’, ‘surface area’ rather than ‘large or increased surface area’,

'concentration gradient' rather than 'increased concentration gradient', 'membrane thickness' rather than 'thinner membrane'.

- A few candidates suggested variables without linking them to the red blood cell. An example would be suggesting 'diffusion distance' rather than specifying 'thinner membrane'.

Question 4

(a) (i) Comprehensive responses

- Most candidates stated 'cathode'.

Limited responses

- Some candidates suggested anode or a material used to make electrodes such as carbon.

(ii) Comprehensive responses

- Some candidates predicted the anode and cathode products of the electrolysis of molten magnesium chloride and stated their chemical formulae and appearances. Some responses included correct electrode equations in place of chemical formulae.

Limited responses

- Some candidates suggested the formulae of ions, Mg^{2+} or Cl^{-}.
- Some candidates suggested Cl rather than Cl_2.
- Many candidates were unfamiliar with the appearance of metallic magnesium and/or chlorine gas.

(iii) Comprehensive responses

- Many candidates predicted that aqueous magnesium chloride could be electrolysed, using a range of wording to express this idea.

Limited responses

- A few candidates suggested adding magnesium chloride to dilute acid.
- A few candidates suggested procedures that involved heating.
- A few candidates suggested trying to electrolyse magnesium chloride in a gaseous state.

(b) (i) Comprehensive responses

- Some candidates drew perfectly correct reaction pathway diagrams which showed the product energy level above the reactant level and a rounded energy maximum between the two. The activation energy was labelled using a vertical arrow connecting the reactant energy level with the energy maximum. The overall energy change was shown by a vertical arrow connecting the reactant and product energy levels.

Limited responses

- Many candidates used double-headed arrows to indicate both the activation energy and the overall energy change. Double-headed arrows were commonly seen for the activation energy, while for the overall energy change, other approaches were more appropriate.
- Some candidates drew arrows that were inaccurately positioned.
- Some candidates drew a diagram that showed an exothermic reaction pathway.

(ii) Comprehensive responses

- Many candidates stated the definition of activation energy given in the syllabus. This expresses the idea of minimum energy required for a reaction to occur or to start. Some candidates found alternative ways of expressing the ideas such as 'the lowest amount of energy needed to break bonds in the reactants'.

Limited responses

- Some candidates referred to the energy rather than minimum energy.
- A few candidates stated that activation energy was the highest point in the reaction pathway diagram.
- A few candidates suggested that the activation energy was the minimum energy needed by particles before they could collide.

(iii) Comprehensive responses

- Comprehensive answers were worded carefully and made it clear that the amount of energy required or absorbed when bonds break was greater than the energy released when bonds form.

Limited responses

- Many candidates suggested that more energy is needed to break bonds than is needed to form bonds.
- Some candidates described the relative amounts of energy contained in the reactants and products.

Question 5

(a) (i) Comprehensive responses

- Some candidates were familiar with the colours of iodine and bromine solutions and predicted that the mixture of chlorine water with sodium chloride solution would appear colourless or very pale green or green yellow. Some candidates stated that there would be no reaction for sodium chloride.

Limited responses

- Some candidates suggested that precipitates or gases would be observed.
- Some candidates suggested that the appearance in the test tube containing sodium iodide would be brown changing to blue-black.
- A few candidates gave the answer ‘no observation’ in the test tube containing sodium chloride.

(ii) Comprehensive responses

- Many candidates stated displacement, halogen displacement or redox.

Limited responses

- A wide variety of suggestions were made by candidates who were unfamiliar with these reactions. The more common mistakes included exothermic, endothermic and combustion.

(b) Comprehensive responses

- Some candidates gave fully correct balanced equations, taking care to write chemical symbols accurately and to show subscripts and stoichiometry using digits of the correct size and position.

Limited responses

- Many candidates suggested the formulae of elemental bromine and iodine were Br and I.
- Many candidates were unfamiliar with the chemical formulae of sodium iodide and sodium bromide.
- A few candidates wrote correct formulae without balancing the equation.

(c) Comprehensive responses

- Many candidates were familiar with the changes in electron configuration when sodium and fluorine atoms form an ionic bond. These candidates almost always stated the correct electrical charges on the ions.

Limited responses

- A few candidates left the outer shell of sodium without any electrons.
- A few candidates reversed the electrical charges on the ions.
- A small number of candidates suggested electrical charges which were related to the atomic numbers of the elements.

Question 6

(a) (i) Comprehensive responses

- Almost all the candidates wrote the molecular formula of pentane correctly.

Limited responses

- A small number of candidates mis-counted the number of carbon or hydrogen atoms.

- A few candidates suggested the general formula of alkanes.

(ii) Comprehensive responses

- Almost all the candidates recognised that pentane is an alkane.

Limited responses

- The variety of incorrect suggestions included saturated and covalent.

(iii) Comprehensive responses

- Some candidates completed the table correctly.

Limited responses

- Some candidates missed one or two of the five responses. The two most commonly missed were the first, which concerned the formation of air pollutants, and the third, which referred to the general lack of reactivity of alkanes.

(b) Comprehensive responses

- Many candidates were familiar with the process of cracking and stated that high temperature and the presence of a catalyst were required. Candidates gave a range of suggested high temperatures and named various solid materials as possible catalyst.

Limited responses

- Some candidates suggested 'temperature' rather than 'high temperature'.
- Many candidates suggested the need for high pressure, often without further explanation or additional relevant detail.

Question 7

(a) Comprehensive responses

- Many candidates stated that planet **J** had the greater orbital speed because it was closer to the star and so experienced a higher gravitational force of attraction. Some candidates referred to the idea of greater centripetal force when explaining why planet **J** had the greater orbital speed.

Limited responses

- Many candidates stated only one of the relevant factors influencing the orbital speed.
- A few candidates reversed the arguments and suggested planet K would be moving more quickly.

(b) Comprehensive responses

- Many candidates identified red giant and white dwarf.

Limited responses

- A wide variety of suggestions were seen for one or both stages of the star life cycle. The more common ones included black hole, supernova and nebula.

(c) Comprehensive responses

- Many candidates stated the two key ideas that hotter gases have lower density and that hotter, lower density gas will rise towards the surface.

Limited responses

- Some candidates stated that when gas is heated it becomes lighter rather than becomes less dense.
- Some candidates suggested processes that described conduction rather than convection.
- Some candidates described convection in a way that was too general, for example, 'in convection, thermal energy is transferred when the substance itself moves up and down'.

(d) Comprehensive responses

- Some candidates stated the two key ideas which meant student B is correct. They explained that mass never changes and stated explicitly that weight depends on the gravitational attraction. Some candidates included the relationship w = mg and statements such as 'mass

is independent of gravitational field' or 'mass is just the amount of matter in an object which cannot change'.

Limited responses

- Many candidates stated that **B** was correct because the gravitational field strength is the same on both planets. This answer required further explanation of why this means that the weight would be the same on both planets.
- A few candidates suggested that **A** was correct because Mercury is closer to the sun.

Question 8

(a) Comprehensive responses

- Many candidates used the graph to obtain the distance travelled and the time taken by the car in travelling from Q to R. They then used the relationship speed = distance / time and stated the speed to two significant figures.

Limited responses

- Some candidates substituted incorrect data into the relationship speed = distance / time.
- A few candidates used the relationship speed = distance / time and then made arithmetic mistakes when processing the data.
- A few candidates suggested the relationship speed = distance × time.
- A few candidates attempted to calculate the area under the graph.

(b) Comprehensive responses

- Most candidates were familiar with the relationship kinetic energy (KE) = $\frac{1}{2}$ × mass × (velocity)^2 and used it to process the data correctly.

Limited responses

- Of the incorrect answers, one of the more common ones was the result of calculating KE / mass.
- Some candidates stated the correct equation for KE and then made mistakes in processing the data often involving finding the square root.

(c) (i) Comprehensive responses

- A few candidates drew the circuit symbol for a light emitting diode (LED) exactly as it appears in the syllabus.

Limited responses

- The LED symbol was familiar to some candidates who often drew it with minor inaccuracies. Candidates should be advised to learn how to draw the electrical circuit symbols as they are shown in the syllabus.
- The symbol was unfamiliar to many candidates.

(ii) Comprehensive responses

- Many candidates recalled the speed of light and were familiar with the relationship wave speed = frequency x wavelength ($s = f \times \lambda$). They processed the data and expressed the final answer in standard form. Some candidates gave a final answer that could be readily converted to standard form.

Limited responses

- Some candidates used an incorrect value for the speed of light when using $s = f \times \lambda$ to process the data. In some cases, it was possible to carry this incorrect value forward if it was the only mistake.
- Some candidates made arithmetic errors when processing exponents.
- Some candidates recalled $s = f \times \lambda$ and then made an error when they rearranged the expression, suggesting for example $\lambda = s \times f$.

(iii) Comprehensive responses

- Comprehensive responses clearly related the direction of the vibration of particles to the direction of propagation of the wave for both transverse and longitudinal waves. Some candidates used the phrases 'direction of travel of the wave' or 'direction of energy transfer'.

Limited responses

- Candidates unfamiliar with the term 'propagation' often suggested descriptions of the relation between direction of vibration and direction of propagation which were unclear. Examples include 'in a transverse wave the wave is at right angles' or 'the vibration is the same as the wave in longitudinal waves'.
- Some candidates attempted to describe the direction of vibrations using phrases such as 'up and down' and 'back and forth' or 'side to side'.
- A few candidates answered in terms of longitudinal waves always requiring a medium.

Question 9

(a) (i) Comprehensive responses

- Many candidates realised that they needed to find the product of the charger wattage (kW) and time (hrs).

Limited responses

- Some candidates attempted to use the relationship $E = I \times V \times t$.
- Some candidates looked for a calculation that used all three pieces of data given in the question.

(ii) Comprehensive responses

- Some candidates started by finding a value for the current that would be flowing during battery charging by using the expression power (W) = current (amps) × potential difference (volts). They had converted kW to W for use in this expression. They then converted 1.5 hours to seconds for use in the expression charge (coulombs) = current (amps) × time (seconds). These steps in the working were clearly presented in logical order.

Limited responses

- Many candidates stated several relationships including those relevant to this calculation and then attempted to find a way of processing the data.
- Some candidates omitted to convert the units of the data given in the question to the correct ones for use in the relevant relationships.
- Some miscalculations during data processing were carried forward when appropriate.

(b) Comprehensive responses

- Some candidates worked through to the correct value of the cross-sectional area of the wire. A variety of methods were seen, and all of these were based on the inverse relationship between resistance and cross-sectional area. One typical approach was to find the constant of proportionality in the expression resistance = K / area and then use this to process area = K / resistance.

Limited responses

- Some candidates suggested the idea that since 5 Ω is halfway between 4 Ω and 6 Ω then the corresponding area must be halfway between 2.0 cm^2 and 3.0 cm^2.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

What candidates did well

- In general, candidates completed the experiments and recorded data for all practical tasks.
- Candidates carried out calculations, such as calculating the average in **Question 1(a)(ii)** and calculation of density in **Question 3(c)**.
- Candidates read measuring instruments accurately (see note on decimal places below).
- Some candidates produce detailed graphs, with appropriate lines of best fit and can take readings from them.
- Most candidates were able to identify apparatus for the planning question, **Question 4** and were able to describe a brief method and what to measure.

What candidates needed to improve

- Candidates need to ensure that they use the correct units for measurement, for example, mm for **(a)(i)**.
- Candidates need to ensure that when asked for any relationship they answer in terms of the variables in the question, for example ensuring they discuss number of pieces of beetroot and intensity score in **Question 1(a)(iv),** and surface area and rate of diffusion in **Question 1(a)(v)**.
- It is expected that candidates are fully familiar with all laboratory equipment listed in the Apparatus, Materials and Reagents section of Appendix 4 of the syllabus. Many had the misconception in **Question 1(b)(i)** that a boiling tube is a hot tube.
- There is an established misconception that repeating an experiment (and taking an average) increases the accuracy of results or increases confidence in conclusions. This is a misconception. Repeats alone do not improve the quality of data. The data from repeated experiments could be of poor quality. Averaging values from a wide range of incorrect results does not improve their quality.
- When asked to record to a specific number of decimal places, they need to include zero as a measured decimal place when asked. For example, in **Question 2(a)**, 19.0 is the correct answer to the nearest 0.5 °C. 19 is incorrect as it is given to a whole degree. A similar issue was seen in **Question 3(a)**.
- Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates do not label axes appropriately or choose appropriate scales. Some plot points using 'blobs' rather than crosses or dots in circles.
- Candidates do not know that a proportional relationship is shown by a graph with a straight line through the origin.
- When given a procedure, any questions relating either to the procedure or to sources of error in the results require the candidate to answer in terms of the procedure provided. This applies to answers for questions such as **Question 1(b)(iii)** and **Question 3(e)**. Vague, generic answers such as doing repeats or generic sources of error, such as human error, are not sufficiently relevant to the questions asked.
- Candidates need to ensure, when answering the planning question, that their procedure relates to the two variables in the question and that they answer all bullet points.

Comments on specific questions

Section A

Question 1

(a) (i) Comprehensive responses

- Most candidates correctly measured and recorded the diameter in mm.

Limited responses

- Some candidates recorded the value in cm, for example 1.2.
- Some candidates gave values that were significantly outside of the expected range. This implies issues with the measurement of diameter using a ruler. It appeared that some of the values quoted were length, rather than diameter.

(ii) Comprehensive responses

- Some candidates substituted correctly into the equation and computed their answer.

Limited responses

- Some candidates were unsure how to use their calculator to process the values. Few candidates were able to calculate d^2 correctly. Some multiplied by 2 rather than squaring.

(iii) Comprehensive responses

- Most candidates correctly compared the colours to the scale and gave intensity scores that matched the scale.

Limited responses

- Some candidates described colours rather than comparing the colours to the intensity score in Figure 1.3.

(iv) Comprehensive responses

- Most candidates gave a clear statement of the relationship between the number of pieces of beetroot and the intensity score.

Limited responses

- Some candidates did not answer using the two variables stated in the question. Answers such as ‘the more you cut the beetroot’ and ‘the darker the colour’ do not answer the question.

(v) Comprehensive responses

- Most candidates clearly stated that increasing the surface area increases the rate of diffusion.

Limited responses

- In common with the previous question, some candidates did not answer in terms of the variables in the question. ‘More diffusion’ is insufficient because it does not imply rate. ‘Smaller pieces’ is insufficient because the question asks specifically about surface area.

(b) (i) Comprehensive responses

- Comprehensive responses identified that cutting the beetroot with a sharp knife is the main hazard and that to avoid injury, the precaution is to cut away from the hands on a stable surface.

Limited responses

- There were a significant number of incorrect answers seen. Some answers that identified the correct hazard suggested inappropriate precautions such as ‘wear gloves’ (normal laboratory gloves do not protect hands from sharp cuts and thick gloves would make fine cutting impossible), ‘ask an adult’ (the student is doing the experiment, not an adult) or ‘do not touch the knife’ (this would make it impossible to use).
- Another very significant misconception was that many candidates thought that a boiling tube implies it is a hot tube. This implies unfamiliarity with basic laboratory equipment listed in the syllabus.

(ii) Comprehensive responses

- The most significant reason that it is important to pour the solutions from the boiling tubes is that the diffusion time is a controlled variable at 10 minutes. Pouring the solutions off means that no further diffusion takes place so that the comparison between the colour of the tubes is fair.

Limited responses

- The most common response was ‘to remove the beetroot pieces from the solution’. This does not answer the question prompt ‘why’.

(iii) Comprehensive responses

- Some candidates referred to the detail of Step 9 and described aspects involved in determining the intensity score, such as the subjectivity of judging colour against intensity score or that some colours may be between intensity scores. Responses that discussed intensity scores addressed the requirements of the task.
- A common correct answer was to state that the colour observed is in shades of red, which may not be easily compared with a greyscale diagram.

Limited responses

- Most candidates did not consider the instruction in step 9, which is specifically related to determining intensity score. Answers such as 'difficult to see the colours' are insufficient because they do not specifically relate to comparison of colours to numbers on the intensity score chart.

Question 2

(a) (i) Comprehensive responses

- Comprehensive answers recorded both values, as the question asks, to the nearest 0.5 °C.

Limited responses

- Some candidates did not record their values to the nearest 0.5 °C. It should be noted that where a temperature is read to a whole degree, there should be a zero after the decimal point to show that the temperature is exactly on the whole degree reading, for example 19.0. Answers such as '19' are incorrect because they do not follow the instruction to read the thermometer to the nearest 0.5 °C.
- Some candidates gave temperature values significantly different to that expected. Where this occurs, the candidate values are compared to the supervisor results so that the examiner can check whether they are appropriate to the conditions and equipment used at the centre.

(ii) Comprehensive responses

- Most candidates correctly calculated the temperature increase from their temperature values.

(iii) Comprehensive responses

- In order to describe the observations in Step 5, the candidates need to describe both the initial appearance of solid G (white solid) and the final colour of the solution (blue solution).

Limited responses

- Many candidates either omitted this question or wrote incorrect or incomplete observations. Answers such as 'it went blue' are insufficient because such an answer does not identify the state (solution) and does not describe the initial appearance.

(iv) Comprehensive responses

- Most candidates recognised that the polystyrene cup provides insulation to reduce heat loss to the surroundings.

Limited responses

- Some candidates did not identify the main purpose of the polystyrene cup. Instead, they suggested reasons that are not relevant to the experiment, such as 'glass breaks'. As both methods use the glass beaker, this is not relevant.

(b) (i) Comprehensive responses

- Some candidates labelled their axes with the labels from the question, temperature increase (vertical axis) against mass of G added to water and gave units for both.
- Candidates chose a linear scale to occupy more than half the grid.
- Candidates plotted their results accurately using small crosses or small dots in circles.

Limited responses

- There are a significant number of candidates who did not construct graphs in line with the guidance in the Mathematical Requirements section of Appendix 4 in the syllabus.
- Some candidates omitted axes labels entirely or omitted units from axes labels. Some abbreviated the labels so that their meaning is unclear, for example writing 'temperature' rather than 'temperature increase' or 'mass' alone.

- Some candidates did not follow the instructions in the question and reversed the axes so that the mass of G added to water rather than the temperature increase was placed on the vertical axis.
- Some candidates used awkward scales such as 6 or 3 as intervals.
- Some candidates plotted points using large 'blobs'. This approach made it difficult to judge the precise location of each point. The syllabus states that points should be plotted with a small cross or a dot in a circle.

(ii) Comprehensive responses

- Most candidates identified the anomalous point.

Limited responses

- There was a relatively high omit rate for this question, some candidates did not circle the point.

(iii) Comprehensive responses

- Some very accurate lines of best fit were seen. In this case, the line started at the origin and many candidates drew a straight line with a ruler, considering all points other than the anomalous point.

Limited responses

- Some candidates did not use a ruler to draw their line.
- Some lines started significantly away from the origin.
- Some candidates drew 'dot to dot', double or broken lines.

(iv) Comprehensive responses

- Comprehensive answers recognised that to show proportionality, the line of best fit must be a straight line through the origin.

Limited responses

- There is a significant misconception that when both variables on a graph show an increase, the relationship is proportional. This is incorrect.

(c) (i) Comprehensive responses

- Some responses engaged fully with the information and recognised that the colour of the precipitate is white, which cannot be seen clearly in the blue solution.

Limited responses

- Many candidates gave vague answers that did not fully engage with the information. Common limited responses included 'because copper sulfate is blue'. This answer restates information without showing any additional understanding.

(ii) Comprehensive responses

- Many candidates suggest filtration or leaving the solution to settle to confirm the colour of the precipitate.

Limited responses

- Some candidates stated 'leave it for longer' without stating that this was to all the precipitate to settle.

Question 3

(a) Comprehensive responses

- Most candidates took a reading from the balance and correctly rounded the mass, as asked in the question, to the nearest 0.1 g.
- Some candidate mass values were significantly different to that expected. Where this occurs, the candidate values are compared to the supervisor results so that the examiner can check whether they are appropriate to the conditions and equipment used at the centre.

Limited responses

- A few candidates did not obey the instruction to 'record to the nearest 0.1 g'.

(b) **Comprehensive responses**

- Some candidates recorded a volume within the expected range and obeyed the instruction to record this volume to the nearest cm^3.

Limited responses

- Some candidate values were significantly different from the range expected. In these cases, supervisor values were used to judge whether this reflected the equipment provided.
- Many candidates did not obey the instruction to 'record this volume to the nearest cm^3'. Answers to one decimal place were common incorrect answers.

(c) **Comprehensive responses**

- Almost all candidates correctly calculated density.

(d) **Comprehensive responses**

- Some candidates correctly identified a source of error specific to the procedure described, such as the spilling of water in the transfer between the tray and the measuring cylinder.

Limited responses

- It should be noted that in this type of question it is important that candidates engage with the procedure rather than give vague, generic responses.
- Generic responses such as human error or misreading the measuring cylinder or balance are too vague.
- Some candidates stated that water spills from the trough into the tray. This is part of the experimental procedure and is not a source of error.

(e) **Comprehensive responses**

- Some candidates correctly calculated either a 10 per cent increase in the lower value or a 10 per cent increase in the higher value and commented that the difference was greater than 10 per cent.
- Other correct methods seen included calculating the percentage difference between the two values.

Limited responses

- Some candidates calculated the difference between the values and did not express this as a percentage.

(f) **Comprehensive responses**

- Comprehensive responses both stated that the density would appear larger and justified this with reference to the calculation, stating that the mass is divided by a lower volume.

Limited responses

- Commonly, candidates did not answer in terms of the calculated density but instead referred to particles being closer together. Although this is correct, the question specifically asks for the answer to be in terms of calculated density, rather than actual, so it was essential that the answer relates to the calculation.

Question 4

Comprehensive responses

- Candidates who answered this question fully typically ensured that they engaged with the question asked, in this case the relationship between *d*, the distance between the top of the prism and the point at which the refracted ray leaves the prism, and *i*, the angle of incidence.
- Comprehensive responses addressed all five bullet points.

Limited responses

- A common reason for a limited response was that some candidates did not take care to ensure that their plan addressed the variables given, *d* and *i*. It was relatively common to see plans that instead measured the angle of incidence and the angle of refraction.

- A second reason for limited responses was that many candidates did not address all five bullet points. It was relatively common for answers to omit the results table or omit to describe how to process results to reach a conclusion.
- It should be noted that vague generic statements about ‘doing repeats’ are insufficiently applied to the context. The procedure needs to be a detailed description of an experiment that another student could follow.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

What candidates did well

- They compared colours to judge intensity scores in **Question 1**.
- They carried out calculations, such as calculating the average in **Question 1(d)(i)** and calculation of density in **Question 3(c)**.
- They read measuring instruments accurately (see note on decimal places below).
- Some candidates produce detailed graphs, with appropriate lines drawn to represent the trend in the data and can take readings from them.
- Most candidates were able to identify apparatus for the planning question, **Question 4** and were able to describe a brief method and what to measure.

What candidates needed to improve

- They need to ensure that they use the correct units for measurement, for example, mm for **(a)(i)**.
- They need to ensure that when asked for any relationship they answer in terms of the variables in the question, for example ensuring they discuss number of pieces of beetroot and intensity score in **Question 1(b)(ii)**, and surface area and rate of diffusion in **Question 1(b)(iii)**.
- It is expected that candidates are fully familiar with all laboratory equipment listed in the Apparatus, Materials and Reagents section of Appendix 4 of the syllabus. Many had the misconception in **Question 1(c)(i)** that a boiling tube is a hot tube.
- There is an established misconception that repeating an experiment (and taking an average) increases the accuracy of results or improves the reliability of the data and conclusions. This is a misconception. Repeats alone do not improve the quality of data. The data from repeated experiments may not be reliable or consistent. Averaging values from a wide range of incorrect results does not improve their quality.
- When asked to record to a specific number of decimal places, they need to include zero as a measured decimal place when asked. For example, in **Question 2(a)**, 19.0 is the correct answer to the nearest 0.5 °C. 19 is incorrect as it is given to a whole degree. A similar issue was seen in **Question 3(a)**.
- Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates do not label axes appropriately or choose appropriate scales. Some plot points using ‘blobs’ rather than crosses or dots in circles.
- Candidates do not know that a proportional relationship is shown by a graph with a straight line through the origin.
- When given a procedure, any questions relating either to the procedure or to sources of uncertainty or limitations in the results require the candidate to answer in terms of the procedure provided. This applies to answers for questions such as **Question 1(c)** and **Question 3(d)**. Vague, generic answers such as doing repeats or generic sources of error, such as "human error," are not sufficiently relevant to the questions asked.
- Candidates need to ensure, when answering the planning question, that their procedure relates to the two variables in the question and that they answer all bullet points.

Comments on specific questions

Section A

Question 1

(a) (i) Comprehensive responses

- Most candidates correctly measured and recorded the diameter in mm.

Limited responses

- Some candidates recorded the value in cm, for example 1.2.

(ii) Comprehensive responses

- Some candidates substituted correctly into the equation and computed their answer.

Limited responses

- Some candidates were unsure how to use their calculator to process the values. Few candidates were able to calculate d^2 correctly. Some multiplied by 2 rather than squaring.

(b) (i) Comprehensive responses

- Almost all candidates correctly compared the colours to the scale and gave intensity scores that matched the scale.

(ii) Comprehensive responses

- Most gave a clear statement of the relationship between the number of pieces of beetroot and the intensity score.

Limited responses

- Some candidates did not answer using the two variables stated in the question. Answers such as ‘the more you cut the beetroot’ and ‘the darker the colour’ do not answer the question.

(iii) Comprehensive responses

- Most clearly stated that increasing the surface area increases the rate of diffusion.

Limited responses

- In common with the previous question, some candidates did not answer in terms of the variables in the question. ‘More diffusion’ is insufficient because it does not imply rate. ‘Smaller pieces’ is insufficient because the question asks specifically about surface area.

(c) (i) Comprehensive responses

- Comprehensive responses identified that cutting the beetroot with a sharp knife is the main hazard and that to avoid injury, the precaution is to cut away from the hands on a stable surface.

Limited responses

- There were a significant number of incorrect answers seen. Some answers that identified the correct hazard suggested inappropriate precautions such as ‘wear gloves’ (normal laboratory gloves do not protect hands from sharp cuts and thick gloves would make fine cutting impossible), ‘ask an adult’ (the student is doing the experiment, not an adult) or ‘do not touch the knife’ (this would make it impossible to use).
- Another very significant misconception was that many candidates thought that a boiling tube implies it is a hot tube. This implies unfamiliarity with basic laboratory equipment listed in the syllabus.

(ii) Comprehensive responses

- The most significant reason that it is important to pour the solutions from the boiling tubes is that the diffusion time is a controlled variable at 10 minutes. Pouring the solutions off means that no further diffusion takes place so that the comparison between the colour of the tubes is fair.

Limited responses

- The most common response was ‘to remove the beetroot pieces from the solution’. This does not answer the question prompt ‘why’.

(iii) Comprehensive responses

- Some candidates referred to the detail of Step 9 and described aspects involved in determining the intensity score, such as the subjectivity of judging colour against the scale or that some colours may fall between intensity scores. Responses that discussed intensity scores addressed the requirements of the task.

Limited responses

- Most did not consider the instruction in step 9, which is specifically related to determining intensity score. Answers such as 'difficult to see the colours' are insufficient because they do not specifically relate to comparison of colours to numbers on the intensity score chart.

(d) (i) Comprehensive responses

- Almost all candidates correctly calculated the average change in mass.

(ii) Comprehensive responses

- Some candidates recognised that to increase confidence in the conclusion, a wider range of surface areas should be tested. Some also said that to increase confidence in the existing results, the student could repeat the procedures and check that results are consistent.

Limited responses

- It is a very common misconception that 'repeat the experiment' or 'repeat the experiment' or 'repeat and take an average' increases the confidence in a conclusion. This is incorrect. The repeated results could be wide ranging and inaccurate.

Question 2

(a) (i) Comprehensive responses

- Comprehensive responses recorded both values, as the question asks, to the nearest 0.5 °C, leading to answers of 19.0 and 30.5.

Limited responses

- Most candidates did not record the first temperature correctly. The response '19' did not meet the requirement of the question. There is a misconception that a zero after a decimal point can be omitted. A few misread the thermometers to give incorrect readings such as 21.0 or 31.5.

(ii) Comprehensive responses

- Almost all candidates correctly calculated the temperature increase from their temperature values.

(iii) Comprehensive responses

- Most recognised that the polystyrene cup provides insulation to reduce heat loss to the surroundings.

Limited responses

- Some did not identify the main purpose of the polystyrene cup. Instead, they suggested reasons that are not relevant to the experiment, such as 'glass breaks'. As both methods use the glass beaker, this is not relevant.

(b) (i) Comprehensive responses

- Some candidates labelled their axes with the labels from the question, temperature increase (vertical axis) against mass of G added to water and gave units for both.
- They chose a linear scale to occupy more than half the grid.
- They plotted their results accurately using small crosses or small dots in circles.

Limited responses

- There are a significant number of candidates who do not construct graphs in line with the guidance in the Mathematical Requirements section of Appendix 4 in the syllabus.
- Some candidates omit axes labels entirely or omit units from axes labels. Some abbreviate the labels so that their meaning is unclear, for example writing 'temperature' rather than 'temperature increase' or 'mass' alone.
- Some do not follow the instructions in the question and reverse the axes so that the mass of G added to water rather than the temperature increase was placed on the vertical axis.
- Some candidates use awkward scales such as 6 or 3 as intervals.
- Some candidates plotted points using large 'blobs'. This approach made it difficult to judge the precise location of each point. The syllabus states that points should be plotted with a small cross or a dot in a circle.

(ii) Comprehensive responses

- Most candidates identified the anomalous point.

Limited responses

- There was a relatively high omit rate for this question, some candidates did not circle the point.

(iii) Comprehensive responses

- Some candidates drew very accurate straight lines through the data points. In these cases, the line started at the origin, and many candidates used a ruler to draw a straight line that took account of all points except the anomalous point.

Limited responses

- Some candidates did not use a ruler to draw their line.
- Some lines started significantly away from the origin.
- Some candidates drew 'dot to dot', double or broken lines.

(iv) Comprehensive responses

- Comprehensive answers recognised that to show proportionality, the line of best fit must be a straight line through the origin.

Limited responses

- There is a significant misconception that when both variables on a graph show an increase, the relationship is proportional. This is incorrect.

(v) Comprehensive responses

- Most candidates who had constructed their graph appropriately were able to take this reading correctly.

(c) (i) Comprehensive responses

- Some responses engaged fully with the information and recognised that the colour of the precipitate is white, which cannot be seen clearly in the blue solution.

Limited responses

- Many candidates gave vague answers that did not fully engage with the information. Common limited responses included 'because copper sulfate is blue'. This answer restates information without showing any additional understanding.

(ii) Comprehensive responses

- Many candidates suggest filtration or leaving the solution to settle to confirm the colour of the precipitate.

Limited responses

- Some stated 'leave it for longer' without stating that this was to all the precipitate to settle.

Question 3

(a) Comprehensive responses

- Most candidates took a reading from the balance and correctly rounded the mass, as asked in the question, to the nearest 0.1 g.

Limited responses

- A few candidates did not obey the instruction to 'record to the nearest 0.1 g'.
- Some did not round the value correctly. 301.5 was a common incorrect answer.

(b) Comprehensive responses

- Almost all candidates correctly read the measuring cylinder.

(c) Comprehensive responses

- Almost all candidates correctly calculated density. Where candidates used an incorrect value for mass or volume from earlier in the question, they continued with their calculation using these values.

(d) **Comprehensive responses**

- Some candidates correctly identified a source of error specific to the procedure described, such as the spilling of water in the transfer between the tray and the measuring cylinder.

Limited responses

- It should be noted that in this type of question it is important that candidates engage with the procedure rather than give vague, generic responses.
- Generic responses such as human error or misreading the measuring cylinder or balance are too vague.
- Some said that water spills from the trough into the tray. This is part of the experimental procedure and is not a source of error.

(e) **Comprehensive responses**

- Some candidates correctly calculated either a 10 per cent increase in the lower value or a 10 per cent increase in the higher value and commented that the difference was greater than 10 per cent.
- Other correct methods seen included calculating the percentage difference between the two values.

Limited responses

- Some candidates calculated the difference between the values and did not express this as a percentage.

(f) **Comprehensive responses**

- Comprehensive responses both stated that the density would appear larger and justified this with reference to the calculation, stating that the mass is divided by a lower volume.

Limited responses

- Commonly, candidates did not answer in terms of the calculated density. Instead, they referred to particles being closer together. Although this is correct, the question specifically asks for the answer to be in terms of calculated density, rather than actual, so it was essential that the answer relates to the calculation.

Question 4

Comprehensive responses

- Candidates who answer this question fully typically ensure that they engage with the question asked, in this case the relationship between *d*, the distance between the top of the prism and the point at which the refracted ray leaves the prism, and *i*, the angle of incidence.
- A second common feature of comprehensive responses is candidates who ensure that they have addressed all five bullet points.

Limited responses

- A common reason for a limited response is that some candidates did not take care to ensure that their plan addressed the variables given, *d* and *i*. It was relatively common to see plans that instead measured the angle of incidence and the angle of refraction.
- A second reason for limited responses was that many candidates do not address all five bullet points. It was relatively common for answers to omit the results table or omit to describe how to process results to reach a conclusion.
- It should be noted that vague generic statements about ‘doing repeats’ are insufficiently applied to the context. The procedure needs to be a detailed description of an experiment that another student could follow.