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

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- **Insight assessments**
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  - Focus on assessment
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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/12
Multiple Choice (Core)

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

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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**, **9**, **14**, **16**, **18**, **19**, **20**, **24**, **26**, **27**, **28**, **31**, **32**, **38**, **39** and **40**.

Candidates performed less well on **Questions 6**, **7**, **8**, **13**, **15**, **21**, **25**, **30**, **33**, **34**, **35**, **36** and **37**.

Overall, the standard of performance was high on this paper.

Comments on specific questions

Question 6

- Option **B** was a common incorrect answer.
- Candidates had misinterpreted the diagram. Sucrose cannot pass to the roots.

Question 7

- Option **B** was a common incorrect answer.
- Candidates had reversed the percentages of yellow and white flowers.

Question 8

- Option **B** was a common incorrect answer.
- Candidates could not convert micrometres to millimetres.

Question 13

- Option **B** was a common incorrect answer.
- Candidates had confused what happens to the valves between the atria and ventricles, and between the ventricles and arteries.

Question 15

- Option **C** was a common incorrect answer.
- The particle shown in the diagram is a fluoride ion rather than an atom of neon.

Question 21

- Option **D** was a common incorrect answer.
- Candidates knew the typical properties of high density and high melting point. Candidates incorrectly thought that the sulfate would be white.

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Question 25

- Option **D** was a common incorrect answer.
- Candidates knew that NO was reduced. Candidates thought that two molecules of CO react with one mole of NO.

Question 30

- Option **B** was a common incorrect answer.
- Candidates did not realise that the area quoted in the question was for one leg.

Question 33

- Option **C** was a common incorrect answer.
- Candidates could not use the data provided in the question to determine the most suitable length of 0.60 m.

Question 34

- Option **A** was a common incorrect answer.
- As the angle of incidence at the edge is much smaller than the critical angle, when the incident ray enters the glass block, some of the light will emerge into the air and some will be reflected back into the block.

Question 35

- Option **D** was a common incorrect answer.
- The magnified, virtual image formed will be on the same side as the object.

Question 36

- Option **A** was a common incorrect answer.
- The reason why slip rings are used in an a.c. generator was confusing for some candidates. It is not to connect the ends of the coil to the brushes as the coil turn. Instead, it is to connect the brushes to the external circuit as the coil turns.

Question 37

- Option **C** was a common incorrect answer.
- Candidates knew the direction of the magnetic field around the wire. Candidates did not recognise the distance between the field lines increases with distance from the wire.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/32
Theory (Core)

Key messages

What candidates did well
- Most candidates had a good understanding of what the questions were asking.
- A good standard of scientific knowledge was displayed by many candidates.

What candidates needed to improve
- Candidates should read the stimulus material and each question carefully, ensuring they follow all the instructions provided.
- Candidates need to improve their ability to interpret questions accurately and communicate their ideas clearly, in addition to demonstrating sound scientific knowledge.

Comments on specific questions

Question 1

(a) (i) Comprehensive responses
- All candidates identified at least one cell structure found in both plant and animal cells.

Limited responses
- The only incorrect response suggested was cell wall instead of cell membrane.

(ii) Comprehensive responses
- Most candidates identified the small molecule that glycogen is made from.

Limited responses
- The common incorrect response given was glycerol.

(iii) Comprehensive responses
- Many candidates correctly circled the three chemical elements that make up carbohydrates.

Limited responses
- The only incorrect chemical elements given were magnesium and nitrogen.

(b) (i) Comprehensive responses
- Few candidates identified a plasmid as the part of the bacterial cell.

Limited responses
- Ribosome was frequently suggested incorrectly.

(ii) Comprehensive responses
- Protection was frequently suggested. A number of candidates correctly suggested that the cell wall protects the cell from bursting.

Limited responses
- There were insufficient incorrect responses to identify common errors.

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(c) (i) Comprehensive responses

- Few candidates identified both methods of pathogen transmission that needed direct contact.

Limited responses

- Some candidates were able to identify one method. All the incorrect methods were frequently suggested.

(ii) Comprehensive responses

- Mucus and hairs in nose were frequently suggested as the body defences.

Limited responses

- Some candidates incorrectly suggested external body defences such as wearing a face mask or washing hands.

(iii) Comprehensive responses

- Some candidates suggested a correct link between a lower white blood count, pathogens and possible illness.
- Good answers mentioned fewer antibodies and pathogens not being removed.

Limited responses

- Some candidates gave inaccurate descriptions of the link between a lower white blood count, pathogens and possible illness such as the antibodies fighting the pathogens rather than destroying them.

Question 2

(a) (i) Comprehensive responses

- Most candidates correctly identified both the trachea and the diaphragm.

Limited responses

- The least well known was trachea. Some candidates confused the trachea with a bronchus.

(ii) Comprehensive responses

- Most candidates identified oxygen from the information given in the table.

Limited responses

- There were insufficient incorrect responses to identify common errors.

(iii) Comprehensive responses

- There were no correct responses to this part.

Limited responses

- Some candidates showed their working when attempting the calculation, even when their final answers where incorrect.

(b) (i) Comprehensive responses

- Some candidates were able to construct the correct word equation for aerobic respiration.

Limited responses

- Some candidates attempted to construct a fully balanced symbol equation or use a mixture of words and symbols.

(ii) Comprehensive responses

- Some candidates correctly identified two uses of the energy released from aerobic respiration. These were usually cell division, the passage of nerve impulses or movement.

Limited responses

- Some candidates identified one use of the energy released from aerobic respiration.

(iii) Comprehensive responses

- Some candidates correctly described how a lack of haemoglobin affected aerobic respiration.

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Limited responses

- Some candidates could not make the connection between lack of haemoglobin and less oxygen transport.

Question 3

(a) Comprehensive responses

- Some candidates showed a good understanding of genetic terms.

Limited responses

- Many candidates knew at least one of the genetic terms. This was usually inheritance.

(b) Comprehensive responses

- Most candidates correctly completed the Punnett square.
- Some candidates were able to determine the probability of the second child having attached earlobes.

Limited responses

- Some candidates incorrectly determined the mother's genotype. These candidates then went on to complete the Punnett square.
- Few candidates were able to determine the probability. A common incorrect probability was 75 percent.

(c) (i) Comprehensive responses

- Some candidates identified the description of a mutation.

Limited responses

- Many candidates suggested a variation rather than a mutation.

(ii) Comprehensive responses

- Many correct examples of discontinuous variation were given.

Limited responses

- Many candidates confused discontinuous variation with continuous variation and suggested weight or height as examples.

Question 4

(a) (i) Comprehensive responses

- Most candidates correctly identified two or three words from the list.

Limited responses

- The least well-known word was gland, which was often confused with receptor.

(ii) Comprehensive responses

- Some candidates correctly identified that neurone P is connected to a muscle.

Limited responses

- Some candidates knew that the neurone was a motor neurone and could not identify it from the diagram.

(b) Comprehensive responses

- Most candidates used the data in the table to identify the species which has the lowest number of neurones in its brain.

Limited responses

- There were insufficient incorrect responses to identify common errors.

(c) (i) Comprehensive responses

- Some candidates identified both oestrogen and insulin as the hormones.

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Limited responses
- Some candidates did not attempt this question, suggesting that understanding of this topic could be improved.

(ii) Comprehensive responses
- Some candidates identified adrenaline as the hormone and were able to describe one effect of this hormone. Increased pupil diameter was the most popular suggestion.

Limited responses
- Some candidates were unable to identify adrenaline and consequently were unable to give a suitable answer.

Question 5

(a) (i) Comprehensive responses
- Very few candidates identified methane as the main constituent of natural gas.

Limited responses
- Most candidates incorrectly suggested that carbon dioxide is the main constituent of natural gas.

(ii) Comprehensive responses
- The displayed formula of methane was well known.

Limited responses
- Some candidates confused methane with ethane.

(iii) Comprehensive responses
- Most candidates identified either carbon dioxide or ethanol as a molecule that is not a hydrocarbon.

Limited responses
- There were insufficient incorrect responses to identify common errors.

(iv) Comprehensive responses
- Most candidates recognised the description of a polymer and correctly identified poly(ethene).

Limited responses
- A few candidates could not recognise the description of a polymer.

(v) Comprehensive responses
- Some candidates recognised the description of an alkene and correctly identified ethene.

Limited responses
- Some candidates confused alkenes with alkanes and suggested either methane or ethane.

(b) Comprehensive responses
- Most candidates were able to balance the symbol equation.

Limited responses
- There were insufficient incorrect responses to identify common errors.

(c) (i) Comprehensive responses
- Most candidates were able to complete the sentence to explain the difference between an acidic oxide and a basic oxide.

Limited responses
- Some candidates confused acidic oxides with basic oxides.

(ii) Comprehensive responses

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- Some candidates made the link between acidic oxides and pH and gave an answer within the accepted pH range.

Limited responses
- Some candidates confused acidic pH values with alkaline pH values.

(d) Comprehensive responses
- Many candidates showed a good understanding of the Periodic Table, giving correct period numbers and group numbers.

Limited responses
- Some candidates gave one incorrect response in this question.

Question 6

(a) Comprehensive responses
- Many candidates were able to combine their knowledge of general metal properties and transition metal properties to answer this question.
- Copper being a good conductor of thermal energy was well known.

Limited responses
- A few candidates were unable to identify any correct statements about copper.

(b) (i) Comprehensive responses
- Some candidates identified the definition of an alloy.

Limited responses
- There were insufficient incorrect responses to identify common errors.

(ii) Comprehensive responses
- A few candidates were able to correctly identify the structure showing the arrangement of atoms in an alloy.

Limited responses
- Many candidates selected structures that showed a regular arrangement of atoms.

(c) (i) Comprehensive responses
- Most candidates showed that they understood nuclide notation.

Limited responses
- A few candidates selected the wrong number from the nuclide notation.

(ii) Comprehensive responses
- Many candidates were able to use the proton number to determine the number of electrons in the atom.

Limited responses
- Some candidates determined the number of neutrons in the atom.

(iii) Comprehensive responses
- Many candidates correctly stated that the relative charge on an electron is negative or -1.

Limited responses
- A number of candidates did not understand the question and suggested values such as 32 or 35.

(d) (i) Comprehensive responses
- Most candidates used the information shown on the diagram to determine that there was no reaction between copper and dilute sulfuric acid.

Limited responses

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- A few candidates did not make the connection between an absence of bubbles and no reaction.

(ii) Comprehensive responses

- Some candidates used the information given to write the word equation for the reaction and identify the unknown gas as hydrogen.

Limited responses

- Some candidates ignored the instructions given and attempted to write a fully balanced symbol equation.

(iii) Comprehensive responses

- Many candidates correctly stated that magnesium is more reactive than iron.

Limited responses

- There were insufficient incorrect responses to identify common errors.

Question 7

(a) (i) Comprehensive responses

- There were few correct responses. These responses explained that a chlorine molecule contains two chlorine atoms.

Limited responses

- Most incorrect responses referred to the number of elements contained in a chlorine molecule.

(ii) Comprehensive responses

- Few candidates correctly described the chemical bonding present in sodium chloride as ionic.

Limited responses

- Covalent bonding was suggested by many candidates.

(b) Comprehensive responses

- Some candidates were able to describe a compound as containing two or more elements chemically combined.

Limited responses

- Few candidates were able to describe an element. Some very inaccurate descriptions were given.

(c) Comprehensive responses

- A few candidates were able to determine how the electronic configuration of a sodium atom changed when sodium lost an electron.

Limited responses

- Some candidates attempted to work out the electronic configuration when a sodium atom gained an electron.

(d) (i) Comprehensive responses

- Most candidates correctly identified the electrolyte.

Limited responses

- A few candidates labelled the electrode.

(ii) Comprehensive responses

- Most candidates correctly identified the cathode.

Limited responses

- A few candidates confused the cathode with the anode.

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(iii) Comprehensive responses

- Graphite was the most popular and correct answer.

Limited responses

- Some candidates suggested copper as the material for the electrode.

(iv) Comprehensive responses

- Many candidates knew one or other of the gases produced at the electrodes and not both.

Limited responses

- Candidates frequently confused the cathode product and the anode product.

Question 8

(a) (i) Comprehensive responses

- Most candidates correctly interpreted the information given and suggested a stopwatch as the other piece of apparatus needed.

Limited responses

- A few candidates could not use all the information given and suggested other pieces of apparatus such as a thermometer or stirring rod.

(ii) Comprehensive responses

- Many candidates showed good data handling skills and correctly determined the time for experiment B to complete.

Limited responses

- A few candidates selected experiment C.

(iii) Comprehensive responses

- Most candidates showed good data handling skills and correctly determined the volume of gas collected.

Limited responses

- There were insufficient incorrect responses to identify common errors.

(iv) Comprehensive responses

- Some candidates recognised that the lowest concentration would produce the slowest reaction and then used the graph to identify experiment A.

Limited responses

- A few candidates chose experiment C because it finished the quickest.

(v) Comprehensive responses

- Some candidates were able to draw a steeper line that levelled off at 50 cm^3.

Limited responses

- Some candidates were able to draw either a steeper line or draw a line that levelled off at 50 cm^3.
- A few candidates did not attempt this question.

(b) (i) Comprehensive responses

- Many candidates named both the gases which are present in clean dry air in the highest percentages.

Limited responses

- Some candidates were able to name one of the gases.

(ii) Comprehensive responses

- Planting more trees was the popular and correct answer to this question.

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Limited responses
- Some candidates were unable to explain why planting more trees would reduce climate change.

Question 9

(a) (i) Comprehensive responses
- Many candidates were able to remember all the planets in the Solar System and place them in the correct order.

Limited responses
- Some candidates were able to place at least two planets in the correct positions.

(ii) Comprehensive responses
- Some candidates were able to explain that the gravitational attraction of the Sun is the reason why the planets orbit the Sun and not each other.

Limited responses
- Candidates could not explain that the Sun contains most of the mass of the Solar System.

(b) (i) Comprehensive responses
- A few candidates were able to give a partial description of the differences in arrangement and motion of particles in a gas and in a solid.

Limited responses
- Many candidates confused the arrangement of the molecules with the separation of the molecules.
- Some candidates described bulk properties.

(ii) Comprehensive responses
- Some candidates showed a good understanding of the bulk properties of solids and gases.

Limited responses
- Some candidates described the shape of a gas using terms such as “free” and “random,” and needed to state that the shape is not fixed.

(c) (i) Comprehensive responses
- Some candidates correctly used ideas about conduction and convection needing a medium or that space contains no particles.

Limited responses
- A few candidates incorrectly used ideas about the Sun being too far away or it taking too long for conduction and convection to happen.

(ii) Comprehensive responses
- Some candidates identified infrared radiation as the electromagnetic radiation used in thermal energy transfer.

Limited responses
- Most candidates identified an incorrect electromagnetic radiation.
- Ultraviolet radiation was more popular than infrared radiation.

Question 10

(a) (i) Comprehensive responses
- Most candidates correctly identified weight as the force.

Limited responses
- There were insufficient incorrect responses to identify common errors.

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(ii) Comprehensive responses

- Many candidates used the facts that the submarine was moving and that there was a zero resultant force to determine that the submarine was travelling at constant speed.

Limited responses

- The common incorrect response given was that the submarine was not moving.

(iii) Comprehensive responses

- Many candidates completed the calculation including the unit conversion.

Limited responses

- Some candidates were able to state the correct formula.
- Some candidates did not perform the unit conversion.

(b) (i) Comprehensive responses

- Few candidates identified nuclear fission as the process.

Limited responses

- Some candidates did not answer the question.
- There were no common incorrect answers.

(ii) Comprehensive responses

- Many candidates explained the reason for shielding nuclear reactors with lead.

Limited responses

- A few candidates vaguely suggested not harming people.

(iii) Comprehensive responses

- The charges on a proton and neutron were well known.

Limited responses

- Some candidates misunderstood the question and seemed to be calculating the numbers of protons and neutrons rather than the charges.

(c) Comprehensive responses

- A few candidates were able to suggest a frequency for the ultrasound waves.

Limited responses

- Few candidates were able to link ultrasound to the approximate range of frequencies audible to humans.

Question 11

(a) (i) Comprehensive responses

- Some candidates were able to draw clear circuit diagrams that included all the circuit components with correct symbols.

Limited responses

- Many candidates either missed out the switch or used incorrect symbols for the cell, switch or lamp.

(ii) Comprehensive responses

- Some candidates used the correct symbol and drew a voltmeter connected in parallel across the lamp.

Limited responses

- Some candidates used the correct symbol for a voltmeter and showed it connected in series with the lamp.

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(iii) **Comprehensive responses**
- Many candidates used the correct formula to calculate the resistance.
- Most candidates showed their working.

Limited responses
- Some candidates divided the current by the voltage.
- Some candidates multiplied the current by the voltage.

(b) **Comprehensive responses**
- Some candidates correctly identified the angle of incidence and the angle of refraction.

Limited responses
- The angle of incidence was less known than the angle of refraction.
- Some candidates attempted to measure the angles.

(c) (i) **Comprehensive responses**
- Some candidates completed the visible spectrum correctly.

Limited responses
- Some candidates included extra colours such as purple.

(ii) **Comprehensive responses**
- Some candidates correctly identified red as having the longest wavelength and violet as having the highest frequency.

Limited responses
- Some candidates confused red with violet.

(iii) **Comprehensive responses**
- Many candidates used the correct formula to calculate the frequency.
- Most candidates showed their working.

Limited responses
- Some candidates divided the wavelength by the speed.
- Some candidates multiplied the wavelength by the speed.

Question 12

(a) **Comprehensive responses**
- Most candidates correctly described the motion of the car at all four times.

Limited responses
- There were insufficient incorrect responses to identify common errors.

(b) **Comprehensive responses**
- No correct answers were seen.

Limited responses
- Candidates needed to use the percentages given in the question.

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

Limited responses
- There were no common errors.

(d) **Comprehensive responses**
- Some candidates correctly determined the force by dividing the moment by the distance.
- Some candidates gave the correct unit for a force.

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Limited responses

- Some candidates multiplied the moment by the distance.
- Some candidates stated that the unit for force is the newton-metre (N m).

(e) Comprehensive responses

- Some candidates correctly determined the force by dividing the power by the voltage.

Limited responses

- Some candidates divided the voltage by the power.

(f) Comprehensive responses

- Few candidates were able to answer the question. These candidates explained that an electromagnet could be switched on and off.

Limited responses

- Candidates needed to explain that an electromagnet can have varying strength.

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CO-ORDINATED SCIENCES (DOUBLE AWARD)

Paper 0654/42
Theory (Extended)

Key messages

What candidates did well

- Most candidates demonstrated scientific knowledge and could competently apply their knowledge to scenarios given in the questions.
- Candidates displayed mathematical skills by completing calculations, using the correct formula and showing their working.
- Candidates generally completed the instructions given in the question to answer a range of question types including fill-the-gap type questions, ticking the correct box and drawing ray diagrams.

What candidates needed to improve

- Some candidates misinterpreted the command words and gave a description where an explanation was required.
- Some candidates omitted the conversion of units in some calculation questions.
- Some candidates gave simple explanations and could have provided more detail. For example, in **Question 2(c)**, candidates could have stated where the breakdown of lactic acid takes place, and in **Question 9(b)(ii)**, they could have included a clearer explanation of convection.

Comments on specific questions

Question 1

(a) Comprehensive responses

- Most candidates were able to give two characteristics of living organisms in addition to reproduction.

Limited responses

- Some candidates gave the characteristic of reproduction, which had already been given.

(b)(i) Comprehensive responses

- Many candidates identified the part of the male reproductive system that produced the hormone testosterone and that produced the fluid that sperm is transported in.

Limited responses

- Some candidates stated that part **B** (the bladder) produced testosterone instead of part **D** (the testis).
- Some candidates stated that part **B** (the bladder) produced the fluid that sperm is transported in instead of part **C** (the prostate gland).

(ii) Comprehensive responses

- Many candidates stated that hormones were produced by glands and are carried in the blood.

Limited responses

- Some candidates stated that hormones alter the activity of reproductive organs instead of target organs.
- Some candidates stated that hormones are produced by the brain.

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(iii) Comprehensive responses

- Many candidates could describe the adaptive features of sperm including flagellum, mitochondria, enzymes in acrosome and a haploid nucleus.

Limited responses

- Fewer candidates explained the adaptive features of sperm.
- Some candidates stated that flagellum help the sperm to swim and did not include that sperm swim to meet the egg.
- Some candidates stated that the acrosome was an enzyme.
- Some candidates stated that mitochondria provided energy for the sperm and did not include that energy was needed for the sperm to swim.

(c) Comprehensive responses

- Some candidates described the fusion of pollen and an ovule.

Limited responses

- Few candidates referenced the fusion of nuclei.
- Many candidates used the term ova, egg or ovary instead of ovule.

Question 2

(a) (i) Comprehensive responses

- Many candidates were able to describe that both diffusion and osmosis involved movement down a concentration gradient.
- Some candidates included the presence of a partially permeable membrane in the process of osmosis.

Limited responses

- Many candidates described osmosis as the movement of water and diffusion as the movement of gases.
- Some candidates described osmosis involving water potentials.

(ii) Comprehensive responses

- Many candidates stated that active transport involved movement from an area of lower concentration to an area of higher concentration.
- Many candidates described the need for energy for the process of active transport.

Limited responses

- Some candidates stated that movement was with, down or along a concentration gradient.

(b) Comprehensive responses

- Many candidates were able to identify the features of aerobic respiration and anaerobic respiration.

Limited responses

- Some candidates stated that carbon dioxide was produced during both aerobic and anaerobic respiration.
- Some candidates stated that water was produced during both aerobic and anaerobic respiration.

(c) Comprehensive responses

- A few candidates were able to explain that breathing rate and heart rate stayed high after exercise and explain the reasons for this.
- Some candidates were able to explain the role of the liver and aerobic respiration in the breakdown of lactic acid.

Limited responses

- Many candidates described heart rate and breathing rate increasing instead of remaining high after exercise.
- Some candidates stated that breakdown of lactic acid occurred in the muscles instead of the liver.

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- Some candidates omitted the involvement of aerobic respiration in the breakdown if lactic acid.

Question 3

(a) Comprehensive responses

- Many candidates recognised that enzymes are proteins and gave the four elements that make up proteins.

Limited responses

- Many candidates did not give elements and gave molecules instead, including amino acids and proteins.

(b) (i) Comprehensive responses

- Many candidates stated that amylase was secreted by the small intestine and the pancreas.

Limited responses

- Some candidates stated that amylase was secreted in the large intestine instead of the small intestine.
- Some candidates gave the mouth, stomach or kidneys as a location of amylase secretion.

(ii) Comprehensive responses

- Many candidates stated that reducing sugars were produced by the breakdown of starch.
- Some candidates were able to name a specific suitable reducing sugar.

Limited responses

- Some candidates gave amino acids or fatty acids instead of reducing sugars.

(iii) Comprehensive responses

- Most candidates stated the iodine test to test for starch.

Limited responses

- Some candidates mixed the colours of the starting and the final colour.
- Some candidates gave the colour change of Biuret reagent when testing for the presence of proteins.

(c) Comprehensive responses

- Many candidates could explain the effect of temperature in terms of an increase in kinetic energy and frequency of collisions leading to a faster rate of reaction.

Limited responses

- Many candidates described and explained the effect after 40 °C.
- Some candidates referred to an increase in collisions instead of an increased frequency of collisions.

(d) Comprehensive responses

- Most candidates stated that an extreme of pH would denature the enzyme.

Limited responses

- Some candidates associated the stomach with a high rather than a low pH.
- Some candidates did not use the term denaturation and instead referred to the enzyme not working.

Question 4

(a) (i) Comprehensive responses

- Most candidates identified the term ecosystem.

Limited responses

- A few candidates identified the term community instead of the term ecosystem.

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(ii) Comprehensive responses

- Most candidates identified the Sun as the principal source of energy.

Limited responses

- Many candidates identified producers instead of the Sun as the principal source of energy.

(b) (i) Comprehensive responses

- Many candidates drew an accurate food chain, with the correct number of organisms and arrows showing the transfer of energy.

Limited responses

- Some candidates drew an accurate food chain and included the blackbird as the secondary consumer instead of the tertiary consumer.
- Some candidates omitted the hawk.

(ii) Comprehensive responses

- Most candidates identified two herbivores.

Limited responses

- A few candidates included the names of carnivores.

(c) Comprehensive responses

- Many candidates identified the loss of energy between the trophic levels and gave at least one example of energy loss.

Limited responses

- Some candidates did not explain the number of trophic levels in terms of energy loss.
- Some candidates explained this in terms of size of organisms instead of energy.

Question 5

(a) (i) Comprehensive responses

- Many candidates stated that soluble meant that a solute could be dissolved in a solvent.

Limited responses

- Some candidates muddled the terms and described soluble as a substance that can dissolve in a solute.

(ii) Comprehensive responses

- Many candidates gave several correct conclusions, including stating the number and type of colours contained within the brown ink.

Limited responses

- Some candidates stated that the brown ink contained substances and did not specify the number or type of colours.

(iii) Comprehensive responses

- Many candidates calculated the distance the solvent travels.

Limited responses

- Some candidates omitted the formula they used.
- Some candidates inverted the formula.

(b) Comprehensive responses

- Many candidates stated the value of 78%.

Limited responses

- Common other values included 72% and 21% instead of 78%.

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(c) **Comprehensive responses**

- Some candidates were able to calculate the correct number of moles, using the correct formula and showing their working.

Limited responses

- Some candidates did not convert kg to g giving a value of 0.092.
- Some candidates multiplied the mass by the relative formula mass instead of dividing.

Question 6

(a) **Comprehensive responses**

- Many candidates stated that the temperature would increase.

Limited responses

- Some candidates stated that the temperature of the environment would increase and the temperature of the mixture would decrease.

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

- Most candidates identified the letter **B**.

Limited responses

- Some candidates identified the letter **A** instead of the letter **B**.

(ii) **Comprehensive responses**

- Most candidates identified the letter **C**.

Limited responses

- Some candidates identified the letter **B** instead of the letter **C**.

(c) **Comprehensive responses**

- Many candidates described an increase in concentration resulting in a more particles present per unit volume and the effect on the frequency of collisions.

Limited responses

- Some candidates describe increasing concentration as increasing the number of particles per unit area rather than volume.
- Some candidates stated than an increase in concentration resulted in an increase in kinetic energy of particles.

(d) **Comprehensive responses**

- Most candidates calculated the formula mass of magnesium sulfate as 120.
- Many candidates used the correct formula and rounded correctly to give the value 6.2.

Limited responses

- Some candidates calculated the relative formula mass of magnesium sulfate to give a value other than 120.
- Some candidates divided 120 by the mass rather than the other way round.

(e) **Comprehensive responses**

- Many candidates stated that magnesium was oxidised and could explain this in terms of loss of electrons.

Limited responses

- Many candidates stated that copper atoms rather than copper ions became reduced.

Question 7

(a) **Comprehensive responses**

- Many candidates described the presence of a double bond as indicating that propene is unsaturated.

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Limited responses
- Some candidates omitted the presence of hydrogen and carbon atoms.
- Some candidates described the presence of hydrogen and carbon molecules rather than atoms.
- Some candidates did not include that hydrocarbons are only made of carbon and hydrogen atoms.

(b) Comprehensive responses
- Most candidates identified the correct structure.

Limited responses
- Very few candidates identified other structures.

(c) Comprehensive responses
- Most candidates identified the names of each stage.

Limited responses
- Some candidates identified electrolysis or combustion instead of cracking for stage 2.
- Some candidates identified electrolysis or combustion instead of cracking for stage 3.

(d) Comprehensive responses
- Many candidates included the unit conversion from dm^3 to cm^3.
- Many candidates identified the correct ration of oxygen: carbon dioxide as 3 : 2.

Limited responses
- Many candidates calculated the volume of oxygen needed to a value of something other than 2.7 dm^3.
- Some candidates omitted this question.

Question 8

(a) Comprehensive responses
- Many candidates identified the words to describe the extraction of iron and aluminium.

Limited responses
- Some candidates stated the process of electrolysis instead of reduction for the first gap.
- Some candidates stated the fractioning column instead of blast furnace for the second gap.
- Some candidates stated thermal decomposition instead of electrolysis for the fourth gap.

(b) Comprehensive responses
- Most candidates deduced the formula of iron (III) oxide.

Limited responses
- Some candidates gave the formula FeO or Fe_3O_2.
- Some candidates included charges on the elements.

(c) Comprehensive responses
- Many candidates stated the colour of red-brown.

Limited responses
- Many candidates gave the colour of white instead of red-brown.

(d) (i) Comprehensive responses
- Many candidates stated that a layer of zinc would prevent exposure to water and oxygen.

Limited responses
- Some candidates described prevention of exposure to moisture rather than water.
- Some candidates described prevention of exposure to air rather than oxygen.
- Some candidates described sacrificial protection.

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(ii) Comprehensive responses

- Most candidates described zinc as being more reactive than iron and the greater affinity to lose electrons.

Limited responses

- Some candidates did not refer to electrons.

Question 9

(a) (i) Comprehensive responses

- Most candidates stated the boiling temperature of water and included the unit.

Limited responses

- A few candidates gave values other than 100 including 0.
- A few candidates omitted the units.

(ii) Comprehensive responses

- Many candidates described evaporation by referring to the most energetic particles escaping the surface of the liquid.

Limited responses

- Many candidates described the particles as gaining energy or heating.
- Some candidates referred to the transfer of liquid to gas instead of leaving the surface of the liquid.

(iii) Comprehensive responses

- Many candidates described the increase in rate of evaporation due to increase in kinetic energy of the particles.

Limited responses

- Some candidates described boiling.
- Some candidates described a change in rate instead of an increase in rate.

(b) (i) Comprehensive responses

- Most candidates were able to identify the correct thermal energy transfer.

Limited responses

- A few candidates stated that conduction or convection took place in a vacuum instead of radiation.

(ii) Comprehensive responses

- Few candidates explained the slow melting of the ice cube in terms of convection and the different densities of water caused by the different temperatures.

Limited responses

- Many candidates described the water as being heated at the top of the boiling tube instead of the middle of the boiling tube.
- Some candidates described hot water staying at the top of the boiling tube.
- Some candidates stated that convection was not occurring in the boiling tube.

Question 10

(a) (i) Comprehensive responses

- Some candidates described transverse waves in relation to vibrations of particles and transfer of energy being perpendicular to each other.

Limited responses

- Some candidates did not refer to vibrations or oscillation of particles.
- Some candidates did not refer to direction of travel of the waves.
- Some candidates described the wave as travelling parallel to the vibrations instead of perpendicular to the vibrations of particles.

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(ii) Comprehensive responses

- Most candidates stated an example of transverse waves including water waves, seismic S waves or an example of a wave from the electromagnetic spectrum.

Limited responses

- Some candidates repeated sound waves, that had already been given.
- Some candidates gave examples of longitudinal waves instead of transverse waves.

(b) (i) Comprehensive responses

- Many candidates described diffraction as the spreading out of waves.

Limited responses

- Some candidates described the narrowing of the gaps between the waves or described the bending of waves.

(ii) Comprehensive responses

- Many candidates described diffraction as increasing.

Limited responses

- Some candidates described diffraction as decreasing.

(c) Comprehensive responses

- Many candidates calculated the refractive index, using the correct formula.

Limited responses

- Some candidates divided 60 by 41 instead of sin 60 divided by sin 41.
- Some candidates divided sin 41 by sin 60.

(d) Comprehensive responses

- Many candidates drew and labelled the normal line.
- Many candidates drew the angle of incidence as approximately equal to the angle of reflection.

Limited responses

- Some candidates drew refraction instead of total internal reflection.
- Some candidates did not include the directional arrows on the ray of light.
- Some candidates did not label the angles or the normal line.
- Some candidates did not extend the normal line across the air and water.

Question 11

(a) (i) Comprehensive responses

- Many candidates calculated the value of 72 and included the units of C.

Limited responses

- Some candidates did not convert minutes to seconds giving a value of 1.2 instead of 72.
- A few candidates did not include the units or included alternative units including A/S, V or Ohms instead of C.

(ii) Comprehensive responses

- Many candidates described direct and alternating current in terms of direction of travel of the current.

Limited responses

- Some candidates described alternating current as changing instead of changing direction.
- Some candidates referred to voltage instead of current.
- Some candidates omitted this question.

(b) Comprehensive responses

- Some candidates recognised that if the live wire touched the metal casing, there would be a danger of electrocution.

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Limited responses
- Few candidates referred to fuses or circuit breakers.
- Few candidates described the Earth wire creating a low-resistance path.

(c) (i) Comprehensive responses
- Many candidates drew concentric circles with arrows showing an anticlockwise direction.

Limited responses
- Few candidates drew circles getting farther apart.
- Some candidates drew the pattern of magnetic field lines around a bar magnet instead of a wire.
- Some candidates drew clockwise arrows instead of anticlockwise arrows.

(ii) Comprehensive responses
- Many candidates stated the direction of force as to the right.

Limited responses
- Some candidates gave the direction of force as upwards or downwards instead of to the right.

Question 12

(a) (i) Comprehensive responses
- Many candidates gave tidal and geothermal as examples.

Limited responses
- Some candidates gave examples of fossil fuels.
- Many candidates gave wind as an example instead of tidal.

(ii) Comprehensive responses
- Most candidates described the fusion of nuclei.

Limited responses
- A very few candidates described the splitting of nuclei.

(b) Comprehensive responses
- Many candidates gave a range of statements about the universe from the Big Bang Theory.

Limited responses
- Some candidates described the Earth as being 13.8 billion years old instead of the universe.
- Some candidates described ‘it’ as expanding or starting from a dense point and did not refer to the universe.
- Some candidates referred to the solar system instead of the universe.

(c) Comprehensive responses
- Most candidates stated and used the formula F=kx.

Limited responses
- Few candidates stated and used the formula $F_1d_1 = F_2d_2$.
- Many candidates used the formula moment = force x distance from the pivot.
- Some candidates did not state the formula used.
- Some candidates did not show their working.

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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
- Most candidates followed instructions to obtain good sets of experimental results.
- Some candidates selected apparatus and described its use.
- Some candidates drew a detailed diagram of the slice of okra.
- Candidates measured the width of the slice of okra.

What candidates needed to improve
- Candidates needed to describe how the selected apparatus should be used safely and to produce the results required.
- Biological diagrams needed to have no shading, have a continuous outline, be at least half of the box in size and contain sufficient detail of the seeds in the centre.
- Recognition that repeats of a procedure allow anomalous results to be identified and then excluded.
- Candidates needed to read a question carefully so that all aspects could be answered, for example, drawing the width of the okra on their drawing and measuring it.

Plan experiments and investigations

What candidates did well
- Many candidates selected suitable apparatus.
- Some candidates wrote a method in an order which could be followed easily.
- Many candidates described the test for fats.

What candidates needed to improve
- Candidates need to explain how the selected apparatus is used.
- Candidates need to write methods in a detailed and logical order so that they are easy to follow.
- Candidates need to state control variables.
- Candidates need to identify the dependent and independent variables.
- Candidates need to know that results should be repeated and why the repeating is necessary.
- Candidates need to be able to explain how the results they obtained from an investigation contributed to the formation of a conclusion.

Make and record observations, measurements and estimates

What candidates did well
- Many candidates recorded measurements to match the precision requested in the question.
- Many candidates recorded observations of their experiments in sufficient detail.
- Most candidates recorded the observation from food tests correctly.
- Some candidates drew result tables with appropriate headings.

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, the value should end either .0 or .5.

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- Candidates should record the observations for qualitative analysis in sufficient detail, both the colour of the product and its state.
- Candidates needed to know how to calculate the gradient of a line.
- Candidates needed to recognise the difference between two significant figures and two decimal places.

Interpret and evaluate experimental observations and data

What candidates did well
- Most candidates processed the data from experiments correctly.
- Many candidates carefully considered the selection of consistent and regular scales for the graph axes.
- Many candidates labelled the axes of their graphs with the quantities and the units.
- Some candidates showed the working on their graph to obtain estimates for a specific quantity.
- Most candidates drew a tangent to a curve.

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 be able to identify an anomalous result and describe action that should be taken.
- Candidates need to be able to calculate to determine whether two values are within the limits of experimental accuracy.
- Best-fit lines needed to follow the data, and any anomalous point should be identified and labelled and not be part of the line.
- Candidates needed to give answers specific to the experiments rather than give 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
- Some candidates were able to identify the control variables.

What candidates needed to improve
- Sources of systematic and random error needed to be identified.
- Improvements to lessen the effects of error needed to be suggested.
- Candidates need to be able to evaluate methods, explaining why some techniques and apparatus were used and not others.

Comments on specific questions

Section A

Question 1

(a) Comprehensive responses
- Some candidates drew a clear, continuous outline for the okra containing no shading.
- Some candidates drew the centre seeds and holes accurately.

Limited responses
- Outlines were often sketchy with multiple lines or breaks in the outline.
- Many candidates included shading within their diagram.
- Most diagrams were smaller than half of the box.
- Some candidates either drew five seeds or five holes in the centre of the okra rather than both.

(b) (i) Comprehensive responses
- Many candidates measured and recorded the width correctly.

Limited responses
- Some candidates gave widths that were slightly too large or too small.
- Candidates needed to give their answer to the nearest millimetre, hence decimal values were not appropriate.
- Some candidates confused the units.

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(ii) Comprehensive responses

- Some candidates drew the line on their diagram and measured it correctly.

Limited responses

- Candidates needed to read the question carefully to ensure all parts were answered, as many omitted drawing the width on their diagram.

(iii) Comprehensive responses

- Most candidates calculated the magnification correctly, many giving their answer to two significant figures.

Limited responses

- Some candidates incorrectly stated the value of magnification to two decimal places rather than two significant figures.

(c) Comprehensive responses

- Most candidates gave one visible difference, and some gave two.
- Most candidates gave a visible similarity.

Limited responses

- Some candidates stated shape, size or number of seeds which are insufficient as the property needed to be correctly linked to the okra and the star fruit.
- Some answers included differences which were not visible including xylem, phloem, monocotyledon and hairs.

Question 2

(a) (i) Comprehensive responses

- Most candidates drew a table which included a column or row for the two reagents.
- The colours for the positive tests for the reagents were well known.

Limited responses

- Many tables did not include a column or row for the final colours, which were separate from the reagents.
- Sometimes the heading was test-tube 1 and test-tube 2 or yoghurt 1 and yoghurt 2, rather than final colour, results or observations.

(ii) Comprehensive responses

- Most candidates achieved the correct colours for the food tests.

Limited responses

- Few candidates reversed the final colours of the reagents.

(iii) Comprehensive responses

- Many candidates stated the nutrients correctly.

Limited responses

- Glucose, lactic acid and vitamin C were the common incorrect responses.

(b) (i) Comprehensive responses

- Some candidates considered what the mixing would do to the reagents and how this was of benefit to the reaction.

Limited responses

- Candidates needed to explain why the substances were mixed rather than include mix in their answer. Incorrect responses included mix well, mix easily and for accuracy.

(ii) Comprehensive responses

- Some candidates appreciated that the question detailed step 6 and stated the reagent or solution that would otherwise contaminate the later reaction.

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Limited responses

- Where a question is specific to a particular step in a procedure, the generic stopping contamination is insufficient, candidates needed to state what the glass rod would be contaminated with.

(c) Comprehensive responses

- Many candidates knew the reagents for testing for fats.

Limited responses

- Some candidates listed reagents such as food sample, iodine, Biuret, fat, egg, and protein powder; water was most frequently omitted.
- Few candidates stated that an emulsion would be made.
- Candidates used the terms cloudy or milky. The colours black, purple and green-yellow were seen.

Question 3

(a) (i) Comprehensive responses

- Most candidates obtained a full set of readings.
- Most candidates obtained volumes which increased down the table.

Limited responses

- Some candidates' values decreased down the table or stayed the same.
- Many candidates recorded their volumes to the nearest whole number or nearest 0.1 cm^3.

(ii) Comprehensive responses

- Some candidates plotted the correct graph containing all observations in the table and to the required accuracy.
- Some candidates used sensible and regular scales where all the data occupied more than half the graph grid and all points could be plotted.
- Some candidates used small, neat crosses for plotting the points.

Limited responses

- Candidates plotted the correct graph often with axes partially labelled with the required quantities with units frequently omitted. A small number of candidates omitted labelling the axes.
- Candidates need to use a sharpened pencil to produce clear, precise graph points which are not too large.
- Irregular or awkward scales often led to incorrect readings.
- Graphs often did not cover at least half of the grid.
- The data in the table required a plot at the origin and some candidates did not begin their graph at 0, 0 and so could not plot this point.

(iii) Comprehensive responses

- Some candidates drew a good single, thin curve of best fit within one small square of each point.

Limited responses

- Candidates drew sketchy lines which were feathery, drew more than one line or used a ruler between the points.
- Points which are clearly anomalous should not be included in the line of best fit and should be ringed and labelled as anomalous.

(iv) Comprehensive responses

- Some candidates described the reaction in terms of the variables stated in the question.

Limited responses

- Candidates described the total volume of carbon dioxide made rather than the rate of the reaction.
- Many candidates stated that the rate increased during the first 60 seconds.

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- Candidates omitted any reference to the changes in their graph's steepness, or they discussed the values from the table instead of their graph.

(v) **Comprehensive responses**

- Most candidates read the value from their graph correctly, with many showing how they had arrived at their value.

Limited responses

- Where the scales used were awkward, candidates could not read the value from their graph correctly.

(b) **Comprehensive responses**

- Candidates calculated the rate correctly and quoted their answer to a minimum of two significant figures.

Limited responses

- Candidates added together all the individual volumes of carbon dioxide from the table and divided this by 300 or inverted the division.

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

- Very few candidates used the information in the question stem to explain that the reduced volume would be in a similar proportion each time.

Limited responses

- Candidates stated that the volume would be less because gas is lost when the apparatus is reassembled.

(ii) **Comprehensive responses**

- No candidate could give a correct response.

Limited responses

- Candidates stated doing the experiment more quickly would reduce the systematic error.

(d) **Comprehensive responses**

- Few candidates described the avoidance of parallax.

Limited responses

- Candidates read perpendicularly to the scale rather than perpendicular to the reading or level of the liquid. Some read to the upper meniscus.
- Some candidates used a burette.

(e) (i) **Comprehensive responses**

- Most candidates drew a correct tangent.

Limited responses

- The tangent drawn by some candidates was bent.

(ii) **Comprehensive responses**

- A few candidates calculated the gradient correctly, within the expected range and to a minimum of two significant figures.

Limited responses

- Some candidates inverted the division, gave a value which was 100 times too large or did not read the scales correctly when obtaining their values.

Question 4

(a) **Comprehensive responses**

- Most candidates obtained a correct colour for universal indicator.
- Most candidates obtained the correct observation with both reagents.

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Limited responses
- Some candidates gave a processed pH value rather than the colour observed.
- Some candidates stated milky with no precipitate or gave the precipitate as yellow with aqueous silver nitrate.
- Some candidates obtained a white precipitate with aqueous barium nitrate.

(b) Comprehensive responses
- Many candidates deduced the correct identity of H.

Limited responses
- Incorrect responses included sodium nitrate, zinc, bromide and copper ions.
- Candidates need to look at the Qualitative Analysis sheet towards the end of the examination paper.

Question 5

(a) (i) Comprehensive responses
- Most candidates recorded a mass for water and most quoted it in the correct range.
- Most candidates recorded 2 temperatures for water.
- Most candidates obtained a full set of results for oil.

Limited responses
- The mass of water was not in the required range.

(ii) Comprehensive responses
- Most candidates calculated the temperature changes correctly.

(iii) Comprehensive responses
- Most candidates calculated both values of P correctly.

Limited responses
- Few candidates used 50 g instead of the mass in their table or multiplied by 120.

(iv) Comprehensive responses
- Some candidates calculated 10% of the larger of the two values and then subtracted this from the original to show that the second value was within 10%.

Limited responses
- Some candidates subtracted the two values and gave this as the percentage difference.
- Some candidates gave a statement with no calculations.
- Some candidates omitted the question.

(v) Comprehensive responses
- Some candidates explained in terms of temperature.

Limited responses
- Some candidates described even heat although the question was asking about temperature.
- Other common incorrect responses included increased collision between the particles, accuracy, even spread of heat particles and to mix.

(b) (i) Comprehensive responses
- Some candidates noted the anomaly in the results for wax.
- These candidates explained how an average should be calculated.

Limited responses
- Some candidates discussed a greater difference in values, temperatures decreasing instead of increasing, subtracting the temperature of wax from the temperature of the sand, temperatures being different during the day and during the night for sand, the mass decreases and sand cannot melt.

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(ii) Comprehensive responses

- Some candidates stated the effect on P and explained their answer in terms of energy transfer.

Limited responses

- Many candidates either stated the effect on temperature without mentioning the effect on *P*; or discussed the effect on *P* due to the lower temperature without considering the heat transfer or discussed the heat transfer with no reference to the effect on *P*.

Question 6

Comprehensive responses

- Some candidates addressed the bullet points in the question.
- Many candidates gave the apparatus needed and used it in the method described. Some gave a circuit diagram which helped their explanation.
- Candidates gave a logical description of the investigation.
- Candidates drew a table with headings and unit.
- Candidates stated at least one control variables.
- Repeats were mentioned.
- Candidates gave the axes for the graph to be drawn.
- Candidates explained how the results could be used to draw a conclusion by describing how patterns in the results would answer the investigation question.

Limited responses

- Some candidates listed the apparatus needed and then did not use it in their method, for example, the power supply.
- Some used a voltmeter to measure the current.
- Some measured the current in their method and did not include an ammeter.
- Some candidates' methods could be improved by presenting steps more clearly and providing sufficient detail.
- A table was often not included. When it was included, the header was ammeter reading rather than current or change in current, and the units were often missing.
- Some candidates controlled the current rather than the voltage or had no control variables.
- Candidates either did not repeat each number of lamps or did not explain the reason for repeating an experiment.
- The final bullet point was frequently omitted as most candidates did not consider how to formulate a conclusion.

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CO-ORDINATED SCIENCES

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 were able to draw a detailed diagram of the slice of okra.
- Candidates were able to select apparatus and described its use.
- Food tests were described in detail.
- Candidates were able to draw and measure the width of the okra.

What candidates needed to improve
- The biological diagram of the okra should be drawn without shading and should include sufficient detail of the seeds in the centre.
- Candidates should understand that repeating a procedure allow anomalous results to be identified and then excluded.

Plan experiments and investigations

What candidates did well
- Candidates chose suitable apparatus for the investigation and described how it was used.
- Many candidates wrote methods in a logical order that could be followed.
- Candidates identified a control variable.
- Some candidates understand that results should be repeated, and some gave a reason.
- Some candidates stated the axes of the graph to be drawn from their results.

What candidates needed to improve
- Candidates should write methods in a detailed and logical order so they can be easily followed.
- Candidates should state the range of control variables in an investigation.
- Candidates should know that results need to be repeated and explain why.
- Candidates should explain how the results 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 appropriate observations of the experiments.
- Candidates recorded the observation from food tests correctly.
- Candidates drew result tables with appropriate headings and units where needed.

What candidates needed to improve
- Candidates should check the precision required in the question. Where measurements are to be made to the nearest 0.5 of the unit, the value should end in .0 or .5.
- Candidates should record the observations for qualitative analysis in sufficient detail, including both colour and state.
- Candidates should recognise the difference between two significant figures and two decimal places.

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Interpret and evaluate experimental observations and data

What candidates did well
- Candidates processed the data from experiments correctly, giving answers to a minimum of two significant figures.
- Candidates selected consistent and regular scales for graph axes.
- Many candidates labelled the axes of their graphs with quantities and the units.
- Candidates showed working on their graphs to obtain estimates of specific quantities.
- Candidates drew a tangent to a curve.
- Candidates determined mathematically whether two results were within experimental accuracy.
- Candidates drew lines of best fit appropriately.

What candidates needed to improve
- Graphs should have fully labelled axes, and scales chosen should be appropriate and linear, with plotted points covering at least half of the grid.
- Candidates should be able to identify an anomalous result and describe the action to be taken.
- Anomalous points on a graph should be identified, labelled and not included in the line of best fit.
- Candidates should give answers that are specific to the experiments rather than general statements.
- Candidates should 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 suggested limited improvements to a procedure.

What candidates needed to improve
- Candidates should identify sources of both systematic and random error.
- Candidates should suggest improvements to lessen the effects of errors.
- Candidates should evaluate methods and explain why certain techniques and apparatus were used instead of others.

Comments on specific questions

Section A

Question 1

(a) Comprehensive responses
- Most candidates drew a clear, continuous outline of the okra without shading.
- Diagrams were generally larger than half of the box.
- Some candidates were able to draw the centre seeds and holes accurately.

Limited responses
- Outlines were sometimes sketchy with multiple lines or breaks.
- Many candidates included shading in their diagrams.
- Some candidates either drew five seeds or five holes in the centre of the okra rather than both.

(b) (i) Comprehensive responses
- Most candidates measured and recorded the width correctly.

Limited responses
- Some candidates recorded widths that were slightly too large or too small, commonly 48 mm or 52 mm.
- Candidates should give answers to the nearest millimetre; decimal values were not appropriate.
- Some candidates confused the units, with responses such as 5 mm, 500 mm and 5 cm.

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(ii) Comprehensive responses

- Many candidates drew the line on their diagram and measured it correctly.

Limited responses

- Candidates should read the question carefully to ensure all parts are answered, as many omitted the width on their diagram.

(iii) Comprehensive responses

- Most candidates calculated magnification correctly, with many giving answers to two significant figures.

Limited responses

- Some candidates incorrectly stated the value of magnification to two decimal places rather than two significant figures.

(c) Comprehensive responses

- Most candidates gave one visible difference, and some gave two.
- Most candidates gave a visible similarity.

Limited responses

- Some candidates stated shape, size or number of seeds which are insufficient as the property need to be correctly linked to the okra and the star fruit.
- Some candidates described the shape of the okra as decagon or hexagon.
- Some candidates included differences that were not visible, such as vacuole, xylem, phloem, and cell wall.

Question 2

(a) (i) Comprehensive responses

- Most candidates drew a table that included a column or row for the two reagents.
- The colours for positive tests for the reagents were well known.

Limited responses

- Many tables did not include a separate column or row for the final colours.
- Some headings were test-tube 1 and test-tube 2 or yoghurt 1 and yoghurt 2 rather than final colour, results or observations.

(ii) Comprehensive responses

- Most candidates stated the correct colours.

Limited responses

- A few candidates reversed the final colours of the reagents.
- Some candidates gave incorrect final colours, such as blue-black, brown, or blue.

(iii) Comprehensive responses

- Most candidates stated the nutrients correctly.

Limited responses

- Carbohydrate, glucose and sucrose were often seen in place of reducing sugar.
- Amino acid and fat were sometimes seen in place of protein.

(b) (i) Comprehensive responses

- Some candidates considered what the mixing would do to the reagents and how this was of benefit to the reaction.

Limited responses

- Candidates should explain why the substances were mixed, rather than restating “mix” from the question.
- Common incorrect responses included “to dissolve the solutions,” “to mix properly,” and “to make sure reaction is complete.”

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(ii) Comprehensive responses

- Some candidates recognised that the question detailed step 6 and stated the reagent that would otherwise contaminate the later reaction.

Limited responses

- Where a question is specific to a particular step in a procedure, generic statements such as preventing contamination were not sufficient; candidates needed to state which substance the glass rod would be contaminated with.

(c) Comprehensive responses

- Many candidates identified the reagents for testing for fats.

Limited responses

- Some candidates named reagents as fat, lipid, Benedict's solution, ethanol emulsion or iodine; water was most frequently omitted.
- Many candidates stated that a precipitate or solution would form and very few recognised that an emulsion would be formed.
- Many candidates either did not state a colour or used the terms cloudy or milky.

Question 3

(a) (i) Comprehensive responses

- Most candidates read and recorded the measuring cylinders correctly.

Limited responses

- Candidates should give values to the nearest 0.5; responses such as 50 were not appropriate. Other incorrect values included 30, 31, 300, 30.05, 30.1, and 30.5.

(ii) Comprehensive responses

- Most candidates plotted the correct graph containing all observations in the table, with the required accuracy.
- Many candidates used regular scales where all the data occupied more than half the graph grid and all points could be plotted.
- Points were plotted using neat crosses within half a small square.

Limited responses

- Candidates plotted the correct graph, often with axes partially labelled and with units frequently omitted. Few candidates omitted labelling the axes.
- Candidates should use a sharp pencil to produce clear and precise graph points of an appropriate size.
- Irregular or awkward scales (e.g. 10 squares to 8 units) often led to incorrect readings. Candidates should avoid trying to fit data exactly to the graph grid, as this usually results in inappropriate scale choices.
- The data in the table required a plot at the origin and some candidates did not start their graph at (0, 0) and could not plot this point.

(iii) Comprehensive responses

- Many candidates drew a good single, thin line of best fit within one small square of each point.

Limited responses

- Candidates drew sketchy lines that were feathery, included more than one line, or used a ruler between the points.
- Where misreading of the measuring cylinders in 3(a)(i) resulted in clearly anomalous points, these should not be included in the line of best fit and should be ringed and labelled as anomalous.

(iv) Comprehensive responses

- Few candidates described the reaction in terms of the variables stated in the question.
- The graph was referenced to show the changes described.

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Limited responses

- Candidates described the total volume of carbon dioxide made rather than the rate of the reaction.
- Many candidates stated that the rate increased during the first 60 seconds.
- Candidates omitted any reference to the changes in their graphs' steepness or discussed the values from the table instead of their graph.

(v) Comprehensive responses

- Most candidates read the value from their graph correctly, with many showing how they had arrived at their value.

Limited responses

- Where awkward scales were used, candidates could not read the values from their graphs correctly.

(vi) Comprehensive responses

- Many candidates stated a valid observation of the reaction.

Limited responses

- Candidates should state an observation of the reaction that would be seen by the student, "no more carbon dioxide made" was a common incorrect response.

(b) Comprehensive responses

- Candidates calculated the rate correctly and quoted their answer to a minimum of two significant figures.

Limited responses

- Candidates added together all the individual volumes of carbon dioxide from the table and divided this by 300.

(c) Comprehensive responses

- Candidates drew a line that started at the origin, followed a similar shape to their plotted line with a steeper gradient, which levelled off at a smaller time and at the same final volume of carbon dioxide.

Limited responses

- Candidates drew a line that was less steep than the original plotted line, crossed the original line, or a diagonal straight line.
- The final volume of carbon dioxide was often higher than the original, sometimes lower or the line did not have a horizontal part at its end.

(d) (i) Comprehensive responses

- Very few candidates used the information in the question stem to explain that the reduced volume would be in a similar proportion each time.

Limited responses

- Candidates stated that the volume would be less because gas is lost when the apparatus is reassembled.

(ii) Comprehensive responses

- Candidates described either the use of a small tube on a string inside the conical flask or a divided flask so that the mixing was done in situ.

Limited responses

- Candidates stated using a lid, working with two people, carrying out the experiment more quickly, or using a gas syringe or a burette; these would not reduce the systematic error.

(e) Comprehensive responses

- Some candidates described the avoidance of parallax or the meniscus.

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Limited responses

- Candidates read perpendicularly to the scale rather than perpendicular to the reading or level of the liquid. Some read to the meniscus, to the top of the meniscus or to below the meniscus rather than to the bottom of the meniscus.
- Very few candidates used a burette or a pipette.

(f) (i) Comprehensive responses

- Most candidates were able to draw a correct tangent.

Limited responses

- The tangent drawn either missed the curve at 40 and was a tangent at a higher volume, crossed the curve, or was placed above the curve.

(ii) Comprehensive responses

- Candidates calculated the gradient correctly, within the expected range and to a minimum of two significant figures.

Limited responses

- Some candidates inverted the division, gave a value which was 100 times too large, or did not read the scales correctly when obtaining their values.

Question 4

(a) Comprehensive responses

- Very few candidates gave a succinct reason why the reagents in the test for chloride and sulfate need to be acidified.

Limited responses

- Some candidates rewrote the question stem by stating that acid is added to acidify it. Other incorrect responses included “to react with acids,” “to remove ions” without specifying which ions, “to test for ions,” or “to neutralise.”
- Candidates should refer to the Qualitative Analysis notes at the end of the examination paper.

(b) Comprehensive responses

- Many candidates deduced the correct identity of H. 67

Limited responses

- Some candidates stated chloride and although the test for a chloride proved positive, it is not the name of a substance. Acid and chlorine were also common incorrect responses.

Question 5

(a) (i) Comprehensive responses

- Most candidates stated the mass correctly.

Limited responses

- Candidates either stated the mass as it appeared on the balance or did not round the value.

(ii) Comprehensive responses

- Most candidates recorded both temperatures correctly.

Limited responses

- Candidates did not quote the values to the nearest 0.5, and so 17 and 18 were common incorrect answers.

(iii) Comprehensive responses

- Most candidates calculated the temperature changes correctly.

Limited responses

- Very few candidates subtracted the whole numbers and did not include the decimal.

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(iv) Comprehensive responses

- Most candidates calculated the values of P correctly.

Limited responses

- Few candidates multiplied the oil equation by 4.2 instead of 3.2.

(v) Comprehensive responses

- Many candidates calculated 10% of the larger of the two values and subtracted this from the original to show that the second value was within 10% or calculated 10% of the smaller value of the two values and added this to the original to show that the second value was within 10%. Some candidates carried out both calculations to get a 10% range.

Limited responses

- Some candidates calculated 10% of one of the values and stated that the values were within 10% without using the 10% to show this.
- Some candidates gave a statement with no calculations.

(vi) Comprehensive responses

- Candidates explained in terms of temperature.

Limited responses

- Some candidates described even heat although the question was asking about temperature.
- Other incorrect responses included even spread of particles, even spread of heat particles, more accurate, to get a constant reading and to keep the temperature constant.

(b) (i) Comprehensive responses

- Few candidates noted the anomaly in the results for wax.
- These candidates explained how an average should be calculated.

Limited responses

- Candidates gave a possible error in the procedure such as the initial temperature being recorded incorrectly, or not the same as each other, and suggested more trials should be carried out.
- Some candidates stated that the melting point of a solid cannot be measured.

(ii) Comprehensive responses

- Candidates stated the effect on P and explained their answer in terms of energy transfer.

Limited responses

- Many candidates either stated the effect on temperature without mentioning the effect on *P*; or discussed the effect on *P* due to the lower temperature without considering the heat transfer.
- Some candidates repeated the question stem.
- Many candidates thought that the value of *P* would increase.

(iii) Comprehensive responses

- Some candidates discussed the temperature change that would occur during the longer time of heating.

Limited responses

- Many candidates stated that the liquid would boil within the time or that a maximum would be obtained.
- Other incorrect responses include “to get an even heat” and “to get an even temperature.”

Question 6

Comprehensive responses

- Most candidates addressed the bullet points in the question.
- Many candidates gave the apparatus needed and used it in the method described. Some candidates gave a circuit diagram which helped their explanation.
- Candidates provided a detailed and logical description of the investigation.
- Candidates were able to draw a table with appropriate headings and unit.

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- Candidates stated at least one control variables.
- The reason for repeats was explained and a minimum of five different numbers of lamps was used.
- Candidates gave the axes for the graph to be drawn.
- Candidates explained how the results could be used to form a conclusion, either by describing the meaning of the different shapes of graph or describing how the various patterns of the results would answer the question.

Limited responses

- Some candidates listed the apparatus needed and did not use it in their method, for example the power supply.
- Some used a voltmeter to measure the current.
- Some measured the current in their method and did not include an ammeter.
- Some candidates gave a method which was disjointed and could not be easily followed.
- A table was often not included. When it was included, the header was ammeter reading rather than current, and the units were often missing.
- Some candidates controlled the current rather than the voltage.
- Many candidates did not explain the reason for repeating an experiment.
- Many candidates gave a conclusion from knowledge without showing how the results of the investigation could be used to reach a conclusion.
- The final bullet point was frequently omitted.

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