COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Candidates answered **Questions 1**, **2**, **6**, **7**, **9**, **10**, **11**, **17**, **19**, **20**, **21**, **25**, **31**, **34** and **39** well.
Candidates found **Questions 18**, **35**, **36**, **37** and **40** more challenging.

Comments on specific questions

Question 1

Most candidates selected the correct answer. Nutrition, option **B**, was a common incorrect choice.

Question 3

Most candidates selected the correct answer. Some candidates selected option **A** and thought fats are made from fatty acids and glucose.

Question 4

Most candidates selected the correct answer. Benedict's solution, option **A**, was a common incorrect choice.

Question 5

The waxy cuticle was often identified as the epidermis.

Question 12

Most candidates selected the correct answer. Option **D** was a common incorrect choice.

Question 13

Most candidates selected the correct answer. A common incorrect response was option **C**, grasshopper, rabbit and vole.

Question 14

Option **B** was chosen as often as the correct answer. Candidates selecting this option confused atoms and molecules.

Question 18

Options **B** and **D** were equally common incorrect choices, indicating confusion about how the elements are ordered in the Periodic Table.

Question 22

Most candidates selected the correct answer. Some selected option **B** and thought the aluminium is extracted using carbon.

Question 23

Option **C** was a common incorrect choice and indicated confusion between the observations for the chemical tests for water.

Question 27

Candidates who incorrectly chose option **B** had confused the result for iron(II) ions.

Question 28

Candidates who incorrectly selected option **A** divided the mass of the object on Earth by the value for *g* on the moon.

Question 30

Most candidates selected the correct answer. Some chose option **C** and thought power is work done multiplied by time, rather than divided by time.

Question 35

Option **B** was more often chosen than the correct answer. These candidates thought the optical centre was the principal focus.

Question 36

Options **A** and **C**, conduction and evaporation, were equally popular incorrect choices.

Question 37

Candidates found this the most challenging question on the paper, indicating a lack of confidence in determining current from resistance and voltage, and of converting amps to mA. Options **A** and **C** were both more commonly chosen than the key.

Question 40

Most candidates selected the correct answer. Options **A** and **B** were common incorrect choices, indicating that some candidates were unfamiliar with the order of the planets.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

Candidates answered **Questions 1**, **2**, **4**, **5**, **6**, **9**, **10**, **11**, **12**, **13**, **19**, **20**, **24**, **26**, **28**, **29**, **30**, **33**, **36** and **37** well.
Candidates found **Questions 8**, **16**, **21**, **25**, **34**, **38** and **39** more challenging.

Comments on specific questions

Question 3

Most candidates selected the correct answer. Options **A** and **C** were common incorrect choices.

Question 7

Most candidates selected the correct answer. Option **B** was a common incorrect choice.

Question 8

There was evidence of guessing for this item, with all three incorrect options equally often selected.

Question 11

Most candidates selected the correct answer. Option **B** was a common incorrect choice.

Question 14

Some candidates incorrectly chose option **B** and thought the explanation was that energy increases the temperature of the substance rather than overcoming attractive forces between particles.

Question 15

Most candidates chose the correct answer. Some selected option **D** and thought the number of electrons in their outer shell differs by 9.

Question 16

Most candidates selected the correct answer. A few thought that both sodium ions and chloride ions do not have noble gas electronic configurations. These candidates may have overlooked the 'not' aspect in the question.

Question 21

Option **A** was more popular than the correct answer. This apparatus is incorrect as the delivery tube is in the dilute hydrochloric acid rather than above it.

Question 23

Most candidates selected the correct answer. Some selected option **A** which is a physical test rather than a chemical test for water.

Question 24

Options **B** and **C** were frequently chosen, indicating a lack of confidence with R_f values and interpreting chromatograms.

Question 25

Candidates found this the most challenging question on the paper. The tests for iron(II) and sulfate ions were not well known. Option **C** was chosen as often as the correct answer. Option **B** was also a common incorrect choice.

Question 27

There was evidence of guessing for this item as the incorrect options were often selected. This suggested candidates were not familiar with why carbon dioxide leads to increased global warming.

Question 34

Most candidates selected the correct answer. Options **B** and **C** were common incorrect choices.

Question 35

There was evidence of guessing for this question as all the incorrect options were equally often chosen.

Question 36

Most candidates selected the correct answer. Some candidates selected option **D** and thought the nature of sound waves in air was best described as crests and troughs rather than compressions and rarefactions.

Question 38

Some candidates selected the incorrect option **B**. These candidates did not convert minutes to seconds.

Question 39

Both options **A** and **C** were common incorrect choices. These candidates did not understand how to determine the combined resistance of two resistors in parallel.

Question 40

Most candidates selected the correct answer. Some thought nuclear fission of helium releases energy in a stable star and selected option **C**.

COMBINED SCIENCE

Paper 0653/32
Theory (Core)

Key messages

Candidates who did well on this paper:
- were familiar with the contents of the syllabus, including electrical symbols
- read the questions carefully, including numerical questions that required a unit conversion
- were able to express their answers in a clear and legible way
- showed their working in numerical answers
- were able to apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination, and they demonstrated good knowledge across all three sciences. Other candidates were not sufficiently familiar with the syllabus to answer all the questions.

Candidates used the space on the question paper well. Generally, answers were concise and were contained within the allocated space on the paper. There was no evidence that candidates ran out of time.

Comments on specific questions

Question 1

(a) Most candidates correctly identified the large intestine and the salivary gland.

(b) (i) Many candidates stated the general need for proteins for growth and repair of tissues. Other specific roles of proteins were also awarded credit, e.g., to make enzymes and to build muscle. Some candidates stated that proteins are used for releasing energy. This response was not accepted because proteins can release energy during periods of starvation but not as part of a balanced diet as stated in the question.

(ii) Candidates generally answered this question well, circling amino acids. Incorrect answers included glucose and glycerol.

(c) (i) This was answered well, using the arrow as an indication of the direction of flow of chemical energy.

(ii) This was a well-answered question. Candidates knew to look for the source of chemical energy for the food web, the phytoplankton.

(iii) Candidates found this question more challenging. In responses to this question, just stating that the frog is a carnivore because it eats mayflies and dragonflies was not enough. These insects had to be identified as animals, which most candidates did not do.

(d) There were several possible answers to this question, and some candidates successfully described two reasons why eagles could be endangered. Candidates expressed valid points in a variety of different ways, for example ‘deforestation’ gained credit for habitat destruction. Other valid points that gained credit included the loss of food sources and the introduction of a new disease.

Question 2

(a) Many candidates identified the correct letters. The most common mistake was stating that pollen grains are made by the part labelled **P**, the stigma, instead of part **T**, the anther.

(b) The male gamete, sperm, was correctly stated by most candidates. Incorrect responses included nuclei, zygote and testis.

(c) (i) This question was generally answered well. Most candidates calculated 36/40 × 100. Others could see that two seeds was 5% of 40, so they subtracted the 5 from the 95 written in the first row of the table.

(ii) Some candidates found this question challenging. To get full credit, the two variables had to be addressed separately. Most candidates used evidence from the table to suggest that seeds can germinate without light, therefore gaining partial credit. Fewer candidates stated that more seeds germinate in a warm temperature than in a cold temperature.

(d) (i) Most candidates stated the correct answer, the root hair cell. Incorrect answers included xylem and roots.

(ii) This was generally answered well. A few candidates stated 'active transport' or 'absorbing' instead of osmosis.

Question 3

(a) (i) Most candidates circled plasma, the correct answer. The most common error was red blood cells.

(ii) Some candidates stated a vein or named a specific vein that brings blood towards the heart. The most common error was red blood cells. Candidates should be reminded that blood travels through the blood vessels, namely arteries, away from the heart, capillaries in the organs, and in veins towards the heart.

(iii) The septum, which separates the left and right ventricles, was known by many candidates. The most common error was valve. Candidates should be aware that the valves in the heart allow the one-way passage of blood through the heart, and the septum, which goes down the middle of the heart, keeps the oxygenated and deoxygenated blood separate.

(b) (i) The definition of a pathogen in this syllabus states that it is an organism that causes disease in the body. Specific microorganisms, e.g., bacteria, were acceptable. Responses stating that a pathogen causes disease without mentioning it being an organism were not accepted. Other unaccepted responses stated that a pathogen is a substance or a factor.

(ii) Most candidates understood the concept of indirect transmission of a disease and successfully described a way in which this could happen. The exchange of bodily fluids and transmission by red blood cells were not accepted. The pathogen had to be outside a person's body, on an object or in the air, before entering an uninfected body to cause disease.

(iii) There were several correct answers possible for this question. The most common correct answers given were skin and nose hairs. Many candidates stated either white blood cells or antibodies. These answers were not accepted because the question asked for a defence other than blood.

(c) Candidates found the first part of this question more challenging than the second part. The oxygen is used to release energy from glucose. Many candidates wrote 'breakdown' as their first response, but this could not be correct because energy from glucose is not broken down. Most candidates identified the second answer correctly, understanding that muscles are able to contract using the energy released from glucose.

Question 4

(a) The question required two properties of the Group I metals that show a trend going down Group 1. Many candidates found this challenging. General properties of metals, for example electrical and heat conductivity, were not accepted because there was no obvious trend down the group.

(b) (i) Most candidates circled alloy to gain full credit. The most common incorrect answer was brass. Although brass is an alloy, it is a specific one, and the question demanded the more general term for a mixture of metals.

(ii) Most candidates found this question challenging. Candidates had to use the information in Table 4.1 to decide the state of the mixture of sodium and potassium at room temperature. Room temperature, 25 °C, is warmer that the melting point of –13 °C, and colder than the boiling point of 785 °C. Therefore, the mixture is a liquid. Candidates should be reminded that the melting point and the freezing point are the same in this context, and the mixture will not freeze at room temperature.

(c) This question was generally answered well. Most candidates labelled the subatomic particles accurately.

Question 5

(a) (i) Most candidates successfully calculated the missing percentage of gases in natural gas, which represented other gases.

(ii) Nitrogen, the named gas present in clean air, was given by many candidates. The most common incorrect answer was methane**.** Candidates should be reminded that methane is a pollutant that is also a greenhouse gas.

(b) Many candidates successfully recalled the two products of the complete combustion of methane. Common incorrect answers included oxygen and hydrogen. When complete combustion of a hydrocarbon takes place, the carbon atoms become oxidised to carbon dioxide and the hydrogen becomes oxidised to water.

(c) Most candidates ticked the correct box, indicating that the refinery gas fraction is used as a fuel for heating and cooking. The most common incorrect option ticked was fuel used in diesel engines.

(d) (i) The most important idea here was that saturated molecules contain only single bonds, and this was shown in Fig. 5.1. An alternative way of expressing this idea is that the (C–C) bond in the molecule is single. In unsaturated molecules, double bonds occur between the carbon atoms, so in the absence of these it must be a saturated molecule. Incorrect responses stated that the molecule has a single bond, or just that it contains two carbon and six hydrogen atoms, with no further explanation.

(ii) This question proved challenging for most candidates. Only a few responses were correct, with the answer of two electrons. The most common incorrect answer was six electrons, the number shared by the two carbon atoms with hydrogen in the molecule. Since the bond in the question is a carbon–carbon single bond, the number of shared electrons is two.

Question 6

(a) Most candidates gained partial credit for completing Table 6.1. Generally, candidates identified bromine correctly. The most common error occurred when candidates stated bromide. Candidates should be reminded that bromine is present as the bromide ion before electrolysis, but during the electrolysis the ion loses its charge to become the element bromine. Most candidates correctly identified hydrogen, the product of sulfuric acid electrolysis at the negative electrode. Only a few candidates correctly stated oxygen, the product of sulfuric acid electrolysis at the positive electrode. Common incorrect answers included a variety of gases, for example, nitrogen, carbon dioxide and ammonia. Sulfate and sulfur were also frequently seen in the last line of the table.

(b) Candidates found this question challenging. Since the products of the electrolysis of concentrated aqueous sodium chloride are both gases, the bubbles of gas are released, and the mass of the electrolyte reduces. Most candidates did not make this observation. Common errors included statements that the electrolyte gets hot, or that it evaporates.

(c) This question was generally answered well. Many candidates understood that new substances are formed during electrolysis, therefore the process must be a chemical change.

(d) This question was generally answered well. Others were not familiar with the term inert electrodes, as shown by incorrect answers such as lead and iron. Candidates should be reminded that inert electrodes are used so that they do not take part in the reaction, so they must be unreactive.

(e) Most candidates stated the correct answer, cathode. Incorrect answers included anode and electrolyte.

(f) An endothermic process, one that takes in thermal energy from the surroundings, was stated correctly by many candidates. The most common incorrect answer was exothermic which is the process that gives out thermal energy.

(g) This question was generally answered well. The most common error occurred when candidates matched lead metal to the salt that contains ionic bonds. Candidates should be reminded that lead is an element, not a compound.

Question 7

(a) Generally, candidates matched the boxes successfully to gain full credit.

(b) Most candidates used the correct equation for this calculation. To gain full credit, the cm had to be converted to m. Some candidates did this conversion successfully. Others did not do the conversion and gave the answer 4.5 (m / s) to gain partial credit. Candidates should be reminded to study the units given in the question and compare them with the units required in the answer.

(c) Many candidates gained partial credit. Common mistakes were ‘electrical’ (for the store of the battery) and ‘potential’ or ‘kinetic’ (for the store of the mass).

(d) This question was generally answered well. The most common error occurred when candidates did not use the equation correctly and divided the power by the time, giving 20 (J) as their answer. The energy output is the power multiplied by the time.

Question 8

(a) (i) The question asked which diagram shows the particles in a gas. Most candidates identified the correct diagram, **C**. The evidence had to be taken from the diagram, so any references to movement or intermolecular forces were not allowed. There were some descriptions which used the term ‘packed’, when describing the proximity of the particles to each other. This term is not appropriate when describing a gas. Therefore, explanations that stated ‘loosely packed’ were not accepted.

(ii) Most candidates gave the correct term, condensation, for the change of state. Common mistakes were freezing and evaporation.

(iii) Some candidates answered this question well. The required answer needed a comparison of the speeds of movement of the particles in hot and cold water. Therefore, the distance between particles, or the freedom of movement of particles were not relevant answers. Any references to particles vibrating were ignored because this description of motion applies to particles in a solid.

(b) (i) Some candidates answered this question successfully. Incorrect responses included green, blue and white.

(ii) It was clear that some candidates had difficulty in identifying the correct region of the electromagnetic spectrum. The most common incorrect response was infrared. Some candidates misinterpreted the question and gave the frequency range for their chosen region instead of an application.

(iii) Some candidates applied the formula correctly to get the right answer. Other candidates found the question challenging. Errors most frequently occurred when candidates used the formula incorrectly or had difficulty with interpreting the scientific notation of the numbers.

Question 9

(a) (i) Most candidates gave the correct number of planets in the solar system, eight.

(ii) Almost all candidates correctly named the Milky Way.

(b) Solar energy, the correct answer, was chosen by some candidates. Incorrect answers included chemical energy, nuclear fission and electrical energy. The chosen energy source had to be one that is readily available and renewable. Solar panels were not accepted. Although they can transfer the solar energy to electrical energy, they are not the energy source.

(c) (i) Many candidates knew the symbol for the electric motor. The most common mistake was meter.

(ii) Most candidates knew the symbol for a voltmeter. Fewer made the parallel connection across the lamp. The most common errors were placing the voltmeter in series in the circuit or placing it in parallel across the wrong component.

(iii) The Ohm's Law calculation was done successfully by most candidates. The most common error was multiplying the voltage by the current, instead of dividing the voltage by the current.

(iv) This question was very challenging for candidates. The voltage in a series circuit is shared by the components. Therefore, if the voltage across the variable resistor increases, the voltage across the lamp must decrease because the voltage of the circuit remains the same.

COMBINED SCIENCE

Paper 0653/42
Theory (Extended)

Key messages

Candidates who did well on this paper:

- had learned the syllabus material thoroughly
- read the questions carefully and understood that questions asking for an explanation of some aspect of science needed more detail than a description only
- used the allocation of marks for each question to guide the level of detail they should include in their answers
- set out their working clearly in calculations, included the symbolic relationship between the relevant variables, and ensured that, when appropriate, they converted the data given in the question to the units required in the symbolic relationship.

General comments

Many candidates demonstrated good knowledge with understanding in each of the science disciplines and wrote clear, well-organised answers. Candidates usually showed their working in calculations, whether instructed to do so or not, and this is good practice. Working was often set out very clearly which made it easier to award partial credit for correct steps even if the final answer was incorrect. Candidates generally had no difficulty in finishing the paper in the time allowed.

In the biology questions, in **Question 1**, candidates showed good knowledge of methods of conserving endangered species, were often able to interpret data in the biological contexts in **Question 2**, and were familiar with some aspects of plant biology in **Question 3**. Some candidates were able to explain, in terms of reduced respiration and oxygen demand, why the heart rate decreases when exercise reduces in **Question 2**. They were also familiar with active transport in **Question 3** and that the energy required for this is provided by respiration which occurs in mitochondria.

In the chemistry questions, many candidates were familiar with the physical and chemical properties of metals including examples of redox in **Question 4** and **Question 5**. Some candidates showed understanding of stock notation in **Question 5** and were able to construct fully correct reaction pathway diagrams. The organic chemistry in **Question 6** was generally familiar but the identity of catalysts was known only by some candidates.

Candidates showed good understanding of speed-time graphs in the physics section in **Question 7** and were able to calculate an increase in gravitational potential energy. Some candidates were aware of the need to convert the mass from g to kg in **7(b)**. In **Question 8**, many candidates were challenged when they had to discuss gas pressure in terms of particle collisions with the container walls. Some candidates avoided suggesting that molecular speed increases when the gas pressure is increased at constant temperature. In **Question 9**, candidates were familiar with the calculation of efficiency in an electrical context and with the division of potential difference across components in an arm of an electrical circuit. Although candidates were generally able to use Ohm's Law, only some candidates were also aware that the units of current given in this question had to be converted from mA to A.

Comments on specific questions

Question 1

(a) (i) The secondary consumers were usually identified correctly. The most common mistake was to suggest one of the primary consumers.

(ii) Most candidates gained credit for referring to the impact on rabbits of the loss of grass. Some candidates gained further credit for correctly referring to the impact on mice, grasshoppers or hawks. Some candidates showed awareness of the alternative food sources and so avoided suggesting that the population of hawks would decline because of the loss of rabbits or that the grasshopper population would reduce because of the loss of grass.

(b) Candidates were generally able to suggest at least two approaches to conservation. Candidates did not need to list more than two ways to conserve endangered species, but they often did. Candidates need to be aware that if they state more than the two ways asked for, then they might lose credit if one or both of the first two suggestions are incorrect (see the Mark Scheme, Science-Specific Marking Principles, number 5, List rule guidance). The more popular suggestions included reducing deforestation, introducing captive breeding programmes, educating local communities, and introducing legislation to limit or ban hunting.

(c) (i) Credit was very frequently awarded to candidates who identified amylase, but fewer gained the credit for reducing sugars. Alternative answers that gained credit were carbohydrase for amylase and glucose or maltose for reducing sugar.

(ii) Many correct definitions of what happens during chemical digestion were seen but to gain credit, candidates had to refer to either the influence of molecular size or molecular solubility on absorption.

Question 2

(a) (i) Candidates usually recognised both atrium and valve. The term ‘auricle’ was allowed for atrium.

(ii) Candidates could either describe the thick walls of arteries or the narrow lumen. It was not enough to refer only to muscular walls, but descriptions of the elastic nature of artery walls was accepted. Further credit was awarded for stating a reason for the adaptation and needed a clear idea that high blood pressure had to be sustained or contained. Suggestions such as “because of the blood pressure” were not detailed enough. Some candidates did not answer the question as set and wrote descriptions of the double circulation of blood through the heart.

(b) (i) This was often answered correctly. Candidates needed to make it clear that the heart rate increased after two minutes rather than simply stating that it changed. Some candidates chose to describe the unchanging heart rate before the two-minute point but, on its own, this did not gain credit.

(ii) Candidates usually selected the highest (133) and lowest (64) heart rate values from the data and could use them to calculate the percentage increase. A common mistake was to select 65 as the lowest value, but partial credit could be awarded for the calculation if this was the only error.

(iii) Most candidates gained partial credit for statements implying that the race had finished. Only the best responses explained the decreasing heart rate in terms of decreasing muscle activity, reduced respiration rate and oxygen demand.

(c) The role of white blood cells in producing antibodies was very familiar to most candidates. Lymphocytes was accepted, but phagocytes was not.

Question 3

(a) (i) Guard cells were very frequently identified. The most common incorrect answers were stomata and palisade mesophyll.

(ii) Candidates of all abilities knew that the function of the labelled cell was photosynthesis. A common mistake was to suggest a structural feature of the cell such as cytoplasm, cell membrane or chloroplast.

(b) Some candidates had learned this section of the syllabus very well and gave complete answers. Partial credit was frequently awarded for a reference to active transport or that the uptake of mineral ions requires energy. Large numbers of candidates quoted that “mitochondria are the powerhouse of the cell” but no credit was available for this statement alone, or for the suggestion that mitochondria produce energy. Some candidates correctly stated that energy for active transport is provided by respiration and that the mitochondria are where respiration occurs.

(c) Candidates usually gained at least partial credit. ‘Potential gradient’ and ‘concentration’ were not accepted as alternatives for ‘potential’, and ‘turgid’ was not accepted for ‘turgor’. Some candidates were unfamiliar with the term ‘plasmolysed’.

Question 4

(a) (i) The question asked candidates to describe observations and so answers for sodium such as ‘it reacts’ were not detailed enough. The answer, ‘sodium hydroxide and hydrogen are produced’ was not an observation and so did not gain credit in the context of this question. However, large numbers of candidates had evidently seen this reaction and gave acceptable answers. In the case of copper, candidates had to state clearly that no reaction occurs. Statements such as “copper is less reactive than sodium”, although true, did not gain credit in this case.

(ii) Candidates had to make a statement about compounds of both metals. Answers such as “copper has coloured compounds” without any corresponding comment for sodium compounds did not gain credit.

(iii) The correct formulae for copper(II) oxide and sodium chloride were usually stated. Formulae had to be correct in every detail and so credit was not awarded if subscripts, ionic charges or stoichiometry from a balanced equation were included.

(b) The terms hard and strong were not accepted. Although the question gave high melting point as an example, some candidates still suggested “solid at room temperature” and others suggested chemical properties. Candidates had to refer to conduction of thermal energy/heat or electricity. The answer ‘good conductors’ was not enough.

(c) (i) Candidates had to refer to some features shown in the diagram. Many simply defined the term alloy as ‘a mixture of metals’ or ‘a mixture containing different elements’ without describing evidence from the diagram that reflected this. Answers gaining credit referred in some way to the particles shown in the diagram.

(ii) The idea that a gold alloy would be stronger or more durable than pure gold was generally known.

Question 5

(a) (i) Credit was awarded for any reference to the state symbol for iron in the balanced equation. Answers such as “because iron is a liquid” which did not have any supporting evidence from the equation were not accepted.

(ii) The meanings of oxidation, reduction and redox were generally familiar to candidates and at least partial credit was very frequently awarded. The question asked candidates to make use of the equation and so they needed to describe details of oxygen loss and gain. Answers correctly describing the loss and gain of electrons were accepted.

(iii) Some candidates gained full credit but often this type of ionic equation was unfamiliar. Candidates often gained partial credit for stating Fe. Some candidates may have used the balanced equation given in the question as a clue but suggestions such as 2Fe were not accepted.

(b) Only some candidates were familiar with the terms 'oxidation number' or 'oxidation state'. Alternative ways of stating the meaning by describing ideas which included the valency of iron, electron loss from iron, combining power of iron and iron's ionic charge were accepted. Less detailed answers such as "it has lost three electrons" or "it can have more than one valency" or "this means ferric and not ferrous" were not accepted.

(c) Most candidates were able to draw the correct general shape of the reaction pathway diagram. Candidates should be advised to draw their labelled arrows showing the activation energy and the overall energy change very carefully. The best answers showed the reactant and product energy levels extended so that there was no uncertainty where arrows started and finished. Candidates who drew diagrams showing an endothermic reaction could still gain partial credit for the energy changes.

Question 6

(a) (i) The term 'addition polymerisation' was familiar to some candidates. Some of the more common incorrect suggestions included fractional distillation, condensation polymerisation, polymerisation and either the name or formula for ethene.

(ii) The formula of ethene was known by many candidates. Versions of the formula in its displayed form were accepted. The general formulae for alkenes or alkanes were not accepted.

(b) Most candidates were familiar with the term 'cracking'. Some of the more common incorrect suggestions included combustion, hydrogenation, fractional distillation, and polymerisation.

(c) The most common mistakes were to place ticks in the 'true for alkanes only' column on the first or third rows. Most candidates gained at least partial credit for correct ticks in the second and fourth rows.

(d) (i) The use of an acidic catalyst in the hydration of ethene was not very familiar. A variety of transition metals were suggested.

(ii) This was a little more familiar than **(d)(i)**. Alternative answers for nickel were platinum and palladium.

Question 7

(a) (i) This was answered correctly by most candidates. One common mistake was to suggest that the object was stationary. The response 'constant motion' was not accepted.

(ii) The use of the relationship, $a = \Delta v \div \Delta t$, was very familiar and fully correct calculations showing clear working were frequently seen. A common reason for full credit not being awarded was an omission of the negative sign.

(iii) Many correct calculations were seen. Partial credit was awarded to candidates whose working showed clearly that they knew that an area under the speed-time graph was required, even if they were not able to complete the calculation. Some candidates suggested random mathematical statements that evaluated to 0.36.

(b) The relationship, $\Delta E_P = mg\Delta h$, was very familiar. Candidates needed to use the value 9.8 rather than 10 for the acceleration of gravity. The most common mistake was to leave the value of mass as 130 g rather than converting it to 0.13 kg. When clear working was shown, partial credit was awarded for correct logical steps in the calculation, even if the final numerical answer was incorrect.

Question 8

(a) Candidates usually selected an acceptable colour. Common incorrect suggestions were red, yellow, infrared and ultraviolet.

(b) The key relationship, distance = speed × time, was familiar to many candidates. In the best answers, each of the steps in the calculation were set out clearly and logically, which allowed the award of partial credit even when the final answer was incorrect. Many candidates understood that the question referred to the time the signal took to travel from the helicopter to the ground and back and were awarded credit for showing this in their working even if they could not complete the calculation.

(c) (i) Credit for stating 'volume' was very frequently awarded. The idea of the separation between molecules was accepted as an alternative. Common incorrect answers included 'area', 'space' and references to molecular speed.

(ii) Most candidates found this question challenging. Candidates had to make the point that gas pressure arises through particle collision with the walls of the container. The question stated that the temperature remains constant, but many candidates suggested that the kinetic energy of the particles increased which was the reason for increased force when particles collided with the container. Many answers contained ideas about particle collisions which were more relevant to questions concerned with rate of chemical reactions.

Question 9

(a) (i) Candidates tended to be familiar with the idea that nuclear processes release energy within the Sun. They had to specify 'nuclear fusion' and not just 'fusion' and needed to avoid suggesting 'nuclear fission'. The more common incorrect suggestions included various kinds of radiation and thermal/heat and solar. Fewer candidates correctly filled the second gap. A variety of incorrect answers were suggested including 'thermal' and 'electrical'. The unqualified term 'potential' was not accepted.

(ii) Candidates were familiar with the relationship between efficiency, power input and power output, and full credit was frequently awarded for this calculation. Answers that rounded to 18% were accepted. The key step in the calculation of determining the total power input from 12 m^2 of solar cells was often missed.

(b) (i) Candidates were very familiar with the circuit symbol for a heater. The most common mistake was to suggest 'fuse'. The term 'radiator' was not accepted.

(ii) Candidates often understood that the potential difference across devices in an arm of a circuit is divided and many gave the correct answer of 4.8 V. The most common incorrect responses were 1.2 V and 6.0 V.

(iii) Although large numbers of candidates realised that this question involved a simple application of Ohm's Law, the important step of converting 15 mA to 0.015 A was frequently missed. Error carried forward from **(b)(ii)** was accepted.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

- It is essential that supervisors submit a completed report for all practical tasks and all questions. This is to judge whether the candidate answers are appropriate for the apparatus and reagents provided at the centre.
- Candidates should ensure they use units where necessary and give their answers to an appropriate number of decimal places or significant figures.
- In the planning question, it is important that candidates read the question and investigate the variables in the question. All bullet points in the question should be addressed.
- In the graph, some candidates did not label axes appropriately or choose appropriate scales. Some candidates plotted points using blobs rather than crosses or dots in circles.

General comments

Most candidates engaged with the practical tasks and made attempts at all questions. Some attempted the planning question at some length.

Comments on specific questions

Question 1

(a) (i) Most candidates made appropriate measurements of the length and width of the leaves and entered them correctly in the table. However, the question gave two clear instructions that some candidates did not follow. Some did not arrange their leaves in size order and some recorded results in cm.

(ii) Most calculations of average length were correct. Some candidates added the values in the table but omitted to divide by 5.

(iii) Many candidates answered correctly by either stating that the stalk is not a part of the leaf, or that the leaf stalks vary in length.

(iv) Most candidates gave reasons why it is difficult to measure the length or width of a leaf. Common correct reasons were that it is difficult due to the uneven edges or that the surface of the leaf is curved and so it is difficult to measure on a flat surface.

(v) Most candidates gained at least partial credit. Common errors included:

- omitting axes labels entirely. The graph axes should be labelled with the same labels as shown in the headings of the table
- omitting units (mm) from axes labels
- reversing the axes so that length rather than width was placed on the vertical axis
- using awkward scales such as 6 or 3 as intervals, rather than using numbers such as 2, 5 or 10 to plot the gridlines
- using non-linear axes or axes that did not allow the plotted points to occupy more than half the grid. When candidates collect their own data, it is common for it to be necessary to start the graph at values that are not (0, 0) at the origin. Few candidates did this.

(vi) Many candidates attempted to join the dots rather than drawing a line of best fit.

(vii) The relationship of width to length was not always evident in the candidates' data. When this happened, it was acceptable to say that no clear relationship was seen. However, some candidates said that the data showed proportionality when this was not shown.

(b) The best responses included large drawings which filled more than half the available space. The outline was clear, continuous, unbroken and without overlaps, and showed some detail of the leaf structure. Candidates should note that biological drawings should not be shaded as this obscures the detail and the quality of the lines. On occasion, the outline and the representation of the internal structures were not clear enough. Many drawings had feathered outlines, breaks in the outer line or untidy 'crosses' where lines joined. Many candidates did not indicate any internal structure of the leaf.

Question 2

(a) When recording qualitative observations, best practice is to include a colour and a state. The correct answer for this question was white precipitate. Candidates typically tried to describe the contents of the test-tube rather than state their observations in terms of positive qualitative tests. Therefore, descriptions such as milky, cloudy and white alone were not awarded credit.

(b) Some candidates correctly observed bubbles, fizzing or effervescence. Responses such as "carbon dioxide is given off" was an inference, not an observation and so was not awarded credit.

(c) (i) Most candidates gained at least partial credit, for correct colours for **K** and **L**, but colours for **H** and **J** were often different to those expected.

(ii) Candidates found this question challenging. The key point was that the initial colour of aqueous **H** masked the colour of UI in aqueous **H**. The best answers identified that the initial colour of aqueous **H** was blue, but many answers did not make this clear. Candidates often referred to 'it' or 'the solution' without stating clearly which solution (**H** or the UI) they meant. Some candidates stated "it is a mixture of colours" which could refer only to UI.

(d) Most candidates correctly identified that **K** is an acid.

(e) Most candidates identified **J** as the carbonate. However, for credit it was also essential for an explanation to be included. Stating **J** is an alkali did not explain this. The evidence that **J** is a carbonate is the effervescence produced when it reacts with **K** (the acid).

Question 3

Stronger candidates addressed all the bullet points and used them to guide their answer. Some candidates gave safety precautions which were not required for this task.

Some candidates used language for variables that they did not appear to fully understand. The terms 'control' 'dependent' and 'independent' were often used incorrectly and many candidates stated that they would 'control the temperature'. The scientific definition of a control variable is one that is kept constant, so this was an incorrect statement. Similarly, candidates often used the terms 'dependent' and 'independent' incorrectly.

Stronger candidates were able to engage fully with the variables that they were investigating which in this question was the relationship between temperature and amount of foam. Weaker candidates often varied the wrong variable. Some candidates planned experiments in which the amount of detergent was varied, or hard and soft water was used. Other candidates measured the time taken to produce a foam rather than its volume or height. Candidates are advised to highlight or underline the variables at the start of the question and ensure that they address the correct pair of variables in their answer.

The method needed to be clear and unambiguous but, in many cases, key steps were omitted. Many candidates did not clearly state that the water and the detergent needed to be shaken. Sometimes candidates did not clearly state that the procedure would be repeated at more than one temperature.

The following points were specific to this question:

- Credit was given for stating the essential measuring apparatus and for giving an indication of how each piece of apparatus was used. In this case, a thermometer was needed to measure the temperature of the water, and a means of heating the water was needed (a water bath or Bunsen burner). Depending on the candidate's method, some responses needed a timer to time the duration of shaking or a ruler to measure the height of the bubbles. Where a piece of apparatus was mentioned but not used, or was used incorrectly, credit could not be awarded.
- Only answers that included a workable method to generate results could be awarded full credit. When describing the method, the best answers gave a sequence which included mixing water with detergent, shaking, measuring the foam and repeating at more than one temperature. Many answers omitted one or more of these key stages.
- To measure the dependent variable, in this case amount of foam, it was necessary to state exactly what measurements needed to be taken. The best answers clearly stated that the volume or height of foam would be measured. Some candidates gained credit by describing how the measuring cylinder would be used to measure the total height of the foam and solution and then how the volume of the solution would be subtracted from this value to calculate the volume of foam alone.
- When writing a method, candidates need to check that they are changing the correct variable and measuring the correct outcome variable. Many candidates incorrectly stated that they intended to change the amount of detergent or that they would measure the time taken for foam to form.
- When stating which variables will be kept constant, candidates should take care to use precise language. For example, some candidates stated they would "use the same amount" of something. In this case, it would have been preferable to phrase this as "use the same total volume of water" or "the same volume (or mass) of detergent". Candidates should be encouraged to control amounts by volumes for liquids and mass for solids.
- The bullet point that asked candidates to state how they will process their results was sometimes either ignored or candidates gave vague responses that were not awarded credit. Vague, generic answers such as "repeat and take an average" or "draw a graph of the results" were not given credit.
- Stronger candidates included a sketch with labelled axes on a graph to process their conclusion with the labels of 'volume (or height) of foam' against 'temperature'.

Question 4

(a) (i) The question included the instruction to 'Record each measurement to the nearest 0.1 cm' but this was not followed by all candidates. Some candidates gave measurements in mm and others gave measurements to the nearest whole cm. Fig. 4.1 showed the block laid so that the largest surface was face down, so that width was greater than height. Some candidates reported values where height was greater than width.

(ii) Candidates found it difficult to express why measurements cannot be recorded to 0.01 cm. The best answers stated that such small divisions are not present on a ruler. Some candidates gave vague responses which could not be awarded credit such as "rulers are not that accurate" or "you can't see these values".

(iii) Almost all candidates correctly calculated the area of face **X** based on their earlier measurements.

(b) Almost all candidates correctly recorded an appropriate mass value for their block. Some mass values were very high and seemed unlikely based on candidate measurements.

(c) (i) Most candidates correctly used their value for mass from **(b)** to calculate a value of *F*. However, some candidates could not be awarded full credit as they did not give their answer to two significant figures as requested in the question.

(ii) Some candidates correctly answered that force can be measured directly using a force meter (or Newton meter). The most common incorrect answer was to suggest using a balance, which measures mass rather than force.

(d) Most candidates used their answers to **(a)(iii)** and **(c)(i)** to calculate a correct value for *P*. Fewer were able to state the units for their answer correctly. Although Pa is a unit of pressure, this was incorrect for most responses, which were calculated as N / cm^2.

(e) Most candidates stated that **Y** had an increased surface area compared to **X**, causing a decrease in pressure. A few candidates incorrectly stated that *P* increases as area increases. Some candidates incorrectly stated that the force *F* is also affected.

(f) (i) Most candidates correctly read the measuring cylinder volume.

(ii) Most candidates realised that the block was not fully submerged in the water. A common incorrect answer was to say that 236–200 did not give the volume of the block, without explaining why.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

- Candidates should ensure they use units where necessary and give their answers to an appropriate number of decimal places or significant figures.
- In the planning question, it is important that candidates read the question and investigate the variables in the question. It was common for candidates to choose to vary incorrect variables. All bullet points in the question should be addressed.
- In the graph, many candidates did not label axes appropriately or choose appropriate scales. Some candidates plotted points using blobs rather than crosses or dots in circles.

General comments

Although the alternative to practical is a paper-based assessment, it is still intended that candidates do a substantial amount of practical work in their course. It was noticeable that some candidates appeared to have had limited practical experience.

In general, almost all candidates engaged well with this paper. They used the provided data and information appropriately and answered all questions. Questions involving arithmetic were particularly well answered. There were few omissions, and almost all candidates attempted the planning question at some length.

Comments on specific questions

Question 1

(a) (i) Candidates who followed the instructions to measure the length and width in the correct places usually earned full credit. The most common error was to read the length from the bottom of the leaf stalk, rather than the bottom of the leaf, suggesting that candidates had not used Fig. 1.1 to guide their measurement. Almost all candidates measured correctly in mm, as the question asked, but some incorrectly measured in cm.

(ii) Most calculations of average length were correct. Some candidates added the values in the table but omitted to divide by 5.

(iii) Many candidates answered correctly by either stating that the stalk is not a part of the leaf, or that the leaf stalks vary in length. Most incorrect answers included irrelevant information, such as the function of the leaf stalk, saying its purpose was to anchor the leaf to the stem.

(iv) Most candidates recognised that it is difficult to measure the length or width of a leaf due to the uneven edges. Some answers incorrectly compared leaves to each other, for example by saying that every leaf is a different shape. While this is a true statement it does not in itself identify a difficulty in the measurement.

(v) Most candidates gained at least partial credit. Common errors included:

- omitting axes labels entirely. The graph axes should be labelled with the same labels as shown in the headings of the table
- omitting units (mm) from axes labels
- reversing the axes so that length rather than width was placed on the vertical axis
- using awkward scales such as 6 or 3 as intervals. Scales should be based on numbers such as 2, 5 or 10
- using large blobs to plot points. Points should be plotted either with a small cross or a dot in a circle.

(vi) As stated in the syllabus, a line of best fit (in this case the correct relationship was a straight line, but a line of best fit may also be a curved line) should have an even spread of values either side. In this case, the correct relationship could go through the origin. Some candidates realised this. The plotted points gave a spread and a degree of judgment was needed to decide where the line should be drawn. Some candidates did this correctly, with points spread evenly on each side, but many candidates incorrectly joined the top to the bottom point, ignoring the scatter of points in between.

(vii) Almost all candidates correctly stated that as length increases, width increases. In this case, the relationship was directly proportional because the line on the graph went through the origin, but some candidates stated proportionality when their line did not show this. It should be noted that 'correlation' in describing a graph trend is an incorrect term and could not be credited.

(b) The best responses included drawings which were larger than the original leaf and filled more than half the available space. The outline was clear, continuous, unbroken and without overlaps, and showed some detail of the structure. Candidates should note that biological drawings should not be shaded as this obscures the detail and the quality of the lines. On occasion, the outline and the representation of the internal structures were not clear enough. Many drawings had breaks in the outer line or untidy 'crosses' where lines joined. The structure of the leaf was shown with two features. Firstly, the edges of the leaf were serrated, and most drawings showed this feature. Secondly, internally, there was a central leaf rib with smaller veins coming off this, but this was often omitted. Some candidates drew veins that either did not meet the central rib, crossed it or crossed the outer outline of the leaf.

Question 2

(a) This question tested the ability to design a table to present qualitative data. Most candidates gave a table which showed which solutions were mixed and described the related observations. The best answers included headings such as 'solutions mixed' and 'observations on mixing'. However, some candidates drew tables without headings. Others included a column for 'solutions', listing **H**, **J**, **K** and **L**, but did not make it clear which solution was mixed with which. Some candidates only included the initial appearance of the solutions.

(b) Most candidates completed this table correctly to earn full credit.

(c) Candidates found this question challenging. The key point was that the initial colour of aqueous **H** masked the colour of UI in aqueous **H**. The best answers identified that the initial colour of aqueous **H** was blue, but many answers did not make this clear. Candidates often referred to 'it' or 'the solution' without stating clearly which solution (**H** or the UI) they meant. Some candidates stated "it is a mixture of colours" which could refer only to UI.

(d) Most candidates correctly identified that **K** is an acid.

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Question 4

(a) (i) The question included the instruction to 'Record each measurement to the nearest 0.1 cm'. Most candidates followed this to give the height value as 1.4 cm, but many recorded the value of the width as '3'. The measured value was 2.9 but a tolerance of +/–0.1 cm was allowed. Therefore while 3.0 was credited, '3' alone was not.

(ii) Candidates found it difficult to express why measurements cannot be recorded to 0.01 cm. The best answers stated that such small divisions are not present on a ruler. Some candidates gave vague responses which could not be awarded credit such as “rulers are not that accurate” or “you can’t see these values”.

(iii) Almost all candidates correctly calculated the area of face **X** based on their earlier measurements.

(b) Almost all candidates correctly recorded the mass value to the nearest 0.01 g. Some misunderstood the instruction and gave the mass incorrectly as either 22.721 g or 22 g.

(c) (i) Most candidates correctly used their value for mass from **(b)** to calculate a value of *F*. However, some candidates could not be awarded full credit as they did not give their answer to two significant figures as requested in the question.

(ii) Many candidates correctly answered that force can be measured directly using a force meter (or Newton meter). The most common incorrect answer was to suggest using a balance, which measures mass rather than force.

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