COMBINED SCIENCE

Paper 0653/11
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1** and **5**. **Questions 15**, **19**, **25**, **33**, **34** and **40** proved the most challenging for candidates.

Comments on specific questions

Question 2

Option **D** was a popular incorrect answer. These candidates thought the actual length was determined by multiplying the image size by the magnification rather than by division.

Question 6

Option **B** was more popular than the correct answer. The solution in **B** absorbs carbon dioxide so photosynthesis would be reduced and less oxygen would be produced.

Question 9

Options **C** and **D** were chosen by some candidates, indicating a lack of familiarity with diagrams that show the location of the xylem.

Question 11

Options **A** and **C** were common incorrect choices, indicating a lack of understanding of the function of the sepals.

Question 14

Option **A** was a popular incorrect answer. The diagram does show a mixture but it is a mixture of an element and a compound.

Question 15

Options **B** and **C** were more popular than the correct answer, option **D**. Candidates did not recognise that potassium iodide is an ionic compound and many of those that did, thought electrons are shared between the atoms.

Question 18

Option **B** was more popular than the correct answer, option **A**. These candidates were able to read the thermometer readings correctly but thought that a temperature decrease indicated an exothermic reaction.

Question 19

Options **A** and **C** were both more popular than the correct answer, option **D**. These candidates were not familiar with the process of evaporation.

Question 22

Option **D** was a common incorrect choice. The Periodic Table is ordered by proton number and not by relative atomic mass.

Question 23

Options **B** and **D** were popular incorrect answers, indicating a lack of knowledge on transition elements.

Question 33

All the options were chosen with equal frequency, indicating guessing and a lack of confidence with how thermal energy is transferred by convection in a liquid.

Question 34

Option **D** was more popular than the correct answer, option **B**. Candidates were not confident interpreting a wave diagram to determine frequently.

Question 37

Option **C** was a common incorrect choice. These candidates thought that 50 W indicates current rather than power.

Question 38

Option **A** was more popular than the correct answer, option **D**. These candidates did not recall the formula for resistance.

Question 40

Options **C** and **D** were more popular than the correct answer, option **A**. Candidates thought the Sun is a large mass star and some thought it mostly comprises of hydrogen and oxygen rather than hydrogen and helium.

COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 7**, **11**, **13** and **33**. **Questions 18**, **25**, **31**, **36** and **40** proved the most challenging for candidates.

Comments on specific questions

Question 3

Option **D** was more popular than the correct answer, option **A**. Transpiration occurs in plants, not in animals.

Question 5

Option **B** was a popular incorrect choice. These candidates were not aware that enzymes contain nitrogen.

Question 9

Options **A** and **B** were common incorrect choices. These candidates had either confused respiration with photosynthesis or confused the products of aerobic respiration with the reactants.

Question 10

All the incorrect options were popular choices indicating a lack of confidence with recalling the definition of pollination.

Question 12

Option **B** was a popular incorrect choice, indicating a misconception of the carbon cycle.

Question 14

Option **A** was a common incorrect choice. A charge of 1+ does not result from gaining 1 electron as this would give a 1− charge.

Question 18

Option **A** was more popular than the correct answer, option **B**. Option **D** was also a common incorrect answer. The products of electrolysis of molten lead(II) bromide are required knowledge on the syllabus.

Question 19

Option **D** was chosen more frequently than the correct answer, option **A**. These candidates did not recognise that a temperature decrease indicates an endothermic reaction, instead they opted for the temperatures with the greatest numerical change.

Question 23

Option **A** was a popular incorrect choice. These candidates identified a correct pH but had confused the products of the reactions between acids and metals and between acids and bases.

Question 25

Options **A** and **B** were more popular than the correct answer, option **D**, indicating a general lack of familiarity with the main ore of iron and the process used to extract iron from the ore.

Question 27

Option **B** was as popular as the correct answer, option **D**. These candidates were not familiar with the process of distillation.

Question 31

Option **B** was more popular than the correct answer, option **A**. Candidates incorrectly thought that aluminium is a good thermal insulator.

Question 32

Option **B** was a common incorrect choice. Particles in a liquid are not regularly arranged.

Question 35

Option **D** was a common incorrect choice. These candidates thought time was obtained by speed divided by distance.

Question 36

Option **D** was a common incorrect choice. These candidates did not convert 1.0 minute into seconds.

Question 39

Options **A** and **B** were common incorrect choices. These candidates were not confident interpretating the circuit diagram to determine the impact of a fuse melting.

Question 40

Option **C** was more popular than the key. What causes a protostar to form was not well known.

COMBINED SCIENCE

Paper 0653/13
Multiple Choice Core

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

COMBINED SCIENCE

Paper 0653/21
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **2**, **4**, **6**, **10**, **11**, **15**, **31** and **32**. **Questions 19**, **20**, **22**, **27**, **35**, **38** and **40** proved the most challenging for candidates.

Comments on specific questions

Question 7

Option **B** was a common incorrect choice. The pancreas is not where glycerol is absorbed.

Question 8

Option **C** was a common incorrect choice. These candidates did not appreciate that water is produced during aerobic respiration.

Question 18

Options **A** and **B** were incorrectly chosen by some candidates. These candidates were not confident in determining formulae of ionic compounds.

Question 20

Option **B** was a common incorrect choice. Reaction X is exothermic and reaction Y is endothermic.

Question 22

The correct answer, option **A**, was most commonly selected, but all three of the incorrect options were selected by some candidates. These candidates were not confident in recognising a chemical change.

Question 24

Option **C** was a common incorrect choice. These candidates did not recognise the need to crystalise the liquid obtained from filtration.

Question 27

Options **C** and **D** were both common incorrect choices. Both strategies in these options are correct methods of reducing the effects of climate change but the explanation for this is either not relevant to climate change or incorrect.

Question 29

All three incorrect options were selected, showing a lack of familiarity with how to determine acceleration using force and mass.

Question 33

Both options **A** and **B** were common incorrect choices. These candidates were not confident with thermal conduction in solids.

Question 34

Options **B** and **C** were common incorrect choices. These candidates seemed to think that if amplitude changes then frequency will change in the opposite way.

Question 36

Option **C** was a common incorrect choice. These candidates had reversed the speed of sound in solids and gases.

Question 38

Option **B** was a common incorrect choice. These candidates were not confident calculating power and energy from current, resistance and time.

Question 40

Option **B** was a common incorrect choice. The stages in the life cycle of stars were not well known by these candidates.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **11**, **21**, **31**, **32**, **36** and **37**. **Questions 3**, **7**, **12**, **17**, **20**, **24** and **26** proved the most challenging for candidates.

Comments on specific questions

Question 3

Option **B** was as popular as the correct answer, option **A**. These candidates had confused dilute and concentrated solutions and selected the reverse order.

Question 5

Option **C** was a common incorrect choice. The enzyme site and substrate are complementary in shape rather than the same shape.

Question 7

Due to an issue with question 7, this question has been discounted. Each candidate's total mark has been multiplied by a weighting factor so that the maximum mark for the question paper remains unchanged.

Question 8

Option **A** was a common incorrect choice. The function of hydrochloric acid in the stomach is to kill microorganisms in food and provide an acidic pH for optimum enzyme activity.

Question 16

Option **D** was a popular incorrect choice. This option does not include the triple covalent bond between the atoms of nitrogen.

Question 17

Option **C** was a common incorrect choice. These candidates had confused the release and absorption of energy in bond making and breaking.

Question 20

Option **A** was a common incorrect choice. These candidates knew the physical state of chlorine at room temperature but were unclear on the state of bromine and iodine.

Question 22

All three incorrect options were chosen, showing a lack of confidence with the reactivity of the metals.

Question 24

Option **D** was a common incorrect choice. Rusting is a chemical change not a physical change.

Question 29

Option **D** was a common incorrect choice showing a lack of understanding on how to determine speed from mass, height and gravitational field strength.

Question 30

Options **B** and **C** were popular incorrect choices. Geothermal heating and nuclear fission are not the source of the energy released from the Sun.

Question 39

Option **D** was selected by candidates who were not familiar with how to calculate combined resistance in a parallel circuit. These candidates thought this was obtained by adding the resistance values together.

Question 40

All three incorrect options were chosen, showing a lack of confidence with calculating the radius of an orbit.

COMBINED SCIENCE

Paper 0653/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **7**, **8**, **13**, **15**, **19**, **23**, **29**, **32**, **37** and **40**. **Questions 5**, **11**, **18**, **20**, **21**, **24**, **26**, **27**, **28** and **36** proved the most challenging for candidates.

Comments on specific questions

Question 3

Options **C** and **D** were popular incorrect choices, showing a lack of understanding of how to convert mm to μm.

Question 5

Option **C** was more popular than the correct answer, option **B**. Enzyme activity at W is lower than at X because there are less frequent, effective collisions between the enzyme and the substrate.

Question 6

Option **B** was as popular as the correct answer, option **C**. These candidates had the changes to concentration of carbon dioxide and oxygen reversed.

Question 11

Both options **A** and **B** were common incorrect choices. These candidates were not confident recognising that a vein has a larger lumen than an artery and that the blood pressure is relatively lower in the vein.

Question 12

Option **D** was a popular incorrect choice. The cat in the food web was a secondary consumer as well as a tertiary consumer.

Question 14

Option **C** was as popular as the correct answer, option **D**. The particles in **C** represented an element rather than a compound.

Question 18

Option **D** was more commonly selected than the correct answer, option **C**, and option **A** was almost as popular as the correct answer. These candidates were not confident interpreting the reaction pathway diagram.

Question 20

Option **C** was as popular as the correct answer, option **D**. Candidates had correctly identified dilute sulfuric acid but the method used to obtain barium sulfate from the reaction mixture is filtration rather than crystallisation.

Question 21

Option **B** was as commonly chosen as the correct answer, option **C**, indicating a lack of familiarity with halogen-halide displacement reactions.

Question 24

Option **A** was more popular than the correct answer, option **D**. As all the compounds were alkanes (not alkenes), they do not contain double carbon-carbon covalent bonds.

Question 26

Options **B** and **D** were common incorrect choices. These candidates were not confident with how chain length and boiling point of fractions of petroleum change from the bottom to the top of a fractionating column.

Question 27

Options **A** and **D** were both more commonly chosen than the correct answer, option **B**. This indicates a lack of familiarity with how iron is extracted from hematite in the blast furnace.

Question 28

Options **C** and **D** were more popular than the correct answer, option **B**, suggesting candidates were not familiar with calculating speed, given mass, acceleration of free fall and height.

Question 33

Option **C** was a common incorrect choice. Candidates confused smaller surface area with greater surface area.

Question 36

Option **B** was more popular than the correct answer, option **C**, indicating that many candidates were not able to rank the time taken for sound to travel in different materials and states of matter.

COMBINED SCIENCE

Paper 0653/31
Theory (Core)

Key messages

Candidates should always show their working in numerical answers as they could gain partial credit even if the calculation contains an arithmetical error.

Candidates should read the questions carefully and use the number of marks for each question as a guide to the detail required in their answers.

It is important for candidates to be able to apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination, and they demonstrated sound knowledge across all three sciences. Other candidates were not sufficiently familiar with the syllabus to answer all the questions. These candidates are advised to learn definitions of key terms in the syllabus. In this paper, correct definitions of nutrition, alloy and hydrocarbon would have helped many candidates to achieve a higher score.

Some candidates did not attempt to answer questions when a choice must be made from a list, or a labelled diagram. Examples of these are **1(b)(ii)** and **1(c)(i)**. Candidates are advised to attempt these questions even if they are unsure of the correct answer.

Comments on specific questions

Question 1

(a) (i) Many candidates successfully identified the vacuole. Incorrect responses included nucleus and cytoplasm. These candidates are reminded that most plant cells have a large central vacuole and the cytoplasm, containing the rest of the cell organelles, is found around the large vacuole within the cell wall.

(ii) Some candidates gained credit for this question, stating that the function of the mitochondria is to release energy by aerobic respiration. A common response that was not awarded credit occurred when candidates stated that mitochondria are the powerhouse of the cell. This response does not have enough detail to gain credit.

(iii) Many candidates gained partial credit for stating that the root hair cells are found underground and therefore there is no light available. Fewer responses linked the lack of chloroplasts to their normal role of photosynthesis, which they are unable to do underground.

(b) (i) There were many correct answers from candidates who had learned the definition of osmosis. The most common mistake was diffusion. Candidates are reminded that osmosis is a special type of diffusion involving the net movement of water through a partially permeable membrane.

(ii) Generally, this question was not well known. Water enters the root hair cells which are in the outer layer of the root. The water then moves to the xylem in the centre of the root, so it passes though the root cortex cells to get there.

(c) (i) This question was well answered by most candidates who correctly interpreted the flow diagram of the carbon cycle.

(ii) Candidates could see that the cows eat grass, but this needed to be linked to herbivore. A herbivore only eats plant material. Some responses contained the word 'only' and these were awarded credit. Candidates who stated that herbivores do not eat meat also gained credit.

Question 2

(a) Most candidates identified **Q** and **P** correctly. A common error was identifying the septum, **R**, as the muscular wall of the left ventricle. The left ventricle needs to be powerful enough to contract and send the blood around the body. **Q** is muscular enough to do this. The septum divides the two sides of the heart to ensure that oxygenated and deoxygenated blood do not mix**.**

(b) The use of a stethoscope that monitors the sound of heart valves closing, and the measurement a person's pulse were the most common correct answers. Many candidates chose one of these methods. Less successful candidates stated methods that were provided in the question, for example ECG, heart monitor and cardiogram.

(c) White blood cells and red blood cells were identified correctly by most candidates. Fewer candidates stated plasma for the transport of hormones. A common error was writing platelets instead of plasma. Candidates are reminded that the plasma, a liquid, contains many dissolved substances, including hormones. The platelets are involved with the clotting of blood.

(d) Candidates found this question demanding. There were many vague answers, including arteries are bigger, longer or wider. These answers did not have enough detail. References to the thicker walls, the smaller lumen and the absence of valves were all acceptable. Some candidates wrote comparisons between the functions of arteries and veins, and these did not score credit. Therefore 'arteries take blood away from the heart' and 'veins bring blood back to the heart' are examples of their functions and not their structure, as asked in the question.

Question 3

(a) The definition of nutrition on the syllabus involves two parts, the taking in of materials and a subsequent function of these materials inside the body. An example of an acceptable response is 'taking in nutrients for energy', but there were several ways of wording the answer. Candidates found this question demanding. Vague statements such as 'gives you what you need to stay alive' or 'a healthy diet' were not awarded credit.

(b) (i) Most candidates successfully answered this question, stating fibre.

(ii) To answer this question, 0.0087 had to be divided by 0.04 to find out what fraction of the daily requirement for vitamin C is provided by 100 g of bananas and then this fraction expressed as a percentage. There were many correct answers. Common errors included just multiplying the 0.0087 × 100 or calculating the fraction by working out 0.04 ÷ 0.0087.

(c) Most candidates gained partial credit in this question. A common mistake was confusing the anther and the stigma. Candidates should be aware that the pollen is produced by the anthers, and it is then transferred to the stigma. Some candidates confused fertilisation and germination for the last response. They are reminded that fertilisation is the fusion of nuclei in the ovule, and germination is the start of growth of a seed.

Question 4

(a) The response for **A** was widely known, less so for **B**, condensation. Incorrect answers for **B** included boiling and evaporation. Both responses are changes form liquid to gas, not gas to liquid as shown in the diagram.

(b) This question was generally answered well by most candidates. Incorrect responses for the second marking point included regular and stable as adjectives to describe the arrangement of particles in a liquid instead of random.

(c) (i) The state symbols were not well known by most candidates. State symbols are all lower case and are chosen from (s), (l), (g) and (aq). In this question, the iron is solid (s), and the oxygen is a gas (g). Only a few candidates gained credit. Incorrect responses included attempts to write formulae, numbers, or G for the gaseous state.

(ii) Candidates found this question demanding. The definition of oxidation at this level is the gain of oxygen by a substance, in this case iron. Answers had to point out clearly that the oxygen has combined with the iron. An example of a correct answer is 'the iron has combined/reacted with oxygen'. Vague answers such as 'because it shows it in the equation' or 'because it gains oxygen' were not accepted.

(d) Most candidates knew that catalysts increase the rate of reaction.

Question 5

(a) It was clear that candidates were unfamiliar with the method of doing a flame test. A few candidates stated to use a splint but hardly any mentioned to burn the compound in the blue flame of the Bunsen burner. Credit was given to the candidates who knew that potassium gives a lilac colour in the flame test.

(b) (i) Generally answered well. Most candidates knew that an exothermic reaction gives out thermal energy.

(ii) Candidates had to describe an observation of an exothermic reaction. An observation can be made by the sense organs or by instruments. The fact that the potassium catches fire is a good indicator of an exothermic reaction. In this case, answers that stated the water felt warm or increased in temperature (checked with a thermometer) were also credited. Just to say 'heat energy is given out' without describing a way of showing this does not give enough information to gain credit.

(iii) A small number of candidates answered this question correctly. The two boxes on the left, potassium and water, are the reactants and between them they have the elements potassium, K, and hydrogen and oxygen in water, H_2O. The two boxes on the right of the arrow are the products of the reaction and they can only contain the same elements as the reactants. Therefore, carbon dioxide, given by many candidates, can be ruled out as a correct product. The actual products are potassium hydroxide and hydrogen. Potassium oxide was written by many candidates, and oxygen and water were other incorrect products.

(c) Candidates found the definition of an alloy challenging. Correct responses had to contain the following points. Firstly, an alloy is a mixture, secondly, it contains a metal, and thirdly it contains one or more other elements. Common errors included stating that the elements in the alloy were chemically combined and that there are compounds in the alloy.

(d) Some candidates knew the correct electronic configuration of magnesium, 2,8,2. This configuration shows the electrons in each shell of the atom. Other candidates wrote 12. This is correct for the total number of electrons, but it does not give information about the electrons in each shell.

(e) The different elements had to be grouped together to get a total for each type. Many candidates did this successfully. Others grouped the elements correctly but then put + signs between each one. Therefore, instead of the correct formula C_4H_7MgBr, they wrote C4 + H7 + Mg + Br, and these answers were not acceptable. The elements could be written in any order as long as the numbers of atoms of each type of element were correct.

Question 6

(a) In this part question candidates were asked to select the formulae of the correct compound from the list. It was therefore important that the formulae of these compounds on the syllabus are learned in addition to their names. In the case of $CaCO_3$, candidates should be familiar with the formula of a metal carbonate. This compound was chosen by many candidates for the various responses, and it did not correspond to any of the definitions.

(i) Some candidates knew the compound C_2H_4, ethene, that decolourises aqueous bromine. The main error was $CaCO_3$.

(ii) Candidates who were successful stated CH_4 (methane). Incorrect answers included CO_2 and CO.

(iii) The monomer C_2H_4, was successfully stated by some candidates. The main incorrect response was CH_4.

(iv) Carbon dioxide, CO_2, was correctly identified by most candidates who were familiar with its role in contributing to global warming.

(v) Some candidates knew that CO, carbon monoxide, is a toxic gas caused by incomplete combustion.

(vi) The waste gas produced by digestion in animals is methane, CH_4. Some candidates did not appear to realise that the question was asking about digestion, and they wrote CO_2, the waste gas produced by respiration.

(vii) Candidates of all abilities found this question demanding. Oxides of non-metals, in this case carbon dioxide, form acidic solutions when dissolved in water.

(b) Many candidates knew that the elements hydrogen and carbon are found in a hydrocarbon. Fewer stated that a hydrocarbon only contains hydrogen and carbon. The word only was essential in the definition. This question was answered quite well by some candidates, others stated that hydrogen was mixed with carbon.

(c) The use of refinery gas for cooking and heating was well known by many candidates. Less well known was the use of bitumen for making roads.

(d) There were few candidates who wrote the correct answer, sulfur dioxide. The most common incorrect answer was sulfuric acid.

Question 7

(a) (i) Most candidates drew a straight arrow pointing left. Some candidates drew their arrow beneath the surface of the road. These were not awarded credit because the question was asking for air resistance acting on the motorcycle, which would be above ground. A few candidates drew the air resistance arrow in the direction of motion of the motorcycle. This is an incorrect response because the air resistance acts to oppose the forward motion.

(ii) Only a few candidates knew the term resultant force. Candidates are reminded that an object will either remain still or continue to move at a constant speed unless a resultant force is acting on it. In the question there is no resultant force, so the motorcycle will continue at a constant speed.

(iii) Most candidates knew newtons, the unit represented by N. It was important that candidates spelled this correctly because incorrect spelling could be ambiguous and could be mistaken for other scientific terms. Therefore, nutrons and newtrons were rejected.

(b) (i) To gain full credit, candidates did a unit conversion and a calculation. The equation $t = s \div v$ was used. The kilometres must be changed to metres before dividing by the speed which makes the calculation 24000/16. An alternative conversion was to change the speed to km / s, making the calculation 24/0.016. Both calculations result in the correct answer, 1500 s. Many candidates scored full credit for this question.

(ii) The voltage and current were multiplied together to give the power of the battery. This was done successfully by some candidates. The most common error was dividing the voltage by the current to give an answer of 1.6. Dividing the voltage by the current gives the resistance.

(iii) The power calculated in **7(b)(ii)** is used to calculate the energy supplied by the battery in 1500 s by multiplying the power by the time. An error carried forward (ecf) was allowed for those candidates who did an incorrect calculation for the power in **(b)(ii)**.

Question 8

(a) (i) Most candidates could see the connection between the melting point of iron and the very high temperature of the petrol burning. They concluded correctly that the iron in the engine would melt if it was not cooled down.

(ii) This question was challenging for candidates. Many wrote the correct formula for density, $\rho = m \div V$, but did not rearrange the formula correctly to give $V = m \div \rho$. Only a minority succeeded in doing the calculation by dividing the mass by the density. Many candidates calculated 7900 ÷ 150, which gave a result of 52.7 m^3. Candidates should always assess how realistic their answers are and check their working.

(b) (i) There were not many correct answers to this question. One wavelength is the distance from a particular part of a wave to the same part of the next wave. They could be drawn from crest to crest, trough to trough or on the resting line. Some candidates seemed to have the idea of a wavelength, but they were not sufficiently accurate with their drawing. Some lines were too short or too long. A ruler would have been useful here, to measure and draw the wavelength accurately.

(ii) Candidates found this question demanding. The equation $f = v / \lambda$ was used to calculate the frequency of the radio waves. Some candidates did the numerical calculation correctly. Stating the correct unit was difficult for all candidates. The correct unit, Hz, was seen a few times. Some variations of this unit were not allowed, for example, hz, HZ, and hurts. Other incorrect units included ohms and m / s.

(iii) Some candidates answered this question well, giving an acceptable use for radio waves. Other responses were too vague. Candidates should be specific when describing the uses of radio waves. An example of this is instead of just saying 'for phones' they should state 'for phone signals', which was accepted for credit.

Question 9

(a) (i) A few candidates knew that the component was a fuse, but most did not know its function to prevent the current from becoming too high. Incorrect responses for the component were battery and resistor.

(ii) A small number of candidates identified **D** as a variable resistor and gained credit. Fewer candidates explained that the higher the resistance the lower the current, so the component is used to control the current in the motor.

(iii) The equation $R = V \div I$ is used to calculate the resistance of the lamp. There were many correct answers, 14 Ω. The most common mistake was multiplying the voltage and the current together to give 2.835. Candidates should be aware that multiplying the voltage by the current gives the power, not the resistance.

(b) Full credit was obtained by those candidates who knew the order of planets in the solar system. Some candidates did not appreciate that the spacecraft was travelling away from the Sun so it would not cross the orbit of Venus.

(c) Generally, candidates found this question demanding. Some responses gained partial credit by stating that the planets orbit the Sun due to the Sun's gravitational attraction. Only a few responses mentioned that the Sun has most of the mass of the Solar System, and this explains why the planets orbit the Sun. Many candidates stated that the planets need light and heat, so that is why they are orbiting the Sun.

COMBINED SCIENCE

Paper 0653/32
Theory (Core)

Key messages

Candidates should always show their working in numerical answers as they could gain partial credit even if the calculation contains an arithmetical error.

Candidates should read the questions carefully and use the number of marks for each question as a guide to the detail required in their answers.

It is important for candidates to be able to apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination, and they demonstrated sound knowledge across all three sciences. Other candidates were not sufficiently familiar with the syllabus to answer all the questions. This was shown by weaker responses to questions which required recall of statements on the syllabus.

Some candidates did not attempt to answer questions when a choice must be made from a list, or a labelled diagram. Examples of these are **1(a)(iii)** and **4(a)(i)**. Candidates are advised to attempt these questions even if they are unsure of the correct answer.

Comments on specific questions

Question 1

(a) (i) The nucleus was named successfully by many candidates. The main incorrect answer was vacuole. Candidates are reminded to read the introduction to the question carefully. A large vacuole is only found in plant cells, and this white blood cell must be an animal cell. Other incorrect responses included cell membrane and cytoplasm.

(ii) Some candidates answered this question well, giving antibody production or phagocytosis. Credit was also given for stating that white blood cells destroy or kill pathogens. Responses such as white blood cells fight or protect against infections or diseases were not acceptable because they were too vague.

(iii) Most candidates gained partial credit for cell membrane. Incorrect responses included cell wall and circular DNA. Candidates should be aware that white blood cells do not have cell walls or circular DNA.

(b) The description of the circulatory system in the question is one of the syllabus statements. Only a few candidates scored full credit for this question. The reason that the term blood vessels is used in this definition is because it includes arteries, veins and capillaries. Therefore, just mentioning one of these blood vessels does not explain the whole system, just part of it. More candidates knew the second answer, that valves ensure the one-way flow of blood.

(c) Most candidates successfully read the two heart rates from the graph and calculated the increase in heart rate. Only a few candidates performed the percentage increase calculation correctly. To gain full credit for this calculation, candidates had to find the change of heart rate as a fraction of the original heart rate and multiply this by 100. So, the calculation would be $90 \div 60 \times 100 = 150\%$. Very few candidates showed their working.

Question 2

(a) (i) The part labelled **P** corresponded to the lower epidermis layer of cells. This was not widely known. The main incorrect answers were guard cells and stomata. Candidates should be aware that they should be able to identify the structures in a dicotyledonous leaf, including the lower epidermis.

(ii) Some candidates identified a spongy mesophyll cell correctly. Credit was also given to those candidates who successfully identified the whole spongy mesophyll layer. Candidates should make sure that their label line touches the intended cell, rather than the air spaces that surround the spongy mesophyll cells.

(iii) Chlorophyll, the pigment found in the part labelled **Q** was successfully named by many candidates. The most common incorrect response was chloroplast. Candidates should be aware that the part labelled **Q** is the chloroplast, this is the part of the cell that contains the green pigment chlorophyll.

(b) Most candidates gained partial credit for the second part of the question. They understood that the plant had not photosynthesised because there was no light present. Fewer responses showed an understanding of the negative test for starch, the yellow-brown colour described in the question.

(c) (i) Generally well answered. Candidates successfully identified a herbivore, fish, fly or slug. Although the turtle was shown to feed on aquatic plants, it also feeds on the slug and the fly (both animals). This means that the turtle does not feed on plants only, so cannot be described as a herbivore.

(ii) There is only one tertiary consumer in the diagram, the frog, and many candidates worked this out successfully. Although the kingfisher is at the same position as the frog in the diagram of the food web, it is only a secondary consumer. The snake is a quaternary consumer, feeding only on the frog. The flow of chemical energy to the frog is shown below

aquatic plant → fly → dragonfly → frog

(iii) Candidates found this question demanding. Few candidates stated the correct answer, decomposers. Incorrect responses included organisms such as, fly, insect, slug and bacteria.

Question 3

(a) The characteristics of living organisms were well known by candidates.

(b) (i) Many candidates gained partial credit for this question. There was some flexibility allowed for the first response, with descriptions of physical digestion in the mouth accepted as well as ingestion. Incorrect responses for the second response included movement, travel and flow. Candidates are reminded of the two functions of the small intestine, digestion and absorption of food.

(ii) Candidates found this question demanding. Many candidates stated fatty acids, but fewer stated glycerol. Candidates are reminded that several food materials are made from larger molecules that must be digested into smaller molecules before they can be absorbed into the blood. In the case of fats, the two smaller molecules are fatty acids and glycerol.

(c) (i) The relationship between pH and enzyme activity was described correctly by most candidates. The highest activity, at pH6.8, was also identified successfully. Some candidates stated that after the peak the enzyme denatured without stating how this affects the activity. Candidates should take special care to read the question and respond accordingly.

(ii) Most candidates stated temperature.

Question 4

(a) (i) Hydrogen was identified by many candidates. There was no pattern to the incorrect answers that were chosen in roughly equal numbers. Candidates should be aware that the elements reacting are sodium metal, and water, made up from hydrogen and oxygen. Therefore, chlorine and carbon dioxide can both be excluded as products.

(ii) Many candidates knew that potassium is more reactive than sodium, and they described a difference in many ways. In addition to the mark scheme, examples of acceptable answers included a statement to say that the reaction with potassium is more vigorous or that it produces a lilac flame.

(b) Candidates found this question demanding. The similarity is that a compound and a mixture both contain two or more different elements. The main difference is that in a mixture the elements are not combined chemically, but they are chemically combined in a compound. Answers that were not awarded credit included explanations using the words atoms, particles and substances.

(c) (i) The two correct properties of a liquid were not widely known. Some candidates chose only one correct property, and others ticked the box stating that liquids have no fixed volume. Neither of these responses were awarded credit.

(ii) A few candidates wrote l in lower case to gain credit. Incorrect responses included aq, H_2O, li and L. Candidates should be aware that the state symbols are all written in lower case and are chosen from aq, g, s, and l.

(d) Candidates had to state that neon has a full outer shell and this makes it unreactive. Some described the full outer shell but did not explain the effect this has on its reactivity.

(e) (i) A small number of candidates successfully stated that the percentage of nitrogen gas in clean, dry air is 78%. There was no pattern to the incorrect answers.

(ii) The source of oxides of nitrogen, car engines, was known by only a small number of candidates. The high temperature and pressure inside the internal combustion chamber of the car engine causes oxygen and nitrogen from the air to combine. The oxides of nitrogen are then emitted through the car's exhaust.

(iii) Generally answered well. Most correct answers stated that acid rain is an adverse effect of oxides of nitrogen, with fewer stating respiratory problems.

Question 5

(a) Most candidates knew that iron and Group I elements are metals and therefore conduct electricity. Fewer also responded that iron has a higher melting point than Group I elements. Candidates should be aware that the melting points of transition elements are high, so the melting point of iron is likely to be higher than the Group I metals. Transition metals are denser than Group I elements and tend to form coloured compounds, so the third and fourth options are ruled out as being correct.

(b) Most candidates found this question demanding. It appeared that some candidates did not understand the structure of a word equation as many left all four boxes blank. The reactants, given in the question, go on the left of the arrow and the products go on the right. Some of the responses that were completed were correct. Others wrote water or carbon dioxide as a product instead of hydrogen. Candidates are reminded that only the elements in the reactants will be present in the products. Therefore, carbon dioxide cannot be a product.

(c) Many candidates stated **B** as the test-tube that enabled the fastest rate of rusting and so gained partial credit. To get full credit, candidates had to make the point that test-tube **B** has both water and oxygen present. The most common error occurred when candidates wrote air instead of oxygen. It is the oxygen present in the air, along with water, that causes rusting.

(d) The removal of oxygen from a compound is reduction, and some candidates answered this correctly. There was no pattern to the answers chosen by the remaining candidates.

(e) Some candidates knew bauxite, the main ore containing aluminium. Incorrect answers included aluminium, iron or other metallic elements. It was clear that many candidates did not understand what an ore is. An ore is a naturally occurring rock that contains metals or metal compounds.

(f) (i) Many candidates scored partial credit. Incorrect responses included the statement of either hydrogen or carbon as a metal. These elements are included in the list so that the reactivity of the metals can be compared to their reactivity allowing a suitable method of extraction of the metals in the reactivity series to be chosen.

(ii) Few candidates gained credit for this question. Candidates should be aware that the reactivity of the metals determines their method of extraction. Metals that are more reactive than carbon will be extracted by electrolysis. Metals that are less reactive than carbon can be extracted by heating with carbon.

Question 6

(a) Many candidates balanced the equation correctly.

(b) Generally, candidates found this question demanding. A minority knew that oxygen relights a glowing splint. It was clear that most of the remaining candidates were not familiar with the test. Inaccuracies included the test for hydrogen which results in a 'pop' sound, the test for carbon dioxide, and the use of a completely extinguished match or splint to relight, not a glowing one.

(c) One test for water is that anhydrous cobalt(II) chloride paper changes from blue to pink. Only a few candidates knew this positive result. All colours were stated.

(d) The idea that a catalyst speeds up the rate of reaction was stated by many candidates. The idea that the catalyst is unchanged at the end of the reaction, was only given by some candidates. The definition of a catalyst as being a biological molecule, as in an enzyme, was frequently seen. This was not accepted because an enzyme is an example of a catalyst but there are many other chemicals which are used as catalysts that are not enzymes.

(e) Many candidates successfully predicted that the increase in temperature increases the rate of reaction.

Question 7

(a) (i) Force **Q**, friction or air resistance, was identified correctly by many candidates who could see that it was acting against force **P**, the forward driving force.

(ii) Since forces **P** and **Q** were not of the same magnitude there was a resultant force of 500 N. The main mistake, made by a minority of candidates, was adding the two forces together, getting 4300 N instead of calculating the difference between **P** and **Q**. Candidates should be aware that the arrows indicate the direction in which the forces are acting. **P** and **Q** are acting in opposite directions, so they go towards cancelling each other out.

(iii) The resultant force on the tram means that it will not be moving at a constant speed, but it will be accelerating. Some candidates wrote this. Others described the motion of the tram as moving forward, moving to the right or at constant speed. These answers did not gain credit because they ignored the fact that there was a resultant force acting on the tram that would make it accelerate.

(b) The weight of the tram is calculated by multiplying the mass by 9.8 m / s^2 (g). Many candidates did this successfully. The most common mistake occurred when candidates divided the mass by 9.8, so instead of the correct weight they wrote 3571 N.

(c) The movement of the tram uphill means that the tram is gaining gravitational potential energy as it climbs. Some candidates knew this answer. The two spaces for the answer were an indication that two words were needed. Some candidates gave single-word answers, for example, kinetic, potential and thermal.

(d) There were two stages to this calculation. The first stage was finding out how much energy was used, using the equation $E = P \times t$. This gives the amount of energy in kWh, 13.2. The second stage is to find the total energy cost by multiplying the amount of energy, 13.2 by 0.25 to give $3.3. Overall, candidates found this question demanding. Some candidates could have gained partial credit if they had shown their working.

Question 8

(a) (i) Generally answered well.

(ii) The temperature increases because the particles move faster. The volume increases because the particles move further apart from each other. Some candidates gained partial credit for the first part of the question. A common error described the motion of the particles as vibration. This term is used to describe the motion of particles in a solid. They can vibrate around their fixed point without changing places with each other. Some candidates gained partial credit for the second part of the question. A common error occurred when candidates stated that the particles were expanding. It is the total volume of the gas which is expanding due to there being greater separation of the particles.

(b) (i) The electrical symbol for a fuse was not known by many candidates. The most common incorrect answer was resistor. Although the symbol for a resistor is similar in shape to the fuse, it does not have a straight line through the middle as shown by the fuse in the question.

(ii) The response to this question needed a rearrangement of the equation $R = V \div I$. In this case, the resistance and current had to be multiplied by each other to get the voltage. Many candidates did the calculation correctly to get a voltage of 112 V. Many incorrect answers included a division of the resistance by the current to give 10.93 (V).

(iii) In this parallel circuit the total current is shared by the two branches. The information at the start of the question states that the current in the electric heater is 3.2 A. For this part of the question, the current through the lamp is 0.20 A. Adding the currents in the two branches together gives a total ammeter reading of 3.4 A. A few candidates gained credit for this question. Many responses gave the answer of 0.20 A. Candidates are reminded that the current only remains the same in a series circuit not a parallel one. No credit was awarded for these responses.

(c) Some candidates knew that direct current (d.c.) describes current that flows in only one direction and has a constant value. Only a few candidates gained credit for stating that alternating current (a.c.) goes forwards and backwards in the circuit. Most incorrect descriptions of a.c. speculated that the current could have alternative routes, as in a parallel circuit.

Question 9

(a) (i) Generally well answered.

(ii) The distances in space are so huge that they are measured in light-years. A light-year is the distance travelled by light in space in one year. So, the time taken for light to travel from the Sun to the centre of our galaxy is 25 000 years. A few candidates answered this correctly. Many responses stated 25 000 light-years. Candidates should be aware that a light-year is a distance, and the question was asking for a time.

(iii) Some candidates did well with this question, ticking the correct two boxes. Many others gained partial credit, identifying one type of radiation successfully.

(b) Many candidates found this question challenging. The equation $v = f \times \lambda$ had to be rearranged to calculate the frequency. Also, many candidates found difficulty understanding the scientific notation of the wavelength and speed. As a result of both the equation rearrangement and dealing with the numbers, only a few candidates gained credit for this question. Only a few candidates stated Hz. Incorrect responses included s and m / s. Candidates are reminded to state the units correctly; ‘hz’, ‘hrz’ and ‘hurts’ were not accepted.

(c) The two parallel rays had to continue until reaching the eye, refract in the lens, and converge on the back of the eye. Candidates should be familiar with the formation of an image by a thin converging lens. A small number of candidates gained full credit in this question. Common mistakes were showing the rays focusing before the back of the eye and refraction of the light before reaching the eye, with nothing to cause this refraction.

COMBINED SCIENCE

Paper 0653/33
Theory (Core)

Key messages

Candidates should always show their working in numerical answers as they could gain credit even if the calculation contains an arithmetical error.

Candidates should read the questions carefully and use the number of marks for each question as a guide to the detail required in their answers.

It is important for candidates to be able to apply their knowledge to unfamiliar situations.

General comments

Some candidates had prepared well for the examination, and they demonstrated sound knowledge across all three sciences. Many of the remaining candidates were not sufficiently familiar with the syllabus to answer the questions. This was shown by weaker responses to questions which require recall of material on the syllabus.

Some candidates did not attempt to answer questions when a choice must be made from a labelled diagram or by joining boxes. Examples of these are **1(a)** and **1(b)**. Candidates are advised to attempt these questions even if they are unsure of the correct answer.

Comments on specific questions

Question 1

(a) Many candidates successfully identified the ovary (**B**) as the place where gametes are produced. Generally, candidates found it difficult to identify the cervix, **D** and the oviduct, **A**. It is important that the functions of the reproductive organs are learned, in addition to the structures.

(b) Most candidates correctly linked the parts with their functions.

(c) (i) Most candidates were unfamiliar with the style, the part of the flower between the stigma and the ovary. The most common mistake was labelling the stigma with the letter **S**.

(ii) The idea of pollen transfer was described by many candidates. Further detail about pollination, that the pollen is transferred from an anther to a stigma, was not well known.

(d) Many candidates gained full credit for this question. Others gained partial credit for stating that there are many different species but omitted to say that these are in a specific area.

Question 2

(a) (i) Generally answered well by most candidates. The main mistake by some candidates was to state slow walk instead of sitting for the second part of the question. The scale of the *y*-axis should be interpreted correctly when readings are taken from the bar chart. The heart rate for the slow walk is 74 beats per minute, not the rate of 68 beats per minute as requested in the question.

(ii) Many candidates gained credit for this question. As in the previous question, correct interpretation of the scale was essential.

(iii) Candidates found this question demanding. The most common error occurred when candidates described measuring the pulse rate in the neck or wrist. The pulse rate was excluded by the stem of the question, so an ECG or a stethoscope (used to listen to the sounds of valves closing) could be used instead.

(b) (i) The word equation for respiration was not well known.

(ii) Some candidates successfully stated mitochondria as the site for aerobic respiration. The most common mistake was lungs. Candidates should understand the difference between aerobic respiration and breathing. Aerobic respiration is a chemical reaction which occurs in the mitochondria of cells whereas breathing ventilates the lungs.

(c) Full credit was obtained by many candidates. Amino acids was the most well-known response, followed by absorption and assimilation.

Question 3

(a) (i) Candidates knew that the food web must start with a producer. Some candidates circled herbivore. They are reminded that herbivores are animals that only feed on plants.

(ii) Primary consumers feed on plants, the phytoplankton. Most candidates wrote zooplankton or unicornfish to gain credit. The most common incorrect answer was parrotfish. This fish was a tertiary consumer. Some candidates thought that the coral was a plant.

(iii) This was generally well answered.

(b) (i) Candidates interpreted the food web well, showing an understanding of the interdependence of nature. The loss of the only food source for the parrotfish would cause their numbers to decrease.

(ii) There were several possible answers to this question as shown on the mark scheme. The most popular answer was deforestation. A common response stated that overfishing is a cause of habitat destruction. This did not gain credit because overfishing is more likely to result in endangering species living in the habitat than the destruction of the habitat itself.

(c) Some candidates answered photosynthesis correctly. Others gave raining or respiration.

Question 4

(a) Most candidates successfully completed the first sentence. Fewer candidates knew that ionic compounds are solids at room temperature and pressure.

(b) Some candidates answered this question correctly, describing how an electron goes from the lithium atom to the fluorine atom. A common error was using the terms atoms and ions for the transfer instead of electrons. Any references to sharing electrons, as in covalent bonding, were rejected.

(c) The proton number of fluorine is the atomic number shown at the top of the box, 9. The bottom number in the box is the relative atomic mass, 19. This indicates the total number of protons and neutrons in the atom. Since we know that there are 9 protons, there must be 19 – 9 neutrons = 10. Incorrect answers included 10 and 9 in the wrong places, and 19 anywhere was incorrect.

(d) This question is about Group VII of the Periodic Table. Most candidates gained some credit for this question. Trends in reactivity and density were tested in the first two responses. In Group VII, reactivity decreases and density increases going down the group. Many candidates knew that the elements in Group VII have the same number of electrons in their outer shell.

Question 5

(a) Some candidates stated that the universal indicator gives a colour change when it is added to the dilute sulfuric acid. These candidates gained partial credit. Fewer candidates described referring to a chart to discover the actual pH value.

(b) (i) Candidates were not familiar with this experiment. Only a few candidates knew that oxygen was produced at the positive electrode and hydrogen at the negative electrode.

(ii) The anode, the positive electrode, was known by some candidates. Incorrect responses included cathode, anion and cation.

(iii) Some candidates correctly identified the electrolyte. Candidates are reminded that an electrolyte is a molten or aqueous substance that undergoes electrolysis. In this case, the sulfuric acid is the electrolyte.

(c) (i) This question was answered well. Candidates could see that that for each reading there was twice the volume of gas produced at the negative electrode compared with the positive electrode.

(ii) Many candidates divided the total volume by the total time to give the answer 0.3 (cm^3 / s). Incorrect answers included 9 and 3.

Question 6

(a) Some candidates balanced the equation successfully. Fewer wrote the state symbol correctly. Incorrect responses included formulae and numbers. Candidates are reminded that state symbols, in this case, g, are lower case. Therefore, G was not accepted.

(b) Some candidates stated exothermic correctly. Incorrect responses included endothermic and oxidation.

(c) (i) In this question, the compound that exists as simple molecules had to contain two different elements. Water, H_2O, was the only correct answer. The other simple molecules, O_2 and H_2, are molecules of elements. Candidates found this question very demanding.

(ii) Many candidates identified the transition element, iron (Fe), successfully. The most common error was hydrogen. Candidates are reminded that the transition elements are metals.

(d) The best answers stated that iron is oxidised because it gains oxygen or explained that the iron has combined with the oxygen. Candidates found this question demanding.

(e) Many candidates explained that using iron as a fuel does not produce carbon dioxide. They were aware that carbon dioxide build-up leads to global warming.

Question 7

(a) (i) The weight of the car acts downwards due to the force of gravity. Some candidates gained credit for this answer. Candidates should be aware that force arrows should touch the object they are acting on.

(ii) A constant speed occurs because forces **D** and **F** have the same magnitude. This gives a resultant force of 0 N, and therefore neither acceleration nor deceleration can take place. A few candidates gave the correct answer.

(b) (i) The equation for speed had to be rearranged for time to calculate the time taken, 15 s. The main error occurred when candidates multiplied $s \times v$ to get 21.6 (s).

(ii) Some candidates gained full credit by multiplying the driving force by the distance moved. Fewer candidates knew the unit, J. Incorrect units included N, m, and kg.

(c) A few candidates gained some credit for this question. The car battery contains chemical energy. The amount of chemical energy decreases as it is transferred to gravitational potential energy as the car goes up the slope. At the same time thermal energy is released to the surroundings.

Question 8

(a) Many candidates successfully drew the diagram of the gas particles in the box. The particles had to be in a random arrangement and widely spaced from each other.

(b) Candidates found this question demanding. The main method of heat transfer was by convection. Incorrect responses included exothermic and heat energy.

(c) Some candidates did well on this question, making four correct choices. Many others scored partial credit. Candidates should be aware that when a gas is heated at constant pressure, the temperature of the gas, the kinetic energy and the speed of the particles all increase. As the gas expands its volume increases too.

(d) The correct colour, green, was written by those candidates who successfully remembered the colours of the visible spectrum. The most common incorrect answer was orange.

(e) (i) Candidates found this question demanding. Candidates were not familiar with the range of frequencies of human hearing, from 20 Hz to 20 kHz, as stated in the syllabus.

(ii) Candidates had to rearrange the equation, $v = f \times \lambda$, to $\lambda = v \div f$ so that the wavelength of the sound wave could be calculated. Most of the responses were incorrect and did not show any working. Some of these answers were close to being correct. It is possible that some credit could have been gained if working had been shown.

Question 9

(a) (i) Generally quite well answered. The most common incorrect answers were Venus and Neptune.

(ii) Some candidates answered this question well, giving two objects from the list. Others mentioned stars or galaxies. Candidates should be aware that the Sun is our star, and any other stars are outside the Solar System. The Sun is one of many billions of stars that make up the Milky Way, our galaxy, so we would not find a galaxy in the Solar System.

(iii) A few candidates knew the missing stages in the life cycle of a small mass star. The most common incorrect answers were the word star written in both places, instead of completing red giant and white dwarf.

(b) (i) The resistance is calculated by using the equation $R = V \div I$. Candidates found this question demanding, and most multiplied the voltage by the current to give 0.256 (Ω). The voltage multiplied by the current gives the power of the circuit and the unit for this is the watt, W.

(ii) The equation for electrical energy had to be rearranged to answer this question. So, to calculate the time in $E = I \times V \times t$ becomes $t = E \div I \times V$. The time is calculated in seconds, and this value is divided by 3600 to convert it into hours. Only a few candidates gained credit for this question.

COMBINED SCIENCE

Paper 0653/41
Theory (Extended)

Key messages

Those candidates who performed well on this paper:

- were well-prepared for this type of examination and demonstrated knowledge with understanding of the syllabus
- used syllabus definitions and descriptions of scientific ideas
- read questions carefully and used the number of marks for each question as a guide to the detail required in their answers
- included working and relationships between variables in questions involving calculations and organised this information clearly so that key steps could be awarded credit even if the final answer was incorrect.

General comments

Many candidates showed mastery of all sections of the syllabus and were very well-prepared in terms of examination technique. Many answers were well-organised and written clearly.

Many candidates recalled definitions and specific descriptions as stated in the syllabus. This is an efficient way to gain credit. Examples where this was appropriate included:

1 (c) active transport and diffusion
3 (b)(ii) active immunity
4 (c)(i) elements in stainless steel
4 (c)(ii) properties of alloys
5 (a)(i) the colour of bromine
6 (c) structure of an ionic solid
7 (a)(ii) energy efficiency
8 (a)(ii) gas pressure
9 (c)(ii) age of the universe

Comments on specific questions

Question 1

(a) (i) Lipase, was very frequently stated. The most common incorrect suggestion was amylase.

(ii) Glycerol was very frequently identified. Amino acid was the most popular incorrect suggestion.

(b) (i) The trend in the graph was correctly stated by almost all candidates. A small number misinterpreted the question and wrote about causes of heart disease.

(ii) This calculation was usually completed correctly. Some candidates misunderstood the label on the vertical axis of the graph and stated that the lowest and highest numbers of deaths were 130 000 and 370 000. Partial credit was awarded if these, or other misread values, were then processed correctly. Another common mistake was to use the value 370 as the denominator in the calculation. Numerical answers that corrected to 185% were accepted.

(c) The differences between diffusion and active transport had been learned very well and at least partial credit was frequently awarded. Some candidates worded their answers carefully and either described the two processes in terms of concentration or concentration gradient. Credit was not awarded for suggestions such as 'in diffusion particles move from the higher concentration gradient to the lower concentration gradient'. Some candidates missed the idea that active transport requires energy or described either diffusion or active transport when both were required.

Question 2

(a) (i) Anther was very frequently identified. Incorrect suggestions included stigma, petal, stem, seeds and leaf.

(ii) Partial credit was frequently awarded for any reasonable statement suggesting that pollen is moved by wind. For full credit, candidates had to state that pollen moves from anther to stigma. It was not enough to refer only to pollen collection by the stigma. Some accurate descriptions of fertilisation or the way flowers are adapted for wind pollination were given but no credit was available for these.

(b) The details of the denaturing of enzymes, loss of the shape of the active site and consequent inability to bind with the substrate had been learned very well by many candidates. All of these ideas were required for full credit. Common reasons for credit being missed included omitting to use the term active site, omitting to state that the shape of the active site changes or suggesting that the active site is located on the substrate.

(c) (i) Only some candidates explained the results in terms of germination. There were many correct statements referring to both respiration and photosynthesis, but credit was not awarded unless these statements also referred to germination. Partial credit was more frequently awarded for comments about the results in test-tube **C**. The idea that light is not required for germination in test-tube **A** was usually missed.

(ii) Full credit was frequently awarded for completion of these statements. The most common mistake was to suggest carbon dioxide instead of oxygen. The better answers included the formula of glucose that had been carefully written, with subscripts smaller than the chemical symbols.

Question 3

(a) (i) Some candidates could identify the plasmid. Many other interior and exterior structures were suggested, the most popular of these being the nucleoid.

(ii) This was well answered, and full credit was frequently awarded. The term nucleus was not accepted but reference to DNA or chromosomes was accepted.

(b) (i) Credit was often awarded for the idea that over-use of antibiotics could lead to them becoming less effective. Some candidates avoided suggesting that bacteria might become immune rather than resistant to antibiotics. They also made it clear that it is the bacteria, and not the human body, that becomes resistant.

(ii) The definition of active immunity in terms of antibody production was known by some candidates. Other candidates wrote lengthy answers, but these often did not include any reference to antibodies and so could not be credited.

(c) (i) Candidates generally identified decomposers. The question asked for 'the type of organism' and candidates should be advised that this wording means that they should avoid suggesting specific examples such as fungi.

(ii) Credit was usually awarded. The most popular answer was good personal hygiene. Answers that were too vague to be accepted included suggestions such as education, put up posters and the unqualified term sterilisation.

Question 4

(a) This was very well-answered. Boiling was accepted as an alternative for evaporation, and solidification was accepted for freezing.

(b) This question proved to be challenging because candidates had to describe the arrangement and motion of particles in both solids and liquids. A common problem was that accurate statements were frequently made about the arrangement and movement of particles in either solids or liquids but not both. The significance of the instruction to 'describe how the arrangement and movement changes' appears to have been missed by most candidates. Candidates needed to confine their answers to particle arrangement and movement and so suggestions referring to energy, bonding, attractive forces and unqualified particle separation did not gain credit.

(c) (i) Only the elements shown in the syllabus, chromium, nickel and carbon were accepted.

(ii) This part of the syllabus was familiar to many candidates and full credit was often awarded. The term ions was accepted as an alternative for atoms, but molecules was not. The suggestion that differently sized atoms can no longer move was not accepted as an alternative for the idea that atoms could not slide past one another.

(d) The idea that reduction refers to oxygen loss was very familiar to candidates and credit was very frequently awarded.

Question 5

(a) (i) The colour of bromine is described in the syllabus as red-brown. The only alternative that was accepted was orange-brown.

(ii) The temperature range allowed for the melting point of bromine meant that credit was often awarded. Credit for suggesting that astatine would be a solid was gained by almost all of the candidates.

(b) (i) Some candidates were familiar with the term displacement. Popular incorrect suggestions included replacement and endothermic and exothermic.

(ii) Candidates were asked to write a word equation which many did correctly. Candidates who wrote the balanced symbol equation were not awarded credit. The most common mistake was writing bromide instead of bromine.

(iii) It was usually recognised that this question concerned the relative reactivities of chlorine and fluorine. Mistakes included using the terms chloride and fluoride and suggestions that the reactivity of potassium was involved.

(c) Some candidates gained credit. This was a demanding question and answers often included mistakes such as Fe_2, and I_3 or showed ionic charges. Credit is not awarded for balancing an equation if formulae are incorrect.

(d) (i) The correct answer, addition, was familiar to many candidates. Combustion and polymerisation were frequently suggested.

(ii) The aqueous bromine test for unsaturation was familiar to some candidates. Red-brown was accepted as an alternative for orange, and decolourised was allowed for colourless. Transparent, clear and white are not accepted as alternatives for colourless.

Question 6

(a) Some candidates wrote some very good descriptions of this process which suggested that they had experience of carrying out the preparation themselves. Some candidates clearly knew in principle how to carry out the procedure but could not express the correct sequence of steps clearly enough. Many descriptions referred to 'heating to crystallisation point', but no credit was available for this without explaining that this involves the evaporation of some of the water. Phrases such as 'evaporate the solution' 'evaporate all of the water' and 'heat to dryness' were not accepted. Details of the separation and careful drying of the product had to make it clear that these processes were being applied to the copper nitrate crystals and not to the saturated solution.

(b) Candidates did well on this question. On this occasion there was no penalty for incorrect relative numbers of crosses and dots provided the correct total number of electrons were present on each shell. Common mistakes included not realising that additional shells needed to be drawn, drawing the electron configurations of the atoms rather than the ions and writing atomic or mass numbers instead of the ionic charges.

(c) The description of the sodium chloride structure is stated in the syllabus and some candidates had learned it and gained full credit. Full credit was also awarded to candidates who could use their own words to describe the structure in sufficient detail. Full credit could also be awarded for a clear, labelled diagram.

Question 7

(a) (i) Candidates frequently recalled that chemical energy is stored in batteries. The unqualified term potential was not accepted. The most common misconception was the suggestion of electrical.

(ii) Some candidates had learned the definition of energy efficiency as it appears in the syllabus. Candidates who understood the concept sometimes found it challenging to find wording that clearly referred to useful energy output divided by total energy input.

(b) The use of the relationship *acceleration = change in speed ÷ time* was very familiar to candidates. It was important that candidates avoided missing out that the calculated value of the acceleration was 4.5 m / s^2. Only partial credit was awarded for stating 18 ÷ 4 = ~ 5.

(c) The relationship *force = mass x acceleration* was familiar to many candidates and full credit was often awarded. Either 4.5 or 5 or the value of acceleration calculated in **7(b)** were accepted in this calculation. Although some candidates could not make any progress with the calculation, they often gained credit for stating the units. The equivalent units, kg m s^{-2} and correct variations were accepted alternatives for N.

(d) The expression $\frac{1}{2}mv^2$ was very familiar and ensured at least partial credit for many candidates. Some candidates avoided the mistake of calculating the increase in speed (23 – 5 = 18) and then using this in the expression for kinetic energy.

Question 8

(a) (i) The idea that tyre **A** exerted the greater pressure because there was a smaller area in contact with the road was very often recognised. Most candidates missed the fact that the force exerted on both tyres due to the weight of the motorcycle was the same. Common mistakes included the suggestions that the answer would be tyre **B** because it had a greater area in contact, and ideas based on the mass of air inside each tyre.

(ii) There were many correct references to the collisions of particles with the wall of the tyre. Only some candidates then explained that this causes a force and that pressure is defined as *force ÷ area*. Many answers described collisions between particles but omitted to include wall collisions.

(b) (i) This was usually answered correctly. Infrared and ultraviolet were common incorrect suggestions.

(ii) The speed of light was very familiar.

(iii) The relationship between wave speed, frequency and wavelength was frequently recalled and used correctly. Numerical answers that corrected to 0.86 (m) were accepted and an error carried forward from **8(b)(ii)** was allowed.

Question 9

(a) (i) Few candidates gained credit. Although many stated the correct polarity on the power supply, the idea that the LED allows current to flow through it in only one direction was usually missed. Many candidates suggested answers such as ‘it (polarity) has to be that way because of the LED’ or ‘electrons have to flow through the LED’, which were insufficient for credit to be awarded.

(ii) Most candidates understood that this was an Ohm's Law calculation and partial credit was frequently awarded. The most common reason for credit being missed was the incorrect calculation of the current through the motor, although this error could be carried forward through the calculation. Common mistakes included using the sum (6.6 A + 0.3 A) or the individual currents, 6.6 A or 0.3 A.

(b) (i) Generator had been learned by some candidates but many others had to guess. Of the many incorrect suggestions, galvanometer was popular.

(ii) Some candidates correctly identified work and/or charge, and at least partial credit was often awarded. Of the large number of incorrect suggestions for both parts, the most popular for work included energy, current and power. The most popular suggestions for charge included coulomb, volts and electrons.

(c) (i) Many candidates had learned the equation for orbital speed and were able to rearrange it and calculate T correctly. Others used the value 15 000 (÷ 17) instead of $2 \times \pi \times 15\,000$ (÷ 17). Slight variations in the final answer were accepted to allow for variations in the exact value used for pi.

(ii) The syllabus value for the age of the universe is 13.8 billion years, but an answer in the range 13.0 to 14.4 billion years was accepted. Credit was not awarded if candidates omitted the units. Some candidates suggested that the units were light-years.

COMBINED SCIENCE

Paper 0653/42
Theory (Extended)

Key messages

Those candidates who performed well on this paper:

- demonstrated knowledge and understanding in all three science disciplines with good recall of scientific terms and phrases
- used the command words, e.g. describe, explain, calculate, to guide their answers
- recalled equations and showed the steps taken when making calculations
- used data provided in the question to explain or justify conclusions.

General comments

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

Comments on specific questions

Question 1

(a) Most candidates correctly identified parts of the digestive system and described their functions. Some candidates could identify the salivary gland but not describe its function.

(b) Few candidates linked the acidic environment to enzyme activity.

(c) Candidates generally stated that the enzyme denatures and that the enzyme and substrate shapes will not be complementary. Some candidates also referred to the active site of the enzyme.

Question 2

(a) (i) Most candidates identified the root hair but fewer were able to identify the xylem.

(ii) Most candidates correctly completed the sentences about how the root hair cell is adapted to its function.

(b) Candidates were required to sketch a graph to show the effect of wind speed on the rate of transpiration. Most candidates labelled the *y*-axis correctly and indicated a positive trend. Some candidates showed the positive trend reaching a maximum.

(c) Some candidates recalled the reactants and/or the products but they were less likely to recall the role of chlorophyll or describe the transfer of light energy to chemical energy.

Question 3

(a) (i) Candidates were required to interpret a graph to identify evidence for active immunity. Many candidates found this demanding but usually gained partial credit for stating that more antibodies are produced when the body is infected a second time. Some candidates gained credit for stating that this antibody production takes less time. Some candidates also recognised that the remaining antibodies are at a higher concentration following the second infection.

(ii) Few candidates recalled that active immunity can be gained through vaccination, although some gave descriptions of the process.

(b) Many candidates understood why clean water is needed, but many did not refer to pathogens, bacteria or viruses.

(c) (i) Some candidates were unable to convert the units μm or mm to a common unit to gain full credit.

(ii) Some candidates knew that antibiotics only work on bacterial infections and that overuse of antibiotics may lead to bacteria that are resistant. Some candidates also knew that the body has beneficial bacterial that can be removed by antibiotics.

(iii) Few candidates could recall a structural feature of viruses.

Question 4

(a) Many candidates knew that a property of sodium fluoride is its high boiling point, but many also placed ticks in additional incorrect boxes.

(b) Most candidates gained partial credit for stating the charge of the ions. Some candidates drew an additional outer shell with 8 electrons on each ion, often with some indication that one electron had been donated from Na to F.

(c) (i) Only some candidates gained full credit on this question about electrolysis. Candidates are referred to the definition of electrolysis given in the syllabus. Candidates should refer to electric current rather than electricity when describing how the ions are separated.

(ii) Candidates needed to identify the element formed at each electrode. A common error was to name the ion, fluoride, at the positive electrode.

(d) Some candidates correctly rearranged the components of each compound to balance the products with the reactants.

Question 5

(a) (i) Some candidates recognised that CO_2 is a product of the cement making process and linked this to global warming.

(ii) Many candidates found this question about endothermic reactions demanding. Some candidates referred to the energy required to break bonds, though many often referred to heat on its own, which is insufficient. Other candidates also referred to the energy released when new bonds are made. The best responses explained how the energy balance is endothermic overall.

(iii) Most candidates gained partial credit for drawing a reaction profile with the energy of the products higher than the energy of the reactants (endothermic). Some candidates labelled an arrow to identify the activation energy. Common errors included a double arrow for the overall energy change (this should indicate direction as well as magnitude) and also arrows that do not completely fill the space from the reactant energy to the profile line that is drawn. Candidates should draw arrows that touch their line.

(b) (i) Few candidates remembered to place (OH) inside brackets when stating the formula for calcium hydroxide.

(ii) Many candidates thought that the indicator would turn blue in the presence of an alkali. Some candidates knew that methyl orange is yellow in aqueous calcium hydroxide.

Question 6

(a) Most candidates stated two general characteristics of homologous series. A common error was to refer to the same chemical formula rather than the same general formula. A common misconception was that homologous series only contain hydrogen and carbon (alcohols such as methanol also contain oxygen).

(b) Some candidates referred to double bonds when stating what is meant by unsaturated. Other candidates were more precise in referring to this double (or triple) bond, describing it occurring between carbon atoms and frequently also wrote C=C in their answer.

(c) Candidates generally recalled the term cracking as the process used to manufacture alkenes from alkanes.

(d) Few candidates knew that monomers join together to form a polymer.

(e) (i) Some candidates recalled that an acidic catalyst is used in the production of ethanol from ethene and steam.

(ii) Most candidates noted the presence of oxygen in the structure of ethanol to explain why it is not a hydrocarbon.

Question 7

(a) (i) Almost all candidates identified the label of the driving force in the diagram of a moving tram.

(ii) Explaining why the forces must be balanced was demanding for candidates. These forces are in the vertical direction so candidates that referred to the constant speed of the tram were expressing a misconception. Candidates needed to refer to movement in the vertical direction, so to say that there is no downwards movement or no upwards movement was insufficient. Both directions needed to be stated.

(b) (i) Candidates were given values for the mass of the tram, its acceleration and the time for the acceleration. Some candidates knew not to include time in the calculation. A common error was to name the unit of force as the Joule.

(ii) Some candidates tried to use $s = d/t$ rather than $s = at$.

(iii) Only some candidates gained full credit, generally by calculating the kinetic energy increase and dividing by time, although a few other methods were also seen. Other candidates generally gained partial credit for recalling one or two relevant equations, demonstrating the value of showing working.

Question 8

(a) Many candidates recognised the circuit symbol for a variable resistor.

(b) (i) Almost all candidates could name a suitable insulating material.

(ii) Some candidates gained partial credit for referring to moving electrons or vibrations of particles to explain thermal conduction. Other candidates could explain both ideas and sometimes with high-level descriptions of collisions of moving delocalised electrons with the lattice. Some candidates also knew that thermal energy transfers from a high temperature area to a low temperature area.

(c) Some candidates recalled the symbol for a light emitting diode, including a line that passes through the triangle. Most candidates gained partial credit for a power supply capable of producing a direct current and some gained further credit for an orientation that would allow a conventional current through the LED.

Question 9

(a) (i) Many candidates referred to the gravitational force of the Sun rather than its mass. This is a misconception because gravitational force is due to the interaction between masses, not something contained in an object.

(ii) Many candidates recalled and applied the equation for orbital speed. A common error was to omit the conversion of 365 days to seconds.

(iii) Most candidates knew that Venus is closer to the Sun than Mars. A common misconception was that the orbital speed of Mars is less than Venus due to the greater distance of its orbital path.

(b) (i) Many candidates knew that a red supergiant forms either a neutron star or a black hole. Some candidates recalled that it must first go through a supernova phase.

(ii) Some candidates recalled that fusion is the process that releases energy in stable stars. Fewer candidates were able to describe the process using scientific terminology.

COMBINED SCIENCE

Paper 0653/43
Theory (Extended)

Key messages

Those candidates who performed well on this paper:

- demonstrated knowledge and understanding in all three science disciplines with good recall of scientific terms and phrases
- used the command words, e.g. describe, explain, calculate, to guide their answers
- recalled equations and showed the steps taken when making calculations
- used data provided in the question to explain or justify conclusions.

General comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates identified the red blood cell in the photomicrograph.

(ii) Candidates found this question demanding. Candidates needed to recognise the cell as a white blood cell and then recall its function. Many referred to its role in destroying pathogens, but this was not sufficient for credit. They needed to describe either the production of antibodies or the process of phagocytosis. Only a few candidates could do this.

(iii) Most candidates gave two reasons why blood clots when the skin is damaged.

(b) (i) In this question, candidates needed to use evidence from the diagram. Some candidates described valves and low pressure, but these could not be observed in the diagram and so were not credited. Candidates should use the term lumen for the space inside the walls of a blood vessel.

(ii) Some candidates gained partial credit for calculating the ratio of image size to magnification. Only a few candidates completed the unit conversion to give an answer in micrometres.

Question 2

(a) Candidates were required to identify structures in a diagram of a cross-section through a leaf. Candidates could generally identify the cells specialised for photosynthesis but were less likely to identify the cuticle or a cell transporting mineral ions.

(b) Most candidates knew that the green pigment is chlorophyll, and some gained additional credit for describing its role. A few candidates gave sufficient detail for full credit.

(c) (i) Almost all candidates stated the optimum temperature.

(ii) Most candidates correctly used the term denaturing. A common error was the term 'denaturalising'. Candidates who understood that the shape of the active site is no longer complementary to the substrate generally gained full credit.

Question 3

(a) (i) Candidates needed to recognise the structure in the diagram as a bronchiole. Many referred to bronchus, bronchi and alveoli.

(ii) Some candidates gained full credit for describing features of gas exchange surfaces. Other candidates often got partial credit for knowing that they have a large surface area, are thin, or have a good supply of blood.

(b) Most candidates gained credit, either for the correct products or the correct reactants, in this question requiring recall of the equation for respiration. There were often errors in balancing and recalling the proportion of atoms in glucose. There was also some confusion with photosynthesis.

(c) (i) Candidates needed to explain why deforestation impacts the carbon cycle. Some candidates gained credit for explaining that the concentration of carbon dioxide in the atmosphere increases. Some candidates explained that deforestation results in less removal of carbon dioxide by photosynthesis.

(ii) Most candidates gained credit for stating one other undesirable effect of deforestation.

Question 4

(a) (i) Some candidates found this demanding. For the correct identification of **B**, a reference to melting point was needed to explain why it is solid at 25 °C and the link to covalent bonding as it does not conduct electricity.

(ii) Some candidates gained credit for identifying compound **C** as a gas (due to its boiling point) and linked that with the phrase simple molecular compound.

(b) Most candidates found it difficult to express how the particle motion and arrangement changes. They needed to refer back to the table to see that that temperature change was in the region where the compound melts and therefore describe the transition from solid motion and arrangement to liquid motion and arrangement. Only a few candidates were able to do this.

(c) Very few candidates seemed to recognise the description as electrolysis. The chemical change of a compound includes a process and new products. Candidates should use the term breakdown/separation (or electrolysis if they recognise the role of the electric current) and identify the products as elements rather than using the vague term substances.

Question 5

(a) (i) Some candidates used the information in the question, which refers to aqueous bromide ions, to identify the substance causing the colour change as bromine, although a common error was to refer to the substance as bromide.

(ii) The question refers to Group VII, so candidates needed to recall that reactivity decreases down the group and therefore the appearance of bromine is explained by displacement by chlorine. Only a few candidates gained credit.

(iii) Only a few candidates recognised that bond breaking is an endothermic reaction.

(b) (i) Some candidates gained full credit for drawing 8 electrons in an additional outer shell on each ion.

(ii) Candidates needed to draw an alternating pattern of sodium and chloride ions horizontally and vertically to demonstrate knowledge of the lattice structure of sodium chloride. A common error was to forget to vertically alternate the ions.

(c) (i) Only a few candidates recognised the description in the question as a precipitation reaction.

(ii) Some candidates could deduce the name of the salt (sodium nitrate) from the reactants given in the question.

Question 6

(a) (i) Most candidates gained credit for deducing the formula of the product. Occasionally further credit was gained for recognising H_2 as the molecule responsible for reacting with C_2H_4 to produce C_2H_6. Some candidates recognised that the reaction with water needed to be at a high temperature as they recalled that the water needed to be in the form of steam.

(ii) Most candidates recognised (g) as the state symbol for a gas.

(b) (i) Most candidates applied the pattern of alkene molecular formulae in the table to deduce the formula of the alkene with 7 carbon atoms.

(ii) Many candidates gained credit for explaining how each additional carbon needs two additional hydrogen atoms. Some candidates used other information from the table to describe the trend in boiling points.

(iii) Most candidates were familiar with the term hydrocarbons and knew that it is essential to use the word 'only' when referring to them containing only hydrogen and carbon atoms.

Question 7

(a) (i) Most candidates completed both sentences to explain mass and weight.

(ii) The syllabus requires candidates to use 9.8 N / kg as the force due to gravity and most candidates applied this value in the calculation of weight.

(b) (i) Most candidates gained credit in this question about resultant force. Recall of $F = ma$ was essential. A common error was to try and include the value of time in the calculation.

(ii) A common error was to try and apply the equation $s = d/t$ rather than $s = at$. Weaker candidates often tried to rearrange the equations that they could recall which, for this question, was not necessary.

(c) (i) Most candidates calculated the efficiency of the car using the power values given.

(ii) Many candidates recognised that friction reduces the efficiency of the car. However, a more detailed response that referred to the thermal energy produced due to the friction or the work done against the friction was required for credit.

Question 8

(a) Many candidates knew that warmer water is less dense than colder water and therefore it rises. Many candidates gave confusing or incorrect responses by trying to explain convection in terms of particles, which was not required in the question.

(b) (i) Many candidates confused boiling (change in state from liquid water to steam) with evaporation. Steam is formed at the boiling point of water whereas evaporation can occur at any temperature, forming water vapour.

(ii) Most candidates knew that forces between particles decrease when liquid water becomes steam. A common error was to describe how particles gain energy and move further apart with no reference to forces.

(c) (i) Only a few candidates recognised the symbol for an a.c. power supply.

(ii) Candidates needed to recall the equation relating power to voltage and current. Candidates who recalled this equation generally gained credit for calculating the current in the circuit. A common error was to use the rating of the fuse in the calculation. Only a few candidates could justify that the 30 A fuse was unsuitable as it could allow a current that could damage the appliance.

Question 9

(a) Few candidates could recall the approximate age of the Universe.

(b) Few candidates were able to describe the formation of a stable star. Some candidates gained a mark for referring to gas or dust or a nebula. Other candidates occasionally referred to the role of gravity in bringing the material together and some referred to protostars or the balance of inward and outward forces.

(c) (i) Only a few candidates could recall the speed of light and record it with a correct unit.

(ii) Most candidates applied wavelength data in the question to identify ultraviolet light as a wavelength detectable by the telescope. A common error was to include microwave radiation at the other end of the range due to missing the change of unit from nm to mm.

(iii) Most candidates gained credit for one difference between sound waves and electromagnetic waves.

COMBINED SCIENCE

Paper 0653/51
Practical Test

Key messages

Candidates are advised to read through the whole question before starting practical work as this helps plan for the tasks required.

Candidates need to take careful note of the command word at the start of the question. Questions asking candidates to 'explain…' require candidates to give reasons (why or how) rather than restate provided information. Candidates frequently confuse the command words 'describe' and 'explain' and therefore cannot gain full credit because their answers do not fully address the question asked.

Candidates should avoid giving generic responses to questions. Such answers are not usually creditworthy. These include answers such as 'human reaction time' as a reason for poor data quality or 'repeat and take an average' as a means of improving data. In all cases candidates should apply their understanding specifically to the procedure or experiment in the question and give a relevant answer that focuses on the particular context.

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

General comments

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

Comments on specific questions

Question 1

(a) It is expected that candidates are familiar with the tests in the syllabus and that they know the expected positive and negative results of tests, such as using iodine to test for starch and biuret to test for protein. It should be noted that red is not an acceptable colour for iodine solution. Some candidates gave different colours for drinks **A** and **C**, despite both being negative for starch.

(b) Some candidates answered this correctly, interpreting the information to make correct statements about the starch and protein content of the drinks. However, some common errors were seen. Firstly, some candidates did not know that the biuret test was for proteins and instead described the sugar content. Some omitted to state the significance of a negative test. For example, for drink **A**, the negative result of the iodine test should have led to the conclusion 'Drink **A** contains protein, but no starch.'. The absence of starch was often omitted.

(c) Many knew that ethanol tests for fats, but some misinterpreted the question, which asked candidates to state the reagent. Some stated 'emulsion test' without identifying the reagent.

Question 2

Some candidates gave full, detailed answers but others were unsure how to approach the planning task.

Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for missing credit in the planning question is that the response only addresses some, but not all, of the bullet points. For full credit it is essential that each bullet point is addressed.

It is essential that candidates engage fully with the variables that they are investigating. In this case, it was to investigate the relationship between the activity of invertase and temperature. In order to answer this, candidates needed to decide how they would vary temperature and how they would measure the activity of the enzyme and then outline what they would do to collect the results. Many answers did not do this. It was relatively common for candidates to vary volume or concentration of invertase solution (rather than temperature) and to state that they would 'measure the activity' without any explanation of how they would do so.

In addition, it is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted. A common omission was to discuss measuring time without being specific of what would be mixed or when the timer should be started.

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

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a measuring cylinder was needed to measure volumes of the two solutions and a thermometer to check the temperature at the start of the reaction. A stop-watch was needed to measure time to colour change. The water-bath was to bring solutions to the required temperature before mixing.

It was very common for candidates to make incorrect statements about the temperature of the solutions. Stronger responses stated clearly that the solutions would be brought to a defined temperature before mixing. Some answers heated invertase solution directly using a Bunsen burner (this would denature the enzyme); some applied heat after mixing the solutions; some discussed measuring temperature changes after mixing, implying that they were monitoring a reaction temperature change. All such answers showed a lack of understanding about the aim of the investigation.

When describing the method, stronger responses described bringing the invertase and sucrose separately to the correct temperature, adding Benedict's solution and starting the timer immediately on mixing. Many said they would 'watch for the colour change'. This was accepted, but in practice, samples should be taken and tested on a spotting tile.

Commonly, planning questions have one variable that it is not possible to directly measure. In this case, it was the activity of the enzyme. The time until a positive result with Benedict's solution was to determine the presence of reducing sugars. Some candidates talked vaguely about 'measuring the time' or 'measuring the activity'.

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

The bullet point that asks candidates to state how they will process their results is demanding. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not creditworthy. Stronger responses included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice.

Question 3

(a) (i)(ii) Almost all candidates completed the experiment to gather data. Almost all recorded four reaction times. Some candidates processed the stop-watch data to record their values to the nearest second as instructed in the question; however, some candidates left their values in minutes and seconds. The expected results were that the reaction times increase as the volume of aqueous **H** decreases. This pattern was usually evident in the candidate results, although in some cases there were anomalies in the data. Where time allows these should be repeated to show that the candidate is monitoring the quality of the data as they record their values.

(iii) Some candidates correctly calculated the rate of reaction, using the equation provided, but not all followed the instruction to record these values to two significant figures. One decimal place was a common error. In addition, those who had recorded time values in minutes and seconds were often unable to complete the calculations for rate.

(iv) Most candidates correctly interpreted the data to describe the relationship between volume and rate.

(v) Candidates found this question demanding. Stronger responses described reacting surface area and explained that submerging the magnesium exposes the entire surface area to the acid. Vague answers such as 'so it all reacts' were not accepted because the information in the question states that all the magnesium reacts. Some answers described what 'under the surface' means saying 'so it is all submerged' or 'so it is fully below the level of the acid'. Such answers restated the question without engaging with the command to 'Explain why'.

(vi) When candidates are referred to a step of the method, they need to go to that step and make a specific comment relating to the actual procedure. Some correctly stated that the apparatus needed to be rinsed to remove traces of aqueous **H** or the remaining reaction mixture. However, many answers were vague and did not specifically relate to step 8, stating that it was necessary to 'avoid contamination' or to 'remove impurities'. Although not incorrect, such vague answers are insufficient to gain credit.

(b) For all parts of question **(b)**, the Notes for Qualitative Analysis provided with the paper were useful for candidates to refer too.

(i) Observations should be stated clearly. Many candidates gave vague statements, such as 'it went white' or 'bits of solid appear'. These answers were not awarded credit. Also, it should be noted that 'clear' is not acceptable for 'colourless'.

(ii) Most knew that **H** was an acid, but fewer identified it as hydrochloric acid.

Question 4

(a) Most candidates followed this instruction and correctly recorded their value to the nearest 0.1 cm.

(b) (i)(ii) Values provided by candidates varied significantly but most aligned with the Supervisor results.

(iii) Most candidates calculated the average time correctly.

(iv) Most candidates were able to calculate T, but fewer correctly calculated T^2.

(v) The reason that results are repeated is to check that they are similar/concordant. Few candidates stated this. Most candidates said that repeating results can be used to eliminate anomalies. This answer was accepted but if an experiment is conducted properly there may not be any anomalies to eliminate. A common misconception is that repeating 'makes results more accurate' or 'prevents anomalies'. Repeating does not prevent anomalies, but it does allow anomalies to be identified. Similarly, some candidates stated incorrectly that repeating the experiment removes human error.

(vi) There were several acceptable routes in this calculation. Most candidates calculated an increase of 10% from the smaller value or a decrease of 10% from the larger value.

(c) (i) There are three key features when constructing graphs.

- The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis (in this case the vertical axis was labelled already). Both axes need to include units.
- The scale must be linear and chosen so that the plotted points occupy more than half of the grid. The scale should be simple, for instance whole numbers, 2, 5 or 10, so that plotting is straightforward. Axes with awkward scales such as 3 should be avoided.
- Plots should be small crosses or dots in circles. Large blobs are rejected because it is impossible to judge the accuracy of the plotting.

Most candidates gained credit by addressing each of these factors in their graphs. A common error was omitting the units for *x*. Another relatively common error was to use a non-linear scale on the horizontal axis. Another common error was to use large blobs to plot points so that it is impossible to accurately judge their centre. A further error commonly seen was mis-plotting of values that required judgment of 0.01. For example, 1.21 was often mis-plotted as 1.22 and 1.39 was often plotted as 1.38. 1.02 was often plotted as 1.20.

(ii) As outlined 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 plotting gave a clear relationship which gave a negative gradient. This confused some candidates who attempted to join some points to the origin. However, in general, most candidates drew lines with a ruler that were appropriately positioned with respect to their plotted points. Some candidates did not use a ruler. Some drew dot-to-dot lines between points. Both of these errors meant that credit was not awarded.

(iii) This question was well answered. Most candidates extrapolated their line correctly and most correctly read the value of the *y*-axis intercept.

(d) Candidates found this question demanding. Some ignored the partially drawn string and drew their own string and bob resting on the table. It was very common to see bobs drawn above, below, through or resting on the bench. The strongest answers continued the string and showed a bob with its centre in line with the top of the bench.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

Some questions instructed candidates to give their answers to a specified number of decimal places or significant figures or use a specific unit. It was very common for candidates to miss this instruction.

To gain full credit in the planning question, it is important that candidates read the question carefully and investigate the variables given in the question. It is very common for candidates to vary incorrect variables. Secondly, it is essential that all the bullet points in the question are addressed. Omitting to address some of the bullet points prevents full credit from being awarded. For the graph question, candidates need to ensure they are using as much of the grid provided as possible and they need to work out what each division of the scale represents.

Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates did not label axes appropriately or chose inappropriate scales. It was relatively common for candidates to use non-linear scales, often omitting values near the origin.

General comments

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

Comments on specific questions

Question 1

(a) Candidates were asked to draw a biological diagram of a slice of carrot root. Diagrams should use at least 50% of the space in the box, have a single clear and continuous outline and some detail of the structure of the carrot root.

Common errors included diagrams that were too small or so large that they went outside of the box, outlines that were broken, shading to make the diagrams look more artistic than scientific and not drawing enough detail to identify the central section of the slice.

(b) (i) Most candidates correctly measured the distance between points **A** and **B** and gave the value in millimetres. A tolerance of ±1 mm was applied to the measurement. Some candidates wrote 8.4, indicating they were measuring in cm, and this was insufficient for the mark as the question required the answer in mm. Some candidates wrote 840.

(ii) Candidates were generally able to calculate the magnification and report their final answer to two significant figures. A common error was to give the answer to two decimal places rather than two significant figures.

(iii) This question proved demanding for most candidates. Even though candidates had the general idea, some candidates did not give sufficient detail to be awarded credit. Strong responses described the idea of taking additional measurements of diameter and then gave a detailed description of exactly how to calculate an average.

(c) (i) Candidates were generally successful at identifying a similarity between the two types of plant root. A comment about a circular or rounded shape was the most common response.

(ii) Most candidates correctly identified one difference between the two sections of root. The fact that one of them had holes in it and the other one did not was the most common observation. It proved more challenging to give a second difference. Some candidates did observe that the carrot was more regular than the lotus root but did not say that this was related to the shape and so this was insufficient for credit. Candidates are encouraged to be precise in their use of language.

(d) (i) Candidates were generally successful in writing down the correct colours that are observed when testing for starch with iodine solution. Some candidates wrote unusual colours or did not include the word brown for the negative iodine test while others just recorded blue (without reference to dark blue or black) for the positive iodine test. Some candidates tried to interpret what they saw rather than using the generally accepted colours of brown for negative and blue-black for positive. Where the candidate's non-standard answer matched the Supervisors' results, credit was awarded.

Most candidates gave correct conclusions. However, instead of the absolute 'no starch' or 'presence of starch', some candidates wrote 'positive' and 'negative' which did not receive credit.

(ii) Most candidates did not recognise that the colour of the carrot would mask the colour change of the Benedict's reagent and often thought the carrot may not fit in the test-tube or would somehow affect the colour change in another way.

Question 2

(a) (i) Many candidates were able to correctly write down both temperatures to the nearest 0.5 °C. Common errors included omitting the .0 from a whole number reading or rounding up the readings ending in .5 to the next number up.

(ii) Most candidates were able to calculate the difference between the two readings.

(b) (i) This question proved to be demanding for most candidates as both the colour and the state were required. It was common to see the correct colour but not the state, e.g. grey/pink but no mention of solid. Stating the solid was either aluminium or foil were not treated as synonyms for grey or solid because this is not a description of what is actually seen by the candidate.

(ii) Candidates needed to note that there was a grey solid or aluminium or foil visible at the end.

(c) Candidates were familiar with identifying potential errors from an experimental procedure with most of them stating a suitable source of error and a good suggestion of how to improve it. Where candidates were not awarded credit, it was usually because the answer did not relate to the procedure that was given in the question. Other candidates identified that heat was escaping to the surroundings but said to use a plastic cup (which was already being used in the procedure). Some candidates thought there were issues with the amounts of substances being used and that they should use a measuring cylinder with a higher resolution or to look at the scale perpendicularly.

(d) (i) Many candidates were awarded full credit in this question. Common errors were to omit the units from the axis labels or to use non-linear scales. Others chose scales that made the graph squeeze into the bottom corner of the graph paper, reversed the axes or plotted points with an inappropriate amount of precision by using large blobs.

(ii) Candidates generally drew good lines of best fit. However, some candidates did not use a ruler, attempted to join the first and last plot without considering those falling between, drew a dot-to-dot line or feathered their line.

(e) Most candidates obtained a correct value from their graph, but many did not show on their graph how they had obtained their value. A horizontal line from the temperature change obtained in **2(a)(ii)** across to the line of best fit and then another line vertically downwards until it intercepts the horizontal axis. It was common to see a dot on the line of best fit or just the vertical line. Some horizontal lines were drawn so faintly that it was difficult to see as it merged with the grid line.

Question 3

(a) Most candidates were able to record a value for V_0 in the expected range 1.5 – 2.0 V. Where this was not the case, the recording was compared with the Supervisors' report.

(b) Most candidates obtained a value lower than V_0.

(c) Most candidates obtained a value similar to the one in **3(b)**.

(d) Many candidates found it difficult to explain why the switch should be opened between readings. Some wrote vague answers about saving energy, damaging the circuit or the misconception of being electrocuted.

(e) Most candidates were able to add their results and make an appropriate statement.

(f) Most candidates knew the symbol for an ammeter and that it should be in series, but many missed credit by drawing a line through the circle.

Question 4

Some candidates gave full, detailed answers but others were unsure how to approach the planning task.

Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for partial credit in the planning question is that the response only addresses some, but not all, of the bullet points. For full credit it is essential that each bullet point is addressed.

The aim of this question was to investigate the relationship between the mass dropped on to the rod and the distance the rod moves into the sand. In order to answer this, candidates needed to state that different masses would be dropped onto the rod. Some candidates said to place the masses on the rod, which would not cause the rod to be noticeably pushed into the sand.

It was necessary to measure the length of rod above the surface of the sand before and after dropping the mass. Some candidates suggested to measure the distance of the rod below the sand – but this would have required digging up the sand, thereby making it impossible to measure the depth accurately. Candidates need to think carefully how their measurements might affect the experiment. It was common for candidates to try to measure the distance the rod moves into the sand without any explanation of how they would do so. Responses needed to describe the idea of measuring the length above the sand before and after the mass was dropped and then calculating the difference between these to obtain the distance moved. Other candidates said to put markings on the side of the rod every few mm. This idea received credit.

Many candidates did not measure the mass of the masses or suggest using a balance. We are not told in the question that the masses are the usual type of slotted masses used in a school that have the mass stamped onto them, so the mass of the masses must be measured. Note also we are investigating mass and not weight. Therefore, weighing the masses to find the mass was acceptable, but finding the weight was not.

Some candidates investigated their own independent variable. It was not uncommon to see candidates varying the height of the mass before dropping it and keeping the mass constant. Candidates need to investigate the variables given in the question.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a balance was needed to measure mass of the masses and a ruler or equivalent to measure the height the masses are dropped from and to measure (and control) the length of the rod above the sand.

In the table it was common to see the units, kg or cm, in the body of the table rather than in the column headings. Candidates will only be credited for the table if the units are in the correct place. Also, with tables, a column should be present for all measured variables. In this experiment, a column for distance moved alone would not be correct as distance moved is processed data. A complete table would need to have columns for the initial and final distances of the rod above the sand (or the distance between the markings on the rod if they were doing it that way).

The bullet point that asks candidates to state how they will process their results is demanding. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not given credit.

Candidates needed to specify averaging the distance moved by the rod for each individual mass dropped or drawing a graph of mass against distance moved by the rod. Stronger responses included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice.

It was common for candidates to write ‘repeat each mass to exclude or identify anomalies’. The act of repeating does not in itself exclude or identify anomalies. They would have to repeat each mass and then exclude anomalies from the data before calculating an average.

COMBINED SCIENCE

Paper 0653/61
Alternative to Practical

Key messages

It is very important that candidates are familiar with the Notes for Qualitative Analysis provided in the syllabus and in the question paper. Questions expect candidates to be able to extract relevant information from these notes. In **Question 3(b)**, the answers depended on candidates using the information provided in these notes.

Sometimes, questions instruct candidates to give their answer to a specified number of decimal places or significant figures. It was very common for candidates to ignore this instruction or confuse decimal places and significant figures.

Other questions where the number of decimal places is important are where candidates are asked to take readings on instruments or where they are expected to give consistent decimal places in a table of results. For this paper, **3(a)(i)** included the instruction to 'Record these reaction times to the nearest second'. For **4(b)(ii)** the instruction was to 'Record these readings to one decimal place'. Also notice that the period T and the values of T^2 / s^2 in Table 4.1 are all given to two decimal places. Candidates are expected to follow the same pattern in the values that they record.

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

General comments

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

Comments on specific questions

Question 1

(a) It is expected that candidates are able to recall the colours for the negative and positive results of food tests. In this case, the tests for starch and protein were tested. Many candidates knew that the positive result of testing starch with iodine solution is a blue-black colour, but fewer gave brown as a description of the negative result. Although **A** and **C** were the same result (negative) it was common to see candidates write different colours in each space. The colours of biuret for a positive and negative protein test result were not usually known.

(b) Some candidates answered this correctly, interpreting the information to make correct statements about the starch and protein content of the drinks. However, some common errors were seen. Firstly, some candidates did not know that the biuret test was for proteins and instead described the sugar content. Some omitted to state the significance of a negative test. For example, for drink **A**, the negative result of the iodine test should have led to the conclusion 'Drink **A** contains protein, but no starch.'. The absence of starch was often omitted.

(c) Many knew that ethanol tests for fats, but some misinterpreted the question, which asked candidates to state the reagent. Some stated 'emulsion test' without identifying the reagent.

Question 2

Some candidates gave full, detailed answers but others were unsure how to approach the planning task.

Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for missing credit in the planning question is that the response only addresses some, but not all, of the bullet points. For full credit it is essential that each bullet point is addressed.

It is essential that candidates engage fully with the variables that they are investigating. In this case, it was to investigate the relationship between the activity of invertase and temperature. In order to answer this, candidates needed to decide how they would vary temperature and how they would measure the activity of the enzyme and then outline what they would do to collect the results. Many answers did not do this. It was relatively common for candidates to vary volume or concentration of invertase solution (rather than temperature) and to state that they would 'measure the activity' without any explanation of how they would do so.

In addition, it is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted. A common omission was to discuss measuring time without being specific about what would be mixed or when the timer should be started.

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

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a measuring cylinder was needed to measure volumes of the two solutions and a thermometer to check the temperature at the start of the reaction. A stop-watch was needed to measure time to colour change. The water-bath was to bring solutions to the required temperature before mixing.

It was very common for candidates to make incorrect statements about the temperature of the solutions. Stronger responses stated clearly that the solutions would be brought to a defined temperature before mixing. Some answers heated invertase solution directly using a Bunsen burner (this would denature the enzyme); some applied heat after mixing the solutions; some discussed measuring temperature changes after mixing, implying that they were monitoring a reaction temperature change. All such answers showed a lack of understanding about the aim of the investigation.

When describing the method, stronger responses described bringing the invertase and sucrose separately to the correct temperature, adding Benedict's solution and starting the timer immediately on mixing. Many said they would 'watch for the colour change'. This was accepted, but in practice, samples should be taken and tested on a spotting tile.

Commonly, planning questions have one variable that it is not possible to directly measure. In this case, it was the activity of the enzyme. The time until a positive result with Benedict's solution was to determine the presence of reducing sugars. Some candidates talked vaguely about 'measuring the time' or 'measuring the activity'.

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

The bullet point that asks candidates to state how they will process their results is demanding. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not creditworthy. Stronger responses included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice.

Question 3

(a) (i) Most candidates correctly read the stop-watches and converted the times to seconds. As candidates were specifically asked to record times to the nearest second, answers that included any decimal places were not awarded credit.

(ii) This was well answered. In this case, the relationship was that as volume increases, reaction time decreases. Some candidates stated that both increased.

(iii) Most candidates correctly calculated the rate of reaction, using the equation provided, but not all followed the instruction to 'record these values to two significant figures'. One decimal place was a common error.

(iv) Most candidates correctly interpreted the data to describe the relationship between volume and rate.

(v) Measuring cylinder was a common correct answer, but many incorrectly thought a beaker could be used to measure volume.

(vi) Candidates found this question demanding. Stronger responses described reacting surface area and explained that submerging the magnesium exposes the entire surface area to the acid. Vague answers such as 'so it all reacts' were not accepted because the information in the question states that all the magnesium reacts. Some answers described what 'under the surface' means saying 'so it is all submerged' or 'so it is fully below the level of the acid'. Such answers restated the question without engaging with the command to 'Explain why'.

(vii) When candidates are referred to a step of the method, they need to go to that step and make a specific comment relating to the actual procedure. Some correctly stated that the apparatus needed to be rinsed to remove traces of aqueous **H** or the remaining reaction mixture. However, many answers were vague and did not specifically relate to step 7, stating that it was necessary to 'avoid contamination' or to 'remove impurities'. Although not incorrect, such vague answers are insufficient to gain credit.

(b) For all parts of question **(b)**, it was essential that candidates referred to the Notes for Qualitative Analysis provided with the paper.

(i) Most candidates used the Qualitative Analysis notes to correctly identify chloride ions.

(ii) The fact that **H** fizzes when added to a carbonate and turns universal indicator red indicates that **H** is an acid. Most stated this but some listed all of the observations given in the table, rather than identify the relevant ones that indicate that **H** is an acid.

(iii) Most candidates identified that the gas produced was carbon dioxide. A relatively common incorrect answer was hydrogen.

Question 4

(a) (i) Most candidates followed this instruction and correctly recorded their value to the nearest 0.1 cm.

(ii) Where values are provided in a table it is essential that any values added by the candidate are recorded to the same degree of resolution. Distance *X* should be 15.0, to match the other values in the table. It is incorrect to give the distance as '15' alone.

(b) (i) Values were provided in the question for the candidates to consider. Stronger responses identified that the first two readings were too far apart, so a third reading needed to be taken to look for concordance. Vague answers such as 'to take an average' or 'to look for anomalies' were not accepted as these are not reasons for repeating, they are how results are processed.

(ii) Most candidates recoded the readings correctly to one decimal place.

(iii) Most candidates calculated the average time correctly.

(iv) Most candidates were able to calculate T, but fewer correctly calculated T^2.

(v) There were several acceptable routes in this calculation. Most candidates calculated an increase of 10% from the smaller value or a decrease of 10% from the larger value.

(c) (i) There are three key features when constructing graphs.

- The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis (in this case the vertical axis was labelled already). Both axes need to include units.
- The scale must be linear and chosen so that the plotted points occupy more than half of the grid. The scale should be simple, for instance whole numbers, 2, 5 or 10, so that plotting is straightforward. Axes with awkward scales such as 3 should be avoided.
- Plots should be small crosses or dots in circles. Large blobs are rejected because it is impossible to judge the accuracy of the plotting.

Most candidates gained credit by addressing each of these factors in their graphs. A common error was omitting the units for *X*. Another relatively common error was to use a non-linear scale on the horizontal axis. Another common error was to use large blobs to plot points so that it is impossible to accurately judge their centre. A further error commonly seen was mis-plotting of values that required judgment of 0.01. For example, 1.21 was often mis-plotted as 1.22 and 1.39 was often plotted as 1.38. 1.02 was often plotted as 1.20.

(ii) As outlined 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 plotting gave a clear relationship which gave a negative gradient. This confused some candidates who attempted to join some points to the origin. However, in general, most candidates drew lines with a ruler that were appropriately positioned with respect to their plotted points. Some candidates did not use a ruler. Some drew dot-to-dot lines between points. Both of these errors meant that credit was not awarded.

(iii) This question was well answered. Most candidates extrapolated their line correctly and most correctly read the value of the *y*-axis intercept.

(d) Candidates found this question demanding. Some ignored the partially drawn string and drew their own string and bob resting on the table. It was very common to see bobs drawn above, below, through or resting on the bench. The strongest answers continued the string and showed a bob with its centre in line with the top of the bench.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

Some questions instructed candidates to give their answers to a specified number of decimal places or significant figures or use a specific unit. It was very common for candidates to miss this instruction.

To gain full credit in the planning question, it is important that candidates read the question carefully and investigate the variables given in the question. It is very common for candidates to vary incorrect variables. Secondly, it is essential that all the bullet points in the question are addressed. Omitting to address some of the bullet points prevents full credit from being awarded. For the graph question, candidates need to ensure they are using as much of the grid provided as possible and they need to work out what each division of the scale represents.

Candidates need to look at the guidance for constructing graphs given in the syllabus. Many candidates did not label axes appropriately or chose inappropriate scales. It was relatively common for candidates to use non-linear scales, often omitting values near the origin.

General comments

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

Comments on specific questions

Question 1

(a) Candidates were asked to draw a biological diagram of a slice of carrot root. Diagrams should use at least 50% of the space in the box, have a single clear and continuous outline and some detail of the structure of the carrot root.

Common errors included diagrams that were too small or so large that they went outside of the box, outlines that were broken, shading to make the diagrams look more artistic than scientific and not drawing enough detail to identify at least three circular sections and some of the medullary rays towards the centre of the slice.

(b) (i) Most candidates correctly measured the distance between points **A** and **B** and gave the value in millimetres. A tolerance of ±1 mm was applied to the measurement. Some candidates wrote 8.4, indicating they were measuring in cm, and this was insufficient for the mark as the question required the answer in mm. Some candidates wrote 840.

(ii) Candidates were generally able to calculate the magnification and report their final answer to two significant figures. A common error was to give the answer to two decimal places rather than two significant figures.

(iii) This question proved demanding for most candidates. Even though candidates had the general idea, some candidates did not give sufficient detail to be awarded credit. Strong responses described the idea of taking additional measurements of diameter and then gave a detailed description of exactly how to calculate an average.

(c) (i) Candidates were generally successful at identifying a similarity between the two types of plant root. A comment about a circular or rounded shape was the most common response. A common incorrect response was to make a comment about the colour of the root, but given the photographs were in black and white, this was not an appropriate response.

(ii) Most candidates correctly identified one difference between the two sections of root. The fact that one of them had holes in it and the other one did not was the most common observation. It proved more challenging to give a second difference. Some candidates did observe that the carrot was more regular than the lotus root but did not say that this was related to the shape and so this was insufficient for credit. Candidates are encouraged to be precise in their use of language.

(d) Candidates were generally successful in writing down the correct colours that are observed when testing for starch with iodine solution. Some candidates wrote unusual colours or did not include the word brown for the negative iodine test while others just recorded blue (without reference to dark blue or black) for the positive iodine test.

Most candidates gave correct conclusions. However, instead of the absolute 'no starch' or 'presence of starch', some candidates wrote 'positive' and 'negative' which did not receive credit.

Question 2

(a) (i) Many candidates were able to correctly write down both temperatures to the nearest 0.5 °C. Common errors included omitting the .0 from the second reading or rounding up the first reading to 22 °C.

(ii) Most candidates were able to calculate the difference between the two readings.

(b) This question proved to be demanding for most candidates and responses tended to repeat information that was given in the question rather than adding to it. Candidates needed to say the blue colour had disappeared and this was due to the absence of copper chloride. It was common for candidates to note the change of colour but not to link this to the absence of copper chloride. Similarly, candidates needed to note that the grey solid was still there at the end and that this was aluminium. It was common for candidates to omit the fact that this was aluminium so all they had done was repeated information that was given in the question.

(c) Candidates were familiar with identifying potential errors from an experimental procedure with most of them stating a suitable source of error and a good suggestion of how to improve it. Where candidates were not awarded credit, it was usually because the answer did not relate to the procedure that was given in the question. Other candidates identified that heat was escaping to the surroundings but said to use a plastic cup (which was already being used in the procedure). Some candidates thought there were issues with the amounts of substances being used and that they should use a measuring cylinder with a higher resolution or to look at the scale perpendicularly.

(d) (i) Many candidates were awarded full credit in this question. Common errors were to omit the units from the axis labels or to use non-linear scales. Others chose scales that made the graph squeeze into the bottom corner of the graph paper, reversed the axes or plotted points with an inappropriate amount of precision by using large blobs.

(ii) Candidates generally drew good lines of best fit. However, some candidates did not use a ruler, attempted to join the first and last plot without considering those falling between, drew a dot-to-dot line or feathered their line.

(e) Most candidates obtained a correct value from their graph, but many did not show on their graph how they had obtained their value. A horizontal line from 20 °C on the vertical axis across to the line of best fit and then another line vertically downwards until it intercepts the horizontal axis. It was common to see a dot on the line of best fit or just the vertical line. Some horizontal lines were drawn so faintly that it was difficult to see as it merged with the grid line.

Question 3

(a) Some candidates were able to draw the correct symbol and connect it across resistor 1. Some candidates tried to draw a voltmeter in series and others drew a line through the circle part of the symbol. Both of these are incorrect.

(b) The question asked for the results to be recorded to the nearest 0.01 V. Most candidates correctly recorded the first voltage as 0.65 V, but many recorded the second as 0.7 V, rather than 0.70 V.

(c) There were a range of alternative options for allowable calculations, such as finding the difference between the two readings and calculating this as a percentage of one or other of the readings or dividing one reading by another and comparing this with 90% and 110%. Candidates were only awarded full credit if they had a correct calculation as it is not possible to say whether the readings are within the limits of experimental accuracy without doing such a calculation.

(d) Many candidates found it difficult to explain why the switch should be opened between readings. Some wrote vague answers about saving energy, damaging the circuit or the misconception of being electrocuted.

Question 4

Some candidates gave full, detailed answers but others were unsure how to approach the planning task.

Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for partial credit in the planning question is that the response only addresses some, but not all, of the bullet points. For full credit it is essential that each bullet point is addressed.

The aim of this question was to investigate the relationship between the mass dropped on to the rod and the distance the rod moves into the sand. In order to answer this, candidates needed to state that different masses would be dropped onto the rod. Some candidates said to place the masses on the rod, which would not cause the rod to be noticeably pushed into the sand.

It was necessary to measure the length of rod above the surface of the sand before and after dropping the mass. Some candidates suggested to measure the distance of the rod below the sand – but this would have required digging up the sand, thereby making it impossible to measure the depth accurately. Candidates need to think carefully how their measurements might affect the experiment. It was common for candidates to try to measure the distance the rod moves into the sand without any explanation of how they would do so. Responses needed to describe the idea of measuring the length above the sand before and after the mass was dropped and then calculating the difference between these to obtain the distance moved. Other candidates said to put markings on the side of the rod every few mm. This idea received credit.

Many candidates did not measure the mass of the masses or suggest using a balance. We are not told in the question that the masses are the usual type of slotted masses used in a school that have the mass stamped onto them, so the mass of the masses must be measured. Note also we are investigating mass and not weight. Therefore, weighing the masses to find the mass was acceptable, but finding the weight was not.

Some candidates investigated their own independent variable. It was not uncommon to see candidates varying the height of the mass before dropping it and keeping the mass constant. Candidates need to investigate the variables given in the question.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a balance was needed to measure mass of the masses and a ruler or equivalent to measure the height the masses are dropped from and to measure (and control) the length of the rod above the sand.

In the table it was common to see the units, kg or cm, in the body of the table rather than in the column headings. Candidates will only be credited for the table if the units are in the correct place. Also, with tables, a column should be present for all measured variables. In this experiment, a column for distance moved alone would not be correct as distance moved is processed data. A complete table would need to have columns for the initial and final distances of the rod above the sand (or the distance between the markings on the rod if they were doing it that way).

The bullet point that asks candidates to state how they will process their results is demanding. Vague, generic answers such as ‘repeat and take an average’ or ‘draw a graph of the results’ are not given credit. Candidates needed to specify averaging the distance moved by the rod for each individual mass dropped or drawing a graph of mass against distance moved by the rod. Stronger responses included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice.

It was common for candidates to write ‘repeat each mass to exclude or identify anomalies’. The act of repeating does not in itself exclude or identify anomalies. They would have to repeat each mass and then exclude anomalies from the data before calculating an average.

COMBINED SCIENCE

Paper 0653/63
Alternative to Practical

Key messages

It is very important that candidates are familiar with the Notes for Qualitative Analysis provided in the syllabus and in the question paper. Questions expect candidates to be able to extract relevant information from these notes. In **2(a)** and **2(b)**, the answers depended on candidates using the information provided in these notes.

Sometimes, questions instruct candidates to give their answer to a specified number of decimal places or significant figures. It was very common for candidates to ignore this instruction or confuse decimal places and significant figures.

Other questions where the number of decimal places is important is where candidates are asked to take readings from instruments or where they are expected to give consistent decimal places in a table of results. For this paper, **4(c)(i)** included the instruction to 'Record in Table 4.1 these temperatures to the nearest 0.5 °C', and in **4(c)(ii)** 'Calculate the difference between the temperature of water in **P** and **Q** at 240 s. Record your value in Table 4.1'. All values in a table column must be shown to the same resolution, in this case to one decimal place.

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

General comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates correctly counted the number of ungerminated seeds and germinated seeds.

(ii) Many candidates calculated the percentage of germinated seeds in flask **B** correctly. A correct calculation from incorrect values in **1(a)(i)** was also credited.

(iii) Candidates frequently used a non-linear scale on the horizontal axis, the percentage concentration of oxygen. This often meant that the results plotted were incorrect.

There are three key features when constructing graphs.

- The graph axes should be labelled with the same labels as shown in the headings of the table, with the dependent variable on the vertical axis. Both axes need to include units when given.
- The scale must be linear and chosen so that the plotted points occupy more than half of the grid. The scale should be simple, for instance whole numbers, 2, 5 or 10, so that plotting is straightforward. Axes with awkward scales such as 3 should be avoided.

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

(iv) As outlined in the syllabus, a curve of best fit should have an even spread of values either side. In this case, the correct plotting gave a clear relationship.

(v) Most candidates correctly described the relationship between the percentage concentration of oxygen and the percentage of pea seeds that germinated.

(vi) Few candidates explained that the reason for plotting percentage germination rather than the number of seeds that germinated is because not all the flasks had the same number of seeds in at the start.

(vii) Few candidates made the link between germinating seeds producing heat and the investigation not being fair. Some candidates were able to state that this production of heat would cause a temperature increase, but very few went on to link the different number of seeds in each flash to a different temperature increase in each flask. It was uncommon for candidates to explain that more than one variable had therefore been changed.

(viii) Some candidates were able to state that the time for germination had been kept constant in the investigation. Other credited answers included volume of water or same type of seed. A common incorrect response was to keep the number of seeds at the start the same.

(b) Candidates should be aware that Benedict's solution is used to test for reducing sugars.

Question 2

(a) Few candidates correctly used the 'Notes for use in Qualitative Analysis' to describe the observations for an ammonium ion. The 'Test for aqueous cations' and 'Test for gases' tables should have been used to state a gas was formed that would turn damp red litmus paper blue.

(b) Again, few candidates correctly used the 'Notes for use in Qualitative Analysis' to state the observations for a carbonate ion. In this case they should have used the 'Test for anions' and the 'Test for gases' tables to state that the solution would fizz and the gas would give a white precipitate when bubbled through limewater.

(c) (i) Candidates often incorrectly stated that the blue Bunsen flame allowed the identification of, e.g. copper ions, or that the yellow flame would identify sodium ions. This was possibly the result of incorrectly using the 'Notes for use in Qualitative Analysis'. Few candidates simply stated that the blue Bunsen flame would be hotter.

(ii) Candidates frequently missed the instruction to record the mass to one decimal place with many recording '13.97' instead of '14.0'.

(iii) Candidates found this a very demanding question with few realising that if the hot test-tube was not left to cool it might damage the balance or burn the students' hands.

(iv) Many candidates stated that a gas had been produced as the reason why the total mass decreased.

(v) Very few candidates correctly explained how to change the procedure to ensure all of **H** reacts. Some candidates suggested continuing to heat the sample of **H** but did not go on to find the mass until it was constant.

Question 3

Some candidates gave full, detailed answers but others were unsure how to approach the planning task.

Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for partial credit in the planning question is that the response only addresses some, but not all, of the bullet points. For full credit it is essential that each bullet point is addressed.

It is essential that candidates engage fully with the variables that they are investigating. In this case, it was to investigate the relationship between the volume of aqueous ammonium carbonate and the mass of barium carbonate made. In order to answer this, candidates needed to decide how they would vary the volume of aqueous ammonium carbonate, how they would measure the mass of barium carbonate and then outline what they would do to collect the results. Many answers did not do this. It was relatively common for candidates to vary the 'amount' of ammonium carbonate (rather than the 'volume') and to state that they would 'add some barium nitrate'.

In addition, it is necessary to outline a workable method. This needs to be clear and unambiguous enough for another learner to follow. In many cases, key steps were omitted. A common omission was to not add barium nitrate to the ammonium carbonate. A second common omission was to not filter the solution made.

Apparatus points are given for stating the essential measuring apparatus needed and to give an indication of how it is used. In this case, a measuring cylinder was needed to measure volumes of the aqueous solutions and a balance to measure the mass of barium carbonate. Few candidates listed a filter paper and funnel.

When describing the method, the strongest responses gave a sequence which included adding five different volumes of ammonium carbonate to a controlled volume of barium nitrate, filtering and drying the barium carbonate, then finding the mass. Any method that did not follow these basic steps was likely to earn partial credit.

When stating which variables will be kept constant, note that candidates should take care not to state only that they will 'use the same amount' of something. In this case, it would be preferable to 'use the same total volume of barium nitrate'.

Candidates were asked to include a table for their results in their plan. Tables often included suitable headings but missed units (in this case cm^3 for the volume of ammonium carbonate and g for the mass of barium carbonate). Units should be included in the table headings only (not the body of the table).

The bullet point that asks candidates to state how they will process their results is demanding. Vague, generic answers such as 'repeat and take an average' or 'draw a graph of the results' are not given credit. Stronger responses included a sketch of the labelled axes of a graph to process their conclusion. This is very good practice.

Question 4

(a) (i) Most candidates correctly measured the diameter as 6.5 cm.

(ii) Many candidates correctly used the equation to calculate the surface area, with many recording their answer to two significant figures. Error carried forward was awarded from **4(a)(i)**.

(b) (i) Most candidates correctly stated a measuring cylinder would be suitable to measure the volume of water. The most common incorrect answer was to use a beaker.

(ii) This question was completed well, with candidates correctly drawing the water level in beaker **Q** below the level in beaker **P**. The thermometer was well drawn with an obvious bulb, not touching the sides or bottom of the beaker. Credit was not awarded if the water level was wavy or not horizontal.

(c) (i) Candidates were able to correctly read the thermometers but many did not record to the nearest 0.5 °C. The second value should have been 55.0.

(ii) Most candidates correctly calculated the difference in the temperature of water in beakers **P** and **Q**. Error carried forward was awarded from **4(c)(i)**. Recording to the nearest 0.5 °C was not assessed in this question as the correct answer was 12.5, however, it remains good practice to follow the pattern in the table.

(iii) Few candidates gained credit for this question with many giving descriptions of different layers of heat in the beaker or changing the kinetic energy of the particles. Stirring is important to make sure all of the water is at the same temperature before the reading is taken.

(d) Many candidates stated the temperature of water in both **P** and **Q** decreased but few went on to state the temperature in **Q** decreases faster than in **P**.

(e) Few candidates were able to describe a change they could make in the experiment to investigate the rate of cooling from the open top of the beaker only. Many suggested adding more water, not stirring the water in the beaker or leaving it for longer. The correct response described insulating the sides of the beakers so heat would mostly be lost through the top surface of the water.