COMBINED SCIENCE

Paper 0653/11
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 8**, **13**, **32** and **34**. **Questions 1**, **11**, **22** and **38** proved the most challenging for candidates.

Comments on specific questions

Question 1

Many candidates found this question demanding. Whilst most candidates did choose the correct option many chose option **A** (excretion) or **B** (nutrition).

Question 2

The correct option was chosen by most candidates. Some candidates selected option **B**, indicating that animal cells had cell walls, but lacked cytoplasm.

Question 3

The correct option was chosen by most candidates. Some candidates selected option **A** or **C** missing the fact that the starch test was negative.

Question 4

The correct option was selected by most candidates of all abilities. Where candidates did select a distractor, they tended to go for option **A**, the waxy cuticle labelled incorrectly as the upper epidermis.

Question 6

Some candidates seemed to be guessing when answering this question. Stronger candidates did opt predominantly for the correct answer, however, some incorrectly selected option **C** or **A**.

Question 7

Most candidates who got this question wrong selected option **A** (aorta) or **C** (vena cava).

Question 8

Most candidates found this question straightforward. The few candidates who selected an incorrect option selected option **B** (the trachea).

Question 9

Candidates who chose the incorrect option predominantly selected option **B** (photosynthesis).

Question 10

Most candidates chose the correct option. However, some candidates incorrectly selected option **B** (genetically identical offspring following the fusion of nuclei).

Question 11

Most candidates found this question demanding. When asked which structure produces pollen in a flower, most incorrectly selected option **C** the stigma.

Question 12

Some candidates found this question demanding with many incorrectly selecting option **D** (the snake) as the primary consumer rather than option **B** (the grasshopper).

Question 13

Most candidates found this question straightforward. Where candidates chose an incorrect option, it appeared that they were guessing.

Question 22

Candidates chose the incorrect options **B** and **C** more often than the correct option, **D**. Candidates are expected to be able to describe and use the tests to identify iron(II), iron(III), carbonate and chloride ions.

Question 26

Many candidates chose the incorrect option **A** rather than the correct option, **C**. Candidates should be able to describe chemical tests for water using copper(II) sulfate and cobalt(II) chloride.

Question 27

There was evidence that many candidates had guessed at the answer. Candidates are required to know that the complete combustion of hydrocarbons produces carbon dioxide and water.

Question 29

The expression for density is often expressed as a fraction with the volume of an object as the denominator. This question, however, used this definition to find the mass of an object and required the equation to be rearranged. The incorrect option **B**, where the volume was the denominator, was selected by more candidates than the correct option, **D**. Perhaps candidates did not rearrange the expression correctly or did not realise that this was necessary.

Question 30

The two most commonly chosen options for this question were options **C** and **D**. In one case, the area of contact with the surface is the largest shown and in the other case, it is the smallest. The objects have equal weights and so option **D** is correct. Perhaps some candidates considered the option where the weight acts over the greatest area to correspond to the greatest effect and therefore the greatest pressure.

Question 36

The correct option, **C**, was the most frequently chosen and only a small number of candidates selected options **A** or **D**. Option **B**, however, was chosen by a significant number of candidates even though the rays that passed through the right-hand principal focus had not entered the lens parallel to the principal axis.

Question 38

The question stated that the two rods were uniformly charged. Therefore, the rods repel each other in all orientations and the correct option is **D**. This question was poorly answered and the options that were chosen by many candidates suggested that the two rods were being treated as magnets. Candidates often confuse electrostatics with magnetism.

Question 39

Many candidates were unsure about the distinction between electric current and potential difference (p.d.). This can often lead to an uncertainty concerning the positioning of ammeters and voltmeters in electric circuits. Each of the four options were selected by a very similar number of candidates even though, in two of the circuits, the positioning of the voltmeter and ammeter were essentially the same.

COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1**, **7**, **28**, **34** and **35**. **Questions 18**, **24** and **30** proved the most challenging for candidates.

Comments on specific questions

Question 1

Most candidates chose the correct option. Some candidates incorrectly selected option **B** (egestion) or option **A** (digestion).

Question 2

While most candidates selected the correct option, many selected option **C** (cell membrane). When labelling the cell membrane, the label line will touch the membrane. On a plant cell, the cell membrane is pushed against the inner side of the cell wall, so the label line will touch the inner side of the cell wall.

Question 3

Many candidates correctly selected option **B** for this question. Some candidates selected option **C** (starch and protein). The only positive food test in this question was the Benedict's test.

Question 4

Most candidates correctly identified option **D** due to it having the shortest reaction time.

Question 5

Most candidates chose the correct option when answering this question. Some candidates incorrectly selected option **D**: stomach → large intestine → small intestine as the order of the alimentary canal.

Question 6

Most candidates selected the correct option, **C**, when answering this question. Some candidates incorrectly opted for option **D** (red blood cells and white blood cells).

Question 7

Most candidates of all abilities selected the correct answer. Some candidates incorrectly selected option **C** (bronchioles) and **D** (trachea) as the structure where oxygen enters into the blood.

Question 8

Most candidates of all abilities found this question straightforward. Some candidates incorrectly selected option **B** (glycogen).

Question 10

Many candidates found this question demanding. Some candidates incorrectly selected option **C** (photosynthesis).

Question 11

Candidates seemed to be split between the correct option, **A**, and the incorrect option, **B**. This would indicate that they appreciated that asexual reproduction involved one parent, but they were confused as to whether the offspring were genetically identical.

Question 12

Some candidates incorrectly selected option **C** as they switched the names of the anther and stigma.

Question 13

Some candidates incorrectly selected option **C**, this may be because this option was the only one that contained the sperm duct.

Question 14

Some candidates selected the incorrect option **C** rather than the correct option, **B**. Candidates are expected to be able to identify elements and compounds and to know the difference between atoms and molecules.

Question 17

Candidates selected the incorrect options **A** and **C** more often than the correct option, **D**. Candidates should be able to identify different compounds from their diagrammatic representations.

Question 18

There was evidence that many candidates had guessed at the answer. Candidates are required to describe the electrode products, using inert electrodes, in the electrolysis of molten lead(II) bromide.

Question 24

Candidates chose the incorrect options **B** and **D** more often than the correct option, **C**. Candidates are expected to know that the noble gases are monatomic gases present in clean air and found in Group VIII of the Periodic Table. They should also know the uses of argon and helium.

Question 25

Many candidates selected the incorrect option **B** rather than the correct option, **C**. Candidates are expected to know that pure gold is very unreactive and therefore unlikely to corrode. They should also be able to explain, in terms of their properties, why alloys are used instead of pure metals.

Question 26

Most candidates selected the incorrect option **B** rather than the correct option, **A**. Candidates should be able to describe the chemical test for water and aqueous solutions using cobalt(II) chloride.

Question 30

Only a small number of candidates selected the correct option **C**. Air resistance is primarily the friction between a moving object and the air. Option **B** was the most frequently selected option. Air resistance may act in the direction opposite to the force of gravity but does not always do so. In the case of a car or a train, moving horizontally, the force of air resistance is also horizontal.

Question 33

Few candidates selected either option **A** or option **B** as they realised that evaporation reduces the mass of the liquid that is evaporating. More candidates, however, selected option **D** rather than the correct option, **C**.

Question 36

In this question, the glass blocks are shown with light entering at the vertical side whereas more commonly diagrams of refraction show light entering a block at the top surface. The behaviour of the light is identical, it refracts towards the normal on entry and away from the normal on returning to the air.

Question 39

Although most candidates selected option **A** or **C** and indicated an understanding of the distinction between a series connection and a parallel connection, a small number of candidates did not do so and chose a circuit in which the lamps were connected in series. The incorrect option **C** was selected more often than option **A**. This is possibly because the fuse in **C** is in close physical proximity to both lamps.

Question 40

The correct answer **B** was the most frequently selected and candidates that chose this value had calculated the current in the appliance and realised that the most appropriate fuse rating was one that is greater than this value but not hugely greater. Despite being smaller than the required current, option **A** was quite commonly chosen by candidates.

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

General comments

Candidates performed very well on **Questions 1**, **2**, **3**, **14**, **15**, **16**, **17**, **20**, **25**, **29**, **32** and **35**. **Questions 8**, **13**, **31**, **34** and **36** proved the most challenging for candidates.

Comments on specific questions

Question 1

Most candidates got this question correct. Some candidates who had selected an incorrect option chose option **B** (nutrition) or option **A** (excretion).

Question 2

The candidates that selected an incorrect option, selected option **C** or option **B**. Both options indicated that the candidates thought that animal cells lacked cytoplasm.

Question 3

A significant proportion of candidates incorrectly opted for option **A**. They had identified that osmosis was through a partially permeable membrane, but they got the direction incorrect: low water potential to high water potential.

Question 4

Most candidates correctly selected option **A**. However, some selected the correct temperature, but the incorrect pH.

Question 7

While most candidates did select the correct option, many selected option **A**. Candidates need to be reminded that plants gain most of their glucose from photosynthesis, not the soil.

Question 8

Some candidates found this question demanding. Most candidates selected arteries, not veins. Option **A** (the aorta) was the most frequently selected option.

Question 10

Where candidates got this question incorrect, they had identified that sexual reproduction involved the fusion of nuclei, but incorrectly thought that the offspring were genetically identical.

Question 12

Most candidates found this question straightforward. Some candidates incorrectly selected option **B** as the secondary consumer, possibly missing **A** as the producer in the food chain.

Question 13

Many candidates seemed to be guessing, mainly between options **A**, **B** and **D**.

Question 15

Most candidates knew the relative mass and relative charge on a proton and selected option **D**.

Question 16

Candidates understood, in terms of atomic structure, the changes that occur when sodium reacts with chlorine.

Question 17

Candidates were able to balance a symbol equation and select option **C**.

Question 20

Candidates were able to use an equation to identify the reducing agent, and to explain what happens to the reducing agent in the reaction.

Question 25

Candidates understood the effect of increasing concentrations of carbon dioxide and methane in the air.

Question 30

Many candidates were able to use the information in the question to calculate the correct value for the spring constant. Those that did not, tended to select either option **A** or option **B**.

Question 31

Many candidates selected the correct option **B** and very many candidates selected option **A** or **B**, both of which contain the correct equation for power. A few candidates did not appreciate the significance of the k in kW and selected option **A** where the energy transferred is a thousand times too small.

Question 34

Thermal energy can be conducted through metals as vibrating particles (ions) collide with neighbouring particles and transfer energy to them. The second and much more effective conduction mechanism in metals is by the free movement of electrons travelling very significant distances in the metal and transferring energy over large distances very quickly. There are many candidates who confuse the two mechanisms and seem erroneously to think that the electrons transfer energy by passing on vibrations to neighbouring electrons. This probably explains why option **B** was selected by more candidates than the correct option **A**.

Question 36

Although all the rays that emerge from an object eventually pass through a real image, or seem to come from a virtual image, there are only three rays which can be traced without knowing the location of the image. The diagram in this question shows all three of these rays. The fourth ray shown (**D**) emerges parallel to the principal axis but does not pass through a principal focus or seem to have come from one before entering the lens. This is not a possible path for the light and so it is the correct option to choose.

Question 37

The correct option, **B**, was selected more frequently than any other option. Candidates that did not select it, did not favour any one of the incorrect options significantly more often than any other.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **6**, **8**, **11**, **13**, **25**, **29** and **35**. **Questions 17**, **31**, **37**, **38** and **40** proved the most challenging for candidates.

Comments on specific questions

Question 1

Most candidates found this question straightforward. Where candidates did not select the correct option, they selected option **B** (egestion) or option **A** (digestion).

Question 2

While most candidates selected the correct option, many candidates selected option **C** (cell membrane). When labelling the cell membrane, the label line will touch the membrane. On a plant cell the cell membrane is pushed against the inner side of the cell wall, so the label line will touch the inner side of the cell wall.

Question 4

Most candidates found this question straightforward. Some candidates selected option **D**, indicating that the glucose facilitated the transfer of light energy to chemical energy.

Question 5

Most candidates found this question straightforward. Some candidates were split between the correct answer: scurvy and the incorrect answer: anaemia.

Question 6

Whilst most candidates selected the correct option, some selected option **D**: stomach → large intestine → small intestine.

Question 8

Where candidates selected an incorrect option, they selected options **B** and **D**. Both contained red blood cells, which are not involved directly with clotting or infection control.

Question 10

Most candidates identified that adrenaline increases pulse rate. Where candidates selected incorrectly, they had thought that adrenaline decreases blood sugar.

Question 12

Candidates that got this question wrong, incorrectly selected option **B**. This is probably because they misread the question or the table. They picked two primary consumers instead of two producers. Candidates need to carefully read the question and any associated tables and figures.

Question 17

Candidates selected the incorrect option **C** more often than the correct option, **B**. Candidates are expected to be able to construct ionic equations. They should also be able to identify the spectator ions in precipitation reactions, and to exclude these from the ionic equation.

Question 24

Candidates selected the incorrect option **B** more often than the correct option, **C**. Candidates are expected to know that pure gold is very unreactive and therefore unlikely to corrode. They should also be able to explain, in terms of their properties, why alloys are used instead of pure metals.

Question 31

The calculation associated with this question is not entirely straightforward and having reached the figure 64, it is very easy to forget to proceed by determining the square root. This error was only made by a small number of candidates and neither option **A** nor option **D** were widely selected by candidates. The most frequently selected incorrect option was **C** which would have been chosen by a candidate who had confused kinetic energy and momentum.

Question 36

This question, concerning the cause of refraction, assessed through the incorrect options a few other aspects of wave motion. Candidates who understood the distinction between longitudinal waves and transverse waves would not have chosen either option **A** or option **B**. Likewise, candidates who understood what is represented by the frequency of a wave would not have selected option **C**. More candidates did select the correct option than any other but clearly those who did not revealed an uncertainty about the topic.

Question 37

A magnifying glass is not simply a type of lens, it is a converging lens that is used in a particular manner. The option that describes this use is option **C** and although this was a popular choice amongst candidates it was not the most popular. A slightly larger number of candidates selected option **B**. Very few candidates selected either of the other two options.

Question 38

A large number of candidates selected option **C** or **D**, both of which derive from the application of the equation $Q = It$. This suggests that this equation and its significance are understood quite widely. Rather more candidates selected option **D**, rather than the correct option **C**. It is possible that these candidates simply used the current value given in the question without considering the splitting of the current into two equal halves at the point where the lamps are connected in parallel. It may also be the case, that these candidates had confused current with potential difference. Both lamps receive the full potential difference across that part of the circuit.

Question 40

The correct option, **B**, was the most frequently selected and candidates that chose this value had calculated the current in the appliance and realised that the most appropriate fuse rating was one that is greater than this value but not hugely greater.

COMBINED SCIENCE

Paper 0653/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **5**, **9**, **25**, **30** and **34**. **Questions 3**, **6**, **7**, **12**, **17**, **18**, **19**, **23**, **24**, **33**, **36** and **40** proved the most challenging for candidates.

Comments on specific questions

Question 1

Candidates of all abilities found this question straightforward. The few candidates that got this question wrong opted for egestion or ingestion.

Question 2

Some candidates found this question straightforward. Other candidates predominately picked the incorrect option **B** (cytoplasm).

Question 3

Candidates found this question very demanding. The enzyme has the least kinetic energy at cooler temperatures. In this graph this would be represented by letter **A**. Candidates selected the option where the enzyme was denatured, but this enzyme had the greatest kinetic energy.

Question 4

When candidates made an error, they incorrectly thought that chlorophyll transferred heat to chemical energy, rather than light to chemical energy.

Question 5

Candidates that got the question incorrect were evenly split between options **B** and **D**. These incorrectly stated that the function of the oesophagus is digestion and the function of the small intestine is egestion.

Question 6

Many candidates found this question demanding. Many candidates incorrectly thought that an increase in humidity leads to an increase in transpiration, this is a common misconception.

Question 7

Few candidates correctly selected option **B**, the left ventricle. Most candidates selected option **A** (the left atrium), where blood enters the heart.

Question 8

While many candidates did select the correct option, many others were evenly split between the incorrect options **B** and **C**.

Question 9

Some candidates incorrectly selected option **B**. Adrenaline increases blood glucose concentration, pulse rate and pupil size.

Question 10

Many candidates selected an option indicating that asexual reproduction involves a single parent but some of these thought that asexual reproduction produces genetically different offspring, a common misconception.

Question 11

While the correct option was selected by many candidates, options **B** (contains an energy store and can swim) and **D** (does not contain an energy store and cannot swim) were frequently selected.

Question 12

Many candidates selected an incorrect option. Most opted for option **A** which stated that there were two primary consumers, when there were in fact three. It may be that candidates misread the question and instead of answering how many primary consumers there were, they indicated how many producers there were, a common mistake.

Question 13

Most candidates correctly selected option **B**, although many candidates selected option **A**. The increase in nitrates causes increased growth of producers, this was the first step in this sequence.

Question 17

There was evidence that many candidates had guessed at the answer. Many candidates selected the incorrect options **A** and **D** rather than the correct option, **B**. Candidates are expected to be able to construct ionic equations.

Question 18

Candidates selected the incorrect options **A** and **C** more often than the correct option, **B**. Candidates are required to describe the electrolysis, using inert electrodes, of dilute sulfuric acid.

Question 19

Many candidates selected the incorrect option **C** rather than the correct option, **B**. Candidates should be able to interpret energy level diagrams showing exothermic and endothermic reactions and the activation energy of a reaction.

Question 21

There was evidence that many candidates had guessed at the answer. Candidates are required to describe the characteristic properties of acids, including dilute sulfuric acid, and their reactions with metals, bases and carbonates.

Question 23

Candidates selected the incorrect options **A**, **B** and **D** more often than the correct option, **C**. Candidates should be able to describe and explain the relationship between the number of outer-shell electrons and metallic/non-metallic character.

Question 24

Candidates chose the incorrect option **C** more often than the correct option, **A**. Candidates are expected to be able to describe the use of carbon in the extraction of copper from copper oxide.

Question 25

Most candidates knew that carbon dioxide and methane are greenhouse gases whose increased concentrations in the air cause the enhanced greenhouse effect.

Question 32

This question was one where the correct option was also the most frequently selected. There were, however, many candidates who selected one of the other options. This may well be due to an uncertainty around the exact form of the equation that defines kinetic energy or perhaps due to inaccurate rearranging of the correct equation. It is possible that those who selected option **A** were confusing kinetic energy with momentum, even though momentum is not a topic in this syllabus.

Question 33

This question was not well answered with many candidates either misunderstanding what was being asked or missing the information that steam is used to drive the turbine in the power station. The most commonly chosen option was **A**. The generator in a hydroelectric power station is indeed rotated by a turbine but that turbine is not driven by steam, it is driven by water. Perhaps candidates were also confused by what happens in a nuclear power station which is the correct choice here. A nuclear power station is rather like a fossil fuel power station. The source of the energy transferred to the water, however, is a nuclear reactor rather than burning fossil fuels.

Question 36

In this question, candidates needed to understand the relationship between current, resistance and voltage and also how current and voltage behave in relation to components connected in parallel. There was scope in this question for more than one misunderstanding to lead to error. As it turned out, all four options were chosen by similar numbers of candidates and the correct option **D** was not the most frequently chosen. There are clearly candidates who do not realise that the potential difference across different components in parallel is the same for all the components and candidates who did not relate a greater resistance to a smaller current. Some of these might have also been misled by an incorrect assumption about the voltage.

Question 37

Although the correct option was the most commonly selected, all of the other options were chosen by a significant number of candidates. Some candidates confuse the words longitudinal and transverse but know what they signify in terms of particle vibrations. Some thought that sound is a transverse wave.

Question 40

A small number of candidates selected the correct option for this question. The label on the heater reveals the voltage that this appliance is designed to work with and the current in it and the power transferred when it is operating normally. Fuses have a current rating and hence it is the operating current that needs to be known. Only a minority of candidates chose an option that had the unit of current, and of these rather more chose the option that had a current rating smaller than the operating current of the device.

COMBINED SCIENCE

Paper 0653/31
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 all questions carefully to ensure they are answering the question being asked. In **4(d)(ii)** many candidates compared the function of veins and capillaries, rather than their structures.

General comments

There were some good responses from candidates who demonstrated a thorough knowledge of all three Sciences in the syllabus. Candidates were able to answer questions in both familiar and unfamiliar contexts. Other candidates left questions unanswered. Candidates are advised to attempt every question, especially those questions where they have to make a choice of answers that are already given in the question.

Comments on specific questions

Question 1

(a) (i) Most candidates gained at least partial credit. Some were not familiar with the sepal, **C**, which protects the flower when in bud.

(ii) Many candidates identified both parts of the stamen correctly. The most common incorrect answer was **A**, the stigma.

(b) (i) Many candidates gained credit for stating 6 days. Others copied the lowest value for each seed directly from the table without drawing the necessary conclusion that all seeds will have germinated by 6 days.

(ii) Most candidates identified pumpkin correctly. The instruction to use Table 1.1 was often missed, so candidates stated that the temperature was too low without clearly showing how this came from the table. The best answers stated that 21 °C was the minimum temperature for germination.

(iii) Water was the most popular correct answer, with fewer candidates stating oxygen. The most common incorrect answer was sunlight. Candidates are reminded that light cannot reach many seeds when they germinate underground. Other incorrect answers included soil, dirt and the weather.

(c) A few candidates gained credit here. Common errors included the ground or the Sun, confusing gravitropism with phototropism.

Question 2

(a) (i) Generally well answered with most candidates naming a thermometer.

(ii) Most knew that the change was physical, but they found it difficult to give a clear explanation. For example, many just described the change of state, or that the change is a physical one not a chemical one. The best answers stated that it is a physical change because no new products are formed.

(iii) Almost every candidate wrote one endothermic and one exothermic answer. Both melting and boiling are endothermic changes, requiring thermal energy to cause the changes of state.

(b) Many candidates did not use the term distillation in their answers. Filtration and evaporation were frequently seen. Many candidates thought that filtration would separate the salt. Since the salt was in solution it would go straight through the filter paper. Successful candidates explained that distillation separates pure water from salt because the pure water evaporates, the water can then be condensed and collected, leaving the salt behind.

(c) Some candidates found this question challenging. They had difficulty in understanding the difference between the arrangement, separation, and motion of particles. Common errors for particle arrangement included close together for the solid, and that it takes up the shape of its container for the liquid. For particle separation, a common error was to state that particles in a liquid are further apart, rather than close together. The movement of particles in a gas was not well described. Many just stated that they move around without making it clear that the particles move at a faster speed than in a liquid.

(d) (i) This question was answered well by stronger candidates. The most common error given by other candidates was covalent bonding. These candidates are reminded that ionic bonding occurs between a metal and a non-metal, as described in the question.

(ii) Generally answered well by stronger candidates. The most common error was to state ionic bonding. Candidates are reminded that covalent bonding occurs between two non-metals.

Question 3

(a) Very few candidates stated convection, though many gave descriptions of hot smoke rising. Other incorrect responses included combustion and exothermic.

(b) Generally, well answered. The most common error was 0 °C.

(c) (i) There were very few correct answers. Candidates should be aware that the process by which the energy from the fire warms the people is radiation. Thermal, heat and convection were the most common incorrect answers. Convection would take the thermal energy upwards away from the players.

(ii) A few candidates correctly named infrared. Incorrect responses included the names of other electromagnetic waves, heat waves and waves.

(d) (i) Generally, answered well.

(ii) The hearing range of the bat is from 2000 Hz to 110 000 Hz. Therefore, the only two instruments producing sound in this frequency range are the flute and the violin. The main error was from those candidates who looked for the range 2 Hz to 110 Hz resulting in their selection from guitar, trombone and French horn.

(e) Some candidates stated microwaves as given in the syllabus. Radio waves was also allowed. Incorrect responses included sound waves and the remaining waves in the electromagnetic spectrum.

Question 4

(a) Many candidates labelled the diaphragm correctly. The rest either labelled the wrong part or did not attempt the question.

(b) Generally answered well. Incorrect answers included oxygen, hydrogen and nitrogen.

(c) Most candidates knew that respiration involves glucose, oxygen, carbon dioxide and water but most mixed up the reactants and products, often confusing the respiration equation with that of photosynthesis.

(d) (i) Many candidates scored well on this question, with the majority correctly answering the third response, red blood cells. Common errors included artery for the first response and capillary for the second response.

(ii) This question was challenging for most candidates who did not answer in enough detail. Responses that did not gain credit simply stated smaller, thinner or one cell thick. Some candidates described differences in function between a capillary and a vein. Careful reading of the question indicates that the structures of the capillary and vein should be compared.

Question 5

(a) (i) A suitable use of refinery gas was stated by many candidates. Common errors included petrol for cars, engine oil and vague responses such as providing energy.

(ii) Few candidates gained full credit for this question. Many stated that a hydrocarbon contains carbon and hydrogen, but most omitted the word 'only' in their definitions. Hydrocarbons do not contain any other elements apart from hydrogen and carbon.
The term saturated was not well known. Many of the responses referred to water and saturated solutions. A saturated hydrocarbon is a different use of the word saturated, meaning that the hydrocarbon only has single bonds between carbon atoms.

(b) (i) Most candidates were unfamiliar with the term cracking. The most common incorrect answer was fractional distillation.

(ii) A small number of candidates knew the colour change of aqueous bromine when added to ethene, an unsaturated hydrocarbon. A wide range of colour changes were seen, some of which stated that the solution changed from brown to blue-black, confusing it with the iodine test for starch.

(iii) Candidates found this question challenging. While several scored credit for the numbers of product molecules, fewer balanced the equation by writing the correct number of oxygen molecules. Other candidates attempted to balance the equation by adding symbols such as C and H on the dotted lines instead of numbers. Candidates should be aware that the formulae of the molecules cannot be changed but the numbers of molecules can be changed to balance the equation.

(iv) Few candidates gained credit. Incorrect answers included polymer and hydrocarbon.

Question 6

(a) (i) Some candidates drew the arrow correctly pointing vertically downwards. Many others drew the arrow pointing either parallel to the belt, or at right angles to the belt. Candidates are reminded that the gravitational force acts vertically downwards on the box to produce its weight.

(ii) Most candidates answered this question correctly.

(b) Candidates are reminded to show working in this type of question. Credit can be given for a correct equation if this is followed by an incorrect answer. The correct answer was 5 m.

(c) Many candidates gained credit for the first two responses. A common error for the third response was stating gravitational energy instead of gravitational potential energy.

(d) Candidates found this question challenging. Very few stated that the box stays at rest because the forces on it are balanced. The most common incorrect answers were either that there are no forces acting on the box, or that the forces were equal.

(e) Candidates found this question challenging. Many calculated the numerical difference between the two numbers in the question and gave this as their answer. Others restated the information in the question, stating that the total work done is greater than the energy gained by the box.

Question 7

(a) (i) Although most candidates knew that iodine turns blue-black in the presence of starch, there appeared to be confusion when selecting the correct leaf. Few candidates clearly explained how the results supported their choice.

(ii) Very few candidates gained credit for this question. The majority stated chlorophyll. Although chlorophyll is needed to make the leaves green, the question was asking for a mineral ion. Magnesium is the mineral ion which is needed to make chlorophyll.

(b) Many candidates scored at least partial credit for this question. A common choice that did not gain credit for this was water evaporates from the surface of stomata. The water evaporates from the surfaces of mesophyll cells inside the leaf and then the water vapour diffuses through the stomata. Statements about cortex cells were not correct because the cortex cells are contained in the root and stem.

(c) (i) Many candidates scored full credit in this question. Common errors included writing the organisms in the correct order, but without arrows, or with arrows pointing in the wrong direction. The arrows indicate the flow of energy along the food chain from the flowers to the owls. A minority of candidates were unfamiliar with the structure of food chains and merely rewrote the bullet points on the answer line.

(ii) Those candidates who had drawn a correct food chain usually identified the snakes correctly as the tertiary consumer. The most common incorrect organism given was the owl.

(d) Generally, well answered. Many candidates scored full credit.

Question 8

(a) (i) Generally, candidates found this question challenging. Many candidates identified the correct acid, sulfuric acid. Others did not identify sulfuric acid and just stated dilute acid as given in the stem of the question. Few stated the correct product, water. The most common incorrect answers included oxygen, hydrogen, and carbon dioxide. Since both sulfuric acid and water were needed to gain credit, many did not score.

(ii) Many candidates gave two correct answers to this question. Adding more reactants was the most common incorrect response. This will increase the amount of products formed but does not directly affect the rate. Candidates are reminded to state increase temperature and not just temperature if they want to change this variable to increase the rate.

(b) (i) Many candidates gave the correct colour for the flame test of the copper(II) ion.

(ii) Generally, this test was not known by the candidates.

(c) Most candidates did well in this question, successfully stating the number of electrons and calculating the number of neutrons in the atom. The number 63 was the most common incorrect answer, seen for both the number of electrons and the number of neutrons.

Question 9

(a) A few candidates gained full credit for the ray diagram. Most found this question challenging. Common errors included:

- diagrams drawn without using a ruler and pencil
- the drawn ray did not reach the eye
- the point of reflection was not in a possible position to allow the angles of incidence and reflection to be equal
- the point of refection did not touch the computer screen
- normal rays were either omitted or not vertical.

(b) (i) Some found this question challenging. Many divided 250 by 5 instead of 5 divided by 250. Many candidates were unfamiliar with the symbol for current, A. The correct answer was 0.02 A

(ii) There were few correct answers to this question which concerned resistances in series. The calculation was a subtraction of 70 Ω from 250 Ω to give the answer 180 Ω.

(c) Some candidates gained full credit for this question. Others did not know the symbol for a resistor, with many drawing either a variable resistor or a fuse. Quite often the switch was missing from the circuit, so credit could not be awarded.

COMBINED SCIENCE

Paper 0653/32
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.

When the function of a structure is requested in a question, it means 'what job does it do?'. In **4(b)(i)** many candidates gave the name of the cell wall instead of its function.

General comments

There were some good responses from candidates who demonstrated a thorough knowledge of all three Sciences in the syllabus. Candidates were able to answer questions in both familiar and unfamiliar contexts. Other candidates left questions unanswered. Candidates are advised to attempt every question, especially those questions where they have to make a choice of answers that are already given in the question.

Comments on specific questions

Question 1

(a) (i) Most candidates scored partial credit, and many gained full credit. The septum was less well known than the aorta.

(ii) There were many correct responses in this question. The most common incorrect answer was the pulmonary artery.

(b) (i) Almost all candidates identified star jumps, therefore gaining full credit.

(ii) Some candidates misread the graph to identify the two pulse rates. An ecf (error carried forward) enabled these candidates to gain credit for calculating the difference in pulse rates.

(c) Many candidates gained partial credit for the correct identification of **P**, a red blood cell. Fewer stated plasma for **S** and a minority gave both marking points for **Q**, a white blood cell. Although many of the candidates stated **Q** correctly, only a small number stated phagocytosis or antibody creation for the function. Unacceptable responses for the function included killing, fighting or getting rid of pathogens.

Question 2

(a) (i) All candidates found both parts of this question challenging. A common incorrect statement for aqueous was 'a liquid containing water' rather than stating that the solute is dissolved in water.

(ii) There were several correct answers to this question. Common errors included naming the electrodes and stating that the product was chloride, not the element chlorine.

(iii) Some candidates gained credit for this question. Incorrect responses included covalent, single, and double bonds candidates should be aware that ionic bonds exist in compounds with charged particles (ions). The charges on the ions when dissolved in water cause them to be attracted to the electrodes of the opposite charge during electrolysis.

(b) Only a few candidates answered this question correctly. The majority were unfamiliar with the analytical test for a chloride ion.

(c) (i) The question states that the reaction is a neutralisation. Therefore, the aqueous solution must be a base. Incorrect answers included sodium, sodium chloride and chlorine.

(ii) Many candidates gained full credit in this question. Common errors included (the pH) decreases and descriptions of colour changes of universal indicator. Candidates are reminded that the pH scale is numerical, with low numbers indicating an acid. As the solution becomes neutral the pH values increase.

(iii) Many of the stronger candidates answered this question correctly. The most common error seen was endothermic. Since the temperature in the beaker increases, the thermal energy has been released by the reaction, making it exothermic.

(d) Many candidates used the representation of the sodium atom to deduce the correct numbers of electrons and neutrons. Some of the candidates who did not gain credit reversed the numbers to give 12 and 11 for the number of electrons and the number of neutrons respectively.

Question 3

(a) (i) Generally, well answered. Candidates chose the correct horizontal line to give the answer 10 s.

(ii) Generally, well answered. Candidates interpreted the scale correctly to give the answer 20 s.

(iii) Many candidates gained credit by placing their **X** on the descending part of the graph. Some candidates placed their **X** exactly on t = 10 s. These candidates were not awarded credit because they had not made it clear that they had selected a part of the graph with a downward gradient.

(b) The double conversion from m / s to km / h was successfully done by some candidates.

(c) Most candidates successfully rearranged the speed = distance ÷ time equation to find the distance travelled by the car. The correct answer is 1950 m.

(d) (i) Candidates found this question challenging. Common incorrect responses included reflection for the first marking point and frequency for the second marking point. Candidates should be aware that the frequency of the light waves does not change during refraction, but the speed of the light waves does change.

(ii) Many candidates drew the ray diagram correctly. Several candidates tried to make the three given parallel rays converge into the eye of the driver. Careful reading of the stem states that the ray diagram should be completed only from the lamp to the lens and not any further. Candidates are reminded to use a ruler and a pencil for drawing ray diagrams.

Question 4

(a) The vast majority of candidates found this question challenging. Frequently, photosynthesis and respiration were quoted together. An example of this for test-tube **B** is ‘photosynthesis and respiration occurred because carbon dioxide is used’. Photosynthesis and respiration do occur at the same time, but in test-tube **B** the rate of photosynthesis is much greater than the rate of respiration. This is responsible for removing carbon dioxide from the tube to give the red colour of the indicator.

Credit for the second marking point was awarded to many candidates who explained that photosynthesis could not occur in the dark in test-tube **C**. Most did not develop their response to state that only respiration could occur, producing carbon dioxide which gave the yellow colour of the indicator.

(b) (i) There were some correct responses for the function of the cell wall shown in Fig. 4.2. Candidates are reminded that function describes what job it does. Therefore, credit was not awarded for just identifying the cell wall. Incorrect responses included ‘controls what enters and leaves the cell’ which refers to the cell membrane, and ‘reduces the rate of transpiration’ which is the function of the guard cells.

(ii) Many candidates successfully completed the sentences. Common mistakes included naming cell **X** as a mesophyll cell or a palisade cell and completing the last sentence with air instead of water. Air can go both in and out of the stomata when they are open, but during transpiration water vapour diffuses out of the stomata.

(iii) Many candidates gained credit for this question. Others identified an environmental condition accurately but did not say how the condition changes. For example, candidates wrote temperature and humidity without stating whether the condition increases or decreases. Those who were awarded full credit stated increased temperature or decreased humidity.

(iv) Xylem was correctly identified by many candidates. Common errors were stem and root hair cells.

Question 5

(a) (i) Many candidates stated a physical property correctly. Most found the chemical property more challenging and wrote a second physical property, which did not gain credit. Candidates should be aware that physical properties can be observed without the element changing chemically. Chemical properties refer to the way elements behave during a chemical reaction.

(ii) There were many correct answers here. Suggestions that were not awarded credit included cheaper and long-lasting. Long-lasting is the result of the alloy becoming harder, not a property in itself. Candidates who stated that the alloy does not rust were not given credit because rusting is a term applied to iron only. In this context, corrosion-resistant was accepted.

(b) (i) Candidates found this question challenging. Often seen was the number 2 in front of all four chemicals. Candidates should be aware that the number of atoms of each type should be the same on both sides of the equation.

(ii) Many candidates stated oxidised correctly. They found the explanation more challenging, with many describing oxidation as the loss of oxygen by the copper, rather than the gaining of oxygen by the carbon.

(iii) The most important point here is the comparison of the reactivities of aluminium and copper, with the less reactive copper being unable to displace aluminium. Common incorrect statements were that the aluminium would burn or melt.

(iv) Many stronger candidates gained credit for describing the full outer shell of electrons in argon and the consequences of this regarding reactivity. Other candidates found this question challenging, with many restating the question saying that the gases do not react.

Question 6

(a) Generally, candidates did not know the energy resources which supply energy from moving water. Most responses stated types of energy, for example, kinetic energy and gravitational potential energy.

(b) (i) Generally well answered.

(ii) Candidates were unfamiliar with the term geothermal energy. Incorrect answers seen frequently included heat energy and thermal energy.

(iii) Candidates found this question challenging. Some described the change of state from water to steam to gain some credit, but only a few continued to describe how the kinetic energy of the steam is used to generate electricity.

(c) (i) Many candidates answered this question correctly. The most common incorrect answer was electrical energy.

(ii) Only a few candidates were awarded full credit for this question. For the first marking point, both words in the term ‘gravitational potential’ were needed for credit. Therefore, candidates who wrote either gravitational or potential did not score. The second marking point was challenging for most candidates who did not state that the second, lower-powered motor would take more time to complete the task.

Question 7

(a) (i) Many candidates added the arrows correctly to the food web. A few had their arrow heads pointing in the wrong direction from the bluefish, so did not gain credit. The arrow shows the direction of energy flow, so it points from prey to predator.

(ii) Generally, well answered.

(iii) Only a few stated that the Sun is the principal source of energy for all food webs. Most candidates stated algae, plants or producer. The question was asking for the principal source of energy for all food webs, not just this aquatic one. The Sun provides the energy for photosynthesis in plants, which in turn can pass their energy on to animals.

(b) Most candidates correctly stated that asexual reproduction requires only one parent. Although many stated that the offspring are identical, to gain full credit they had to state that the offspring are genetically identical and most omitted to say this.

(c) (i) Some candidates gained full credit in this question. Common incorrect answers included the functions of other food groups, for example proteins and carbohydrate.

(ii) Some candidates correctly circled ethanol.

(iii) Generally, well answered.

Question 8

(a) (i) Many candidates completed the equation correctly. Incorrect responses included hydrogen for the reactant, instead of oxygen, and carbon for the product, instead of carbon dioxide.

(ii) The bonding pairs of electrons were drawn correctly by many candidates. Fewer were able to gain full credit because the remaining electrons were not drawn correctly. For example, extra electrons on the hydrogen atoms, incorrect numbers of electrons on the oxygen atom or no additional electrons at all.

(b) (i) Successful candidates made a correct reference to the presence of a double bond in the compound. Incorrect responses included ‘not saturated’ and descriptions of a dilute solution in water.

(ii) Only a few of the stronger candidates identified **Y** correctly as (aqueous) bromine.

(iii) Only a few candidates stated addition polymerisation.

(c) Many candidates made correct statements comparing the spacing and movement of gas and liquid particles. Candidates should be aware that stating that particles are further apart in a gas and closer together in a liquid is only one difference and not two. Very few candidates stated that there are stronger forces of attraction between the particles of a liquid than between the particles in a gas. This was a valid alternative marking point.

Question 9

(a) Many candidates successfully rearranged Ohm’s Law to do a correct calculation. Fewer stated the unit, Ω, correctly. The most common incorrect answer was 13.5, where candidates had multiplied the voltage (9 V) by the current (1.5 A) instead of dividing it. The correct answer was 6 Ω.

(b) (i) Some of the stronger candidates identified the variable resistor correctly. Many wrote just ‘resistor’, which was insufficient detail. Others stated a variety of incorrect electrical components.

(ii) The main idea with this question was to state that as the resistance increases, the current into the loudspeaker decreases, (and this in turn decreases the loudness of the sound emitted). Some of the stronger candidates gained credit for this question but the rest found it very challenging.

(iii) Some candidates were awarded credit for this question by stating amplitude. Others gave incorrect responses referring to other wave properties, for example, wavelength.

(c) Many candidates drew the lamp symbol correctly. Most did not gain full credit for the question because they did not put the lamp in the correct position in a parallel circuit.

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.

Due to the small number of entries, it is not possible to comment on every question in this paper.

General comments

Some candidates were familiar with the contents of the syllabus and demonstrated some scientific knowledge.

Candidates are advised to attempt every question, especially those questions where they have to make a choice of answers that are already given in the question.

Comments on specific questions

Question 1

(a) Generally, well answered.

(b) (iii) Most candidates scored at least partial credit on this question. The most common incorrect answer was cell membrane instead of cell wall.

Question 2

(a) (i) All candidates knew the name of the thermometer, used to measure temperature.

(iii) Some candidates stated that a hydrocarbon contains carbon and hydrogen, but they omitted the word only in their definitions. Hydrocarbons do not contain any other elements apart from hydrogen and carbon.

(b) A few candidates gained credit by stating exothermic. The most common error seen was endothermic. Since the temperature of the water in the beaker has increased, thermal energy was given out by the reaction, showing that it is exothermic.

Question 3

(a) (i) Most candidates read the speed from the graph successfully. The speed was 31 m / s.

(ii) Candidates had to place their **X** on the line of negative slope of the graph. Many did this successfully.

(b) Some candidates successfully used the equation $W = mg$ to calculate the mass of the ball. The most common incorrect answer was 40 kg, where candidates multiplied the force of 4.0 N by 10 N / kg instead of dividing it by 10 N / kg. The correct answer was 0.4 kg.

(c) Some candidates calculated the density successfully and gave the correct unit. Candidates are reminded to include working for calculations. Credit may then be given for a correct equation even with an incorrect answer. The correct answer was $0.83\,g/cm^3$.

Question 4

(a) (i) Generally, well answered.

(ii) The gall bladder was successfully identified by stronger candidates.

(c) (i) Most candidates gained full credit for this question. Although testicles are not stated on the syllabus, this answer was allowed as a valid alternative to testes.

Question 5

(a) Some candidates used the information in the introduction to complete the boxes for the reactants, gaining partial credit. Fewer gave water as the second product. Oxygen was the most common incorrect answer.

(b) (ii) A few candidates stated numbers for pH within the required range. Most either gave numbers in the alkaline range or just stated a word, for example, low. These answers were not awarded credit.

(c) Most candidates identified the salt, magnesium sulfate, correctly.

(e) A few of the stronger candidates gained credit for stating electrolysis.

Question 6

(a) A minority of candidates identified the parallel circuit to gain credit.

(c) A few candidates correctly stated chemical energy. The most common incorrect answers were electric and kinetic energy.

(e) A few candidates gained some credit for this question. Most were unfamiliar with the symbol for a fuse.

(f) (i) Some of the stronger candidates gained credit for this question.

Question 7

(a) (i) Generally, well answered.

(ii) Generally, well answered. The most common incorrect answers were chipmunk and grouse. These are both primary consumers.

(b) Most candidates gained some credit for writing photosynthesis in the first gap.

(c) Candidates generally did well in this question, with many giving valid trends shown in the bar chart.

Question 8

(a) (ii) Some candidates correctly stated that the reactivity increases down the group. The most common incorrect answer stated that the trend is for decreasing reactivity.

Question 9

(a) Many candidates chose the correct words from the list to gain full credit.

(b) Some candidates knew that electrons have a negative charge. Fewer stated that the current in the copper wire is due to the flow of electrons.

(c) (i) Candidates did not know that microwaves are used for mobile phone communications, as stated in the syllabus. However, credit was also awarded for radio waves.

(ii) Several candidates placed infrared waves correctly in the electromagnetic spectrum.

(iii) Candidates found the mathematics of this question challenging. Some credit was awarded to those who stated the equation speed = total distance ÷ total time. The correct answer was 6×10^{-2} s or 0.06 s.

COMBINED SCIENCE

Paper 0653/41
Theory (Extended)

Key messages

Candidates who performed well on this paper:

- had prepared thoroughly for this type of examination and were familiar with the required knowledge and definitions of scientific terms shown in the syllabus
- read the questions carefully and used the number of marks for each question as a guide to the detail required in their answers
- ensured that they included working and relationships in questions involving calculations and that this was set out clearly enough for partial credit to be awarded 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. Candidates generally did equally well in the three Science disciplines. In this examination, parts of the syllabus that seemed relatively unfamiliar were the chemical test for chlorine, **2(c)(ii)**, a clear reason why two given hydrocarbons appear in the same fraction in fractional distillation **5(d)(ii)** and showing the direction in which friction acts, **6(a)(ii)**.

Comments on specific questions

Question 1

(a) (i) All types of blood vessel, blood types and blood components were suggested but the great majority of candidates opted for the correct answer. Aorta was also accepted.

(ii) Most candidates interpreted the two heart diagrams correctly and many were awarded credit. A common answer that was insufficient for credit was the statement that, unlike the frog, the human heart has a double circulatory system.

(iii) The idea that a double circulatory system avoids the mixing of oxygenated and deoxygenated blood was very familiar to many candidates. Stronger candidates knew that the double circulatory system allows low pressure blood to the lungs and higher pressure to the rest of the body. The answer that this allows blood to flow at different pressures was insufficient.

(b) (i) Almost every candidate was awarded credit.

(ii) Most candidates correctly calculated the number of people. The most common error was using the incorrect data from the table, usually the percentage of people whose risk factor was lack of physical activity.

(iii) Many candidates were awarded credit but many others suggested a risk factor that was linked to lifestyle, usually stress, obesity or smoking even though two of these were already listed in the table. Some candidates misinterpreted the question and gave the definition of CHD.

(c) Most candidates were very familiar with the dietary requirements needed to prevent scurvy and constipation. Credit was not awarded if any vitamin other than vitamin C was mentioned in relation to scurvy. Roughage was allowed as an alternative to fibre in relation to constipation.

Question 2

(a) (i) Many candidates completed the table correctly. The least familiar row was the name of the hydroxide ion and that the source of this ion is water. Other common mistakes occurred in the charge, or lack of charge, on the hydrogen and/or sodium ions.

(ii) Some candidates used correct chemistry in their explanations but omitted, or simply overlooked, the requirement to describe how the concentration of chloride ions changed. Without this, credit could not be awarded. Many stated that chlorine gas is formed and/or that chloride ions were discharged. A common mistake was to suggest that chloride ions gain electrons.

(b) Most candidates avoided writing 'the pop test' which was not a sufficient answer. Any words which stated or implied that a flame is applied to the gas were accepted. Although a 'glowing' splint was not accepted.

(c) (i) The majority of candidates stated that the litmus colour indicted the presence of acid but the main challenge was to avoid attributing the presence of acid or acidity to an incorrect substance. Several candidates could not be awarded credit because they referred to either sodium chloride or chlorine as being acidic.

(ii) Only a minority of candidates realised that the presence of chlorine would decolourise litmus. Most candidates suggested that the red litmus would turn blue and gave a variety of suggestions for the cause of this change.

Question 3

(a) Many candidates correctly stated radiation. Other suggestions which were accepted were infrared radiation and thermal radiation. UV radiation was not accepted. The most popular answer that did not gain credit was convection.

(b) Stronger candidates identified the three essential ideas required for full credit. These were the higher speed of molecules in hot gas, reference to the expansion of hot gas and the idea that hot gas has lower density and this is the reason it rises. Many candidates suggested at least one or two of these ideas. Some candidates discussed the molecular theory associated with the evaporation of liquids.

(c) (i) Any answer which included the term vibration was accepted and large numbers of candidates were awarded credit. Although little space was available for their answer and only one mark was allocated, some candidates wrote at length about compression and rarefaction. No credit was awarded for this without reference to vibration.

(ii) The majority of candidates were familiar with the relationship between wave speed, wavelength and frequency, and used this correctly. The answer produced on a calculator is 1.289…. . Answers that were accepted included 1.289, 1.29 and 1.3. A significant number of answers were left as 1.28 which was not credited. A common mistake was to evaluate *wave speed* × *frequency.*

(iii) Most candidates were familiar with how to describe the meaning of compression and rarefaction in terms of molecular density. For full credit they also had to find some words to explain the idea of succession. This was more challenging and any reasonable attempt gained credit. Some of the accepted answers included 'and these (c and r) happen one after the other', 'occur as a pattern (often with a diagram which was helpful)'. Credit was also awarded for use of the term '…as a longitudinal wave'.

Question 4

(a) (i) Almost all candidates recognised the herbivores and secondary consumers.

(ii) Large numbers of candidates were awarded at least partial credit because they had learned that energy is lost to the environment through the trophic levels. Most were able to state that energy losses occurred through respiration, heat loss, incomplete digestion and waste materials. Full credit was awarded to those candidates who also stated that the cougar is in a higher trophic level than the beaver.

(b) Many candidates were familiar with the adaptations shown in pollen involved in insect pollination. Some candidates referred to adaptations which applied to the plant or to flowers rather than pollen.

Question 5

(a) The general formula of the alkenes was known by most candidates. A common mistake was to suggest $C_nH_{(n + 2)}$.

(b) The formulae of ethane and octene were correctly stated by many candidates. The most common mistake was to follow down the right-hand column and suggest C_5H_{10} for octene.

(c) (i) Most candidates were awarded full credit. The meaning of unsaturated had to refer to double bonding and so answers such as 'does not have the full amount of hydrogen' were not accepted. Most candidates knew how to define hydrocarbon and were careful to state that these compounds contained hydrogen and carbon only.

(ii) Many candidates answered this question very well. The two key points to make were that the imagined compound methene would contain only one carbon atom and so the carbon-to-carbon double bond required in an alkene could not form. Many candidates found an acceptable way of expressing these ideas. Some candidates attempted their explanation in terms of numbers of electrons and the impossibility of forming a double bond with hydrogen.

(d) (i) Most candidates had learned a use of refinery gas, usually selecting the uses in the syllabus.

(ii) Candidates needed to state that propane and butane have similar boiling points to each other. The idea that these compounds have similar intermolecular forces was accepted as an alternative. Suggestions that could not be rewarded included ' they have the same boiling point', 'they are in the same homologous series', 'they are both hydrocarbons' and references to melting point.

Question 6

(a) (i) Most candidates correctly stated weight. Common incorrect suggestions included, pull/push, force, friction and mass.

(ii) Only a minority of candidates drew a correctly located arrow which was also in contact with the box. Many candidates did not attempt an answer and the majority of those who did, drew the arrow pointing down the ramp. A small number drew arrows perpendicular to the ramp.

(b) Most candidates used the relationship *time* = *distance* ÷ *speed* to calculate the correct final answer. The most common mistake was to evaluate *distance* × *speed*. Partial credit was awarded to candidates whose working started with a correct statement of the relationship between the three variables, even if mistakes were made later. Candidates who showed no working and who stated an incorrect final answer cannot be awarded any credit.

(c) (i) The use of the relationship *GPE* = *mass* × *height* × *g* was very familiar and most candidates worked through to the correct final answer. Common mistakes included calculating (*mass* ÷ *height)*, (*mass* × *height* ÷ *g)* and (*mass* × *g)*.

(ii) Stronger candidates answered this question very well and many were awarded full credit. Some of these candidates could not be awarded full credit because they stated incorrect units. Most candidates gained at least partial credit for stating the relationship *pressure* = *force* ÷ *area* or showing in their working that they had attempted to use this relationship. Partial credit was also available for converting the mass of the box to its weight or for calculating the area of the base of the box. Candidates should be advised that they should always show working and that this should be easy for another person to follow.

Question 7

(a) (i) Many candidates were very familiar with photosynthesis and obtained full credit. Some of the stronger candidates associated magnesium ions with chlorophyll and so suggested magnesium instead of carbohydrates. The marks for chlorophyll and chemical were most frequently awarded throughout the ability range. Chloroplast was sometimes suggested instead of chlorophyll and thermal, kinetic or food were sometimes suggested instead of chemical.

(ii) Stronger candidates avoided confusing gravitropism and phototropism. These candidates also described clearly that auxin moves from the tip of the shoot to the lower side of the stem where it promotes cell elongation. Candidates needed to avoid suggesting that auxin forms in the stem and that it causes excess growth. It was possible for candidates to be awarded partial credit even if they stated that phototropism was occurring.

(b) Many candidates knew that the root hair cell is adapted by having a large surface area. Candidates could usually relate this to increased absorption of water and/or mineral ions. The more general term 'nutrients' was not accepted as an alternative, neither was the unqualified phrase 'to absorb water'. One common mistake was to suggest that the root hairs, being long and thin, could penetrate the soil to a greater distance.

(c) Stronger candidates had learned the processes causing eutrophication and were able to describe how decomposers or bacteria break down dead aquatic plants. These candidates also stated that the decomposers respire aerobically and it is this that removes the oxygen from the water. The question guided candidates away from discussing reduced photosynthesis but many still gave this as the cause of oxygen reduction.

Question 8

(a) (i) The equation was correctly balanced by the majority of candidates.

(ii) The formula of the iron(III) ion was frequently stated correctly. Common mistakes included Fe^{2+} and suggesting the formula of iron oxide. The suggestion $Fe^{3+}O^{2-}$ was not awarded credit as it was not obvious that the candidate knew which was the iron ion.

(b) (i) Most candidates were very familiar with the conditions and reactants involved in rusting. Both agents, air/oxygen and water/moisture were required for full credit. Some candidates wrote lengthy answers describing sacrificial protection. These did not gain credit unless reference was also made to air and water.

(ii) Most candidates were able to suggest an acceptable barrier method to prevent rusting. The most popular suggestions were painting and oiling.

(c) Many candidates correctly stated that four electrons are shared in the bond holding the oxygen atoms together. In their reasoning, candidates had to state or imply that each of the bonds in the double bond involves the sharing of a pair of electrons. Many candidates stated that oxygen atoms require two more electrons for a complete outer shell. On its own, this was not quite enough to explain why four electrons are shared.

(d) Stronger candidates answered this question very well. The two essential ideas that candidates needed to explain were that the bonding and/or structure of iron oxide and oxygen are different and that this leads to the attractive forces between particles being stronger in iron oxide. Partial credit was frequently awarded for simply stating that iron oxide is ionic and/or oxygen is covalent. Candidates often omitted to make it clear that the forces involved exist between particles. Answers such as 'iron oxide is ionic and so has stronger forces' was not awarded full credit.

Question 9

(a) Many candidates were familiar with the law of reflection and most met the challenge of stating it in words rather than simply drawing a ray diagram. Some candidates chose to add rays, the normal and the angles of incidence and reflection to the diagram and in most cases, this was enough to gain credit. The most common reason for credit not being awarded was that candidates had not recognised the significance of the term normal and either did not attempt to include the idea or thought that it referred to things such as normal eyesight or normal reflection.

(b) (i) The majority of candidates correctly used Ohm's Law to work through to the final answer. The most common mistakes were evaluating $V \times I$ or inverting the Ohm's Law ratio to calculate $I \div V$.

(ii) The majority of candidates correctly evaluated $V \times I$. The most common mistake was to find the value of $V \div I$.

(iii) Most candidates were awarded full credit for their circuit diagrams. Common reasons for credit being missed included omitting the arrows from the LED symbol, drawing the diagram for a fuse or variable resistor instead of a resistor and including the resistor and/or switch in one or both LED branches. Credit was also missed if extra components such as lamps or cells had been included in the circuit.

COMBINED SCIENCE

Paper 0653/42
Theory (Extended)

Key messages

Candidates who performed well on this paper:

- had prepared thoroughly for this type of examination and were familiar with the required knowledge and definitions of scientific terms shown in the syllabus
- read the questions carefully and used the number of marks for each question as a guide to the detail required in their answers
- ensured that they included working and relationships in questions involving calculations and that this was set out clearly enough for partial credit to be awarded 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. Candidates generally did equally well in the three Science disciplines. In this examination parts of the syllabus that seemed relatively unfamiliar were the meaning of inert in the context of inert electrodes, **2(c)(i)**, that the source of the Sun's energy is nuclear fusion, **6(a)(i)** and the meaning of the term feedstock, **8(e)(ii)**.

Comments on specific questions

Question 1

(a) (i) Almost all the candidates presented the food chain correctly.

(ii) Many candidates gave fully correct answers. There was no particular pattern in the incorrect suggestions, primary and tertiary consumers being as popular as each other, as were trophic levels one and two. The answer of second was not accepted as an alternative for secondary, but third was allowed for the trophic level.

(b) (i) Many candidates completed this calculation and worked through to the correct final answer. Many candidates missed out on some credit because they omitted to correct the answer to one significant figure. The answer 0.70 shows two significant figures and so full credit could not be awarded for this.

(ii) Many stronger candidates had learned the role of lipase and the products of fat digestion. The most common reasons for credit being missed were for suggesting lipids instead of lipase and omitting one of the products of fat digestion, usually glycerol.

(iii) The importance of dietary fibre in helping to prevent constipation was familiar to many candidates. Common incorrect answers referred to carbohydrate, protein and various vitamins.

Question 2

(a) (i) Stronger candidates correctly stated water or H_2O. The most popular answer that did not receive credit was aqueous sodium chloride.

(ii) The best answers used the terms, ions, atoms and molecules correctly. They also described the movement of hydrogen ions to the negative electrode and how hydrogen ions are discharged by

electron gain. Full credit was awarded to those candidates who went on to describe how pairs of hydrogen atoms combined to form hydrogen molecules. The most common reasons for credit not being awarded included careless use of vocabulary e.g. reference to hydrogen atoms or molecules instead of ions, suggesting that hydrogen ions are negative and so move to the positive electrode and omitting to make it clear that two hydrogen atoms bond to form the molecule.

(b) (i) The correct answer, chlorine, was stated by many candidates although a similar number suggested hydrogen. Carbon dioxide and oxygen were also suggested. Candidates had to avoid writing chloride.

(ii) Only the stronger candidates were familiar with the test for chlorine.

(c) (i) Many candidates stated a relevant property of platinum but two were required for credit. The inert nature of platinum was unfamiliar to many candidates. Many correct but irrelevant properties were suggested.

(ii) Most candidates were awarded credit. Some candidates stated the names of individual metals rather than the collective term, transition.

Question 3

(a) (i) Most candidates recognised that the car maintained constant speed. The term constant motion is not an acceptable alternative.

(ii) Stronger candidates correctly located a point clearly on one of the two curved portions of the speed–time graph. Placing **X** on the linear part of the graph between 50 s and 58 s was a common mistake. Candidates are often asked to label a position on a graph and they should be advised to do this very carefully. The clearer answers located the exact position of **X** on the graph using a small labelling line or a dot.

(b) The majority of candidates who could see how to answer this question chose to convert the maximum speed of 25 m / s to 90 km / h. A smaller number showed that 100 km / h converted to 27.8 m / s. Some candidates found this question challenging although many gained partial credit for reading from the graph that the car's maximum speed was 25 m / s.

(c) Many candidates were very familiar with calculations of this type and were awarded full credit. Partial credit was awarded when a candidate made a clear attempt to calculate at least some of the area under the graph between 0 and 25 s.

(d) (i) Focal length was recognised by some candidates. Suggestions that did not gain credit included focus, convergence point and focal distance.

(ii) Many candidates used the relationship *time* = *distance* ÷ *speed* and worked through to the correct final answer. As with all calculations, candidates are advised to show their working. A significant number of candidates were awarded partial credit for stating the relationship or showing that they had attempted to use it.

Question 4

(a) The parts of the leaf and their function were familiar to many candidates who were awarded full credit. For part **A**, the key term was palisade. For part **D**, the idea of gaseous exchange rather than simply allowing material into or out of the stomata was important. For part **C**, candidates needed to avoid suggesting transport of glucose. A common mistake was to identify the phloem cell as **B**.

(b) (i) Full credit was awarded to many candidates who had learned the photosynthesis equation. Those obtaining partial credit usually stated the reactants correctly. Some candidates wrote the word equation but no credit was available for this even if correct.

(ii) Large numbers of candidates were awarded at least partial credit for their explanations. Candidates were also awarded credit for stating that the rate of photosynthesis decreases at temperatures greater than that which gives the maximum rate.

(c) This was answered very well by many candidates. The least familiar of the three terms was the third one, elongation, with the terms growth, division and production often being suggested.

Question 5

(a) Most candidates understood what was required to complete the table and were awarded full credit. Any values lower than 20 °C and 1.0 g / dm^3 were accepted.

(b) The best answers referred to the higher temperature in experiment 2, consequential ideas about particle energy and/or collision frequency and finally ideas involving the activation energy and/or greater numbers of successful collisions. The first two of these key ideas were very frequently stated by candidates. The third point was not so common. Overall, this part of the syllabus had been well-prepared by many candidates.

(c) This question was answered correctly by many candidates. A common mistake was to suggest experiment 4 with the reasoning that the gaseous product has a lower volume and so must be more concentrated. Candidates suggesting this answer might have missed the word acid in the question.

(d) (i) Most candidates realised that the context of this question concerned the reactivity series. It was not quite enough to state that copper is the least reactive metal in the table. The emphasis had to be more focused on the fact that no gas at all is produced. Consequently, answers that were awarded credit included copper does not react with acid, copper is unreactive and copper is less reactive than hydrogen.

(ii) Many candidates selected a suitable metal, usually from Group 1 but sometimes from lower down Group 2. To be awarded credit they had to state or imply that their choice was more reactive than calcium. A common type of answer which could not be awarded credit was sodium because it is an alkali metal or potassium because it is really reactive.

Question 6

(a) (i) The source of the Sun's energy was unfamiliar to most candidates. Nuclear fusion (or detail of the process) was the only answer that gained credit. The answer nuclear was not enough and nuclear fission was not accepted. The large number of incorrect responses included, heat, light, thermal, solar and chemical reactions. Suggestions closer to the answer included it does it itself, from within itself and substances in its core.

(ii) In this case the answer 'nuclear' was accepted along with 'tidal'. The Sun's energy is the driver of waves, wind and rain so these suggestions along with HEP did not gain credit. The use of fossil fuels was often suggested but this also was not accepted.

(b) (i) Candidates had to notice that the temperature of the rocks at the lowest point in the journey taken by the water was higher than its normal boiling point. The best answers referred to this and quoted the normal boiling point as 100 °C. Candidates could also gain credit for stating that the water would turn to gas. Large numbers of candidates suggested that the water would simply get hotter as it descended and then cool down again to 15 °C when it emerged. Some candidates wrote complicated suggestions involving molecular motion and kinetic energy but then omitted to compare 250 °C with the boiling point.

(ii) Many candidates recognised that this calculation involved use of the relationship *pressure = force ÷ area* and candidates of all abilities gained at least partial credit for stating this. Many stronger candidates worked through the calculation to the correct final answer and showed their working clearly. Final answers that would round to 270 000 were accepted. Some candidates missed credit by stating an incorrect unit, usually Pa. Many candidates were challenged by the need to recall the formula for the area of a circle often omitting to square the radius.

(c) (i) It was essential for candidates to state 'gravitational potential energy' rather than leave it as 'potential energy'. Many different incorrect responses were suggested including kinetic, geothermal and water energy.

(ii) The use of the relationship *GPE* = *mass* × *height* × *g* was very familiar and large numbers of candidates worked through to the correct final answer. The only common mistake of note was to divide the mass by *g*.

Question 7

(a (i) The only answer accepted was diffusion and many candidates were awarded credit. Common mistakes included gas exchange, osmosis and respiration.

(ii) Many candidates were familiar with the features of a gas exchange surface and gained full credit. The most popular choices were thin walls and large surface area. Suggestions that did not gain credit included semi-permeable and good blood supply as the latter was stated in the question.

(b) Full credit was frequently awarded to candidates who had learned the role of goblet cells in producing mucus which then traps pathogens and particles. Common mistakes included discussing cilia and their role in protecting the lungs, or to suggest that goblet cells filter out particles without mentioning mucus.

(c) COPD was known by some candidates. Other conditions such as emphysema and bronchitis were accepted but asthma was not. Some candidates suggested cancer even though it is given in the question. Many candidates suggested heart disease, mainly CHD, even though the question clearly directs candidates towards diseases of the lungs.

Question 8

(a) The correct answers, decane and pentane, were popular choices. The most common error was the selection of the two alkenes. Candidates had to make it clear that alkanes contain only single bonds between carbon atoms, and so suggesting that they contain single bonds was not enough.

(b) In this syllabus no distinction is made between catalytic and thermal cracking and so high temperature, high pressure and use of a catalysts were all accepted in any combination. Many candidates were familiar with these conditions. Candidates less familiar with the meaning of the term conditions tended to suggest answers which included a large alkane molecule. Candidates needed to state high temperature rather than simply temperature and the unqualified term heat although high heat was accepted. Phrases such as ‘a suitable temperature’ are not sufficient.

(c) Most candidates stated that bonds break during cracking. Some also went on to state that double bonds are formed. Some candidates stated that the process produces alkanes and alkenes, but without details of the bonding changes, the credit was not awarded.

(d) Candidates needed to recognise that this question concerned fractional distillation and so their answer simply had to focus on the different boiling points of the two alkanes. Some correct science was often suggested, for example, pentane is C_5H_{12} but decane is $C_{10}H_{22}$, or pentane has smaller molecules than decane, but a direct reference to boiling point was required to answer the question.

(e) (i) Most candidates had learned a use of refinery gas, usually selecting the uses in the syllabus.

(ii) The majority of candidates were unfamiliar with the term feedstock in the context of this question. The most common suggestion was that it referred to animal food.

Question 9

(a) (i) Most candidates used Ohm’s Law to work through to the correct final answer. Partial credit was awarded for a correct statement of Ohm’s Law or a correct step in the calculation. Candidates should be advised to show working even if they consider the calculation to be a simple one. Most of the incorrect answers arose from the use of an incorrect rearrangement of Ohm’s Law.

(ii) Stronger candidates drew the correct circuit symbol for a voltmeter and correctly located it in parallel with the battery only. Candidates should be advised to use the circuit symbols exactly as shown in the syllabus. A voltmeter symbol with the connecting wire drawn through the middle of the symbol is not accepted. The most common mistakes included locating the voltmeter in parallel with components other than the battery or inserting the voltmeter in series.

(b) Most candidates found it challenging to explain fully what was happening in this circuit. Many gained partial credit for stating that the increased length of the bell wire would increase its resistance. Some of these candidates were awarded credit for stating that the consequence of the increased resistance would be reduced current through the bell. Explaining why the lamp would not be affected was the most challenging part and the simplest way of doing this was to emphasise that the current is only decreased through the bell. Some candidates suggested that in a parallel circuit when one component fails the other still works, but this does not quite answer the question.

COMBINED SCIENCE

Paper 0653/43
Theory (Extended)

Key messages

Candidates who performed well on this paper:

- had prepared thoroughly for this type of examination and were familiar with the required knowledge and definitions of scientific terms shown in the syllabus
- read the questions carefully and used the number of marks for each question as a guide to the detail required in their answers
- ensured that they included working and relationships in questions involving calculations and that this was set out clearly enough for partial credit to be awarded even if the final answer was incorrect.

General comments

Candidates often showed that they understood many sections of the syllabus and were familiar with the examination techniques required for success. The performance in the three Science disciplines was generally similar. Questions that used unfamiliar contexts, such as **9(a)(ii)**, presented the greatest challenges to candidates, and practice in these kinds of questions is recommended.

The following areas of the syllabus were the least well known:

- characteristics of human egg cells, **1(b)**
- electrolysis, **2**
- interpreting data, for example **4(a)(ii)**
- interpreting an energy level diagram, **5(b)(i**)
- reasons for the choice of a particular fuse rating, **6(d)**
- definition of coronary heart disease, **7(b)(i)**
- hydrocarbon Chemistry and intermolecular forces, **8**
- description of compression and rarefaction in terms of particles, **9(a)(i)**.

Comments on specific questions

Question 1

(a) Many candidates recognised some of the parts of the male reproductive system and gained at least partial credit. The most common mistakes included omitting that the scrotum holds the testes outside of the body, suggesting that the testes created semen rather than sperm and identifying the urethra as **A** rather than **C**. Penis was allowed as an alternative for urethra and the idea of controlling the temperature of the testes was accepted for holding the testes outside the body.

(b) Some candidates knew that fertilisation involves the fusion of nuclei but the jelly coating surrounding egg cells was generally unfamiliar. Common mistakes included suggesting gametes, chromosomes, DNA and sex cells or simply cells for nuclei. A very wide range of incorrect suggestions for jelly coating were seen and many candidates did not suggest any answer.

(c) Many candidates knew that the placenta allowed nutrients to pass to the fetus and allowed waste products to pass from the fetus to the mother. Answers that suggested or implied that the mother's blood passed to the fetus did not gain credit. Many candidates wrote answers that described the function of amniotic fluid and its role in protecting the fetus. At this level, simple ideas such as to feed the baby are not accepted.

Question 2

(a) (i) Most candidates found this a demanding question but many gained at least partial credit. The stronger candidates recognised hydroxide and used the terms ion and molecule correctly, avoiding terms such as hydroxide atoms. The appearance of the term $4e^-$ on the right-hand side of the electrode equation was difficult for some candidates who did not appear to associate this with the idea that the hydroxide ions had lost these electrons. Many candidates gained credit for stating that oxygen was produced.

(ii) The general form of electrode equations was unfamiliar to many candidates. Many candidates attempted to include particles derived from dilute sulfuric acid in the equation.

(b) Many candidates were familiar with the term electrolyte but could not describe the meaning other than to state that it is the liquid used in electrolysis. Many candidates were awarded partial credit for the idea that the electrolyte contains a compound that is split up or that the electrolyte contains ions.

(c) Several correct possibilities were suggested including sodium chloride, hydrochloric acid and other soluble metal chloride salts. Hydrogen chloride was not accepted.

Question 3

(a) (i) Most candidates correctly stated the speed of the ball to be 25 m / s.

(ii) A small number of stronger candidates understood that **X** should be located on the graph between time = 0 s and time = 0.3 s. Of those candidates attempting this question the majority placed **X** anywhere in the range time = 2.8 s and time = 5.0 s, with most opting for 2.8 s.

(iii) This question was answered well and many candidates were awarded full credit. The idea that gravity would act to slow the ball was familiar and many candidates realised that air resistance would also cause deceleration.

(b) (i) Most candidates realised that they needed to calculate the weight of the ball and were very familiar with how to do this.

(ii) Candidates generally found it difficult to give an explanation. Any reasonable reference to the idea that motion would mean that the forces in part **(b)(i)** would not be balanced or that there would be other unknown forces acting, were awarded credit.

(c) Candidates needed to show clear working so that at least partial credit could be awarded for correct steps in the calculation. Candidates needed to show that they knew the relationship between density, mass and volume either by stating the formula or by showing in their working that they had used the formula. Candidates needed to convert the mass to kilograms and the volume to cubic metres before substituting these values into the formula. Partial credit could be awarded if the only mistake was in one of the unit conversions.

Question 4

(a) (i) This question was answered well by most candidates.

(ii) Some candidates knew that the root hair cell is adapted by having a large surface area. Stronger candidates could relate this to increased absorption of water and/or mineral ions. The more general term ‘nutrients’ was not accepted as an alternative, neither was the unqualified phrase ‘to absorb water’. One common mistake was to suggest that the root hairs, being long and thin, could penetrate the soil to a greater distance.

(iii) The process of photosynthesis was familiar to many candidates who gained full credit for discussing the presence of chloroplasts, chlorophyll and the trapping of light energy. Many candidates added extra detail which was not required to answer this question. A significant number of candidates seemed to be unfamiliar with photosynthesis.

(b) (i) Candidates usually selected the correct data from the table but only the stronger candidates correctly calculated the percentage increase. The most common mistake was to evaluate (170 ÷ 54) × 100.

(ii) Candidates had to avoid answers which discussed the reverse argument for one or both conditions of temperature and humidity. Between 14:00 and 18:00 the temperature decreases and the humidity increases. Candidates had to state that both changes in conditions causes the rate of transpiration to decrease. Answers that stated when the temperature increases the rate of transpiration increases were not accepted in this case. Credit could also be gained for discussion of reasons why the rate of transpiration changes but only a very small number of candidates attempted to do this.

Question 5

(a) Candidates who gained full credit stated the names of the two substances as required and avoided stating the chemical formulae. Aqueous ammonium nitrate was not accepted as the solvent. One common mistake was to suggest ammonium as the solute and nitrate as the solvent.

(b) (i) Stronger candidates understood that the word 'overall' in the question referred to the relative energy levels before and after the ammonium nitrate dissolved. Many candidates attempted to describe the changes in energy as the process proceeded over the energy barrier. Partial credit was awarded to candidates who stated that the process of dissolving ammonium nitrate is endothermic. It was less common to see this explained in terms of the relative energies before and after dissolving.

(ii) Some of the stronger candidates were awarded partial credit for stating that bonds break during energy change **A**, and that bonds form during energy change **B**. Full credit was awarded to a small number who also correctly identified **A** and **B** as either exothermic or endothermic processes. The suggestion that bonds weaken rather than break during **A** was not accepted.

(c) This was well answered and many candidates were awarded full credit.

Question 6

(a) Most of the stronger candidates recognised that the lighting unit was connected in parallel with only a relatively small number suggesting series. A significant number of candidates appeared to be unfamiliar with this part of the syllabus.

(b) Some stronger candidates correctly stated kinetic. A common mistake was to suggest the idea of wind or moving air energy.

(c) (i) Candidates needed to show that they had used the relationship *current* = *power* ÷ *voltage* usually by simply stating 11 W ÷ 12 V .

(ii) Some of the stronger candidates realised that they had to calculate the total power rating available (12 V × 8 A = 96 W) and then subtract the power rating of the lighting unit to find the rating of the fan. Partial credit was awarded to candidates getting as far as 96 W.

(d) Only a very small number of candidates found an acceptable way of explaining the action of the fuse in this circuit. Some understood the general principle of how fuses work but their descriptions did not answer this question.

(e) Some candidates correctly located the components in the circuit diagram but only a relatively small number were familiar with the circuit symbol for a fuse. Most candidates were awarded credit for showing the two lamp symbols in series.

Question 7

(a) (i) Many candidates correctly located an atrium.

(ii) Many candidates were familiar with the problems caused by a hole in the septum. The most popular answer that gained credit was the mixing of oxygenated and deoxygenated blood. Consequences of blood mixing were not so well known and so only stronger candidates gained full

credit. Some candidates who understood some of the consequences of the mixing of blood suggested answers such as 'so no oxygen can get to the body' which was not accepted.

(b) (i) Candidates had to specify that it is the coronary arteries that becomes blocked causing CHD. Simply referring to blockage of arteries or blood vessels was insufficient.

(ii) There was a long list of acceptable risk factors for CHD and many candidates were awarded full credit. One suggestion that did not attract credit was the vague idea of poor diet.

(c) It is always important when defining respiration that candidates avoid confusing this process with breathing. Stronger candidates were able to describe aerobic respiration and either stated or implied that it is a reaction involving oxygen which releases energy. Some candidates were awarded credit for describing the reactants and products of aerobic respiration. It was important that candidates avoided the suggestion that respiration 'creates' energy in the body.

Question 8

(a) Candidates who recognised the aqueous bromine test for alkenes had no difficulty in identifying ethene and butene and could explain their choices. Some candidates identified the two alkanes and others appeared to guess, often suggesting one of the alkenes and one of the alkanes.

(b) Some candidates were familiar with the products of complete combustion of alkanes and were awarded full credit. A large number made no mention of either water or carbon dioxide and instead suggested particular hydrocarbons.

(c) Some candidates recognised butane and decane as alkanes. Only stronger candidates seemed familiar with the meaning of homologous series and many others could not suggest an answer.

(d) Some of the popular answers that were awarded credit included the idea that cracking was not reversible and the general ideas that molecules or chemical bonds are broken down or that new bonds are formed. The suggestion that cracking involves a chemical reaction is a repetition of information in the question and so cannot be awarded credit. Different ways of expressing the same idea, such as new products are formed and molecules are changed were awarded partial credit.

(e) (i) Stronger candidates were able to explain the difference in boiling point in terms of the difference in intermolecular forces. Answers such as butane has lower attractive forces between molecules or the reverse argument that the forces in decane are greater were awarded credit. Answers that were true but irrelevant such as butane has smaller molecules could not be awarded credit without reference to weaker intermolecular forces.

(ii) The best answer here was that propane and butane have similar boiling points. Many candidates suggested that they have the 'same' boiling point but this was not accepted. Suggestions that could not be rewarded included they are in the same homologous series, they are both hydrocarbons and references to melting points.

Question 9

(a) (i) Some stronger candidates understood how to answer the question and many of these gained full credit. Although the question points candidates towards an answer in terms of particle separation many made no attempt to do this. Many candidates interpreted the graphical representation of the sound wave in terms of pitch, volume and frequency. Some candidates attempted to describe the graph in terms of the separation of peaks and troughs without reference to particles.

(ii) Some of the strongest candidates realised that the ear defenders caused the transfer of sound energy into other forms of energy, but only the idea of transformation into heat or thermal energy could be accepted.

(b) A relatively small number of candidates were awarded full credit. Popular answers referred to light having higher frequencies, shorter wavelengths and not requiring a medium. Despite being guided away from discussing relative speed some still offered this in their answer. One common misconception was that sound waves cannot be reflected. Many suggested that light waves cannot be heard and sound waves cannot be seen.

(c) Stronger candidates were familiar with the relationship *wave speed* = *frequency* × *wavelength* and could work through to the correct final answer. An independent mark was awarded for the correct unit, expressed as either hertz or Hz, but not hz or HZ. Candidates should be encouraged to express answers using standard form.

COMBINED SCIENCE

Paper 0653/51
Practical Test

Key messages

Candidates should ensure that they read the questions carefully before starting to answer. This is particularly important for any planning exercise that is required. Identification of the dependent and independent variables is vital before a plan is completed. Controlled variables must also be considered and included in a plan. It is also important that candidates take care to investigate the relationship in the question. Some plans investigated other variables, for example, the boiling point.

In all questions, candidates need to take care with measuring and reading from scales, including those on graphs, to an appropriate precision. When selecting scales for graphs, candidates need to ensure they are using as much of the grid as possible and they know what each division of the scale represents.

General comments

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

A pencil, rubber and ruler are essential for any practical exam. There was evidence that some candidates did not have these and therefore were unable to correct errors.

Comments on specific questions

Question 1

(a) (i) Candidates demonstrated they could use a syringe with the reading nearly always in line with the Supervisor's value.

(ii) Candidates were usually able to get readings for all the concentrations required and in the correct pattern. The most common error was not recording all their readings to one decimal place.

(iii) Candidates were generally able to calculate the correct volume of iodine solution added.

(iv) Graph skills were generally good. Most graphs were drawn with labelled axes and care was taken to plot points precisely using crosses. Most candidates were therefore awarded at least partial credit for their graph. Common errors included:

- Omission of labels or units from axes. Labels on graph axes should include the same wording as the headings used in the table. In this case, the headings in the table are 'volume of iodine solution added / cm^3' and 'percentage concentration of vitamin C'.
- Inverting the axes so that they are the wrong way around.
- Choosing inappropriate scales. Scales should be chosen so that points occupy at least half of the grid. The size of the grid printed on the question paper is chosen to make this as straightforward as possible. The scales must be linear (it is assumed that the origin is (0, 0) if not labelled and should show values in ascending order. Many candidates reversed the *x*-axis scale, causing it to be non-linear (i.e. showing the scale as 0.00, 1.00, 0.75, 0.50, 0.25).
- Some scales chosen are not appropriate because they are difficult to read. Scales should increase in standard intervals such as 0.1 or 0.2. Candidates do not have to use the actual concentrations used in the practical as the intervals labelled on the graph but should consider the largest number required for each axis and then divide the scale appropriately. Those who

used intervals of 0.25 rather than 0.20 found plotting the graph and reading off a value much more difficult and mistakes were often made. The size of the grid provided was designed to accommodate intervals of 0.20.

- Points need to be drawn precisely using small crosses or dots in circles. Large blobs are not accepted as it is impossible to judge exactly where the centre of the plot has been placed.

(v) Some candidates drew a suitable line of best fit with a fine line. However, there were frequent errors in the line of best fit. These included:

- joining values 'dot-to-dot', either using a ruler or freehand
- attempting to force the line through the origin
- the line not being equidistant from each point.

(vi) and **(vii)** Candidates were generally able to record both volumes for the fruit juice and then correctly estimate its concentration using their graph.

(b) (i) The strongest responses referred to repeated readings being used to check the quality of results by looking for and excluding any anomalous results. It should be noted that answers such as 'to prevent anomalous readings' are not accepted. Repeating alone does not prevent anomalous readings from occurring, but it allows them to be identified and excluded.

(ii) Many candidates correctly stated that more values of concentration should be tested. The idea of using different measuring apparatus, for example a burette, was not accepted. This may improve the precision of the readings but does not improve the confidence in the estimate.

Question 2

(a) Candidates demonstrated they could carry out the procedure but often omitted all the detail needed to be awarded full credit. In relation to filtration, the description of the residue should include 'solid' and filtrate should include 'solution'. These were often omitted. The filtrate should be colourless, many candidates described it as clear. Candidates need to know the difference between clear and colourless. An easy example to use is copper sulfate solution, which can be described as clear because it is see-through but it is blue and is therefore not colourless.

(b) The key word expected is dissolve. It also needed to be in respect to the salt, which the question described as soluble, and not the sand, which is insoluble. **'**Dissolve the fertiliser' was not accepted as there is an insoluble component to the fertiliser.

(c) (i) and **(ii)** The strongest candidates observed a lilac flame and correctly identified potassium.

(d) (i) and **(ii)** Candidates are expected to use the standard terminology which is in the notes for use in qualitative analysis at the end of the question paper. Descriptions such as 'cloudy' or 'milky' were not creditworthy. Some candidates observed a white precipitate and correctly identified sulfate.

Question 3

Many candidates find the planning question demanding. Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for a low mark is that the response addresses some, but not all, of the bullet points. For full credit it is essential that at least one mark is awarded against each of the bullet points.

Credit can be awarded from a table with correct headings and in this case, some examples of different masses of salt. There is a space before the answer lines for a table, diagram or sketch graph. Most candidates left this area blank but then tried to squeeze them in at the end.

In this question, the apparatus is shown set-up. It is not necessary to describe this set-up in the answer. Doing so wastes time and space and often results in candidates failing to address the rest of the method fully.

Most candidates addressed the first bullet point well, usually suggesting that a balance and thermometer are needed. Candidates often state what they are measuring in their method but omit to name the piece of apparatus.

Candidates are generally skilled at selecting variables to control. However, they should note that controlling the 'amount' of a substance is not sufficient. They need to state whether they will do this by using a constant volume (for liquids) or mass (for solids). In this question, it was important that candidates identified that a constant mass of cetyl alcohol was used in each experiment. It was common for candidates to state that a fixed volume of cetyl alcohol would be used, despite the question stating that the alcohol is a solid.

Method marks could be earned in this question by varying the mass of salt added to the cetyl alcohol. Stating clearly that the mass is measured was a further mark. It was common to see answers which discussed 'varying the mass of salt' without ever clearly stating that the salt needed to be added to the cetyl alcohol.

As 'melting point' is in the question, credit was not awarded for stating 'measure the melting point'. In planning questions, it is essential that candidate state clearly how the dependent variable will be measured in practice. An ideal method to measure melting point is to heat the mixture of the solids in the water-bath until completely liquid and then allow it to cool, noting the temperature at which solid first appears to form. It is almost impossible to record a sharp melting point by heating a solid and recording when it turns to a liquid, as this is difficult to see when it first happens. However, as this method may be unfamiliar to candidates, the temperature at which solid changes to liquid was accepted.

In order to record the melting point, candidates needed to identify and describe the state change they were observing. 'The temperature when the cetyl alcohol melts' does not describe how the candidate can judge when to take the reading. The strongest responses clearly stated 'when solid alcohol turns to a liquid'.

The processing of results is always challenging in planning questions. The best responses stated clearly that at the end of the experiment it is necessary to draw a graph which identified the dependent variable (melting point) as the *x*-axis value, and the independent variable (mass of salt) as the *y*-axis value.

Question 4

(a) (i), **(ii)** and **(iii)** Candidates demonstrated that they were able to read a voltmeter and an ammeter and then use these values to calculate the resistance of the lamp.

(b) (i), **(ii)** and **(iii)** Candidates were generally able to add a lamp to the circuit in series with lamp **L**, obtain new voltage and current readings and calculate the combined resistance. A common error was to state the units for current as *I*.

(c) (i) Stronger candidates were able to complete the parallel circuit diagram with the correct symbols that had already been used in Fig. 4.1 and Fig. 4.2. Common errors included:

- Using incorrect symbols, such as the letters **L** and **M** in circles to represent the lamps.
- Drawing circuits with significant gaps.
- Drawing the circuit with lamps **L** and **M** in series.
- Drawing correct symbols but with lines through them.

(ii) and **(iii)** Stronger candidates were able to obtain readings in the expected range and calculate the combined resistance.

(d) The strongest responses identified that opening the switch saves electrical energy or prevents overheating in the circuit.

(e) This question asks candidates to evaluate a prediction about resistance. Most responses referred to the raw difference between the two resistance values rather than the difference between double the resistance of lamp **L** and the combined resistance of **L** and **M**. The value of double the resistance of lamp **L** needed to be stated and then compared to the value of the combined resistance of **L** and **M** to clearly show if the two values are, or are not, within 10% of each other.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

Candidates should ensure that they read the questions carefully before starting to answer. This is particularly important for any planning exercise that is required. Identification of the dependent and independent variables is vital before a plan is completed. Controlled variables must also be considered and included in a plan. It is also important that candidates take care to investigate the relationship in the question. Some plans investigated other variables.

In all questions, candidates need to take care with measuring and reading from scales, including those on graphs, to an appropriate precision. When selecting scales for graphs, candidates need to ensure they are using as much of the grid as possible and that they know what each division of the scale represents.

General comments

A pencil, rubber and ruler are essential for any practical exam. There was evidence that some candidates did not have these and therefore were unable to correct errors, particularly for the drawing in **Question 1** and plotting the graph and drawing the line of best fit in **Question 4**.

Comments on specific questions

Question 1

(a) Most candidates were awarded at least partial credit on this question. The most common errors were drawing a diagram that took up less than half the available space, drawing an outline that was not one single continuous line or shading the diagram rather than leaving it as a line drawing.

Some candidates had difficulty drawing the shape. The correct pentagon/hexagon shape was drawn by many, but some candidates drew an okra that was more like a star, so it did not accurately represent a slice of okra.

(b) (i) Most candidates successfully measured the diameter of the okra. A small number of candidates gave their answer in centimetres and were not awarded credit as the question specified the diameter in millimetres.

(ii) Many candidates got the general idea, but they could not always express it in a clear enough way. The best explanations were in relation to the sides being different lengths or that the diameter varied because it was a pentagon/hexagon or not a circular shape.

(iii) Most candidates correctly measured the diameter of their drawing. Some candidates did not draw the line on their diagrams, so it was not possible to confirm the measurements as it was not clear which parts of the diagram were being measured. Again, some candidates measured the diameter in centimetres rather than in millimetres.

(iv) This question was well answered by most candidates who successfully calculated the magnification. Some candidates tried to do the division with the measurements inverted and so ended up with a magnification that was less than 1 despite having a large diagram.

Question 2

Many candidates find the planning question demanding. Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for low credit is that the response addresses some, but not all, of the bullet points. For full credit it is essential that at least one mark is awarded against each of the bullet points.

Marks can be awarded from a table with correct headings and in this case, some examples of different temperatures to use. There is a space before the answer lines for a table, diagram or sketch graph. Most candidates left this area blank but then tried to squeeze them in at the end.

It appeared that candidates were unfamiliar with the experiment involving amylase breaking down starch at different temperatures. There were many responses about testing leaves or doing various types of food test. Candidates who were familiar with the experiment often did not get the idea of removing samples from the mixture and instead added iodine to the amylase-starch mixture and assumed that the colour would turn from blue-black to orange-brown once all the starch had been broken down.

Most candidates got the idea that time had to be measured and correctly stated that a stop-watch, stop-clock or timer would be needed. Very few suggested measuring volumes using a syringe or measuring cylinder. Candidates often state what they are measuring in their method but then omit to name the piece of apparatus. The use of a water-bath was rarely suggested, but most candidates did use a thermometer and were given credit for this in the apparatus section.

In the method section, many candidates suggested mixing starch and amylase but did not mention starting the timer right away and instead there was a suggestion or implication of a time delay (in which time the reaction would have started before they began timing). Most candidates suggested using different temperatures, with a large number of candidates suggesting at least five.

Safety precautions tended to be vague and did not specifically reference the chemicals/situation in the experiment and so were not awarded credit. Answers about acid or non-specific ‘chemicals’ going into the eye were insufficient. Similarly, answers about the apparatus being hot were insufficient as candidates need to make it clear how they would avoid injury. The use of (rubber) gloves was common but this was an inappropriate safety precaution as none of the chemicals would have caused damage to skin. Safety precautions should be specific to this experiment rather than general safety precautions.

Candidates found obtaining marks in the measurement section challenging because the details of what they were measuring were often too vague. For example, candidates often tried to measure the time until the starch had broken down. Few gave detail about how they knew the starch would have broken down, i.e. time until the sample stayed orange-brown or did not turn blue-black. It was common to see candidates measuring the amount of amylase or the amount of starch. This was insufficient as it needs to be volume rather than amount.

In the control variable section, candidates were not awarded credit for using the same amount of amylase or starch, as again, volume must be stated. Some candidates did state to keep the concentration of amylase or starch constant. Some answers vaguely suggested keeping the concentration of ‘the chemicals’ constant, but this was insufficient.

Many candidates gained credit for processing results and the most common way of doing this was to sketch the graph axes with the correct labels or to describe taking averages of repeated results at the same temperature. It was not sufficient to repeat the whole experiment and find the average because it needed to be clear that candidates were repeating the same temperatures and finding the average of those temperatures rather than the average overall temperature for the experiment.

Question 3

(a) (i) Candidates were able to record a mass for the empty test-tube and a higher mass for the test-tube with solid **H** before heating. The most common error was not having both masses to the same number of decimal places.

(ii) Supervisor results showed that the expected colour change to yellow was observed when heating but many candidates failed to state this.

(iii) Most candidates were able to record a mass for the cooled test-tube that was in the correct range.

(iv) Candidates who had observed the colour change in **(ii)** generally observed the correct colour change on cooling, either going back to white or a paler yellow. In this scenario candidates need to specify the colour. Responses such as 'returned to original' are insufficient.

(v) and **(vi)** Candidates were usually able to correctly calculate the mass of the solid **H** before and after heating.

(vii) Few candidates described a gas being produced and escaping from the test-tube. Many candidates gave incorrect answers that did not imply that a reaction had taken place, for example describing changes of state such as evaporating, subliming or boiling.

(viii) Stronger candidates correctly calculated the final percentage loss in mass to two significant figures. Many gave correct calculations using the wrong numbers or answers that were left to one decimal place rather than the two significant figures as requested by the question.

(ix) Few candidates recognised that the longer heating time was to ensure the reaction was complete and all the gas had been given off. Common incorrect answers included vague references to accuracy or the result being clearer.

(x) Stronger candidates made a correct statement about either the temperature of the flame or the idea that a yellow flame would obscure the colour. Many answers were insufficient, such as the flame being faster to heat the solid or that the flame was stronger.

(b) Most candidates were able to describe bubbling or fizzing. The most common incorrect answer was that a gas is given off. This is not an observation but a conclusion based on the observation of bubbles or fizzing.

Question 4

(a) (i) and **(ii)** Candidates were generally able to get a set of readings for all the distances required and with the correct pattern. The most common error was not having all the data recorded to the nearest 0.1 cm.

(iii) Candidates demonstrated they were able to correctly perform the calculation and record their answer in the table.

(iv) Most candidates were able to add the correct unit to the table heading.

(b) (i) Many candidates gained some credit for the graph axes and plots. To improve graphical skills in the future, these points should be noted:

- Labels on graph axes should include the same wording as the headings used in the table. It was common for candidates to omit the units from the table when labelling their axes. These incomplete labels were not awarded credit.
- Candidates should carefully consider their chosen scales. The scales must be linear if not labelled and should show values in ascending order. Some candidates used non-linear scales. One common error was to see the values for *D* just copied from the table and having 65, 70, 75, 85 and 95 equally spaced on the horizontal axis. Some candidates started their axes at (0, 0) despite the instruction in the question.
- Scales chosen should allow plotted points to cover at least half the grid in both directions. Some candidates tried to extend their graphs beyond the edges of the grid.
- Plotted points should be drawn using a small cross or a dot in a circle. Large blobs are not accepted as it is impossible to judge exactly where the centre of the plot has been placed.

(ii) The line of best fit was challenging for many candidates. In this case, the relationship was expected to be a straight line, so it is important that candidates draw this line with a ruler and a sharp pencil. Answers using pen are not penalised but if a candidate makes a mistake, it is impossible for them to redraw an improved line. Common errors included forcing the line through the origin or joining the first and the last points. Where points do not occur directly on a perfect straight line, lines of best fit should take into account all of the points (where there are no anomalous results) so that there is an even spread of points on each side of the line.

(c) Some candidates calculated *F* correctly but very few showed how they arrived at this value by drawing a triangle on their graph line. Many of those who drew the triangle had used data from less than half the length of the line (too small a triangle), which was also not creditworthy.

(d) (i) Candidates did not seem familiar with the concept behind this question. Some repeated the information given in the question by saying that it was more accurate to use the line rather than individual points, whilst others referred to the idea of stopping anomalous results from happening in the first place rather than it being easy to spot them after they had happened. Other responses were insufficient because they phrased their answers in terms of using all of the values or using more than one value but did not explain why this would be more accurate than using one.

(ii) Candidates found this demanding. It was clear that many had appreciated it was difficult to see the image clearly in an illuminated room as the most commonly accepted answer was to use a darkened room.

COMBINED SCIENCE

Paper 0653/61
Alternative to Practical

Key messages

Candidates need to look at the guidance for drawing graphs given in the syllabus. Many candidates did not label axes appropriately or choose appropriate scales.

Data should be recorded to the degree of precision expected in the question. For some questions the precision is given in the question (for example **Question 2 (a)** 'Record to two decimal places'). In other cases, candidates are expected to record values consistently with other readings already given in the question. For example, all values in Table 1.1 are to one decimal place. Readings that are not given to the correct number of decimal places are marked as incorrect. Further, candidates need to realise that the decimal place may be zero, for example the answer 5.0 for **Question 1(a)(v)**.

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.

Mathematical processing was a strength. Many candidates earned almost full credit in questions that asked for processing of data or substitution into formulae and subsequent calculation of values.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly read the syringe and identified that the interval between the divisions on the scale was 0.2 cm^3. A few incorrectly gave the reading as 8.2 or 8.6 cm^3.

(ii) Almost all candidates correctly subtracted the values. An error carried forward was allowed from an incorrect answer to **(a)(i)**.

(iii) Many candidates gained partial credit for the graph axes and plots. However, to improve graphical skills in the future, the following points should be noted:

- Labels on graph axes should include the same wording as the headings used in the table. In this case, the headings in the table are 'volume of iodine solution added / cm^3' and 'percentage concentration of vitamin C'. Many candidates did not label their graph axes fully. Common omissions were to omit the units from the *y*-axis or to give incomplete labels such as 'volume' or 'concentration' alone. These incomplete answers were not awarded credit.
- Candidates should carefully consider their chosen scales. The scales must be linear (it is assumed that the origin is (0, 0) if not labelled) and should show values in ascending order. Many candidates reversed the *x*-axis scale, causing it to be non-linear (i.e. showing the scale as 0.00, 1.00, 0.75, 0.50, 0.25).
- Scales chosen should allow plotted points to cover at least half the grid in both directions.
- Plotted points should be drawn using a small cross or a dot in a circle. Large blobs are not accepted as it is impossible to judge exactly where the centre of the plot has been placed.

(iv) Credit for the line of best fit was not always given. In this case, the relationship was a straight line, so it is important that candidates draw this line with a ruler and a sharp pencil. Answers using pen are not penalised but if a candidate makes a mistake, it is impossible for them to redraw an

improved line. Common errors included drawing the line through the origin or joining the bottom and the top point. In both cases this was not the relationship shown by the spread of points. Where points do not occur directly on a line, the line of best fit should take into account all points (where there are no anomalous results, as in this case) so that there is an even spread of points on each side of the line.

(v) Many candidates did not consider the degree of precision shown in the table. The syringe may be read to one decimal place. The correct values were 5.0, 5.0 (cm^3). Many candidates gave 5, 5. This was not accepted.

(vi) This question was well answered. Most candidates correctly read the value from their graph.

(vii) Most candidates recognised that the same syringe should not be used as contamination will occur. Some did not read Step 1 and Step 7 carefully, however, leading them to suggest that contamination of 'iodine' would result. In Step 1 and Step 7 only vitamin C was in the syringe, so any answer that implied contamination with other substances was not accepted.

(b) (i) The strongest responses referred to repeated readings being used to check the quality of results by looking for and excluding any anomalous results. It should be noted that answers such as 'to prevent anomalous readings' are not accepted. Repeating alone does not prevent anomalous readings from occurring, it allows them to be identified and excluded.

(ii) Many candidates correctly stated that more values of concentration should be tested. The idea of using different measuring apparatus, for example a burette, was not accepted. This may improve the precision of the readings but does not improve the confidence in the estimate.

(c) Many knew that biuret reagent is used to test for proteins and most also knew the correct colour for a positive result. The spelling of biuret was often incorrect but phonetically correct answers were accepted. Some incorrect reagents were seen, including iodine and Benedict's reagent.

Question 2

(a) Almost all candidates correctly recorded the mass to two decimal places.

(b) (i) Almost all candidates used the values and subtracted correctly to give the mass of sand. An error carried forward from **(a)** was allowed.

(ii) Most candidates correctly used their values to correctly calculate the percentage of sand.

(c) Many correctly stated that stirring was used to ensure that all the salt dissolved. However, some common errors were seen. These included:

- Some candidates incorrectly stated that stirring dissolved 'the fertiliser'. This is incorrect. All of the fertiliser is not soluble.
- Some stated that stirring 'ensures an even temperature'. That is not relevant to this procedure.
- A common error was to state that stirring 'ensures everything is mixed'. This response is too vague and was not awarded credit.

(d) The main reason the sand is washed is to ensure that all the salt has been removed and that it enters the filtrate. Many candidates gave vague references based on the idea of washing such as 'to make sure it is clean' or 'to remove impurities'. These answers are insufficient.

(e) Some candidates correctly identified potassium, but all answers were chosen with a similar frequency, implying that some candidates selected an answer at random.

(f) Some knew that aqueous barium nitrate shows that a solution contains sulfate ions, but many incorrectly identified 'nitrate' as the anion.

Question 3

When answering the planning question, the best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for low 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 a mark is awarded against each of the bullet points.

In this question, an apparatus is shown set-up. It is not necessary to describe this set-up in the answer. Doing so wastes time and space and often results in candidates failing to address the rest of the method fully.

Most candidates addressed the first bullet point well, usually suggesting that a balance and thermometer are needed.

Candidates are generally skilled when selecting variables to control. However, they should note that controlling the 'amount' of a substance is not sufficient. They need to state whether they will do this by using a constant volume (for liquids) or mass (for solids). In this question, it was important that candidates identified that a constant mass of cetyl alcohol was used in each experiment. It was relatively common for candidates to state that a fixed 'volume' of cetyl alcohol would be used, despite the question stating that the alcohol is, in this case, a solid.

Method marks could be earned in this question by varying the mass of salt added to the cetyl alcohol. Stating clearly that the mass is measured was a further mark. It was common to see answers which discussed 'varying the mass of salt' without ever clearly stating that the salt needed to be added to the cetyl alcohol.

As 'melting point' is in the question, marks were not awarded for stating 'measure the melting point'. In planning questions, it is essential that candidates state clearly how the dependent variable will be measured in practice. An ideal method to measure melting point is to heat the mixture of the solids in the water-bath until completely liquid and then allow it to cool, noting the temperature at which solid first appears to form. It is almost impossible to record a sharp melting point by heating a solid and recording when it turns to a liquid, as this is difficult to see when it first happens. However, as this method may be unfamiliar to candidates, the temperature at which solid changes to liquid was accepted.

To record the melting point, candidates needed to identify and describe the state change they were observing. 'The temperature when the cetyl alcohol melts' does not describe how the candidate can judge when to take the reading. The strongest responses clearly stated, 'when solid alcohol turns to a liquid'.

The processing of results is always challenging in planning questions. The best responses stated clearly that at the end of the experiment it is necessary to draw a graph which identified the dependent variable (melting point) as the *x*-axis value, and the independent variable (mass of salt) as the *y*-axis value.

Question 4

(a) (i) Most candidates read the voltmeter correctly.

(ii) Most candidates read the ammeter correctly.

(iii) Most candidates correctly substituted the ammeter and voltmeter readings correctly into the provided formula to calculate the resistance of lamp **L**.

(b) (i) Most knew that the voltmeter needed to be in parallel. However, some candidates drew the voltmeter in parallel to one, but not both, lamps.

(ii) Most correctly recorded both readings. 1.8 A as the current I_s was a common incorrect answer.

(iii) Most substituted into the equation and calculated the resistance correctly. The most common reason credit was not awarded was that unit for resistance, Ohms or Ω, was not well known.

(c) (i) Most answers showed an ammeter correctly placed in the common part of the circuit. The second mark, awarded for placing the two lamps and the voltmeter in parallel, was not always awarded. Common errors included:

- Using incorrect symbols, such as the letters **L** and **M** in circles to represent the lamps.
- Drawing circuits with significant gaps.
- Drawing the circuit with lamps **L** and **M** in series.
- Drawing correct symbols but with lines through them.

(ii) Again, candidates typically substituted values into the equation correctly to calculate the correct value for the power.

(iii) Most knew that the lamps would shine more brightly, although answers such as 'the voltage is higher' or 'the lamps have more power' were common incorrect responses.

(d) The strongest responses identified that opening the switch saves electrical energy or prevents overheating in the circuit.

(e) This question asks candidates to evaluate a prediction about a doubling of the resistance of lamp **L**. Most answers referred to the raw difference between the two resistance values rather than the difference between double the resistance of lamp **L** and the combined resistance of **L** and **M**. The strongest responses identified the value of double the resistance of lamp **L** (20.8 Ω) and compared this to the value of the combined resistance of **L** and **M** (14.4 Ω) to clearly show that the two values are not within 10% of each other.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

Data should be recorded to the degree of precision expected in the question. For some questions the precision is given in the question (for example **Question 3(a)(ii)** 'Record … to **two** decimal places'). In other cases, candidates are expected to record values consistently with other readings already given in the question. For example, all printed values for *u* and *v* in Table 4.1 are to one decimal place. Readings that are not given to the correct number of decimal places are marked as incorrect. Further, candidates should realise that the final decimal place may be zero, for example the answer 2.50 for **Question 3(a)(iii)**.

In some questions, candidates are asked to give their measurements using a particular unit. For example, **Question 1(b)(i)** required a distance in millimetres but many candidates wrote their answer in centimetres.

General comments

Mathematical processing was a strength. Many candidates earned almost full credit in questions that asked for processing of data or substitution into formulae and subsequent calculation of values.

Some candidates appear to have had limited practical experience. This was particularly evident in the planning question.

Comments on specific questions

Question 1

(a) Most candidates were awarded at least partial credit on this question. The most common errors were drawing a diagram that took up less than half the available space, drawing an outline that was not one single continuous line or shading the diagram rather than leaving it as a line drawing.

Some candidates had difficulty drawing the shape. The correct pentagon shape was drawn by many, but some candidates drew an okra that was more like a star, so it did not accurately represent the slice of okra.

(b) (i) Most candidates successfully measured the diameter of the okra between point **A** and point **B**. A small number of candidates gave their answer in centimetres and were not awarded credit as the question specified the diameter in millimetres.

(ii) This question proved to be demanding. Many candidates got the general idea, but they could not express it in a clear enough way. Descriptions needed to relate to this particular okra rather than okra in general. Many candidates suggested that the difficulty in measuring the diameter was because it was a photograph rather than an actual okra, whilst others thought the okra was still growing so the diameter would change.

(iii) Most candidates correctly measured the diameter of their drawing. Some candidates did not mark points **A** and **B** on their diagrams so it was not possible to confirm the measurements as it was not clear which parts of the diagram were being measured. Again, some candidates measured the diameter in centimetres rather than millimetres.

(iv) This question was well answered by most candidates who successfully calculated the magnification. Some candidates tried to do the division with the measurements inverted and so ended up with a magnification that was less than 1 despite having a large diagram.

Question 2

Many candidates find the planning question demanding. Best practice is to consider the bullet points carefully and use these to structure the response. The most common reason for low credit is that the response addresses some, but not all, of the bullet points. For full credit it is essential that at least one mark is awarded against each of the bullet points.

Marks can be awarded from a table with correct headings and in this case, some examples of different temperatures to use. There is a space before the answer lines for a table, diagram or sketch graph. Most candidates left this area blank but then tried to squeeze them in at the end.

It appeared that candidates were unfamiliar with the experiment involving amylase breaking down starch at different temperatures. There were many responses about testing leaves or doing various types of food test. Candidates who were familiar with the experiment often did not get the idea of removing samples from the mixture and instead added iodine to the amylase-starch mixture and assumed that the colour would turn from blue-black to orange-brown once all the starch had been broken down.

Most candidates got the idea that time had to be measured and correctly stated that a stop-watch, stop-clock or timer would be needed. Very few suggested measuring volumes using a syringe or measuring cylinder. Candidates often state what they are measuring in their method but then omit to name the piece of apparatus. The use of a water-bath was rarely suggested, but most candidates did use a thermometer and were given credit for this in the apparatus section.

In the method section, many candidates suggested mixing starch and amylase but did not mention starting the timer right away and instead there was a suggestion or implication of a time delay (in which time the reaction would have started before they began timing). Most candidates suggested using different temperatures, with a large number of candidates suggesting at least five.

Safety precautions tended to be vague and did not specifically reference the chemicals/situation in the experiment and so were not awarded credit. Answers about acid or non-specific **'**chemicals' going into the eye were insufficient. Similarly, answers about the apparatus being hot were insufficient as candidates need to make it clear how they would avoid injury. The use of (rubber) gloves was common but this was an inappropriate safety precaution as none of the chemicals would have caused damage to skin. Safety precautions should be specific to this experiment rather than general safety precautions.

Candidates found obtaining marks in the measurement section challenging because the details of what they were measuring were often too vague. For example, candidates often tried to measure the time until the starch had broken down. Few gave detail about how they knew the starch would have broken down, i.e. time until the sample stayed orange-brown or did not turn blue-black. It was common to see candidates measuring the amount of amylase or the amount of starch. This was insufficient as it needs to be volume rather than amount.

In the control variable section, candidates were not awarded credit for using the same amount of amylase or starch, as again, volume must be stated. Some candidates did state to keep the concentration of amylase or starch constant. Some answers vaguely suggested keeping the concentration of 'the chemicals' constant, but this was insufficient.

Many candidates gained credit for processing results and the most common way of doing this was to sketch the graph axes with the correct labels or to describe taking averages of repeated results at the same temperature. It was not sufficient to repeat the whole experiment and find the average because it needed to be clear that candidates were repeating the same temperatures and finding the average of those temperatures rather than the average overall temperature for the experiment.

Question 3

(a) (i) Few gave a correct answer for this question. Most candidates described allowing the reaction to end rather than describing the safety issues.

(ii) Most candidates correctly recorded the masses as required by the question.

(iii) Most candidates used their answers from **(ii)** to correctly calculate the difference in mass.

(iv) Similarly, most candidates also used their previous answers to calculate the difference in mass.

(v) Few candidates described a gas being produced and escaping from the test-tube. Many candidates gave incorrect answers that did not imply that a reaction had taken place, for example describing changes of state such as evaporating, subliming or boiling.

(vi) Stronger candidates correctly calculated the final percentage loss in mass to two significant figures. Many gave correct calculations using the wrong numbers or answers that were left to one decimal place rather than the two significant figures as requested by the question. A common incorrect answer was 4.7%, obtained by using the measurements from the balances rather than the data they had processed in previous questions.

(vii) Few candidates recognised that the longer heating time was to ensure the reaction was complete and all the gas had been given off. Common incorrect answers included vague references to accuracy or the result being clearer.

(viii) Stronger candidates made a correct statement about either the temperature of the flame or the idea that a yellow flame would obscure the colour. Many answers were insufficient, such as the flame being faster to heat the solid or that the flame was stronger.

(b) (i) Most candidates were able to recall the test for carbon dioxide. A significant proportion of candidates were not able to recall the chemical test. Iodine solution and various indicators were common suggestions.

(ii) This question proved demanding for most candidates. Carbon dioxide was a common incorrect answer, possibly uncovering a misconception about ions and elements/compounds. Similarly, oxygen rather than oxide and chlorine rather than chloride were common incorrect answers. This perhaps indicates that candidates are confused about ions in compounds versus the elements contained in them.

(iii) Many candidates correctly identified zinc. It was common to see more than one box ticked.

Question 4

(a) (i) The majority of candidates successfully measured the height of the image. Some candidates converted this result into millimetres, which did not gain credit.

(ii) This question was well answered with most candidates correctly measuring the distance *u*.

(iii) Many candidates were awarded credit. Incorrect answers included 24.0 suggesting that candidates had not realised this was a scale that could measure to the nearest millimetre.

(iv) Again, this question was well answered with most candidates using their two previous answers to calculate *uv*.

(v) Many candidates deduced the units of cm^2 for *uv*. This question was often left blank, implying that candidates did not read the questions fully and instead looked for gaps where they should write answers. Candidates should use all the information given on the paper rather than looking for the usual series of dotted lines to write on.

(b) (i) Many candidates gained some credit for the graph axes and plots. To improve graphical skills in the future, these points should be noted:

- Labels on graph axes should include the same wording as the headings used in the table. It was common for candidates to omit the units from the table when labelling their axes. These incomplete labels were not awarded credit.
- Candidates should carefully consider their chosen scales. The scales must be linear if not labelled and should show values in ascending order. Some candidates used non-linear scales. One common error was to see the values for *D* just copied from the table and having 65, 70,

75, 85 and 95 equally spaced on the horizontal axis. Some candidates started their axes at (0, 0) despite the instruction in the question.

- Scales chosen should allow plotted points to cover at least half the grid in both directions. Some candidates tried to extend their graphs beyond the edges of the grid.
- Plotted points should be drawn using a small cross or a dot in a circle. Large blobs are not accepted as it is impossible to judge exactly where the centre of the plot has been placed.

(ii) The line of best fit was challenging for many candidates. In this case, the relationship was expected to be a straight line, so it is important that candidates draw this line with a ruler and a sharp pencil. Answers using pen are not penalised but if a candidate makes a mistake, it is impossible for them to redraw an improved line. Common errors included forcing the line through the origin or joining the first and the last points. Where points do not occur directly on a perfect straight line, lines of best fit should take into account all points (where there are no anomalous results) so that there is an even spread of points on each side of the line.

(c) Some candidates calculated *F* in the range of 14 to 16 cm but very few showed how they arrived at this value by drawing a triangle on their graph line.

(d) (i) Candidates did not seem familiar with the concept behind this question. Some repeated the information given in the question by saying that it was more accurate to use the line rather than individual points, whilst others referred to the idea of stopping anomalous results from happening in the first place rather than it being easy to spot them after they had happened. Other responses were insufficient because they phrased their answers in terms of using all of the values or using more than one value but did not explain why this would be more accurate than using one.

(ii) A small number of candidates answered this question in terms of safety rather than experimental accuracy. It could be that they saw the word precaution and assumed this relates to safety rather than experimental technique.

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Key messages

When drawing graphs, candidates should be careful when choosing a scale so that their data fills at least half of the grid in both directions. Axes should be labelled appropriately, including units.

When making a biological drawing, candidates should ensure they use at least half of the space provided. The drawing should have a smooth, continuous outer line and have no shading. Some details should be provided, e.g. in **1(a)** the line between the darker top of the mushroom cap and the paler underside.

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.

Mathematical processing was a strength. Many candidates were awarded full credit in questions that asked for processing of data or substitution into formulae and subsequent calculation of values.

Comments on specific questions

Question 1

(a) Many candidates did not draw the mushroom as it was given to them in Fig. 1.1. Several drew the mushroom as viewed from the top and some drew the structure of a leaf. When candidates did draw the correct image, they often incorrectly added shading or made their image too small.

(b) (i) Almost all candidates measured the diameter of the mushroom correctly.

(ii) Most candidates identified the diameter of 40 mm for mushroom 2 grown at 20 °C as the anomalous result. A common error was to circle the average diameter value or to circle two values.

(iii) The average diameter was correctly calculated by most candidates with most giving their answer to two significant figures.

(iv) Candidates usually identified that the conclusion was incorrect because there was no experimental data for the higher temperature.

(v) Few candidates were able to identify that the mushroom cap is curved or has an irregular diameter and that this was a source of error. Several candidates suggested that not enough temperatures had been used, or that their ruler was somehow faulty. Candidates who correctly identified the error were able to go on to suggest an improvement, such as using a flexible tape or ruler, or taking multiple measurements of the diameter and finding an average.

(vi) Candidates suggested a variety of ways to improve the investigation, including using more temperatures, using the same type of mushroom, or controlling the amount of water that was given to the mushrooms.

(c) A common mistake was to suggest the use of indicators, such as litmus. However, that would only give a result as acid or alkaline and not give the pH of the soil. Many candidates did not realise that

the soil was dry (as given in the question) and so they would need to add water for universal indicator paper to work.

Question 2

(a) (i) Few candidates were able to describe how to carry out a flame test, often omitting to state that the Bunsen flame should be blue. Common mistakes included describing how to test for certain gases or simply stating that the solution should be put in a flame.

(ii) Most candidates correctly chose copper(II) as the cation.

(b) (i) Most candidates correctly read the two values and recorded them to two decimal places.

(ii) Candidates were able to use their values to calculate the mass lost during heating.

(iii) Many candidates gained credit for the graph axes and plots. However, to improve graphical skills in the future, the following points should be noted:

- Labels on graph axes should include the same wording as the headings used in the table. In this case, the headings in the table are 'time of heating / minutes' and 'mass lost / g'. Many candidates did not label their graph axes fully. Common omissions were to omit the units from the axis or to give incomplete unit abbreviations such as 'm' for minutes. These incomplete answers were not awarded credit.
- Candidates should carefully consider their chosen scales. The scales must be linear. It is assumed that the origin is (0, 0) if not labelled and should show values in ascending order.
- Scales chosen should allow points to cover at least half the grid in both directions.
- Plotted points should be drawn using a small cross or a dot in a circle. Large blobs are not accepted as it is impossible to judge exactly where the centre of the plot has been placed.

(iv) Many candidates correctly identified the point at 4 minutes as anomalous. The most common error was to identify the point at 5 minutes. A few candidates identified the point on Table 2.1, rather than on the graph grid, these correct answers were credited.

(v) Credit for the curve of best fit was not always given. It is important that candidates draw this line with a fine pencil. Answers using pen are not penalised but if a candidate makes a mistake, it is impossible for them to redraw an improved line. The most common error was drawing the line through the anomalous point.

(vi) Most candidates correctly stated that as the time of heating increased, the mass lost also increased. Few candidates went on to state that mass then stayed constant or that no more mass was lost.

(vii) Few candidates stated that the solid should be heated with a blue flame because it is hotter. Many candidates suggested that it was to avoid confusing the colour of solid **H** with the colour of the flame.

Question 3

(a) (i) Most candidates correctly read the rulers as 51.0 and 52.1 cm.

(ii) Candidates were able to use their values from **(a)(i)** to calculate the displacement. A few missed the instruction to give this in mm.

(b) (i) Almost all candidates recorded the reading on the stop-watch to one decimal place.

(ii) Nearly all candidates correctly described the relationship between the load and the period.

(c) Most candidates thought that the period was proportional to the load because the period increased in regular intervals. However, when the load doubles the period does not double so the relationship is not proportional. A few candidates quoted numbers to justify their ideas, which is to be encouraged.

(d) Some candidates realised that they needed to repeat the experiment to obtain more accurate results but only a few stated that it should be repeated 5 or more times, and that an average could then be calculated.

Question 4

Best practice when writing a plan is to consider the bullet points carefully and use these to structure the response. The most common reason for low credit in the planning question is that the response addresses some, but not all, of the bullet points. For full credit it is essential that a mark is awarded against each of the bullet points.

In this question, the apparatus is shown set-up. It is not necessary to describe this set-up in the answer. Doing so wastes time and space and often results in candidates failing to address the rest of the method fully.

Most candidates addressed the first bullet point well, usually suggesting that a ruler is needed. Some candidates stated a 'meter' was required. This was not credited as it could refer to many pieces of laboratory apparatus.

Candidates are generally skilled at selecting variables to control with most realising that the same car and ramp needed to be used.

Method marks could be earned in this question by varying the height of the ramp, at least 5 times, and measuring the distance travelled by the car, using the ruler. Some candidates varied the angle of the ramp rather than referring to the diagram provided.

Candidates designed good tables with the height in the first column and the distance travelled in the second column. Many candidates included units in their column headings. Credit for their method and processing was awarded here as it was clear when they had taken multiple readings or varied the height five times or more.

The processing of results is always challenging in planning questions. Best answers stated clearly that they would repeat the measurements and take an average.