COMBINED SCIENCE

Paper 0653/11
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1**, **5**, **24**, **28** and **33**. **Questions 7**, **26** and **31** proved the most challenging for candidates.

Comments on individual questions

Question 2

Most candidates correctly selected option **D**. Where candidates had chosen an incorrect option, they had mainly selected option **C**. This could be because they thought that gravity had some effect on diffusion.

Question 3

Many candidates found this question demanding with most candidates selecting the incorrect option **B**. They had correctly identified that glycogen was made from glucose and proteins were made from amino acids, but they incorrectly thought that starch was made from glycerol.

Question 7

Candidates found this question challenging. Most incorrectly selected option **D**. Arrow four was showing osmosis, and arrow 1 diffusion. Although osmosis is a special form of diffusion, arrow 1 is not evaporation.

Question 9

The correct answer, option **C**, was chosen by most candidates. Where candidates selected an incorrect option, they had dismissed the trachea as the labelled item and roughly split their answers between the diaphragm and bronchus.

Question 10

The correct answer, option **D**, was chosen by most candidates. Some candidates incorrectly selected option **B**, indicating that they had recognised that a fright would increase heart rate, but they incorrectly thought that pupil diameter would decrease.

Question 13

Most candidates selected the correct answer, option **D**. Some candidates incorrectly thought that combustion takes carbon dioxide out of the atmosphere and incorporates it into carbon compounds in green plants.

Question 20

Candidates chose the incorrect answer, option **D** more often than the correct option, **A**. Candidates are expected to know that the test for ammonium salts is warming with aqueous sodium hydroxide, with the formation of ammonia gas.

Question 23

There was evidence that many candidates had guessed at the answer. Candidates are required to deduce an order of reactivity from a given set of experimental results.

Question 26

Candidates found this question challenging. There was evidence that many candidates had guessed at the answer. Candidates are expected to know that the naphtha fraction obtained from petroleum by fractional distillation is used for making chemicals.

Question 27

Some candidates selected the incorrect answer, option **A** rather than the correct option, **B**. Candidates are required to describe the complete combustion of hydrocarbons, which includes the saturated alkanes, to give carbon dioxide and water.

Question 31

Candidates found this question challenging, most selecting the incorrect option **C**. The four options describe the motion of four objects. One of them is stationary and two of them are moving in a straight line at constant speed. Of these two, one is specifically stated to be travelling in a straight line while the other is moving vertically upwards and is therefore moving upwards in a straight line. These three objects therefore have no resultant force acting on them and so the correct answer is option **A** which describes the motion of an object in a curved path. Candidates that selected option **C** may have assumed that an object moving vertically is subject only to the force of gravity. Such an object would be decelerating however, whereas the object whose motion is described in option **C** is travelling at constant speed.

Question 32

The correct answer, option **D**, was more frequently chosen than options **A** and **B** but option **C** was the most popular selection. In the three experiments described, each of the objects is subject to a force of magnitude F and is moved by the force a distance x in the direction of the force. It follows that the work done by the force in each case is Fx and that the work done is equal in each case. It does not matter if other forces act on the objects as the question concerns the work done by the force of magnitude F. Some candidates may have thought that work done against gravity or friction was a consideration.

Question 37

The context of this question was the application of the equation that defines speed, to a sound that travels to a wall and the echo that travels back to the source. All the options are divisions of a distance by a time. The incorrect option that was chosen the most often, **C**, divides the distance given in the question by the time that is also given. Sound, however, must make a double journey from the source to the wall and from the wall back to the source and so something must be doubled or halved to deal with this. The correct answer was option **B**, in which the distance is doubled and the time given in the question is not changed.

Question 40

The question supplies four items of information that relate to an electric heater. The question then asks for a suitable fuse rating with each of the four options being obtained from the information supplied. Candidates who knew that fuses protect the wiring from an excessive current or that the unit used for fuse ratings is the ampere (A) were able to select the correct answer, option **A**. Rather more candidates, however, chose option **B** which had the unit of power and a value slightly larger than the power of the heater. The other two choices were less commonly selected.

COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1**, **3**, **5**, **10**, **21**, **33** and **37**. **Questions 8**, **16**, **20**, **27**, **30**, **31** and **38** proved the most challenging for candidates.

Comments on individual questions

Question 2

Most candidates selected the correct option, **D**. However, many candidates incorrectly selected option **B** or **C**. Both of these options had a correct column and an incorrect column. Option **A** was rarely chosen.

Question 4

Most candidates selected the correct answer, option **A**. The most common incorrect answer was option **B**, glucose. Glucose is not needed for photosynthesis; it is made by photosynthesis.

Question 7

Some candidates incorrectly selected option **C**. They had correctly recognised that proteins are digested to amino acids, but they incorrectly identified the type of digestion and property of the small molecules.

Question 8

Candidates found this question challenging. An equal number selected the incorrect answer, option **A**, as the correct option, **B**. The rate of transpiration is higher when the humidity is low.

Question 9

The correct answer, option **D**, was chosen by most candidates. The most common incorrect answer was option **C**. Most candidates knew that the rate of breathing increases during a race, but many also thought that the depth of breathing decreases.

Question 12

Most candidates selected the correct answer, option **C**. Some candidates selected option **A**, perhaps missing the diagonal arrows from small bird and rat. Some candidates incorrectly thought that the number of food chains was 9. This was the number of organisms in the diagram. The food chain starts at the producer and finishes at the top predator; the consumer that is itself not eaten.

Question 13

Many candidates selected the correct answer, option **D**. Several candidates incorrectly thought that an undesirable effect of deforestation was less extinction. While less extinction is desirable, it is not an effect of deforestation. Many other candidates selected the incorrect option **A**.

Question 15

Candidates selected the incorrect answer, option **A**, more often than the correct answer, option **B**. Option **A** showed a compound. Candidates are expected to be able to identify elements and compounds, as well as mixtures, from diagrammatic representations.

Question 16

Candidates found this question challenging. Candidates selected the incorrect answer, option **A**, more often than the correct answer, option **D**. Candidates are required to describe the formation of ions during the formation of ionic bonds between Group I and Group VII elements.

Question 17

Many candidates chose the correct option, **B**. Option **D** was a strong distractor. Candidates are expected to know the formulae of simple compounds, including those named in the syllabus.

Question 18

There was evidence that many candidates had guessed at the answer. Candidates are required to know the electrode products in the electrolysis of molten lead(II) bromide, concentrated aqueous sodium chloride and dilute sulfuric acid.

Question 20

Candidates found this question challenging. Candidates selected the incorrect options **B**, **C** and **D** more often than the correct answer, option **A**. Candidates are expected to be able to interpret data, including graphs, obtained from experiments on rate of reaction.

Question 22

Many candidates chose the correct option, **A**. Option **B** was the most common incorrect answer. Candidates are required to interpret results of simple chemical tests to deduce the identity of a substance.

Question 24

There was evidence that many candidates had guessed at the answer. Candidates are expected to describe the properties of Group I and Group VII elements.

Question 25

Many candidates selected the correct answer, option **C**. The most common incorrect answers were options **A** and **B**. Candidates should know that alloys are mixtures of a metal with other elements, rather than compounds.

Question 26

Candidates selected the incorrect option, **D**, more often than the correct answer, option **B**. Candidates are expected to know the dot-and-cross diagram for water, chemical tests for water and understand the treatment of the water supply.

Question 27

Candidates found this question challenging. Candidates selected the incorrect options **A** and **B** more often than the correct answer, option **C**. Candidates are required to describe the complete combustion of hydrocarbons to give carbon dioxide and water.

Question 30

Candidates found this question challenging. Both option **B** and option **C** were more popular than the correct answer, option **D**. Graph 2 shows a changing speed and so this graph can be eliminated. Graph 1 indicates a constant speed of zero. Consequently, it cannot represent the motion of a moving car.

Question 31

Candidates found this question challenging. Option **D** was the most frequently selected response. In this question, the cart is moving horizontally and so the weight of the cart which is balanced by a contact force of some sort, cannot be of significance when calculating the work done on the cart. The correct choice, option **B**, was the second most popular choice and is deduced from the standard definition of work. The other options were only chosen occasionally.

Question 34

Option **A**, which is correct, was the most frequently selected answer. For many candidates, both the decrease in temperature of the remaining liquid and the escape of the more-energetic particles would be known facts. The second most commonly chosen option was **D**. The statement about the temperature change is incorrect and although the statement about the reduction in the number of molecules remaining is correct, it is their average kinetic energy that determines the temperature of the liquid rather than their number.

Question 38

Candidates found this question challenging. This question assesses two specific facts. Both p.d. and e.m.f. are measured using the volt (V) but answer **D** was rarely selected and all of the other options were chosen more frequently. The name electromotive force is misleading and may well suggest that its unit is the newton (N). The confusion, however, only accounts for a small proportion of the incorrect choices.

COMBINED SCIENCE

Paper 0653/13
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 2**, **5**, **6**, **13**, **16**, **28**, **29**, **30** and **33**. **Questions 4**, **8**, **9**, **19**, **23**, **26**, **27** and **38** proved the most challenging for candidates.

Comments on individual questions

Question 1

Many candidates selected the correct answer, option **C** although option **A** was a popular choice. This identified that one of the characteristics the plant was demonstrating was movement but incorrectly coupled this with nutrition rather than sensitivity. Most candidates had correctly ruled out any involvement with respiration.

Question 3

Most candidates found this question demanding. Many candidates incorrectly selected option **A**. Most candidates recognised that diffusion is the movement of particles from a higher to a lower concentration but many thought that diffusion requires a partially permeable membrane. Perhaps the candidates thought the question was referring to osmosis.

Question 4

Many candidates found this question demanding. Some candidates incorrectly selected option **C**. While most biological molecules contain the elements C, H and O, proteins also contain N.

Question 7

The correct answer, option **B**, was the most popular choice. A few candidates correctly identified the change but got the type of digestion incorrect.

Question 8

Most candidates found this question demanding. The correct answer for evaporation was option **C**, not option **D**. Option **D** represented diffusion. Water evaporates from the cells into the air spaces as water vapour. The water vapour then diffuses through the stomata.

Question 9

Many candidates found this question demanding with many incorrectly selecting option **B**. While the inspired air column is correct (more oxygen) the expired air column is incorrect (less water vapour).

Question 11

Some candidates incorrectly selected option **B**. The plant was grown without light and as such there would not be a phototropic response. Candidates need to carefully read the question, possibly underlining key points to assist them in answering the question.

Question 19

There was evidence that many candidates had guessed at the answer. Candidates should be able to identify the electrolyte, anode and cathode in apparatus used in electrolysis.

Question 20

Candidates selected the incorrect answer, option **B**, more often than the correct option, **D**. Candidates are expected to describe practical methods for investigating the rate of a reaction which produces a gas, including the measurements that need to be made during the investigation.

Question 21

Candidates chose the incorrect answer, option **A**, more often than the correct option, **C**. Candidates are required to recognise the oxidation state of an element in a compound name by the Roman numerals (II) and (III).

Question 22

Candidates selected the incorrect answer, option **B**, more often than the correct option, **D**. Candidates should know the formulae of simple compounds, including those listed in the syllabus, and recognise which are acids and which are bases.

Question 26

Candidates selected the incorrect answer, option **B**, more often than the correct option, **A**, with some candidates selecting the incorrect option **D**. Candidates are required to deduce an order of reactivity from a given set of experimental results, and to know the reactivity order for named metals.

Question 32

The question offered four increases in quantities and asked which one leads to a decrease in the power required by a car being driven up a hill. The correct answer, option **C**, was chosen by more candidates than any other option but there were many candidates who chose one of the other options, all three of which would cause an increase in the power required. The question was essentially assessing an understanding of the concept of power and the fact that its definition positions the quantity time in the denominator.

Question 35

This question concerned the establishment of a convection current in warm water. Candidates are most likely to have encountered convection in a situation where a fluid is heated from below but in this case a convection current is set up by cooling a fluid from above. The consequent density changes explain why the correct option is option **A**. Rather more candidates selected option **B** than option **A** and a significant number gave option **C**. If any water at the top of the water freezes it will continue to float at the top along with the ice that the ice cubes consist of. In practice, the ice at the surfaces of the cubes melts and the cold water sinks and so the poor thermal conductivity of the ice is unimportant.

Question 38

This question was a test of a single piece of factual knowledge. Option **B** was the correct option. Only a few candidates selected the correct answer, with both option **A** and option **C** being more commonly selected.

Question 40

The reason why circuits are designed to include fuses was not fully understood. In this case there is only one fuse that has a rating greater than the operating current of the heater and so option **D** was the correct choice. Many candidates selected options **B** or **C** and some selected **A**.

COMBINED SCIENCE

Paper 0653/21
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **4**, **8**, **10**, **16**, **26**, **29**, **30**, **31**, **32** and **36**. **Questions 13**, **14**, **21**, **25** and **34** proved the most challenging for candidates.

Comments on individual questions

Question 3

Most candidates selected the correct answer, option **B**. Others were split between the incorrect options **C** and **D**. Magnesium is a component of chlorophyll in plants.

Question 5

Most candidates selected the correct answer, option **B**. Some candidates incorrectly thought that veins have a narrow lumen to allow blood to flow quickly.

Question 6

Most candidates selected the correct answer, option **C**, although some incorrectly thought that energy is required for diffusion but not required for growth (option **B**).

Question 7

Most candidates selected the correct answer, option **C**. Some candidates incorrectly selected option **B** as the chemical equation for respiration. Option **B** was the chemical equation for photosynthesis.

Question 11

Most candidates selected the correct answer, option **D**. A few candidates incorrectly selected option **B** thinking that large petals are an adaptation of wind-pollinated flowers.

Question 12

Most candidates selected the correct answer, option **A**. The most common incorrect answer was option **B**. The store of energy is present in the female gamete, not the male gamete.

Question 13

Candidates found this question very demanding. While some candidates selected the correct answer, option **D**, many candidates incorrectly selected option **A**. It may be that these candidates simply identified the arrows pointing at the wolf rather than following the chain from the producer to the wolf. When answering this question candidates could annotate the diagram to help identify the various food chains.

Question 14
Most candidates selected the correct answer, option **C**. Many other candidates incorrectly selected option **A** or **B**. Although evaporation is endothermic, covalent bonds are not broken.

Question 19

Some candidates selected the incorrect answer, option **D** rather than the correct answer, option **C**. Candidates are expected to know that bond breaking is an endothermic process and bond forming is an exothermic process, and to understand how these two processes determine the overall energy change in a reaction involving the breaking and formation of bonds.

Question 21

Most candidates selected the correct answer, option **D**. Options **A**, **B** and **C** were selected by many other candidates suggesting they were not familiar with the tests for anions.

Question 25

Most candidates selected the correct answer, option **D**. Many candidates incorrectly selected option **A**. It is carbon monoxide that reduces iron(III) oxide.

Question 33

Although the correct option **A** was selected by more candidates than any of the others, option **D** was also selected by a significant number of candidates. This answer is the reciprocal of the correct value and it is possible that there were some candidates who had confused the term frequency with period or less specifically were uncertain about the definition of frequency. There may well have been those who were unused to seeing frequency values that are smaller than 1 and who assumed that the value obtained had to be inverted.

Question 34

The first part of this question was a matter of recall and a significant number of candidates selected options **A** or **B** which both indicate that the speed of a sound wave decreases as it passes from a solid into a liquid. The effect on the wavelength can be deduced from the application of the equation $v = f\lambda$ as the question states that the frequency does not change. The consequence is that option **A** is correct and that option **B** is not. Although option **A** was the most popular, there were a significant number of candidates who selected option **B**.

Question 35

This question relied on the fact that in order for a lens to act as a magnifying glass, the object must be closer to the lens than the corresponding principal focus. This is only the case for the position given in option **D**. The correct option was indeed chosen by most candidates although there were some who selected option **B**. This may well have been because the effect of positioning an object at a point that is twice as far from the lens as the focal points is likely to have been specifically learned. In this case, however, this is not the point required.

Question 40

In order to obtain the correct numerical answer, candidates needed to apply the equation $E = IVt$ and also to convert the current in mA to a value in A and the time in minutes to a value in s. Most candidates performed the calculation correctly and obtained the correct answer, option **B**.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 3**, **5**, **6**, **13**, **15**, **25**, **29**, **36** and **40**. **Questions 7**, **11**, **17**, **18**, **21**, **22** and **39** proved the most challenging for candidates.

Comments on individual questions

Question 1

Most candidates selected the correct answer, option **A**. Some selected option **B**, the cell wall. and a few selected option **D**, the nucleus.

Question 2

While the correct answer, option **D**, was chosen by most candidates, some selected option **A**. Osmosis requires a partially permeable membrane, diffusion can occur without one.

Question 4

Most candidates selected the correct answer, option **C**, but some selected option **A**. These candidates had correctly identified the cell where photosynthesis occurs but had the substrate and product columns for aerobic respiration.

Question 7

Most candidates selected the correct answer, option **C**. Although, many candidates selected option **B** or **D**, suggesting the function of plasma in the transport of ions was not well understood.

Question 9

Most candidates correctly selected option **D**, although some candidates incorrectly selected option **C**. Candidates had correctly identified the effect of adrenaline on breathing rate, but incorrectly thought that it causes pupil size to decrease.

Question 11

Most candidates selected the correct answer, option **B**, but some selected option **A**, correctly identifying the insect-pollinated anther, but incorrectly identifying the insect-pollinated stigma.

Question 12

Most candidates selected the correct answer, option **A**, but a significant number thought that the placenta protects the embryo from mechanical shock.

Question 17

Candidates chose the incorrect option **C** more often than the correct answer, option **B**. Candidates are expected to understand and use ionic equations.

Question 18

There was evidence that many candidates had guessed at the answer as all options were selected almost equally. Candidates are required to describe electrolysis in terms of the ions present and the reactions at the electrodes, using half-equations.

Question 19

Candidates chose the incorrect option **B** more often than the correct answer, option **D**. Candidates are expected to understand exothermic and endothermic reactions in terms of energy transfers and temperature changes.

Question 21

There was evidence that many candidates had guessed at the answer as all options were selected almost equally. The correct answer was option **C**.

Question 22

Most candidates selected the correct answer, option **C**. Other candidates incorrectly selected option **A**, **B** and **D**. Candidates are expected to understand the process of crystallisation in the formation of a salt.

Question 24

Candidates chose the incorrect option **B** more often than the correct answer, option **D**. Candidates are expected to be able to identify representations of alloys from diagrams of structure.

Question 35

Although the correct option **B** was selected by more candidates than any of the others, all three incorrect options were chosen by a significant number of candidates. Candidates who knew that a lens acts as a magnifying glass only for objects that are closer to the lens than the corresponding principal focus would have been able to eliminate options **C** and **D**. To decide between options **A** and **B** proved equally tricky. Some candidates were able to recall the learned fact that relates the position of the object to the location of the principal focus but were not completely clear about how a magnifying glass is used.

Question 37

This question tested the equation $Q = It$. There are several stages to the calculation since the current first had to be calculated from the potential difference and the resistance. Furthermore, the resistance and the time were not given in standard SI base units and so kW needed to be converted to W and minutes to s. Many candidates followed through the stages correctly and so the correct answer, option **A**, was selected more commonly than any other option. Errors were made, however, and option **B** was frequently selected.

Question 38

The length of the wire Y is twice that of wire X and the diameter of wire Y is twice that of wire X. One consequence is that the volume of wire Y is not equal to that of wire X as the cross-sectional area of wire Y is four times that of wire X. The effect of these differences on the resistance means option **A** is correct. This was, in fact, the most widely selected option, although both options **B** and **C** were also commonly selected.

Question 39

Most candidates were able to supply an answer, option **A** or **B**, that was consistent with the correct current in resistor R. There were a significant number, however, that chose one of the other two options. Of the candidates who gave options **A** and **B**, most were able to proceed and deduce the completely correct answer, option **B**. Almost as many, however, selected option **A**. Perhaps such candidates were under the mistaken impression that the two resistors in series are identical or that the e.m.f. (12 V) of the battery is shared equally between the two parallel branches of the circuit rather than that the full e.m.f. of the battery produces a p.d. of 12 V across each of the two branches.

COMBINED SCIENCE

Paper 0653/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **4**, **5**, **6**, **12**, **16** and **34**. **Questions 3**, **10**, **19**, **23**, **26**, **35**, **36**, **39** and **40** proved the most challenging for candidates.

Comments on individual questions

Question 2

The correct answer, option **A** was selected by most candidates although a significant number incorrectly selected option **C**. This indicates that they thought that the trachea does not contain ciliated cells.

Question 3

Candidates found this question demanding and many incorrectly selected option **B** or **C**. Osmosis is the net movement of water and, in this question, while there is some movement of water into the cell, there is more movement out of the cell.

Question 7

The correct answer, option **B** was selected by most candidates, although option **D** was a frequently selected incorrect answer. These candidates identified that an increase in temperature increases transpiration, but incorrectly thought that an increase in humidity increases the rate of transpiration.

Question 8

The correct answer, option **C** was selected by most candidates, however, a significant number of candidates incorrectly thought that valves allow blood to flow in both directions.

Question 9

The correct answer, option **C** was selected by most candidates, however, a significant number of candidates incorrectly thought that cells respire to produce oxygen or to use glucose.

Question 10

Many candidates found this question demanding and there was evidence that candidates had guessed at the answer. There was a slight preference for the incorrect answers, option **B** or **D**.

Question 13

The correct answer, option **D** was selected by most candidates. Some candidates selected the incorrect answer, option **C**, correctly identifying the effect of deforestation on atmospheric carbon dioxide levels, but incorrectly thinking that deforestation causes a build-up of soil.

Question 19

Most candidates selected the correct answer, option **C**. However, many candidates selected the incorrect options **A** and **B**. Candidates are required to know that the products of the electrolysis of concentrated aqueous sodium chloride are hydrogen gas and chlorine gas.

Question 23

There was evidence that many candidates had guessed at the answer. Candidates are expected to know the tests for ions specified in the syllabus, including nitrate ions.

Question 26

More candidates selected the incorrect answer, option **C**, than the correct answer, option **B**. Candidates are required to describe and explain the essential reactions in the extraction of iron from hematite in the blast furnace.

Question 35

Very few candidates selected the correct answer to this question. The correct option was option **D** but the other three options were chosen more frequently than option **D**. The most popular choice was option **B**. The candidates are expected to understand the use of a converging lens as a magnifying glass.

Question 36

More candidates selected the incorrect answer, option **B**, than the correct answer, option **D**. Perhaps there were candidates who thought that the speed of the electromagnetic radiation is dependent on its frequency.

Question 39

The current in one lamp was 4.8 A and this value, option **B**, was the most frequently selected. However, the circuit included two lamps in parallel and so the total current is twice this value. This answer, option **C**, was the second most widely selected with very few candidates choosing either of the other two options. It is possible that candidates were not familiar with the behaviour of current in a parallel circuit or even with the meaning of the term parallel. More likely, however, is that many candidates stopped to calculate the current from the values in the question and while doing so, forgot the context and what was being asked for.

Question 40

More candidates selected the incorrect answer, option **C,** than the correct answer, option **B**. The equation appears in the syllabus as it does in option **B** so this question should be simple recall.

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

It is important that candidates can apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination, and some produced very good answers. Successful candidates read the questions carefully and were able to express their answers in a clear and legible way.

There was evidence that some candidates struggled with some topics, particularly the chemistry questions.

Candidates are advised to attempt every question in the paper, especially those questions where they choose their answers from responses that are already given on the paper.

Comments on specific questions

Question 1

(a) (i) Generally well answered. Many candidates gained full credit.

(ii) Many candidates circled the correct answer, absorption. The most common incorrect answer was egestion. The two functions of **D**, the small intestine, are chemical digestion and absorption.

(b) (i) This was generally answered well. Most candidates successfully identified 48 °C, the temperature where both line graphs cross.

(ii) Most candidates found this question demanding. Some responses stated that enzyme **Y** or the temperature was too hot without mentioning the activity of enzyme **Y**.

(c) (i) Many candidates answered this question correctly. One of the most common errors occurred when candidates drew two lines from each box on the left so that all four right-hand boxes were joined. Careful reading of the question shows that only one line should be drawn from each biological molecule. Protein was often incorrectly linked with Benedict's solution.

(ii) Some candidates struggled to name amino acids. Responses involved a range of biological substances, including enzymes, lipids, glucose and protease.

(iii) Some candidates stated the chemical elements correctly. A common error was leaving out the oxygen or including nitrogen, implying confusion with hydrocarbons and amino acids respectively.

Question 2

(a) Some candidates wrote a correct statement describing the meaning of diatomic. Incorrect responses included descriptions in terms of molecules and the covalent bonding of Group Vll elements.

(b) Many candidates drew the two bonding electrons correctly. Incorrect responses included candidates drawing four bonding electrons or omitting the remaining outer shell electrons or drawing an incorrect number of electrons.

(c) (i) Some candidates found this demanding and were unfamiliar with the term exothermic. Examples of incorrect responses included 'heat outside', 'exit and heating' and 'exerts heat'. Several candidates gave definitions of endothermic.

(ii) Some candidates found this question challenging. They did not answer in terms of electrons but instead wrote about atoms. Other candidates described the reaction of sodium with water.

(iii) Most candidates did not know the meaning of volatility and their responses usually described key facts about ionic and covalent bonding or how the bonds in each type of compound form.

(d) (i) Candidates generally found this question demanding. They frequently gave sodium carbonate as the solute and hydrochloric acid as the solvent. Other candidates gave definitions of solute and solvent that did not relate to the question.

(ii) Some candidates answered this question correctly. Common errors included hydrogen or oxygen as the gaseous product and sodium chlorine instead of sodium chloride as the salt.

(iii) Some candidates stated the formula correctly. Others did not group the atoms, omitted subscripts or stated the elements in words.

Question 3

(a) (i) Candidates were often confused between the terms evaporate, boil and condense and often used these terms interchangeably. Careful reading of the stem of the question shows that the water droplets are the result of condensation. Therefore, the process which forms water vapour at 60 °C, below the boiling point of water, must be evaporation.

(ii) Candidates generally answered this question well. The main error stated was boiling point, rather than the process of boiling.

(b) (i) Some candidates stated conduction to gain credit. Common errors were convection and heat transfer.

(ii) Some candidates who did not identify conduction in **(b)(i)** used the term correctly in this question to compare glass and aluminium as conductors. Other candidates confused the terms conductor and insulator or described heat transfer without using the correct terms.

(c) The term refraction was not widely known. The most common error was reflection. Candidates are reminded to spell refraction correctly because the word is so similar to reflection. Therefore, misspelled attempts such as 'reflaction' and 'refrection' were not acceptable answers for this question.

(d) (i) A few candidates answered this correctly. However, most struggled with this question. Some had no idea about the position of the reflected ray, with the angles of incidence and reflection being widely different. Often the **X** was nowhere near the reflected ray, and it was frequently drawn behind the mirror. Generally, when drawing ray diagrams, candidates should draw them as accurately as possible using a ruler and a sharp pencil.

(ii) Candidates of all abilities found this question demanding. While many placed the 0 first in the box, others struggled to write the laterally inverted 3.

(e) Generally, well answered. Incorrect responses included infrared and microwaves.

(f) Most candidates gained full credit by describing the use of a microwave oven. Candidates who wrote 'microwave oven' without describing its use were not awarded credit.

Question 4

(a) (i) Candidates were generally unfamiliar with the cortex cells in the root. The water must pass through these so that it can get from the root hair cells to the xylem. Answers that did not gain credit included plant cells and several of the specialised cells found in the leaf.

(ii) There were many correct labels of a vacuole. The most common error was labelling a nucleus instead of a vacuole.

(iii) Some candidates gained full credit on this question. Most candidates scored partial credit, usually from the final space, transpiration.

(b) This was generally well answered. Most candidates ticked the first option, offspring are genetically identical to the parent plant, and many ticked the fourth option, fertilisation did not take place to produce offspring. These candidates gained full credit. The remaining answers, chosen in approximately equal numbers, all relate to sexual reproduction, not asexual reproduction.

(c) (i) Many candidates focused on the food chain rather than the role of plants as producers. Therefore, responses such as 'plants start the chain off' and 'plants do not eat anything but are eaten by animals', did not gain credit. To gain full credit, candidates had to explain that plants make their own food by photosynthesis. Only a few candidates mentioned photosynthesis.

(ii) Most responses were correct. The main error was circling the owl instead of the grasshopper.

Question 5

(a) (i) Generally answered well.

(ii) Most candidates successfully stated the use for refinery gas in cooking. Other responses included fuel for jets, in engines, and in petrol. One-word answers that were not allowed were cars, fuel, and stoves without describing the use of stoves for cooking and heating.

(iii) Candidates generally found this question demanding. Many did not realise that fraction **A** was a product of the distillation process, instead describing it as the place where waste gases left the column. Candidates should be aware that fraction **A**, bitumen, is the least volatile product with the highest boiling point, and it is widely used in making road surfaces.

(b) (i) A few candidates named process **B**, cracking. Most candidates were unfamiliar with the term.

(ii) Most candidates attempted the two explanations. Only a few described the need for a double bond in an unsaturated compound. There were more attempts with the definition of the hydrocarbon, stating that the compound contained carbon and hydrogen, but many omitted the essential word 'only'.

(iii) Only a few candidates could describe the test with bromine water. Some described other chemical tests, for example using limewater or Benedict's solution.

(iv) Most candidates were unfamiliar with the term addition polymerisation, the chemical reaction that converts ethene into poly(ethene).

(c) Many candidates wrote methane, knowing that this is a greenhouse gas. The fossil fuel containing mainly methane is natural gas. Only a few candidates stated this. Incorrect responses included carbon dioxide and carbon monoxide.

Question 6

(a) (i) Generally answered well. The main error seen was when candidates multiplied the weight by 10 instead of dividing it by 10 to give the mass.

(ii) Many candidates answered this question well. Since the question relied on the answer to **(a)(i)**, an error carried forward (ecf) was allowed. The main error occurred when candidates multiplied the mass by two instead of dividing it by two to calculate the density.

(b) Most candidates stated that the box would move upwards. Very few responses stated that the box would accelerate upwards, so only partial credit was gained by most candidates.

(c) (i) Most candidates used the speed = distance ÷ time equation to do this calculation successfully. Errors occurred when the distance was multiplied by the speed instead of being divided.

(ii) All three options were chosen in roughly equal numbers. The correct answer, that the second box gains the same amount of GPE, was usually supported by a correct reason.

Question 7

(a) (i) Candidates appeared to be uncertain of the answer to this question because all four alternatives were circled in roughly equal numbers. Candidates should be aware that the direction of blood through **R** is from the body towards the heart, making it the vena cava.

(ii) Most candidates knew that valves have a function in the flow of blood, but many incorrectly implied that this was an active function to push blood forwards, rather than it being a passive function to stop the backflow of blood. Therefore, language such as pushes, pumps and sends blood in one direction were common incorrect answers.

(b) (i) Many candidates gained full credit, but some only gained partial credit for calculating the increase in pulse rate, 42. This number was often divided by 112, the slow walking pulse rate, instead of 70, the pulse rate at rest.

(ii) Generally, candidates found this question demanding. The two important points were that the rate of respiration increases during exercise, and that more oxygen is needed for respiration in the muscle cells to release the energy needed. Most responses did not refer to respiration or the role of oxygen in energy release. Many answers reworded the question and did not add to the information given.

(c) Many candidates knew the correct terms for the parts of the human reproductive system that produce gametes. There was a wide variety of incorrect answers, including scrotum, urethra, ovum, ovules and oviduct.

Question 8

(a) (i) A few candidates gained partial credit for stating time (taken for the reaction). Others described the apparatus they could use for the experiment, so they were not awarded any further credit. Only a handful of candidates described measuring the volume of gas produced.

(ii) Many candidates knew that the pH would increase during the neutralisation reaction. Those who predicted that the pH would go into the alkaline pH range did not gain credit.

(b) (i) The cathode was correctly named by many candidates. Incorrect responses included anode, graphite and anion.

(ii) Very few candidates correctly identified oxygen as the product that forms at the positive electrode. The most common incorrect answer was sulfur.

Question 9

(a) (i) Generally answered well. There was no consistent pattern to the incorrect answers.

(ii) Most candidates could identify either **J** or **H**. Incorrect responses included **F** and **G**. To make a parallel connection there must be a branch in the circuit, as occurs for **J** and **H**.

(iii) Generally, well answered. Most candidates recognised the symbol for an ammeter.

(iv) Most candidates identified the variable resistor correctly.

(b) This question, based on Ohm's Law, was done well by most candidates. The formula had to be rearranged successfully, and the correct unit given. The most common error was to multiply the potential difference by the current to give 1.8 Ω. Another error occurred when the candidates did not use Ohm's Law, but instead subtracted the current from the voltage to get 2.4 Ω.

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.

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

It is important that candidates can apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination, and some produced very good answers. Successful candidates read the questions carefully and were able to express their answers in a clear and legible way.

There was evidence that some candidates struggled with some of the scientific terms, for example, osmosis, phagocytosis and the processes involved in the carbon cycle.

Candidates are advised to attempt every question in the paper, especially those questions where they choose their answers from responses that are already given on the paper.

Comments on specific questions

Question 1

(a) Many candidates identified the urethra and scrotum successfully. The most common error occurred when candidates confused the scrotum with the testis.

(b) (i) The site of fertilisation, the oviduct, was successfully circled by many candidates. The incorrect options were chosen in roughly equal proportions.

(ii) Candidates found this question demanding. Only a few knew nuclei for the first response, although more candidates completed at least one of the next two sentences successfully. Candidates are reminded that the sequence of events in fertilisation is the fusion of the nuclei, followed by the formation of the cell called the zygote. This develops into a ball of cells called an embryo.

(c) (i) Many candidates gained some credit by identifying the temperature that gave the highest percentage of germination. To obtain full credit, the lower percentage germination at both high and low temperatures had to be mentioned. Not all candidates did this.

(ii) Many candidates successfully stated either water or oxygen. The most common error was sunlight. Sunlight is not essential for germination, but it is needed for the growth of the seedlings after they have germinated. Other candidates stated that warmth is needed. This is true but this environmental condition was ruled out by the first part of the question.

(iii) The requirement for carbohydrates to release energy required for germination was successfully described by some candidates. Answers stating that energy was needed for photosynthesis did not gain credit.

Question 2

(a) Many candidates concluded that the rate of reaction would be slowed down by using the acid with a lower concentration. Other candidates did not appear to be familiar with this type of experiment.

(b) Some candidates successfully stated that the litmus paper turns red. Incorrect answers included a range of incorrect colours and that the paper melts, dissolves, burns and wrinkles up. Candidates who have seen this test will know that the strength of hydrochloric acid used in the laboratory will not give any of these effects.

(c) In this question the test had to be correct before the observation could be considered. Therefore, the splint had to be lighted and not glowing. Incorrect responses for the test included 'hydrogen test' and 'limewater test'.

(d) (i) Candidates found this question demanding. To gain credit, candidates had to state that an alloy is a mixture of a metal with one or more other elements. Therefore, responses that omitted to state that at least one component of the mixture is a metal or stated that the components are combined or joined did not gain credit.

(ii) Some candidates found this question demanding. The question had to be answered in the context of the reactivity series. Therefore, copper can be extracted from its oxide using carbon as carbon is more reactive. Carbon cannot be used to extract magnesium from magnesium oxide because carbon is less reactive than magnesium. The most common error was a comparison of the melting points of the two metals, omitting any reference to their relative reactivity.

Question 3

(a) (i) The fact that energy is stored in the oil as chemical energy was only stated by a few candidates. The most common incorrect answer was thermal energy. Some others wrote liquid. The oil, a liquid, is the store of chemical energy which is transferred to thermal energy when the oil is burned.

(ii) Many candidates answered this correctly, stating thermal energy.

(b) The top of the heater is directly above the flame, so the heat travels in a gaseous medium. Therefore, the method of heat transfer is convection. The most common error was to simply state heat transfer.

(c) (i) Many candidates scored credit in this question. Others stated that the process was condensation. Candidates are reminded that condensation occurs when a liquid is formed from a vapour.

(ii) Many candidates stated that the water would reach 100 °C causing the water to boil. These candidates did not realise that the top temperature of the surface of the heater is 75 °C, well under the boiling point of water.

(d) (i) Candidates found this question demanding, with few stating the correct answer, radiation. Many candidates wrote thermal energy, heat energy or thermal energy transfer.

(ii) Many candidates completed the electromagnetic spectrum correctly. However, some entered ultraviolet, visible light and infrared in the correct places but could not be awarded full credit because only visible light and infrared were required. The stem of the question asked for two main forms of electromagnetic radiation emitted by the flame. It is important to read the question carefully and only write what is asked for.

(e) Most candidates found this question demanding. The key term to describe the image was lateral inversion so answers such as inverted and reflected did not contain enough detail to be accepted.

Question 4

(a) (i) The root hair cell was identified correctly by many candidates. Incorrect responses included all types of plant cells, parts of cells and just root on its own.

(ii) This question was quite well answered by most candidates. The nucleus (present in both cells) and the cell wall (not present in the white blood cell) were the most popular correct answers. Several candidates wrote chloroplast for the second response. Candidates are reminded that there are no chloroplasts in root hair cells because they are underground and do not carry out photosynthesis.

(b) (i) Only some candidates mentioned the key words, diffusion, osmosis and partially permeable membrane. The most common incorrect responses either described water entering the root, travelling up the stem and out of leaves or that water enters the leaves and travels down the stem.

(ii) The xylem was stated by many candidates. Incorrect answers included phloem, root and blood vessels.

(c) (i) Some candidates gained full credit for this question. Some candidates stated 'produce antibodies' to gain partial credit. The term phagocytosis was unfamiliar to most candidates. There were many scripts that stated, 'fight off disease / bacteria' or 'kills bacteria / viruses'.

(ii) Generally, well answered.

Question 5

(a) (i) Many candidates correctly circled electrolysis.

(ii) A few candidates knew bauxite. The most common incorrect answer was aluminium ore.

(b) The loss of oxygen from aluminium oxide to explain reduction was correctly stated by some candidates.

(c) (i) The definition of nucleon number, the number of protons added to the number of neutrons, was not known by most candidates. Some answers stated 'it is protons and neutrons' without saying the (total) number of them.

(ii) Generally, well answered.

(d) To answer this question candidates had to know that the aluminium atom loses all three outer electrons to form an ion. This leaves the outer electron shell empty. Candidates who did not know the number of electrons that were lost put either one or two electrons in the outer shell. These candidates were not awarded credit.

(e) Only a few candidates gained full credit. The most common errors occurred when candidates ticked liquid ammonia, a covalent non-conductor, and put a cross for liquid aluminium oxide. Candidates are reminded that when an ionic compound becomes molten the ions become mobile and can conduct electricity.

Question 6

(a) Candidates had to do the unit conversions from metres to kilometres (divide by 1000) and from seconds to hours (multiply by 3600). In this question it was essential for the candidates to show their working. Many candidates found this demanding and did quite complicated and inaccurate calculations.

(b) (i) Generally well answered. Most candidates gave the correct answer of 0.018 m/s. The most common error was 0.0175 m/s, misreading the graph.

(ii) Only a few candidates stated that the vehicle hit the rock at 50 s. Candidates were able to describe the deceleration and subsequent acceleration that occurred at 50 s and 60 s respectively, so were able to score credit here. A minority of candidates interpreted the graph incorrectly, stating that the lines representing acceleration showed uphill movement and the lines representing deceleration showed downhill movement.

(c) (i) Many candidates gained full credit on this question. Others did not use the correct term, gravitational (potential energy), and simply stated gravity.

(ii) Some candidates gained full credit for the calculation of the speed of sound on Mars. The main error was to multiply 120 by 0.5 to get 60 m/s, instead of dividing 120 by 0.5 to get 240 m/s.

Question 7

(a) (i) Most candidates scored full credit for the food chain. The most common error was to draw the arrows pointing in the wrong direction, not reflecting the flow of energy.

(ii) Some candidates only gave one of the carnivores, either the robins or the merlin, but not both, so they did not gain full credit. Some candidates did not refer to Fig. 7.1 and just gave definitions of herbivores and carnivores. These were not awarded credit.

(b) Many candidates found it difficult to interpret the diagram of the carbon cycle and recall the key processes shown by the letters.

Question 8

(a) (i) The formula was deduced correctly by most candidates. Credit was missed when errors occurred with inaccurate counting of the atoms, or when candidates wrote superscripts instead of subscripts for the numbers in the formula.

(ii) Generally answered well.

(iii) Very few candidates gained full credit. Many of the incorrect responses included chemicals mentioned in the question.

(b) The colour change of the test to distinguish between saturated and unsaturated hydrocarbons was not known by many candidates.

(c) (i) Fractional distillation was stated correctly by many candidates. Others gave a variety of chemical processes including filtration, distillation, diffusion and evaporation.

(ii) Candidates had to give the correct change, a physical change, and give a correct explanation to gain credit. Just stating that it was a change of state was not a good enough explanation. It had to be stated that there were no new substances made.

(iii) Most candidates successfully stated the use for refinery gas in cooking. Other responses included fuel for jets, in engines, and in petrol. One-word answers that were not allowed were cars, fuel, and stoves without describing their use for cooking and heating.

(d) Many candidates gained credit by stating coal. Only a few stated natural gas as well to gain full credit. A common error was to state oil. Petroleum, stated in the question, is another name for crude oil, so oil was not accepted.

Question 9

(a) Many candidates used the Ohm's Law equation correctly to get the correct value of 6 V. Some of these candidates struggled with the unit and wrote ohms instead of volts.

(b) Many candidates successfully added up all of the resistances in the circuit as they were all in series.

(c) (i) A few candidates completed the circuit successfully to gain full credit. Common errors occurred when candidates placed the ammeter in one of the branches of the circuit, drew a series circuit rather than the parallel one requested, included some incorrect symbols in the circuit, and drew ammeters with lines drawn through the middle.

(ii) All candidates found this question demanding. If two resistors are placed in parallel the current flowing through the main circuit is greater than when one resistor is in the circuit. This is because when the resistors are placed in parallel the total resistance of the circuit reduces, enabling the current to be higher.

COMBINED SCIENCE

Paper 0653/33
Theory (Core)

Key messages

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

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

It is important that candidates can apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination and some produced very good answers. Successful candidates read the questions carefully and were able to express their answers in a clear and legible way.

Candidates are advised to attempt every question in the paper, especially those questions where they choose their answers from responses that are already given on the paper.

Comments on specific questions

Question 1

(a) Many candidates identified the pulmonary vein successfully. Fewer labelled the septum correctly. Common errors included ventricle and muscle.

(b) Generally answered well. Most candidates matched the components of the blood with their functions to gain full credit.

(c) (i) This question was answered well by some candidates. The most common error occurred when candidates circled vacuole instead of gland. Candidates are reminded that hormones are produced by glands and then enter the blood stream for transport.

(ii) Many candidates subtracted 70 from 91 to get 21, the actual increase in the pulse rate, and gained partial credit. Calculation of this as a percentage increase was more challenging and some candidates did not attempt this part of the question.

(iii) The dilation of pupils was the most common correct answer for another effect of adrenaline on the body. Candidates who described an increase in pulse or heart rate were not awarded credit because this was already described in **(c)(ii)**.

Question 2

(a) (i) Many candidates stated oxygen to gain credit. Air was not precise enough for the answer.

(ii) Many candidates had the general idea of removing one of the conditions needed for rusting, but ‘take away the oxygen’ or ‘take away the air’ were not sufficient methods without further explanation.

(b) (i) Hydrogen was successfully identified by many candidates. Carbon dioxide was the most common incorrect answer.

(ii) Candidates had to use their knowledge of the reactivity of metals to suggest the identities of metal **A** and **B**. Many did not automatically use their knowledge of the reactivity series of metals but instead referred to the Periodic Table. These responses were usually incorrect because the candidates did not have sufficient knowledge about the metals they were suggesting. Silver and gold were also accepted for metal **B** as these metals are unreactive with dilute hydrochloric acid.

(iii) This was generally well answered. Most candidates chose to increase the temperature or the concentration of the acid. Responses such as 'change the temperature' or 'temperature' were not awarded credit. Candidates had to state that the temperature should be increased.

(c) Generally, well answered.

Question 3

(a) (i) Most candidates knew that the gravitational force acted vertically downwards on the bus. Many candidates did not draw the tail of their arrow touching the bus, so they were not awarded credit. It is important that the tail of the arrow touches the object on which the force is acting, and not the air or road near to it.

(ii) Candidates found this question demanding. The gravitational force on an object is its weight. This is because the gravitational force acts on the mass of the object.

(b) (i) The need for balanced forces to maintain a constant speed was stated by some candidates. Many did not refer to the need for balanced forces.

(ii) Generally answered well with most candidates successfully calculating the resultant force.

(iii) Most candidates successfully interpreted the resultant force as one that would cause acceleration.

(c) (i) Generally answered well. Most candidates read the graph successfully to give 12 m/s as the correct answer.

(ii) This question was answered very well by most candidates. Those candidates who wrote 260 s as the start of the deceleration were not awarded credit because the graph of the bus clearly shows it started deceleration before this time.

(d) Many candidates scored partial credit for the second response, kinetic energy. Fewer correctly stated that the potential energy stored in the batteries is chemical (potential) energy.

Question 4

(a) (i) Most candidates successfully identified an ovule and the stigma, the site of pollination.

(ii) Candidates generally knew the role of petals in attracting pollinators to the flower. Fewer knew the function of the sepals, to protect the flower when it is a bud.

(b) This question was answered well, although a few candidates wrote vegetarian or vegan. These terms, usually applied to humans, were not accepted because humans make a conscious choice not to eat meat. Herbivores are born with the physical characteristics, e.g. teeth, that prevent them from eating anything apart from plants.

(c) (i) Many candidates knew the word equation for photosynthesis and gained full credit. Other candidates wrote light, one of the conditions needed for photosynthesis, in one of the boxes. These candidates are reminded that carbon dioxide reacts with water to give glucose and oxygen. This only happens when sunlight is present.

(ii) This question was generally answered well. Many candidates gave their answers as a trend, and then picked out some valid data to illustrate their point. Some candidates did not describe the graph levelling off, so they did not score full credit.

(d) There were several possibilities to score in this question. Responses that were not allowed included an increase in carbon dioxide concentration (given in the question), climate change, and any reference to acid rain or the ozone layer.

Question 5

(a) (i) Many candidates successfully chose the first option to show that the metallic character across a period decreases from left to right. The unsuccessful candidates chose either the second or third option. Candidates should be aware that the metals are found in the groups on the left-hand side of the Periodic Table. The non-metals are found in the groups towards the right-hand side, so the trend is that the metallic character decreases across a period from left to right.

(ii) Only a few candidates stated transition metals correctly. Common errors included reactive metals, unreactive metals and conducting metals.

(b) Candidates found this question demanding. Many did not understand that the question was asking for a trend in melting point going down Group I, and they gave random numbers without indicating a trend. The same responses occurred for the trend in reaction with water, though there were some correct explanations from some candidates.

(c) The diagrams were completed correctly by many candidates. Since the question asked for the diagrams of ions to be drawn, arrows to demonstrate electron transfer should not be included because the transfer between atoms has already occurred.

(d) (i) Most candidates identified argon successfully.

(ii) There were several different ways of expressing the fact that the outermost shell of **Z**, argon, is full and therefore cannot take any electrons from sodium. Candidates who did not gain full credit described the electronic structure of both sodium and argon but did not develop their point to state that there was nowhere in the atom of argon for sodium's electron to go.

Question 6

(a) (i) Many candidates stated infrared waves to gain credit.

(ii) Very well answered by candidates across the range of abilities.

(iii) Many candidates successfully stated radio waves. The most common error was microwaves. The remaining incorrect alternatives were chosen in roughly equal proportions.

(b) (i) To gain credit for this question it was essential that the working was shown. Therefore, distance = speed × time was the appropriate equation, giving 884 m after the numbers were substituted into the equation. This question was successfully answered by most candidates.

(ii) Candidates had to estimate what the speed of sound would be at 25 °C, having been told the speed of sound at 15 °C and at 35 °C. Some wrote a value somewhere between 340 m/s and 352 m/s, though not too close to either. These candidates were awarded credit. Others tried a calculation by proportion without using the speed at 15 °C, so they were unsuccessful. Candidates are reminded to read the whole question to gain as much information as possible.

(c) (i) Many candidates recalled the equation successfully.

(ii) Candidates found this question demanding. The important point is that the volume of the air increases when the temperature increases. This is because the particles in air move further apart from each other. For the same mass of air there is an increased volume, and referring to the equation density = mass / volume it can be seen that the density has to decrease.

Question 7

(a) (i) Almost all candidates gained credit in this question.

(ii) Candidates appeared to know the answer to this question but had difficulty in expressing it. They discussed the need for fibre to help the movement of food through the alimentary canal, but many candidates did not state that avocados had the highest mass of fibre per 100 g. Many responses just stated that avocados were rich in fibre, but the question was asking which was the best fruit, the fruit with the highest fibre content.

(iii) The main point here was to recognise that biuret solution changes colour in the presence of protein. Then when referring to Table 7.1, it can be seen that avocado contains protein, so that fits in with the observation. Credit was not awarded to candidates who identified the wrong food test.

(b) Many candidates answered this question correctly. The main error occurred when candidates wrote egestion for the last answer. Candidates are reminded that the process of digestion breaks down large insoluble molecules into smaller soluble molecules that can be absorbed through the wall of the small intestine. Therefore, the last answer is absorption.

Question 8

(a) (i) Generally answered well by candidates of all abilities.

(ii) Candidates found both parts of this question demanding. Responses that described the arrangement of the molecules as close together were awarded credit. When describing the motion, any description involving vibration of molecules did not score, since this is only appropriate to solids. Moving around each other or a random movement gained credit.

(iii) Simply describing the change of state was not enough for credit. It had to be stated that there are no new substances made during the change. Only some candidates stated this fact.

(b) Some candidates successfully named fractional distillation, the separation process that uses the equipment shown in Fig. 8.1. Responses that were not awarded credit included distillation on its own, or cracking.

(c) (i) Many candidates described an unsaturated solution, one that can dissolve more solute, instead of referring to a double bond being present in a hydrocarbon molecule.

(ii) Cracking was successfully stated by some candidates. Common errors included distillation, fractional distillation, heating and burning.

(iii) Most candidates were unfamiliar with the term addition polymerisation, the type of chemical reaction that changes ethene into poly(ethene).

Question 9

(a) (i) Many candidates did the Ohm's Law calculation successfully, including the correct unit, ohms. Candidates who did not score credit included those who used an incorrect version of the equation. Incorrect units included amps and volts.

(ii) Since the lamps are identical, and they are in series in the circuit, the resistance of each lamp is half of the total resistance of the circuit. An error carried forward (ecf) was allowed for this calculation if candidates wrote an incorrect answer to **(a)(i)**.

(b) (i) This was generally answered well. Candidates related the dimmer bulbs to a lower current.

(ii) Many candidates successfully suggested to check the voltage of the cells.

(c) Many candidates did well with this circuit diagram, gaining full credit. Others were not familiar with the symbols for the electrical components. Candidates are reminded that the required symbols are listed in the syllabus and that straight lines should not be drawn through the symbols for the ammeter and the variable resistor. The circuit should also be complete with no gaps in it.

COMBINED SCIENCE

Paper 0653/41
Theory (Extended)

Key messages

Candidates who scored 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 between relevant variables in questions involving calculations, and that these were set out clearly and logically so that key steps could be awarded credit even if the final answer was incorrect.

General comments

Many candidates showed mastery of all sections of the syllabus and were very well-prepared in terms of examination technique. Candidates generally did equally well in the three science disciplines. Particularly sound knowledge and understanding was shown about the heart, respiration, ionic bonding, acceleration and energy calculations. In this examination, parts of the syllabus that seemed relatively unfamiliar included labelling the energy changes in an energy level diagram for a chemical reaction, the syllabus definition of *g*, the effect of increased humidity on transpiration and knowing that the current divides in a parallel circuit.

Comments on specific questions

Question 1

(a) This question was answered very well by most candidates. The most common mistake was that part **Z** contracts, tightens or narrows, which was not accepted as an alternative to closes.

(b) (i) Almost all candidates answered this correctly.

(ii) Almost all candidates answered this correctly. A small number of candidates described factors which could affect heart rate but were not awarded credit unless they answered the question and described the trend shown on the graph.

(iii) Some candidates had learned this part of the syllabus very well and many gained full credit. Most candidates gained credit for referring to the increased need for oxygen and many made the connection with increased respiration. Some candidates attempted to make the connection between increased respiration and the need for increased energy transfer, but they had to state that the increased energy was required for muscle contraction. The idea that carbon dioxide in the blood would increase was stated by some candidates but this was a less popular answer.

Question 2

(a) Most candidates were awarded at least partial credit for recognising the heat source and the salt solution. A small number of candidates suggested round bottomed flask, but this was not accepted as an alternative answer for **D** or **E**. A common mistake was the idea that water vapour or air circulated in the condenser. Some candidates identified **B** as a condenser.

(b) In their descriptions, candidates had to state that the salt solution needed to be heated and that the purpose of this was to remove or evaporate the water. The unqualified idea that evaporation was important did not gain credit unless water was mentioned.

(c) The diagram of the arrangement of ions in sodium chloride was well known by most candidates.

(d) Several candidates were familiar with the reasons why sodium ions are positively charged and chloride ions are negatively charged. Partial credit was awarded for answers that described electron loss by sodium and electron gain by chlorine but which omitted to specify that one electron was involved. The best answers avoided careless wording such as 'chloride gains one electron'.

Question 3

(a) (i) Some candidates correctly stated convection. Many suggested conduction and a small number suggested radiation.

(ii) Even when candidates had stated convection in part **(a)(i)**, their answers to this part often described conduction. Some candidates made no reference to the movement of thermal energy through the water and limited their descriptions to the movement of heat through the metal of the pan. Candidates who had suggested conduction in part **(a)(i)** were awarded credit in part **(ii)** for a correct description of conduction in terms of molecular collisions (error carried forward). In general, only some candidates could describe convection in terms of warmer water of lower density rising. Candidates needed to avoid suggesting that the density of molecules decreases on heating.

(b) (i) Most candidates correctly referred to boiling, and avoided suggesting evaporation, which was the most common incorrect answer.

(ii) Credit was awarded for any clear reference to the space between the water surface and the glass lid. Many candidates suggested either 'at the water surface' or 'on the underside of the glass lid'. Neither of these were accepted.

(c) (i) Common mistakes included drawing a break between the sections of the thermometer above and below the surface, showing no deviation between the two sections of the thermometer and showing the section below the water bending in the incorrect direction. Credit was infrequently awarded.

(ii) Most candidates were familiar with the numerical value of the speed of light and the correct units.

(iii) Most candidates answered this correctly.

(iv) Credit was awarded to candidates who referred to the increase in the speed of light on passing from water into air. Many candidates described the change in medium, the different densities of air and water or they simply stated that the light rays are refracted. None of these ideas received credit unless candidates also included the change in the speed of light in their answers.

Question 4

(a) Most candidates gained full credit. Candidates should be advised that in questions like this, the credit is awarded for the correct labelling letters and not for stating names of the labelled parts even if they are correct.

(b) (i) Many candidates were familiar with the jelly coating surrounding egg cells. Further credit was awarded for referring to the energy stored inside the cell. The suggestions that the cell contained food or nutrients were not allowed as alternatives, unless energy was also mentioned. Many candidates suggested general features which would be found in other types of cell. Examples were 'contains a nucleus', 'has chromosomes' and 'has mitochondria', none of which gained credit.

(ii) Most candidates were familiar with at least one common feature between the structures of egg cells and sperm cells. Some candidates avoided suggesting adaptive features of these cells, for example being haploid, containing DNA or containing the same number of chromosomes.

(c) (i) Credit was awarded for any wording that implied the amniotic fluid provided protection from external shocks. Unqualified answers such as 'it protects the baby' were not credited. Credit was awarded for alternative correct functions such as maintenance of temperature.

(ii) Candidates needed to focus their answers on the provision of nutrients for the embryo and so descriptions of waste removal could not be awarded credit in this case. Some candidates successfully distinguished between the functions of the placenta and the umbilical cord. The essential points that candidates needed to make were that nutrients passed from the mother through the placenta, and then the umbilical cord provided the means of transport of nutrients to the fetus. Many candidates found it challenging to find words to make this difference clear.

Question 5

(a) (i) Candidates generally were familiar with the correct shape of the energy level diagram and most were awarded at least partial credit. The most common reasons for missing credit included labelling the activation energy as the energy difference between the peak and the energy level of the products rather than the reactants. Other mistakes included showing the horizontal axis as an energy level and reversing the labels for activation energy and overall reaction energy change. Candidates should be aware that if arrows representing energy changes are not drawn carefully then credit can be lost. The best answers avoided using double-headed arrows. In this case these were accepted for activation energy, but not for the overall energy change which had to be shown as an arrow pointing towards the products from the reactants.

(ii) Most candidates were awarded credit. Candidates had to describe the feature on the diagram that shows the reaction is endothermic. Consequently, answers such as 'ΔH is positive' or 'more heat is taken in than released' were not accepted.

(iii) Although some candidates had no difficulty completing the balanced equation, credit for including the state symbols was often missed. Another common reason for missing out on credit was the use of 2N rather than N_2 to represent a nitrogen molecule.

(b) Suggestions for the adverse effect of oxides of nitrogen on buildings had to include the idea that a relevant chemical reaction is involved. Consequently, statements such as 'it damages buildings' and 'it causes metalwork to rust' were not accepted. An example of a better answer is 'it reacts with limestone walls and weakens them'. When discussing the effects on health, many candidates were familiar with the gas being associated with breathing difficulties. Any known effects of oxides of nitrogen on health were accepted, although candidates should be advised that the unqualified suggestion 'cancer' is not accepted.

Question 6

(a) (i) Credit was awarded to candidates who referred to mass, although only a minority did so. In the syllabus, *g* is defined as the force on unit mass. This answer was given by only a very small number of candidates. The most common answers were 'the box' and 'the Earth'.

(ii) Most candidates were awarded credit.

(b) (i) Almost all of the candidates were awarded credit.

(ii) The relationship acceleration = change in speed ÷ time was very familiar to most candidates, who worked through to the correct numerical answer and stated the correct units. Stating incorrect units, usually m / s, was a common reason for missing credit.

(iii) Most candidates were familiar with the calculation of the area under a speed–time graph to find the distance travelled. Candidates needed to state $\frac{1}{2} \times 25 \times 5$ or its equivalent to be awarded credit. Some candidates suggested an expression that evaluated to 62.5 but which was not related to the graph. No credit was awarded for this.

(iv) Although this was one of the most demanding physics questions on the paper, some candidates worked through it successfully, showed very clear working and gained full credit. Candidates who did not identify exactly what was needed still gained partial credit for showing some of the correct steps or expressions in their working. One frequent mistake was that candidates subtracted the value for the kinetic energy from that for the potential energy rather than finding the sum. An error in the speed of the box could be carried forward from part **(b)(i)**, and a value for *g* of 9.8 rather than 10 N/kg was accepted. Consequently, answers emerging from these alternatives were accepted.

Question 7

(a) (i) Many candidates were awarded full credit. Credit was awarded for a description of photosynthesis and for describing how guard cells control the size of stomata or control the entry and exit of named substances. Some candidates missed the significance of the term function and named the cells labelled **P** and **Q**.

(ii) Candidates who recognised that this question concerned transpiration at the leaf surface often gained full credit. Many attempted to complete the passage using terms relating to water absorption by the roots. The terms osmosis, movement and evaporation were often suggested instead of diffusion. The terms air, outside the leaf and environment were accepted for atmosphere. Most candidates gained at least partial credit for decrease.

(b) (i) Most candidates recognised trophic level 1. Credit was not awarded for the answer 'primary'.

(ii) Many candidates were familiar with the context of this question and gained full credit. Candidates needed to make it clear that energy losses occur between trophic levels rather than making unqualified statements such as 'energy is lost'. Stronger answers stated that not enough energy remains to sustain organisms in higher trophic levels rather than simply stating that 'less energy is passed on'. Candidates usually gained at least partial credit for describing the ways that energy is lost.

Question 8

(a) (i) Most candidates stated cracking. The most common incorrect suggestion was fractional distillation.

(ii) Most candidates correctly stated two conditions required for cracking. Candidates should avoid unqualified terms such as temperature or pressure. Candidates who gained credit specified high temperature and high pressure. Reasonable suggestions of numerical values of temperature and pressure were accepted but this is not expected in this examination. Although 'high heat' was accepted in this case, the best answers referred to high temperature. Many candidates stated the need for a catalyst. A correctly named substance that is used as a catalyst was accepted.

(b) (i) Most candidates were familiar with similarities and differences between molecules of ethane and ethene and many were awarded full or partial credit. Candidates needed to make sure that they fully described the differences between these molecules. This means that suggestions such as 'ethene contains a double bond' is not enough for credit. The best answer would be 'ethene contains a double carbon-carbon bond but ethane contains only single carbon-carbon bonds'.

(ii) Most candidates gained at least partial credit for knowing that the products of complete combustion are carbon dioxide and water, even if they could not balance the equation.

(c) Most candidates were awarded credit. Common incorrect suggestions were 10 or $C_{10}H_{20}$.

Question 9

(a) Most candidates selected the correct circuit components and were awarded full credit. Candidates who were less familiar with the context of this question appeared to guess. Two mistakes which seemed to be seen more frequently were to suggest **J** (variable resistor) or **G** (ammeter) instead of **F** (battery) for the component that provides the e.m.f. for the circuit.

(b) Many candidates drew the voltmeter correctly connected and gained full credit. Candidates should be advised to draw circuit symbols exactly as they are shown in the syllabus. Some drew a wire through the middle of the voltmeter symbol and could not be awarded full credited.

(c) (i) Many candidates gained credit. Others appeared to be guessing how to process 5.5 V and 3.0 V, the most common mistake being to add these values.

(ii) Only some candidates gained full credit. Many were awarded at least partial credit for working that showed they knew this calculation was based on Ohm's Law. The most common mistake made by these candidates was that they used the value 0.6 A rather than 0.3 A for the current through one of the lamps.

COMBINED SCIENCE

Paper 0653/42
Theory (Extended)

Key messages

Candidates who performed well on this paper:

- demonstrated knowledge and understanding in all three science disciplines, with good recall of scientific terms, phrases and equations
- demonstrated good factual knowledge
- were guided by the command words e.g., describe, explain, calculate, to structure their answers
- were guided by the number of marks available for each question to inform the detail of their answers
- rearranged equations when necessary and clearly showed the steps in their calculations
- interpreted diagrams and data by providing explanations as well as descriptions
- used data, in different forms, to explain or justify conclusions.

General comments

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

Comments on specific questions

Question 1

(a) Most candidates correctly identified the parts from the diagram. Some candidates had difficulty describing the function of the small intestine, a common misconception was egestion instead of absorption.

(b) Most candidates correctly completed the sentences describing the two types of digestion in the stomach. Some candidates did not know that the digestion of protein produces amino acids.

(c) Most candidates knew that the stomach is an acidic environment. They interpreted the graph to conclude that lipase will not be active at such a low pH. They referred to denaturing and shape changes to the active site to explain the inactivity of lipase. A common misconception was that the pH of the stomach is high.

Question 2

(a) Almost all candidates correctly matched the separation processes with their descriptions.

(b) Most candidates recognised that heat is applied to the solution so that water can evaporate. Some candidates named the condenser or the process (condensation) where vapour becomes liquid again. Only a few stated that the salt is left behind or that only the water leaves the flask.

(c) (i) Some candidates stated that sodium chloride has ionic bonding and that the high melting point can be explained by the strong forces of attraction between ions. Some candidates also referred to the energy required to break these bonds. A common misconception was that the difference is explained by water being a liquid and sodium chloride being a solid.

(ii) Most candidates found this question demanding. Partial credit was often gained for an understanding that energy is required for a change of state. Some candidates who understood this first point concluded that the energy needed to change from liquid to gas is more than the energy needed to change from solid to liquid.

(iii) Most candidates correctly drew the different particle arrangements in the solid and the gas. A few candidates were imprecise and drew particles of varying sizes.

Question 3

(a) Most candidates knew that the energy in the burning oil is transferred to thermal energy or heat (and light). Some candidates recalled that oil contains a store of chemical (potential) energy.

(b) Only a few candidates gained full credit for describing the process of convection. They understood that the flame heats the air above the heater which then rises due to its decreased density. Common misconceptions were that 'particles become lighter', and 'particles of the flame move upwards'. Some candidates described how cool air sinks which is part of a convection current but unfortunately does not answer this question.

(c) (i) Most candidates found this question demanding. Some candidates knew that frequency is a measure of the number of waves or vibrations that occur in one second. Many candidates who knew that frequency is related to the number of waves were quite vague about the time period e.g., describing it as 'a certain time'.

(ii) Most candidates recalled that either microwaves or radio waves have a lower frequency than infrared.

(iii) Many candidates either recalled the wave equation incorrectly or substituted values in an incorrect rearrangement. Candidates should consider the expected unit of the answer – in this case metres and whether multiplication or division of the given values produces a number with this unit.

Question 4

(a) (i) Most candidates recognised that the vacuole and cytoplasm were mislabelled on the diagram.

(ii) Most candidates recognised that the shape of the root hair cell gives it a large surface area. Some candidates distinguished between the volume of water taken up (which may be large or small depending on the time frame) and the rate of water uptake (which responds to changes in the rate of transpiration).

(b) (i) Most candidates described that the rate of photosynthesis increases with increasing light intensity. Only a few candidates noticed that the rate of photosynthesis then stops increasing or reaches a constant or maximum value even when the light intensity continues to increase.

(ii) Only a few candidates were guided by the credit available for this question. Some candidates understood that burning the trees increases the availability of carbon dioxide and a few understood that the removal of trees increases the availability of light. Very few candidates gave both points.

(c) Some candidates confused chlorophyll with chloroplasts. Candidates who gained partial credit generally knew that magnesium is needed to make chlorophyll (a green pigment). A common misconception was that the yellowness of the leaf is simply a sign of the plant dying due to magnesium deficiency.

Question 5

(a) Some candidates recognised from the shape of the energy level diagram that the reaction was endothermic overall. Candidates were generally less clear about the role of bond breaking and bond forming during the reaction. A common misconception was that nitrogen monoxide contains the bond that is being broken. In this example it is the N_2 bonds and the O_2 bonds in the reactants.

(b) (i) Most candidates could state and balance the symbol equation for the reaction between nitrogen monoxide and oxygen. The state symbols were sometimes missed or incorrect. The state symbols for both the reactants and the product were all (g) but 'gas' is not acceptable as a symbol.

(ii) Most candidates gained partial credit for showing the products at a lower energy level than the reactants and included a peak to represent activation energy. This decrease in energy level means that the overall energy change should be shown as a down-arrow and the activation energy is the difference between the energy of the reactants and the peak.

Question 6

(a) (i) In this question candidates needed to determine the highest speed (0.010 m/s) from the speed–time graph and then convert from m/s to km/h. Many candidates recalled that the conversion factor is simply 3.6, but many also used a ratio of 3600 seconds to 1000 metres. Some candidates also gained credit for working backwards from 0.036 to 0.010.

(ii) A common error was to calculate the area under the graph instead of the change in speed per unit time. Some candidates also had difficulty interpolating 0.005 from the speed axis. Some candidates also gave the unit of speed (m/s) instead of acceleration (m/s^2).

(iii) Most candidates understood that there was an acceleration. Many also correctly described this as non-uniform or non-constant.

(b) (i) Most candidates recalled the kinetic energy equation. However, not all candidates completed the calculation to show how 1.1 J is approximately 1.1125 J.

(ii) Only some candidates scored well on this question. Candidates should understand that when questions are subdivided as **(i)**, **(ii)** etc., then information given at the start of the question is usually applied later in the question. In this example, the mass of the vehicle given at the beginning of **(b)** and the value of KE given in part **(i)** must be equated to the gravitational energy gained and substituted into GPE = *mgh* in part **(ii)**.

Question 7

(a) (i) Most candidates recognised vessel **X** returning blood from the lungs to the heart as the pulmonary vein, although some referred to this vessel as an artery. Candidates generally recognised vessel **Y** as the aorta, but less commonly than vessel **X**. A common error was to name these vessels as ventricles and atria.

(ii) Many candidates correctly identified the septum as the tissue between the ventricles of the heart. Some candidates made no response to this question but candidates should be encouraged to have a guess even if they don't know.

(iii) Most candidates found it quite difficult to explain the advantages of a double circulatory system. Candidates probably know that arteries carry oxygenated blood, while veins carry deoxygenated blood. A double circulation simply ensures that these blood flows are kept separate. Some candidates understood that for blood to reach all of the body it must be at a higher pressure than is necessary for it to reach the lungs, where it very quickly becomes divided into many very fine capillaries that are not adapted to withstand such high pressure.

(b) (i) Most candidates were able to describe at least one feature of a gas exchange surface. Commonly they stated that they have a large area and are thin.

(ii) Most candidates selected the two correct statements comparing the composition of inspired and expired air. The most common misconception was that water is a reactant in respiration.

Question 8

(a) Some candidates recalled that sulfuric acid is H_2SO_4, as well as the molecular formulae of the other reactants and products, this was accepted. It was apparent that other candidates simply looked for patterns in the words in order to predict the reactants and products.

(b) (i) and (ii) While most candidates correctly identified either of the acids as having a pH less than 3, far fewer candidates identified water as the covalent substance with a pH greater than 5. Many candidates named one of the salts.

(c) Most candidates gained partial credit for stating that Mg is in Group II and that it has two electrons in its outer shell. Relatively few candidates stated that the left side of the Periodic Table is occupied by metals or that Groups I to III all have low numbers of valence electrons that are easily lost when they form positive ions.

Question 9

(a) Many candidates recognised that the symbol represents a source of power. Only a very small number of candidates recalled that the symbol ~ represents alternating current.

(b) (i) Most candidates recalled and correctly rearranged $V = IR$ to calculate the current in the circuit.

(ii) Most candidates recalled $P = VI$ and correctly used their value from part **(b)(i)** to calculate the power required by the heater.

(c) Most candidates found this question very demanding. The first condition was that the heater and lamp must be on together. This means that they must be in the same branch controlled by the same switch. The second condition was that the current to the heater is not reduced. When components are added in series the total resistance increases, so decreasing the current. This means that the lamp must be in parallel with the heater only. A lamp in parallel with the switch and heater means that the heater could be off while the lamp stays on.

COMBINED SCIENCE

Paper 0653/43
Theory (Extended)

Key messages

Candidates who performed well on this paper:

- demonstrated knowledge and understanding in all three science disciplines with good recall of scientific terms, phrases and equations
- demonstrated good factual knowledge
- were guided by the command words e.g., describe, explain, calculate, to structure their answers
- were guided by the number of marks available for each question to inform the detail of their answers
- rearranged equations when necessary and clearly showed the steps in their calculations
- interpreted diagrams and data by providing explanations as well as descriptions
- used data, in different forms, to explain or justify conclusions.

General comments

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

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified the labels, names and functions of the flower parts shown in the diagrams.

(ii) Most candidates knew that the presence of large petals indicates insect-pollination.

(b) (i) Most candidates had difficulty identifying two adaptive features of sperm cells. Candidates should know that the 'tail' structure is called a flagellum and about the presence of enzymes. Credit was awarded for other valid points about sperm structure for example, that a large number of mitochondria are needed to release energy for movement or that the 'head' structure is called an acrosome.

(ii) The candidates that recognised structure **X** as the nucleus also tended to understand that during fertilisation this nucleus fuses with the nucleus of the egg cell. Many responses indicated that candidates were unsure about the mechanism of fertilisation.

Question 2

(a) (i) Most candidates understood that the energy change and activation energy are indicated by arrows. However, many responses indicated a degree of confusion amongst the candidates. Candidates should know that the activation energy arrow starts from the reactant energy level and ends at the top of the crest of the line showing the progress of the reaction. This may be an up-arrow or a double-arrow. The overall energy change is an arrow from the energy level of the reactants to the energy level of the products. This arrow should point down if there is a decrease and up it there is an increase.

(ii) Candidates found this part of the question less demanding than part **(i)**. A common misconception was that only one of the diagrams (one is exothermic, the other is endothermic) involves breaking bonds.

(iii) Most candidates gained credit. A common error was to use the formulae of different molecules to the ones given in the question.

(b) Candidates found it difficult to describe why oxides of nitrogen have low boiling points. There are weak attractive forces between the molecules so a small amount of energy is needed to increase the separation between the molecules.

Question 3

(a) (i) Most candidates correctly located the position of microwaves in the diagram.

(ii) Most candidates correctly stated one danger of ultraviolet radiation.

(b) (i) Most candidates correctly recalled and rearranged the speed equation to calculate the time for the microwave signal to travel.

(ii) Most candidates who recalled the wave equation also rearranged it correctly to determine the wavelength of the microwave signal.

Question 4

(a) (i) Most candidates correctly located the pancreas on the diagram.

(ii) Most candidates knew that amylase breaks down starch and some knew that proteins are broken down by protease. Only some candidates recognised that this is a difference, not an explanation, so they went on to explain that the active site of amylase in complementary to starch not protein.

(iii) Most candidates knew that amino acids are the products of protein digestion.

(b) (i) and (ii) Most candidates knew that one cause of vitamin D deficiency is a lack of sunlight and many also described an effect of deficiency, such as bone weakness.

(iii) Candidates should know that capillaries have thin walls. This allows substances to pass through, either into cells or from cells for removal by the blood.

Question 5

(a) (i) A common error was to state that zinc sulfide rather than zinc sulfate is produced. In the second reaction, water is a product so an oxygen atom must be in the reactants.

(ii) Candidates should learn that covalent bonds are formed between non-metal atoms. Many candidates named at least one of the zinc compounds.

(b) Most candidates knew that water is a product of the acid–metal carbonate reaction. A common error was to name hydrogen instead of carbon dioxide as the other product.

(c) Most candidates named a suitable indicator and knew that it would change colour. Some candidates also stated that in order to determine the pH number, this new colour must be compared to a chart.

(d) Most candidates knew that the addition of a base or an alkali can be used to control the acidity of soil. A common misconception was that water should be added.

Question 6

(a) (i) The question stated that the bus was travelling at constant speed. This means that the arrow representing the forward force of the bus must be equal in size as well as opposite in direction to the backwards force arrow.

(ii) Most candidates knew that the cause of the backwards arrow was friction (with the air) or air resistance.

(b) Most candidates recognised that force **R** was equal to the weight **P** of the bus (as indicated by equal length and opposite direction force arrows). Alternatively, they showed a calculation using mass and gravitational force. Some candidates were also able to explain that if these forces were not equal then the bus would either rise above or sink into the road.

(c) (i)–(iii) Most candidates correctly used data from the graph to calculate the acceleration, the distance travelled before deceleration and the difference in distances to determine the deceleration distance.

Question 7

(a) (i) and (ii) Some candidates recognised that **X** and **Y** form a structure that transports substances through the plant. A few candidates were able to identify **X** as xylem or **Y** as phloem. Candidates should know that glucose is not transported in phloem. In part **(ii)**, candidates used the same diagram to describe the movement of water from the surface of the spongy mesophyll cells to the outside of the stomata. Candidates should know that there are two processes and one state. The first process is evaporation, the second is diffusion and the state of the water is vapour.

(b) Many candidates successfully completed the sentences about auxin.

(c) (i) and (ii) Most candidates easily identified the organisms at trophic level 2 of the food web and selected words that described the osprey as a consumer.

Question 8

(a) (i) and (ii) Most candidates recognised that alkenes have a carbon-to-carbon double bond, and they could also state the correct general formula for alkanes and alkenes. A common error was to start the formula with C_2 instead of C_n which assumes that the number of carbon atoms is not variable.

(b) Most candidates found this demanding. Some candidates recognised from the first diagram that there are six carbon atoms and that these must be arranged in a chain. Candidates should learn that in forming a polymer chain, the double bond is replaced by a single bond and continuation lines represent the potential for bonds to form with other monomer units.

(c) (i) Most candidates correctly deduced the structure of compound **B** by deducting the correct number of carbon and hydrogen atoms from molecule **A**. A common error was to include carbon-to-carbon double bonds in compound **B**.

(ii) Most candidates knew at least one of the conditions required for cracking of hydrocarbons. Simple references to temperature, heat or pressure are not sufficient.

Question 9

(a) Most candidates recalled that current is a flow of electrons. Candidates found it more difficult to recall the correct unit of potential difference.

(b) (i) Most candidates correctly recalled the equation for electrical power and multiplied the voltage by the current.

(ii) The equation relating charge, current and time required rearrangement to determine the time taken. Candidates found this part of the question demanding.

(c) (i) Most candidates recognised that the description for this new arrangement of lamps was parallel.

(ii) Most candidates found this difficult to explain. In the new arrangement each lamp has the full voltage of the cell across it – whereas when they are in series the voltage is shared. This means that from $V = IR$, V has increased and R is the same so I (the reading on the ammeter) must increase.

COMBINED SCIENCE

Paper 0653/51
Practical Test

Key messages

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

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

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

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

For the graph question, candidates need to ensure they are using as much of the grid provided as possible and they need to work out what each division of the scale represents.

General comments

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

Comments on specific questions

Question 1

(a) (i) Nearly all candidates provided a sensible temperature reading.

(ii) Candidates demonstrated that they could set-up the solutions according to the procedure, take samples at regular intervals to test with iodine solution and obtain the results expected. Where a candidate did not obtain the expected results, they could gain credit for matching the Supervisor results. The provision of a set of Supervisor results is therefore important.

(iii) Many candidates failed to link their colour observations to the presence or absence of starch. Candidates were provided with the information that iodine solution is an indicator for starch. They were then expected to link the colour observations of blue-black to starch being present and brown/orange to starch no longer being present. This would then have enabled them to talk about whether the starch was being broken down/digested or not.

(iv) Copper sulfate was added to one test-tube and this was expected to inhibit (slow down) the action of the amylase. Full credit was still available to candidates who obtained results different to those expected if they correctly explained their own observations. For example, if the copper sulfate had no effect or increased the rate of breakdown.

(v) Most candidates were able to calculate the volume of solution in each test-tube and the difference in volume between the test-tubes.

(vi) A number of candidates identified that the two volumes needed to be equal but were not able to give a correct suggestion. There were several incorrect suggestions such as adding copper sulfate solution or merely 'liquid'. Stronger answers were able to state that 1 cm^3 of water was needed.

(vii) Leaving the test-tubes in the water-baths for a short time before mixing is a standard procedure but may be done for different reasons. In this case it was less important to make sure that the test-tubes reached a particular temperature (which is sometimes the case), but more important to ensure that both test-tubes were at an identical temperature before the reaction started. Some answers stated that the test-tube needs to heat through or similar wording, without stressing the importance that both test-tubes needed to be the same temperature.

(b) (i) Nearly all the candidates correctly measured the length of line **AB** as 58 mm. Some incorrectly recorded their values in cm.

(ii) Most candidates were able to substitute correctly into the equation and calculate a value for the actual diameter. However, the instruction to give the answer to one significant figure was often overlooked. Some candidates confused one significant figure with one decimal place and hence incorrectly rounded the correct answer of 0.06 to 0.1 mm.

Question 2

(a) Candidates reacted a set volume of acid with increasing spatula loads of a carbonate. This produces fizzing and candidates timed until the fizzing stopped. Most candidates were able to get a full set of results and many also obtained the correct pattern, with the time of fizzing increasing as the number of spatulas increased.

(b) (i) Most candidates gained partial credit for their graph. Many graphs were drawn with labelled axes (including units) and care was taken to plot points precisely using crosses. However, some common errors were seen. These 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 were 'reaction time in s and number of spatulas of sodium hydrogencarbonate
- inverting the axes so that they are the wrong way around
- choosing inappropriate scales. Scales should be chosen so that points occupy most 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. Candidates did not have to start the time origin at 0
- some scales chosen were not appropriate because they were difficult to read. Scales should increase in standard intervals such as 0.1 or 0.2. Scales increasing in non-standard intervals such as multiples of 3 or 4 are not usually accepted
- 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.

Teachers and candidates are referred to page 56 of the syllabus for further information on the appropriate presentation of data in graphs.

(ii) Some candidates drew this well with a clear line. However, there were frequent shortcomings in the line of best fit which led to candidates missing out on credit. 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
- drawing a straight line when the plots were clearly forming a curve.

(iii) Nearly all candidates were able to link increasing the number of spatulas to an increase in reaction time. Note that on this occasion it was only correct to state that the two factors were directly proportional if the line of best fit was both straight and went through the origin. Any references to 'positive correlation' were ignored as this is not an accurate term to describe the relationship.

(iv) Somen candidates correctly extrapolated and read a value from their graphs for the reaction time when 6 spatulas are added. Common errors included:

- stating a value without extrapolation
- drawing the extrapolation freehand rather than with a ruler. Such values were usually inaccurate.

(c) (i) Candidates were generally able to identify that it is very difficult to judge when the fizzing has finally stopped. This judgement is likely to vary significantly between individuals doing the experiment. Generic answers such as 'errors in measurement' or 'human reaction time' were not sufficient. In this case, the small error in human reaction time was not a significant issue in the accuracy of the timing.

(ii) This question asked specifically about **step 2** of the procedure. Candidates needed to look back and identify that during this step, a spatula of sodium hydrogencarbonate is added to the acid. Some answers appeared not to have looked back to find out what **step 2** involved and instead gave vague recommendations such as repeating the experiment.

Question 3

(a) (i) This question asked for measurements to be made to a specified degree of resolution, in this case to the nearest 0.1 cm. Many candidates did not appear to know that this means that all measurements should be recorded to one decimal place, even if that value is .0. For example, if the length of the block was 4.0 cm, it was often incorrectly recorded as '4'.

(ii) Candidates were generally able to correctly calculate the volume of the block.

(b) (i) Nearly all initial volumes were within the expected range.

(ii) Most candidates demonstrated they could follow the instructions and provide a final volume that was less than the initial volume.

(iii) Candidates were generally able to use their measurements to calculate *M.*

(c) Candidates demonstrated that they could calculate ρ using their values.

(d) Many candidates stated correctly that the density calculated would be too large and that this was due to a larger than accurate value of $(V_1 - V_2)$ or of the calculated mass. However, some candidates confused the measured value V_2 with the volume of the block and incorrectly stated that density would be increased because the total volume is smaller.

Question 4

The quality of responses to the planning question was generally good with many candidates earning at least partial credit. There were some common reasons why full credit was not awarded. These included:

- some candidates did not refer carefully to the factors that they are asked to investigate (in this case temperature of the water and its effect on the resistance of the thermistor). Some answers did not vary or even measure the temperature but instead appeared to be investigating how resistance varied over time. In addition, some candidates spent time giving information that was not required by this particular question. For this question candidates were not asked to give safety precautions or to list variables to control. Many candidates wasted time by doing so.
- best practice is to consider the bullet points carefully and use these to structure an answer. A common reason for partial credit was that the answer only addresses some, but not all, of the bullet points. For full credit to be awarded it is essential that each of the bullet points is covered
- candidates confused what they were able to measure (temperature, current and voltage) with what they needed to calculate (resistance). It was common to see answers that stated change the temperature and measure the resistance without any means of directly doing so.

Brief Description of Method: The apparatus provided included a supply of hot and cold water. The best answers described how this could be used to provide a range of different temperatures, for example by mixing them in varying proportions or by starting with hot water and adding cold water in between each reading. However, some answers limited the data they could collect by stating only to 'use hot and cold water'. It is usual to expect candidates to suggest five values for the independent variable, in this case five values of the temperature of the water.

Other Apparatus: Most candidates suggested the use of a thermometer and a voltmeter, although some incorrectly drew a voltmeter into the circuit but showed it connected in series. Many candidates stated the need for irrelevant apparatus, such as a stop-watch or timer.

Measurements: To investigate the relationship between resistance and temperature, three variables needed to be measured; temperature, current and voltage. Many candidates stated this clearly. However, some candidates stated only 'take readings' or 'use different temperatures' without stating that it was important to actually measure the temperature at which each reading was taken. Another common error was to state the need to 'measure the resistance' rather than measuring current and voltage in order to calculate resistance.

Results table: This question asked candidates to provide a results table to record measurements. As many candidates stated that they would use the same voltage for each experiment, the essential data to be recorded were values of temperature and current, with the appropriate units, °C and A. Many candidates omitted any table or gave headings with missing or inappropriate units, such as C^{o}.

Processing Results: This bullet point was well addressed. Many restated the equation provided in the question and stated that they would divide voltage by current to find resistance (many candidates made this statement even though they had not measured either). Many suggested appropriate axes for a graph. A common shortcoming in answers was to state to repeat and take an average or repeat and exclude outliers. Such generic answers were not awarded credit. It is essential that the candidates state what is being repeated (repeated readings at the same temperature) and what is being measured (current and voltage) before the data set is analysed for outliers or an average is calculated.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

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

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

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

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

For the graph question, candidates need to ensure they are using as much of the grid provided as possible and they need to work out what each division of the scale represents.

General comments

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

Comments on specific questions

Question 1

(a) (i) Candidates were able to follow the instructions and obtain the expected results. The question asked candidates to measure and then record the height of the layer of bubbles. The column heading was already provided with mm as the units and candidates were expected to use this information to record their results. It was not appropriate to record these to one decimal place, but candidates were not penalised for doing so. Common errors seen included recording these heights in cm or measuring the height of all the liquid in the tube rather than just the bubbles. Candidates are well advised to study diagrams carefully in conjunction with the question as diagrams often help candidates to follow the instructions.

(ii) The graph question was answered well. Most candidates were able to label both axes, although some omitted the units 'mm' from the vertical axis or wrote just 'peas' instead of 'number of peas', on the horizontal axis. Candidates are advised to use the column headings provided, word for word, as their axis labels. Candidates needed to choose an appropriate scale such that the points plotted occupied more than half the available grid. Those who did not tended to write the values from the number of peas column as though they were linear, despite the intervals between the values **not** being linear. Some candidates reversed the axes. Almost all candidates plotted the points correctly. Guidance for the correct presentation of graphs is given in Appendix 5 of the current syllabus and includes the instruction to plot points using either crosses or dots in circles, both drawn using a sharp pencil. Large 'blobs' are incorrect because the exact placement of the plot cannot be judged.

(iii) Most candidates gave an acceptable line of best fit based on their plots. It should be noted that, where the relationship is a straight line, it is expected that candidates use a ruler and that their pencil should be sharp. Thick, feathered lines that are not clearly straight are not accepted. The line needs to be single and continuous. Dot to dot lines between points are not accepted. Where there is a spread of data, candidates should draw their line to show the best trend, with any points not exactly on the line spread evenly on either side. Further guidance can be found in Appendix 5 of the syllabus. Lines of best fit do not need to be forced through the origin and do not necessarily need to touch the first and last plotted point unless this is the most suitable line that can be drawn, but lines should extend as far as the first and last plotted points in order to cover the range of data plotted.

(iv) Candidates who were awarded full credit showed how they obtained their value by drawing a vertical line upwards from six until it intercepted the line of best fit and then drew a horizontal line across to the height. Many candidates did not draw the lines on their graph and just quoted the value. This was only awarded partial credit as the question asks them to 'show on the graph how you obtain your value'.

(v) The relationship was straightforward, and most candidates stated correctly that the height of bubbles increases as the number of peas increases. On this occasion it was correct to state that the two factors are (directly) proportional if the line of best fit was both straight and went through the origin, so in this situation 'proportional' was accepted. However, any references to 'positive correlation' were ignored as this is not an accurate term to describe the relationship. Candidate should state the names of the two variables and the general trend that links them.

(vi) This question asked candidates to consider the relationship between concentration of catalase and the rate of breakdown of hydrogen peroxide. Candidates who were awarded credit mentioned both the concentration and the rate. Candidates who wrote answers in terms of concentration and time were not awarded credit.

(b) Many candidates identified that the reaction was still proceeding so the layer of bubbles was not even or was moving and was therefore difficult to measure accurately. Some candidates found this question challenging and answered with 'standard' answers in terms of human error, parallax and accuracy. Candidates should consider the specific experiment being conducted and tailor their answers to the situation.

(c) Many candidates did not give a correct answer because they stated vaguely that you could take an average. This is not a way of evaluating the quality of the data. Evaluating the quality means a way of checking whether or not the readings are accurate. Answers that stated that repeating allows outliers or anomalies to be identified were credited. Answers that stated clearly that repeated measurements should be consistent or concordant or the same were credited. Many candidates answered in terms of making the procedure more reliable, accurate or fair and this did not gain credit.

Question 2

(a) Candidates demonstrated they were able to follow the instructions and obtain the expected results**.** Where a candidate does not obtain the expected results, candidates are awarded credit for matching the Supervisor results. The provision of a set of Supervisor results is therefore important. Candidates needed to write down their observations. Generally this means what they see, for example the colour, bubbles or formation of a precipitate. A number of candidates wrote 'no change' for test 2. This is not an observation, the colour seen is still expected to be recorded.

(b) Many candidates were able to explain why it was difficult to identify the cation. Some candidates gave vague answers such as 'it is difficult to see' but without explaining why it was difficult.

(c) Candidates were mostly familiar with the chemical tests and many were awarded full credit on this question. The most common incorrect answer was chlorine (the element) rather than chloride (the ion).

Question 3

The responses to the planning question were generally good with many candidates earning at least partial credit. There were common reasons why full credit was not awarded. These included:

- some candidates did not refer carefully to the factors that they were asked to investigate (in this case concentration of salt solution and its effect on the rate of evaporation). Some answers did not vary the concentration but instead appeared to be investigating how the temperature of the solution affected the volume of liquid evaporated
- best practice is to consider the bullet points carefully and use these to structure an answer. A common reason for partial credit was that the answer only addresses some, but not all, of the bullet points. For full credit to be awarded it is essential that each of the bullet points is covered.

Apparatus: Most candidates understood the need to measure time and suggested the use of a timer or stop-watch. A means of measuring concentration (both a balance and measuring cylinder) was only understood by a few candidates. Some candidates thought that different concentrations of salt solution were provided in different bottles despite the question saying they had access to distilled water and solid salt, implying they needed to make their own concentrations. Some candidates were not familiar with the names of common equipment and used terms such as 'weigher' or 'weight machine' and 'measuring jug' or just 'cylinder'.

Method: The apparatus provided included distilled water and solid salt. The strongest answers described how this could be used to make a range of different concentrations, for example by dissolving different masses of salt in water or by multiple dilutions of an initial concentration. Some answers limited the data they could collect by stating only one quantity of salt dissolved in water and then just pure water itself – in effect just one concentration. It is usual to expect candidates to suggest five values of independent variable, in this case five different concentrations of salt solution.

Measurements: In order to investigate the relationship between concentration and rate of evaporation, several variables need to be measured: mass and volumes to make the concentrations of salt solution, mass or volume of salt solution before and after evaporation and a set amount of time. Some candidates stated this clearly. However, many candidates stated just to measure the concentration of salt solution without saying how they would do this or they used vague terms such as the 'amount' of salt solution.

Control variables: Most candidates realised the temperature needed to be kept constant and some realised the initial volume of each solution would also need to be controlled. Answers in terms of 'amount' of salt solution were not given credit. Candidates should use specific terminology such as volume or mass rather than 'amount'.

Processing Results: This bullet point was well addressed. Many suggested appropriate axes for a graph. A common shortcoming in answers was to state 'to repeat and take an average' or 'repeat and exclude outliers'. Such generic answers were not awarded credit. It is essential to state what is being repeated (repeated readings at the same concentration) and what is being measured (volume or mass of solution before and after evaporation for a set time) before the data set is analysed for outliers or an average is calculated.

Question 4

(a) (i) and (ii) Candidates demonstrated they were able to carry out the instructions and obtain a set of results with and without the lid. It was not necessary to record these to one decimal place.

(b) (i) Most candidates correctly calculated the temperature differences.

(ii) This question caused problems for some candidates. The instruction was to give the numbers to two significant figures. Some candidates struggled with this. Others confused significant figures with decimal places. The unit was challenging for some candidates with C°/s being common and non-standard abbreviations for seconds such as sec and secs.

(iii) It was rare to see a correct calculation showing how the results were or were not within 10% of each other. Several methods were acceptable, such as dividing one value by the other and confirming they were or were not within the range 0.9 to 1.1 or finding a percentage difference and then comparing this number with 10%. Candidates who did complete the 10% calculation often then did not do anything with this to show whether they were or were not within the limits of experimental accuracy, thinking just calculating 10% of the value was sufficient.

(c) (i) Some candidates correctly equated parallax with reading the measurement at 90° to the scale. Others gave answers about reading at a straight line (which could be at an angle other than perpendicular). Some mentioned the reading should be taken parallel to the scale or a digital thermometer should be used.

(ii) This question involved reading the procedure through and spotting where improvements could be made. It is worth pointing out the procedure is not the same thing as the equipment used. The standard answers of repeating, calculating averages and removing anomalies were not worthy of credit.

COMBINED SCIENCE

Paper 0653/61
Alternative to Practical

Key messages

Candidates need to take careful note of instructions given in the question. Where they are instructed to 'record to the nearest 0.5 °C', for example in **Question 1(a)(i)**, it is essential that values are given to one decimal place, which may be to .0 or .5.

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

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

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

General comments

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

Comments on specific questions

Question 1

(a) (i) The question asked candidates to record the temperature to the nearest 0.5 °C. In such questions, it is necessary to record to one decimal place, even if that is a zero. Hence the correct answer was '51.0'. Candidates who wrote '51' did not gain credit.

(ii) Most candidates correctly identified that a syringe or a small measuring cylinder is an appropriate piece of apparatus for measuring a volume of 2 cm^3. Note that stating 'pipette' alone is ambiguous because most pipettes used in laboratories are dropping pipettes which are unsuitable for measuring volumes. Graduated pipette was accepted as correct.

(iii) Almost all candidates used the key to appropriately record all observations for both test-tubes.

(iv) The command word for this question was explain. This involves interpreting data and information rather than repeating it. The strongest answers clearly stated that starch was present in the samples taken in the first two minutes (wells **A0** to **A2**) but not at the end (wells **A3** to **A5**) and this was due to amylase breaking down the starch. Answers that did not earn full credit typically described the appearance of the colours, for example by saying that there was a change in colour from blue-black to brown but did not offer any explanation for the change seen. It is important that candidates understand the difference between the command words 'describe' and 'explain'.

(v) Conversely, this question asked candidates to describe the effect of copper sulfate on the reaction. In this case it was sufficient to say that starch remained present for a longer time. Answers such as a slower rate of reaction were also valid. Some candidates appeared to misinterpret the data in the table and stated incorrectly that copper sulfate made the reaction faster or acted as a catalyst. Such answers implied that candidates had not looked carefully at the results for test-tube **C** in the table.

(vi) Almost all candidates correctly calculated the total volumes of solutions in each test-tube and calculated the overall difference.

(vii) This question asked for a change to the procedure to remove the limitation. Although most candidates recognised that the volumes in each test-tube were different, few were able to suggest a viable change to the procedure. Make the volumes the same was insufficient because it does not describe a procedural change. Some incorrectly suggested to add more starch or add more copper sulfate, but these suggestions would change the investigation. The strongest answers said that it is necessary to add 1 cm^3 of distilled water to make the volumes the same.

(viii) Leaving the test-tubes in the water-baths for a short time before mixing is a standard procedure but may be done for different reasons. In this case it was less important to make sure that the test-tubes reached a particular temperature (which is sometimes the case), but more important to ensure that both test-tubes were at an identical temperature before the reaction started. Some answers stated that the test-tube needs to heat through or similar wording, without stressing the importance that both test-tubes needed to be the same temperature.

(b) (i) Most candidates correctly measured the length of line **AB** as 58 mm. Some incorrectly recorded their values in cm.

(ii) Most candidates were able to substitute correctly into the equation and calculate a value for the actual diameter. However, the instruction to give the answer to one significant figure was often overlooked. Some candidates confused one significant figure with one decimal place and hence incorrectly rounded the correct answer of 0.06 to 0.1 mm.

Question 2

(a) Almost all candidates recorded the value of the first stop-watch correctly as 21 s. However, many candidates incorrectly rounded the second stop-watch value, giving the incorrect answer of 96 s by either truncating or rounding down the value rather than rounding up.

(b) (i) The graph question was answered well. Almost all candidates labelled both axes, although some omitted the units ‘s’ from the vertical axis. It should be noted that non-SI abbreviations for units, such as ‘secs’ are not accepted. Almost all candidates chose an appropriate scale such that the plotted points occupied more than half the available grid. Almost all candidates plotted points correctly. Errors were usually due to incorrect values being entered on the axes, non-linear scales or reversing the axes. Guidance for the correct presentation of graphs is given in Appendix 5 of the current syllabus and includes the instruction to plot points using either crosses or dots in circles, both drawn using a sharp pencil. Large blobs are incorrect because the exact placement of the plot cannot be judged.

(ii) Most candidates gave an acceptable line of best fit based on their plots. It should be noted that, where the relationship is a straight line, it is expected that candidates use a ruler and that their pencil should be sharp. Thick or feathered lines, or lines that are not clearly straight are not accepted. The line needs to be single and continuous. Dot-to-dot lines between points are not accepted. Where there is a spread of data, candidates should draw their line to show the best trend, with any points not exactly on the line spread evenly on each side. Further guidance can be found in Appendix 5 of the syllabus. Some candidates missed out on credit by joining the top and bottom points, leading to the three points between all being below the line.

(iii) The relationship was straightforward, and most candidates correctly stated that the reaction time increases as the number of spatulas increases. Note that on this occasion it was correct to state that the two factors are directly proportional, because the line of best fit is both straight and goes through the origin, so on this occasion directly proportional was accepted. However, any references to positive correlation were ignored as this is not an accurate term to describe the relationship.

(iv) Some candidates correctly extrapolated and read a value from their graphs for the reaction time when 6 spatulas are added. Common errors included:

- stating a value without extrapolation
- drawing the extrapolation freehand rather than with a ruler. Such values were usually inaccurate.

(c) (i) Candidates typically did not answer this question well. Many gave generic answers such as errors in measurement or human reaction time. In this case, the small error in human reaction time was not a significant issue in the accuracy of the timing, the most pertinent factor being that it is very difficult to judge when the fizzing has finally stopped. This judgement is likely to vary significantly between individuals doing the experiment.

(ii) In common with the previous question, many candidates did not give a correct answer because they stated vaguely that you could take an average. This is not a way of evaluating the quality of the data. Evaluating the quality means a way of checking whether or not the readings are accurate. Answers that stated that repeating allows outliers or anomalies to be identified were credited. Answers that stated clearly that repeated measurements should be consistent or concordant or the same were credited.

(iii) This question asked specifically about **step 2** of the procedure. Candidates needed to look back and identify that during this step, a spatula of sodium hydrogencarbonate is added to the acid. Some answers appeared not to have looked back to find out what **step 2** involved and instead gave vague recommendations such as repeating the experiment.

(d) The use of limewater to test for carbon dioxide and its positive result were very well known.

Question 3

(a) (i) This question asked for measurements to be given to the nearest 0.1 cm. This meant that all measurements should be recorded to one decimal place, even if that value is .0. Hence, the length of the block, 4.0 cm, was often incorrectly recorded as 4 cm.

(ii) Almost all candidates were able to use their measurements to correctly calculate the volume of the block.

(b) (i) Almost all candidates gained credit. Candidates should routinely record all values to the same degree of resolution. Therefore, as the second value correctly read was 73.5 cm^3, the correct first reading should have been 97.0 cm^3. However, as this skill had already been assessed, a value of 97 alone was accepted here. Some candidates gave both values to the nearest cm^3, stating that the second volume was 74 cm^3. This was not accepted.

(ii) Almost all candidates subtracted their values correctly to work out the mass.

(c) This calculation was well done, with most candidates substituting correctly into the equation and calculating their density value accordingly. Note that error carried forward was allowed, based on the candidate's values for the mass and volume of the block. Also note that, while significant figures were not expressly assessed in this question, it is expected that candidates routinely use at least 2 significant figures for calculated values unless instructed otherwise.

(d) Many candidates stated correctly that the density calculated would be too large and that this was due to a larger than accurate value of ($V_1 - V_2$) or of the calculated mass. However, some candidates confused the measured value V_2 with the volume of the block and incorrectly stated that density would be increased because the total volume is smaller.

Question 4

The quality of responses to the planning question was generally good with many candidates earning at least partial credit. There were some common reasons why full credit was not awarded. These included:

- some candidates did not refer carefully to the factors that they are asked to investigate (in this case temperature of the water and its effect on the resistance of the thermistor). Some answers did not vary or even measure the temperature but instead appeared to be investigating how resistance varied over time. In addition, some candidates spent time giving information that was not required by this particular

question. For this question candidates were not asked to give safety precautions or to list variables to control. Many candidates wasted time by doing so.

- best practice is to consider the bullet points carefully and use these to structure an answer. A common reason for partial credit was that the answer only addresses some, but not all, of the bullet points. For full credit to be awarded it is essential that each of the bullet points is covered
- candidates confused what they were able to measure (temperature, current and voltage) with what they needed to calculate (resistance). It was common to see answers that stated change the temperature and measure the resistance without any means of directly doing so.

Brief Description of Method: The apparatus provided included a supply of hot and cold water. The best answers described how this could be used to provide a range of different temperatures, for example by mixing them in varying proportions or by starting with hot water and adding cold water in between each reading. However, some answers limited the data they could collect by stating only to 'use hot and cold water'. It is usual to expect candidates to suggest five values for the independent variable, in this case five values of the temperature of the water.

Other Apparatus: Most candidates suggested the use of a thermometer and a voltmeter, although some incorrectly drew a voltmeter into the circuit but showed it connected in series. Many candidates stated the need for irrelevant apparatus, such as a stop-watch or timer.

Measurements: To investigate the relationship between resistance and temperature, three variables needed to be measured; temperature, current and voltage. Many candidates stated this clearly. However, some candidates stated only 'take readings' or 'use different temperatures' without stating that it was important to actually measure the temperature at which each reading was taken. Another common error was to state the need to 'measure the resistance' rather than measuring current and voltage in order to calculate resistance.

Results table: This question asked candidates to provide a results table to record measurements. As many candidates stated that they would use the same voltage for each experiment, the essential data to be recorded were values of temperature and current, with the appropriate units, °C and A. Many candidates omitted any table or gave headings with missing or inappropriate units, such as C^{o}.

Processing Results: This bullet point was well addressed. Many restated the equation provided in the question and stated that they would divide voltage by current to find resistance (many candidates made this statement even though they had not measured either). Many suggested appropriate axes for a graph. A common shortcoming in answers was to state to repeat and take an average or repeat and exclude outliers. Such generic answers were not awarded credit. It is essential that the candidates state what is being repeated (repeated readings at the same temperature) and what is being measured (current and voltage) before the data set is analysed for outliers or an average is calculated.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

Candidates need to take careful note of instructions given in the question. Where they are instructed to record their answers in certain units, for example in **Question 1(a)(i)** where the table has the unit mm, candidates should record their values in the units given.

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

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

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

Candidates should routinely record all values to the same degree of resolution. Hence, for example on **4(a)(i)** the correct recording for the second temperature is 76.0, not 76.

General comments

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

Comments on specific questions

Question 1

(a) (i) The question asked candidates to record the height of the layer of bubbles in mm. It was not appropriate to record these values to one decimal place. Many candidates recorded the height in cm and others measured the height of the liquid and the bubbles rather than just the bubbles. Candidates should study diagrams carefully, in conjunction with the question, as diagrams often help candidates to follow the instructions.

(ii) Many candidates missed the main point of the question here, which was the idea that the peas would displace some of the liquid and make the height of the liquids unequal. Incorrect answers referred to accuracy, floating bubbles and the idea of the bottom of the boiling tube being round.

(iii) The graph question was answered well. Almost all candidates labelled both axes, although some omitted the units 'mm' from the vertical axis or wrote just 'peas' instead of 'number of peas', on the horizontal axis. Candidates are advised to use the column headings provided, word for word, as their axis labels. Almost all candidates chose an appropriate scale such that the points plotted occupied more than half the available grid. Some wrote the values from the number of peas column as though they were linear, despite the intervals between the values not being linear. Some candidates reversed the axes. Almost all candidates plotted the points correctly. When plotting points using either crosses or dots in circles, both should be drawn using a sharp pencil. Large 'blobs' are incorrect because the exact placement of the plot cannot be judged.

(iv) Most candidates drew an acceptable line of best fit based on their plots. It should be noted that, where the relationship is a straight line, it is expected that candidates use a ruler and that their pencil should be sharp. Thick, feathered lines that are not clearly straight are not accepted. The line needs to be single and continuous. Dot-to-dot lines between points are not accepted. Where there is a spread of data, candidates should draw their line to show the best trend, with any points not exactly on the line spread evenly on either side. Lines of best fit do not need to be forced through the origin and do not necessarily need to touch the first and last point unless this is the most suitable line that can be drawn, but lines should extend as far as the first and last plotted points so as to cover the range of data plotted.

(v) Candidates who were awarded full credit showed how they obtained their value by drawing a vertical line upwards from six until it intercepted the line of best fit and then drew a horizontal line across to the height. Many candidates did not draw the lines on their graph and just quoted the value. This was only awarded partial credit as the question asks them to 'show on the graph how you obtain your value'.

(vi) Most candidates stated correctly that the height of bubbles increases as the number of peas increases. On this occasion it was correct to state that the two factors were (directly) proportional, because the line of best fit is both straight and goes through the origin, so on this occasion proportional was accepted. However, any references to 'positive correlation' were ignored as this is not an accurate term to describe the relationship. Candidates should state the names of the two variables and the general trend that links them.

(vii) This question asked candidates to consider the relationship between concentration of catalase and the rate of breakdown of hydrogen peroxide. Candidates who were awarded credit mentioned both the concentration and the rate. Candidates who wrote answers in terms of concentration and time were not awarded credit.

(b) Candidates found this question demanding and answered with generic answers in terms of human error, parallax and accuracy. Candidates should consider the specific experiment being conducted and tailor their answers to the situation.

(c) Many candidates did not give a correct answer because they stated vaguely that you could take an average. This is not a way of evaluating the quality of the data. Evaluating the quality means a way of checking whether or not the readings are accurate. Answers that stated that repeating allows outliers or anomalies to be identified were credited. Answers that stated clearly that repeated measurements should be consistent or concordant or the same were credited. Many candidates answered in terms of making the procedure more reliable, accurate or fair and this did not gain credit.

Question 2

(a) (i) Many candidates were able to use the information from the table to explain why it was difficult to identify the cation. Some candidates gave vague answers such as 'it is difficult to see' but without explaining why it was difficult.

(ii) The most common correct answer was to relate the temperature of the flame to the colour, e.g. the yellow flame is not hot enough. Other candidates described the yellow of the flame masking the colour of the ion. Vague answers such as 'it is hard to see the colour' were common but not given credit as this was insufficient detail.

(b) A small number of candidates were able to describe filtering the mixture. Many candidates assumed another chemical test was needed, such as adding other reagents or doing a flame test.

(c) Candidates were generally unfamiliar with the chemical tests and very few were awarded full credit on this question. The answer chlorine (the element) rather than chloride (the ion) was common. There were a variety of incorrect chemicals suggested, such as starch, Biuret and limewater.

(d) Some candidates were able to describe the blue precipitate and the dark blue solution, though many did not include the dark description for the solution. Others described the precipitates as dark blue, which was incorrect, and was possibly confused with the colour of the solution.

Question 3

The responses to the planning question were generally good with many candidates earning at least partial credit. There were common reasons why full credit was not awarded. These included:

- some candidates did not refer carefully to the factors that they were asked to investigate (in this case concentration of salt solution and its effect on the rate of evaporation). Some answers did not vary the concentration but instead appeared to be investigating how the temperature of the solution affected the volume of liquid evaporated
- best practice is to consider the bullet points carefully and use these to structure an answer. A common reason for partial credit was that the answer only addresses some, but not all, of the bullet points. For full credit to be awarded it is essential that each of the bullet points is covered.

Apparatus: Most candidates understood the need to measure time and suggested the use of a timer or stop-watch. A means of measuring concentration (both a balance and measuring cylinder) was only understood by a few candidates. Some candidates thought that different concentrations of salt solution were provided in different bottles despite the question saying they had access to distilled water and solid salt, implying they needed to make their own concentrations. Some candidates were not familiar with the names of common equipment and used terms such as ‘weigher’ or ‘weight machine’ and ‘measuring jug’ or just ‘cylinder’.

Method: The apparatus provided included distilled water and solid salt. The strongest answers described how this could be used to make a range of different concentrations, for example by dissolving different masses of salt in water or by multiple dilutions of an initial concentration. Some answers limited the data they could collect by stating only one quantity of salt dissolved in water and then just pure water itself – in effect just one concentration. It is usual to expect candidates to suggest five values of independent variable, in this case five different concentrations of salt solution.

Measurements: In order to investigate the relationship between concentration and rate of evaporation, several variables need to be measured: mass and volumes to make the concentrations of salt solution, mass or volume of salt solution before and after evaporation and a set amount of time. Some candidates stated this clearly. However, many candidates stated just to measure the concentration of salt solution without saying how they would do this or they used vague terms such as the ’amount’ of salt solution.

Control variables: Most candidates realised the temperature needed to be kept constant and some realised the initial volume of each solution would also need to be controlled. Answers in terms of ‘amount’ of salt solution were not given credit. Candidates should use specific terminology such as volume or mass rather than ‘amount’.

Processing Results: This bullet point was well addressed. Many suggested appropriate axes for a graph. A common shortcoming in answers was to state ‘to repeat and take an average’ or ‘repeat and exclude outliers’. Such generic answers were not awarded credit. It is essential to state what is being repeated (repeated readings at the same concentration) and what is being measured (volume or mass of solution before and after evaporation for a set time) before the data set is analysed for outliers or an average is calculated.

Question 4

(a) (i) This question required measurements to be recorded to a specified degree of resolution, in this case to the nearest 0.5 °C. Many candidates did not appear to know that this means that all measurements should be recorded to one decimal place, even if that value is .0. Hence the second temperature, 76.0, was often recorded as just 76.

(ii) Circling the anomalous result was not a problem for most candidates, however, some circled the entire row for the time of 120 s. Only the 77.0 was the anomalous result.

(b) (i) Most candidates correctly calculated the temperature differences.

(ii) This question caused problems for some candidates. The instruction was to give the numbers to two significant figures, i.e. 0.083 and 0.050. Some candidates wrote these as 0.83 and 0.50, removing the leading zeros, and others confused significant figures with decimal places and wrote 0.08 and 0.05. The unit was demanding for some candidates with C°/s being common and non-standard abbreviations for seconds such as sec and secs were seen.

(iii) It was rare to see a correct calculation showing how the results were or were not within 10% of each other. Several methods were acceptable, such as dividing one value by the other and confirming they were or were not within the range 0.9 to 1.1 or finding a percentage difference and then comparing this number with 10%. Candidates who did complete the 10% calculation often then did not do anything with this to show whether they were or were not within the limits of experimental accuracy, thinking just calculating 10% of the value was sufficient.

(c) (i) Some candidates correctly equated parallax with reading the measurement at 90° to the scale. Others gave answers about reading at a straight line (which could be at an angle other than perpendicular). Some mentioned the reading should be taken parallel to the scale or a digital thermometer should be used.

(ii) Many candidates stated correctly that a measuring cylinder would be the best equipment to measure the volume of 100 cm^3 of water. Burettes, syringes and pipettes, while common, were not suitable for such a large volume.

(iii) This question involved reading the procedure through and spotting where improvements could be made. It is worth pointing out the procedure is not the same thing as the equipment used. The standard answers of repeating, calculating averages and removing anomalies were not worthy of credit.

COMBINED SCIENCE

Paper 0653/63
Alternative to Practical

Key messages

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

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

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

Candidates should routinely record all values to the same degree of resolution. Hence, for example on **4(a)(i)**, the correct answer is 1.85 and 2.10, not 1.85 and 2.1.

General comments

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

Comments on specific questions

Question 1

(a) (i) The question asked candidates to 'record in Table 1.1, the final mass of plants **B** and **C** to the nearest whole number'. Many candidates copied the readings from Fig 1.2 into the table, omitting to round the values, or follow the pattern of data in the table. The correct answers were 348 and 353.

(ii) Most candidates correctly calculated the change in mass. Any errors from **(a)(i)** were carried forwards so candidates were not penalised.

(iii) Very few candidates correctly stated the dependent variable as the change in mass or the final mass of the plant. Many candidates suggested 'mass' which does not differentiate between the mass of the plant at the start and the mass at the end of the experiment. Some candidates confused the independent and dependent variables and gave percentage concentration of nutrients as their response. The data in the dependent variable shows the results of the changes made to the independent variable in an experiment.

(iv) Many candidates were able to state a conclusion about the growth of the plants, with stronger answers correctly linking a higher concentration of nutrients to a greater change in mass of the plant.

(b) (i) Few candidates were able to provide one other reason for repeating the procedure three times, with many restating to calculate an average or suggesting a repeat would prevent an anomalous result. Repeating this procedure would have allowed the student to identify or check for anomalous results, or to make sure their results were consistent. Generic words such as accurate or reliable were not credited.

(ii) Some candidates were able to use the pictures of the plants in Fig 1.1 and realise that the growth of a plant does not only refer to its height. Correct answers suggested that the height does not consider root growth, the number of leaves on the plant or that the plant might not grow straight up, and so mass might be a better measure of growth.

Question 2

The quality of responses to the planning question was generally good with many candidates earning at least partial credit. There were common reasons why full credit was not awarded. These included:

- some candidates did not refer carefully to the factors that they were asked to investigate (in this case temperature and its effect on the rate of respiration of germinating seeds). Some answers did not vary or even measure the temperature but instead appeared to be investigating how the number of seeds affected the drop of liquid. Many candidates wasted time by redrawing the apparatus given in Fig 2.1.
- best practice is to consider the bullet points carefully and use these to structure an answer. A common reason for partial credit was that the answer only addresses some, but not all, of the bullet points. For full credit to be awarded it is essential that each of the bullet points is covered
- candidates confused what they were able to measure (temperature, time, distance the drop moved) with what they needed to calculate (rate). It was common to see answers that stated ‘change the temperature and measure the rate’ without any means of directly doing so.

Apparatus: Most candidates suggested the use of a thermometer but few realised they would also need a stopwatch, or a way to vary the temperature of the germinating seeds.

Method: A common error was to heat the test-tube of seeds with a Bunsen burner. As this would kill the seeds, it was not credited. Some candidates chose to vary the temperature by placing the apparatus in different environments (such as ‘in the fridge’ or ‘in the sun’). These methods limited the data they could collect. It is usual to expect candidates to suggest five values of an independent variable, in this case five different temperatures of the seeds. Few candidates included safety precautions of any detail, with many stating ‘tie hair up’, ‘wear goggles’ or ‘get an adult to help’. Safety precautions should be specific to the investigation being carried out so in this instance ‘wearing gloves to protect skin from the soda lime’ or ‘using tongs to avoid burning hands’.

Measurements: In order to investigate the relationship between temperature and the rate of respiration, three measurements needed to be taken: time, distance and temperature. A few candidates correctly stated that measuring the time taken to move a set distance, or the distance moved in a set time, would allow them to calculate the rate of respiration. Some candidates stated incorrect units for temperature, such as C°.

Constant variables: Most candidates correctly stated that the number of seeds should be kept the same for each temperature used. Few suggested that either the distance the bubble was allowed to move or the time should be kept the same (depending on their suggested measurements).

Processing Results: This bullet point was not well addressed. A common shortcoming in answers was to state to repeat and take an average or repeat and exclude outliers. Such generic answers were not awarded credit. It is essential that the candidate states what is being repeated (e.g. repeated readings at the same temperature) before the data set is analysed for outliers or an average is calculated. Few candidates stated how to use the data they had collected (time and distance) to calculate rate of respiration of the germinating seeds.

Question 3

(a) (i) Almost all candidates explained that the start line must be drawn in pencil so that it does not mix with the ink spots, or move up the paper. A few candidates used good scientific vocabulary and stated that the ink was soluble or that the pencil was insoluble.

(ii) Some candidates correctly stated that the piece of apparatus suitable for placing the green liquid was a pipette. A common, uncredited answer was to state that a green pen should be used.

(b) (i) Most candidates correctly stated that there were four coloured substances in the green liquid.

(ii) A common error was to repeat the question as an answer and state that the number of colourless substances could not be determined because the substances were colourless. However, some candidates were able to link the idea of colourless to not being visible and gained credit.

(iii) Most candidates correctly measured the distance, to the nearest millimetre, as 3.2 cm. Common errors included giving the answer in millimetres or rounding up to 3 cm.

(iv) Most candidates correctly followed the instruction in the question and gave the answer of 4.4 cm.

(v) Most candidates were able to use their values from **(b)(iii)** and **(b)(iv)** to correctly calculate the R_f value. Some candidates only obtained partial credit as they did not provide their answer to two significant figures.

(c) Few candidates were able to describe and explain a safety precaution for the chromatography procedure. The most common error was not providing a precaution that was specific for this experiment and instead suggesting generic laboratory safety rules. By looking at Fig 3.1 candidates should have seen that the solvent used was flammable and been able to state that the solvent should be kept away from naked flames.

(d) (i) Some candidates correctly stated that in test 3 or 4 a green precipitate shows that the green liquid contains iron(II) ions. The most common error was only stating that the result was green.

(ii) More candidates identified test 2 and the white precipitate as the observation for sulfate ions.

(iii) Very few candidates identified ammonia as the gas that turned damp red litmus paper blue, in test 3. A wide variety of other gases were given.

(iv) Candidates rarely identified any cation in their responses to this question.

Question 4

(a) (i) Most candidates were able to correctly read the newton meters and recorded the values of *F* correctly in Table 4.1. Some candidates did not follow the pattern in the table of using 2 decimal places and gave 2.1 instead of 2.10 for one of their answers.

(ii) Many candidates gave a safety precaution in their response, rather than thinking about how it would be to carry out this procedure. Candidates that correctly stated that they would need to wait for the load to stop moving before they could take a reading probably had more practical experience than those who simply stated that the values should be read more than once.

(b) (i) The graph question was answered well. Almost all candidates labelled both axes, although some omitted the units. Almost all candidates chose an appropriate scale such that the plotted points occupied more than half the available grid. Almost all candidates plotted points correctly. Errors were usually due to incorrect values being entered on the axes, non-linear scales or reversing the axes. When plotting points using either crosses or dots in circles, both should be drawn using a sharp pencil. Large 'blobs' are incorrect because the exact placement of the plot cannot be judged.

(ii) Few gave an acceptable line of best fit based on their plots. It should be noted that, where the relationship is a straight line, it is expected that candidates use a ruler and that their pencil should be sharp. Thick, feathered lines that are not clearly straight are not accepted. The line needs to be single and continuous. Dot-to-dot lines between points are not accepted. Where there is a spread of data, candidates should draw their line to show the best trend, with any points not exactly on the line spread evenly on each side. Some candidates missed credit by joining the top and bottom points, leading to the three points between all being above the line. In this case the best-fit line had to extend to cross the vertical axis, some candidates added this in later, leading to them draw a feathered line. Many candidates used pen to draw several attempts at a best-fit line, meaning they were unable to make a correction. It is recommended that graphs be drawn in pencil.

(iii) Most candidates correctly extrapolated and read off a value of F_0 using the point where their best-fit line crossed the vertical axis. Common errors included:

- stating a value without extrapolation
- drawing the extrapolation freehand rather than with a ruler.

(iv) Candidates were able to use their value of F_0 correctly in the given equation to calculate W.

(v) Most candidates correctly used their value for W in the equation. Many also gave their answer in grams but a common mistake was to give an answer in kg.

(c) Candidates typically did not answer this question well. Many gave answers such as 'errors in measurement' or suggested the graph showed repeated measurements. Very few candidates clearly explained that by drawing a best-fit line the effect of any errors on F_0 can be reduced.

(d) Most candidates correctly suggested a balance as an alternative piece of equipment to measure the mass of the ruler.