# COMBINED SCIENCE

**Paper 0653/11**
**Core Multiple Choice**

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

**General comments**

Biology:
No questions were particularly easy for the candidates.

**Question 2** and **Question 12** proved most difficult for the candidates.

Chemistry:
No questions were particularly easy for the candidates.

**Question 16**, **Question 21**, **Question 22**, and **Question 27** proved most difficult for the candidates.

Physics:
In the physics section **Questions 34** and **35** proved the most difficult for many candidates.

**Comments on specific questions**

**Question 2**

Students predominantly picked option **B** in this question. Higher ability students answered this question better, possibly as they realised that in a sugar solution of the same concentration as the cell contents there would not be a net movement into the cells.

**Question 3**

In this question candidates picked one of the distractor answers, choice **B**. This indicates that the students did realise that the heat increased but failed to factor in that at higher temperatures the enzyme denatures, thereby reducing the rate of the reaction. Possibly students were confusing the enzyme temperature graph with the limiting factor in photosynthesis graph.

**Question 4**

Most candidates struggled with this question. The data indicates that lower ability students were favouring answer **A** (calcium) whilst higher ability students identified vitamin C as the correct answer. It may be that there was a failure to link vitamin C to the symptoms of scurvy in lower ability candidates.

**Question 5**

Whilst most candidates identified the correct answer there was evidence that many were under the misconception that the small intestine was to cut food into smaller pieces or to store faeces.

**Question 7**

This question was well answered by higher ability candidates with the majority identifying the correct response. Lower ability candidate responses were evenly spread between the between the four options, indicating that they were guessing.

**Question 8**

This question was generally answered well. Some candidates were under the misconception that adrenaline decreases blood glucose concentration.

**Question 9**

Many candidates opted for option **C** in this question. This was possibly because they were continuing the bend exhibited by the plant before turning the seedling, i.e. the shoot had initially turned anticlockwise and therefore after the seedling was turned candidates continued this anticlockwise movement. They should have answered the question based on the plant's tropic response (that the shoot was negatively gravitropic and the root positively gravitropic).

**Question 10**

The overwhelming majority of candidates identified that sexual reproduction involved the fusion of nuclei but were split when it came to the nature of the offspring. They should be reminded that sexual reproduction produces dissimilar offspring.

**Question 11**

This question was generally answered well. Where candidates tended to get this question incorrect, they confused the anther and stigma.

**Question 12**

Many candidates in this question identified **B** as the answer. Whilst this option did contain the correct answer it also included an animal that did not. This could have been because candidates saw the word organisms and opted for the option that had two organisms.

**Question 13**

This question was generally answered well.

**Question 16**

Candidates chose the incorrect **B** and incorrect **D** more often than the correct answer, **C**. They are required to know the general properties of ionic compounds, which includes solubility in water.

**Question 17**

More able candidates chose the incorrect **D** rather than the correct answer, **C**. They are required to understand both how to deduce the number of each type of atom in a compound and how formula are used to represent these.

**Question 18**

The incorrect **A** was chosen more often than the correct answer, **D**. Candidates are required to know the products formed at each (inert) electrode during the electrolysis of molten lead(II) bromide.

**Question 20**

Candidates chose the incorrect **B** more often than the correct answer, **C**. They are required to understand the meaning of the term redox, in terms of oxygen loss and gain, and to recognise this process in word and symbol equations.

**Question 21**

There was evidence that many candidates had guessed at the answer. Candidates are required to know the tests and positive results for specified cations.

**Question 22**

Candidates chose the correct answer, **B**, least often. Many of the more able candidates chose the incorrect **A**. They are required to know the trend in the physical state of the halogens from chlorine to iodine.

**Question 24**

Candidates chose the incorrect **D** more often than the correct answer, **A**. They are expected to know that alloys are mixtures of one metal with at least one other element, which may be either another metal or a non-metal.

**Question 27**

Candidates chose the incorrect **C** and incorrect **D** more often than the correct answer, **A**. They are required to know that alkane molecules contain only single carbon to carbon bonds, meaning that they are saturated, rather than unsaturated, hydrocarbon molecules.

**Question 28**

This question concerned the electromagnetic spectrum. Although many candidates knew that the waves involved were in the region next to visible light, many opted for **C** (ultraviolet) rather than **B** (infrared).

**Question 31**

Here a sizeable proportion of less able candidates believed that the gradient of a speed–time graph represents average speed.

**Question 30**

Candidates were much more confident in answering this question on the resultant of two forces.

**Question 34**

The topic for this question was transfer of energy thermally, and all three incorrect choices were far more popular than the correct option **D**. Most candidates either appeared not to appreciate that conduction and convection cannot occur in a vacuum, or misread the question and thought that it asked which processes are prevented by the vacuum, leading them to choose option **A**.

**Question 35**

Similar questions to this have appeared in past papers, but once again all the incorrect options were chosen more often than the correct one. Few understood the meaning of the terms amplitude and wavelength.

**Question 36**

A common belief here was that the image formed by a plane mirror is real rather than virtual.

**Question 38**

Most candidates knew that determining resistance involves a division, but many confused numerator and denominator (option **A**).

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/12**
**Core Multiple Choice**

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

**General comments**

Biology:
No questions were particularly easy for the candidates. **Question 6** and **Question 9** were not well answered

Chemistry:
No questions were particularly easy for the candidates.

**Question 16**, **Question 19** and **Question 22** proved most difficult for the candidates.

Physics:
Only **Question 35** in the physics section caused widespread difficulty, although **Question 36** was not particularly well answered. **Question 30** was found the easiest.

**Comments on specific questions**

**Question 1**

This question was generally answered well. Where candidates had made mistakes, they had thought plants had cell membranes on the outermost layer and animals had cell walls.

**Question 2**

This question was generally answered well. Most candidates had identified the correct direction of movement (higher to lower concentration) but a small number had thought that this was up a concentration gradient.

**Question 4**

Most candidates had answered this question correctly. Higher ability students had answered this very well, many lower ability candidates had also identified the correct answer, however, those lower ability candidates that had not identified the correct answer were split between **B** and **C**.

**Question 5**

Whilst most candidates identified the correct answer there was evidence that many were under the misconception that the small intestine was to cut food into smaller pieces or to store faeces.

**Question 6**

It was clear from the spread of data that students guessed this question. Most candidates had identified that the carbon dioxide started in the capillaries, but many seemed to believe that the bronchi were before the bronchioles on exhalation. With a question like this it is always worth taking the time to work out the answer – candidates could always do a sketch diagram beside the question to assist in answering the question.

**Question 7**

This question was generally answered well. Some candidates were under the misconception that adrenaline decreases blood glucose concentration.

**Question 8**

Whilst most candidates had answered this question correctly many were split between answers **C** and **D**. With **C** this was possibly because they were continuing the bend exhibited by the plant before turning the seedling, i.e. the shoot had initially turned anticlockwise and therefore after the seedling was turned candidates continued this anticlockwise movement. They should have answered the question based on the plant's tropic response (that the shoot was negatively gravitropic and the root positively gravitropic). With **D** it could be that the candidates may be under the misconception that the rotation of the seed had no further effect on the direction of growth.

**Question 9**

The overwhelming majority of candidates had identified that sexual reproduction involved the fusion of nuclei but were split when it came to the nature of the offspring. They should be reminded that sexual reproduction produces dissimilar offspring.

**Question 10**

Sixty five percent of the candidates were able to correctly identify where the male gamete is made in a flower, only 41 per cent of the candidates were able to identify where the female gametes are produced.

**Question 13**

Most candidates identified the correct answer. The option main option chosen instead of **D** was **A**. This is an interesting misconception as it indicates that combustion uses carbon dioxide.

**Question 16**

There was evidence that many candidates had guessed at the answer. They are required to know the structure of ammonia, including the three single bonds present and the noble gas electron configuration of the atoms in the molecule.

**Question 17**

There was evidence that many candidates had guessed at the answer. They are expected to interpret simple symbol equations, and so to identify the number of molecules of each reactant and product in the reaction equation.

**Question 18**

More able candidates chose the incorrect **A** rather than the correct answer, **D**. They are expected to know that the electrolysis of concentrated aqueous sodium chloride using inert electrodes produces hydrogen, rather than sodium, at the cathode.

**Question 19**

There was evidence that many candidates had guessed at the answer. They are required to analyse data represented graphically, and so to recognise the highest rate of a reaction.

**Question 20**

Candidates chose the incorrect **D** more often than the correct answer, **A**. They did realise that copper oxide is being reduced during reaction 1, but did not appreciate that carbon is being oxidised during reaction 2.

**Question 21**

There was evidence that many candidates had guessed at the answer. Candidates are required to know the tests and positive results for specified cations.

**Question 22**

More able candidates chose the incorrect **A** more often than the correct answer, **B**. They are required to know the trend in the physical state of the halogens from chlorine to iodine.

**Question 24**

Many candidates chose the incorrect **A** and incorrect **B** rather than the correct answer, **D**. More able candidates chose the incorrect **C**. They are required to know the position of carbon in the reactivity series, and that carbon can only reduce oxides of metals lower in the reactivity series.

**Question 30**

Four out of five candidates understood the concept of gravitational potential energy and chose the correct answered here.

**Question 32**

Although this question on the molecular arrangement in a liquid was well answered, several less able candidates opted for **C**, this showing a loose arrangement with relatively large spacing between molecules.

**Question 35**

The topic for this question was transfer of energy thermally, and all three incorrect choices were far more popular than the correct option **D**. Most candidates either appeared not to appreciate that conduction and convection cannot occur in a vacuum, or misread the question and thought that it asked which processes are prevented by the vacuum, leading many of them to choose option **A**.

**Question 36**

Similar questions to this have appeared in past papers, but more than two thirds of candidates failed to identify the amplitude and the wavelength of the wave.

**Question 37**

A common error here was to believe that the angle of refraction in the glass block is larger than the angle of incidence (option **A**).

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/13**
**Core Multiple Choice**

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

**General comments**

Biology:
Candidates performed very well on **Question 13**.

**Question 6** proved most difficult for the candidates.

Chemistry:
Candidates performed very well on **Question 14** and **Question 26**.

**Question 17**, **Question 24** and **Question 27** proved most difficult for the candidates.

Physics:
In the physics section **Question 29** was very well answered, but **Questions 28**, **33** and **35** caused considerable difficulty.

**Comments on specific questions**

**Question 1**

Most candidates identified the correct answer, and few candidates chose **C**. Where candidates had gone wrong, they had chosen **A** the option with the correct labels, but the nucleus was in the vacuole and not in the cytoplasm; or they had confused the cell wall and cell membrane.

**Question 3**

Most candidates had identified the correct option. Where they had gone wrong some candidates had correctly identified one of the substrates or products in the answer (options **A** and **C**). Very few candidates had confused photosynthesis with respiration (option **C**).

**Question 4**

Whilst most candidates identified the correct answer there was evidence that many were under the misconception that the small intestine was to store faeces or cut food into smaller pieces.

**Question 5**

Most candidates here had incorrectly identified the ventricles as the atria.

**Question 6**

Many candidates were under the impression that an increase in physical activity decreases the depth of breathing. Candidates need to be reminded that during exercise muscles respire more and as such require more oxygen. To supply this oxygen the rate and depth of breathing increases.

**Question 8**

Many candidates opted for option **C** in this question. This was possibly because they were continuing the bend exhibited by the plant before turning the seedling, i.e. the shoot had initially turned anticlockwise and therefore after the seedling was turned candidates continued this anticlockwise movement. They should have answered the question based on the plant's tropic response, i.e. that the shoot was negatively gravitropic and the root positively gravitropic.

**Question 9**

This question was generally answered well. Based on the spread of the data it appears that where candidates had not got this question correct, they seemed to be guessing between the other options.

**Question 10**

This question was generally answered well. Where candidates had got this question wrong, they had chosen fertilization or germination.

**Question 12**

Whilst most students had correctly answered this question, those that did not get the correct answer were split between option **A** and **B**.

**Question 14**

Candidates understood well the limitations of filtration as a separation technique.

**Question 17**

Candidates chose the incorrect **B** more often than the correct answer, **C**. Some of the more able candidates chose the incorrect **A**. They are required to know the gaseous electrode products for concentrated aqueous sodium chloride, and also the effects of these gases on damp litmus paper.

**Question 21**

Some of the more able candidates chose the incorrect **A** rather than the correct answer, **D**. They are required to know the tests and positive results for specified cations.

**Question 22**

Candidates chose the incorrect **D** more often than the correct answer, **B**. Many of the more able candidates chose the incorrect **A**. They are required to know the trend in the physical state of the halogens from chlorine to iodine.

**Question 23**

Candidates chose the incorrect **D** more often than the correct answer, **A**. Many of the more able candidates chose the incorrect **C**. They are expected to know that alloys are mixtures of one metal with at least one other element, which may be either another metal or a non-metal.

**Question 24**

Candidates chose the incorrect **B** and incorrect **C** more often than the correct answer, **A**. They are required to describe the use of carbon in the extraction of copper from copper oxide.

**Question 26**

Candidates understood well why petroleum is described as a mixture.

**Question 27**

Candidates chose the incorrect **B** and incorrect **C** more often than the correct answer, **D**. They are expected to know that alkanes are generally unreactive and so methane will not react with ethene.

**Question 28**

In this question on mass and weight very few responses were correct. Although a fair proportion of candidates correctly multiplied the mass by 10, they failed to notice that the mass was given in grams, leading them to option **D**. The majority however also divided by 10 and chose option **B**.

**Question 29**

The equation for density was very well recalled.

**Question 31**

Less able candidates frequently believed that the molecules of a gas expand when the gas is heated (option **D**).

**Question 33**

The topic for this question was transfer of energy thermally, and all three incorrect choices were far more popular than the correct option **D**. Most candidates either appeared not to appreciate that conduction and convection cannot occur in a vacuum, or misread the question and thought that it asked which processes are prevented by the vacuum, leading many of them to choose option **A**.

**Question 34**

Similar questions to this have appeared in past papers, but almost two thirds of candidates failed to identify the amplitude and the wavelength of the wave.

**Question 35**

The topic here was reflection of light, and very many believed that the angle given was the angle of incidence, not appreciating that it should be measured to the normal.

**Question 37**

The most common misconception here was a belief that all three frequencies of sound could be heard.

**Question 38**

Widespread guessing seemed evident in this question on the unit for e.m.f.

**Question 39**

A common error for less able candidates here was to divide the resistance by the e.m.f. to find the current (option **C**).

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/21**
**Extended Multiple Choice**

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

**General comments**

Biology:
Candidates performed very well on **Question 6** and **Question 13.**

**Question 2** and **Question 9** proved most difficult.

Chemistry:
Candidates performed very well on **Question 25**.

No questions proved to be particularly difficult for the candidates.

Physics:
In the physics section many candidates found **Question 35** the most difficult.

**Comments on specific questions**

**Question 1**

This question was generally answered well. Candidates that did not answer this question correctly had chosen diffusion. Candidates should read the question very carefully and look for the key word (water) in the text.

**Question 2**

Many candidates incorrectly identified this graph as a temperature/enzyme activity graph. Candidates should recognise the difference between the shapes of an enzyme activity graph with changes in pH and temperature. The even bell-shaped curve of this graph indicates that this is a pH/enzyme activity graph.

**Question 3**

This question was generally answered well. The predominant incorrect answer was chemical digestion. The phrase 'without chemically changing the molecules' may have been incorrectly read when answering.

**Question 4**

This question was generally answered well. Based on the spread of the data it appears that where candidates had not got this question correct, they seemed to be guessing between the other options.

**Question 7**

This question was well answered by higher ability candidates with the majority identifying the correct response. Lower ability candidate responses were evenly spread between the four options, indicating that they were guessing.

**Question 8**

This question was generally answered well. Some candidates were under the misconception that adrenaline decreases blood glucose concentration.

**Question 9**

It was clear from the spread of answers that many candidates were guessing when answering this question. Candidates should be reminded that auxin is produced in the shoot tip.

**Question 10**

The overwhelming majority of candidates had identified that sexual reproduction involved the fusion of nuclei but were split when it came to the nature of the offspring. They should be reminded that sexual reproduction produces dissimilar offspring.

**Question 11**

This question was generally answered well. When candidates answered incorrectly, they confused the anther and stigma.

**Question 12**

Many candidates had correctly identified **C** as the correct option. There were also many that had chosen **B** as the response. Whilst the primary and secondary consumer was correct the leopard is not a tertiary consumer but either a secondary or quaternary consumer.

**Question 16**

Candidates chose the incorrect **A** more often than the correct answer, **C**. Some of the more able candidates chose the incorrect **D**. They are expected to be able to describe the formation of ionic bonds between metallic and non-metallic elements, and to know that the oppositely charged ions formed are strongly attracted to each other.

**Question 21**

Candidates chose the incorrect **A** more often than the correct answer, **B**. They are required to know the reactions of chlorine, bromine and iodine with other halide ions, which relates to their relative positions within Group VII.

**Question 22**

Some of the more able candidates chose the incorrect **D** rather than the correct answer, **B**. They are required to know that slag formed in the blast furnace is an impurity that does not contain iron, and that alloys contain a metallic element mixed with at least one other element.

**Question 23**

Candidates, particularly the more able, chose the incorrect **C** more often than the correct answer, **A**. They are expected to understand that a more reactive metal displaces a less reactive metal from its aqueous salt, and to use this to deduce the reactivity order of metals.

**Question 25**

Candidates understood very well why petroleum is described as a mixture.

**Question 28**

This question concerned the electromagnetic spectrum. Although many candidates knew that the waves involved were in the region next to visible light, many opted for **C** (ultraviolet) rather than **B** (infrared).

**Question 30**

A sizeable proportion of less able candidates forgot to add the original length of the spring to the value obtained from the graph, leading them to option **A**.

**Question 32**

Although it was widely understood that the average speed of the molecules in a cooled gas would decrease, many believed that expansion of the gas would also decrease the intermolecular distance.

**Question 33**

The topic for this question was transfer of energy thermally. The popularity of the incorrect options **A** and **B** seems to indicate that most candidates either appeared not to appreciate that conduction and convection cannot occur in a vacuum, or that they misread the question and thought that it asked which processes are prevented by the vacuum, leading them to choose option **A**.

**Question 34**

Similar questions to this have appeared in past papers, and this one was reasonably answered. However the incorrect options **B** and **C** were quite popular, showing a lack of understanding of the meaning of the terms amplitude and wavelength.

**Question 35**

There appeared to have been widespread guessing for this question on the relative speeds of sound in liquids and solids.

**Question 37**

Higher achieving candidates could mostly identify the unit of electric charge, but many others chose either the watt or, more often, the volt.

**Question 38**

A significant number of less able candidates incorrectly chose option **B** in this question on resistor combinations. Possibly their thinking was to average the values of the two resistors in parallel (3.0 Ω) then to add the value of the third resistor.

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/22**
**Extended Multiple Choice**

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

**General comments**

Biology:
Candidates performed very well on **Questions 2**, **12** and **13**.

**Question 9** was most difficult.

Chemistry:
Candidates performed very well on **Question 15** and **Question 25**.

No question proved particularly difficult for candidates.

Physics:
No question in the physics section was found to be particularly difficult by candidates.

**Comments on specific questions**

**Question 1**

This question was generally answered well. Candidates that did not answer this question correctly had chosen diffusion. Candidates should read the question very carefully and look for the key word (water) in the text.

**Question 3**

This question was answered well by candidates of all abilities. It may be that there was a failure to link vitamin C to the symptoms of scurvy in lower ability candidates.

**Question 4**

This question was well answered by candidates of all abilities. Where candidates had incorrectly answered this question, they had confused chemical and physical digestion.

**Question 6**

Whilst many candidates had identified the correct answer, it was clear from the spread of data amongst those that had not gained this mark that many had guessed the answer. With a question like this it is always worth taking the time to work out the answer – candidates could always do a sketch diagram beside the question to assist in answering the question.

**Question 8**

This question was generally answered well. Some candidates were under the misconception that adrenaline decreases blood glucose concentration.

**Question 9**

It was clear from the spread of answers that many candidates were guessing when answering this question. Candidates should be reminded that auxin is produced in the shoot tip.

**Question 10**

The overwhelming majority of candidates had identified that sexual reproduction involved the fusion of nuclei but were split when it came to the nature of the offspring. They should be reminded that sexual reproduction produces dissimilar offspring.

**Question 11**

This question was generally answered well. Candidates that could not correctly work out the number of food chains in the web seemed to guess between the remaining answers.

**Question 15**

Candidates understood well the limitations of filtration as a separation technique.

**Question 17**

Candidates chose the incorrect **B** more often than the correct answer, **D**. They are expected to understand that when atoms form ions they do so by the loss and gain of electrons to form stable, noble gas electronic structures, and how this compares to the formation of covalent bonds involving the sharing of pairs of electrons.

**Question 25**

Candidates understood well why petroleum is described as a mixture.

**Question 28**

In this question on speed and acceleration a significant proportion of candidates believed that the results given showed constant acceleration, possibly failing to understand the meaning of 'constant' in this context; the car was accelerating at all times, but at differing rates.

**Question 29**

This quite difficult question on energy transfer was tackled very effectively by a good number of candidates.

**Question 30**

Renewable energy sources were very well understood.

**Question 32**

Many candidates either misread the question or did not know that non-metals do not transfer heat by movement of electrons.

**Question 33**

The topic for this question was transfer of energy thermally, and the incorrect options **A** and **B** proved popular. These candidates either appeared not to appreciate that conduction and convection cannot occur in a vacuum, or misread the question and thought that it asked which processes are prevented by the vacuum, leading them to choose option **A**.

**Question 34**

Similar questions to this have appeared in past papers, but almost half of the candidates failed to identify the amplitude and the wavelength of the wave.

**Question 36**

A common error here was to believe that gamma rays travel faster than radio waves in a vacuum.

**Question 37**

It was generally known that the shorter wires have the least resistance, but the inverse relationship between resistance and cross-sectional area was less clear.

**Question 38**

A significant number of less able candidates incorrectly chose option **B** in this question on resistor combinations. Possibly their thinking was to average the values of the two resistors in parallel (3.0 Ω) then to add the value of the third resistor.

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/23**
**Extended Multiple Choice**

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

**General comments**

Biology:
**Question 2**, **Question 7** and **Question 13** candidates found straightforward.

**Question 6** was found to be very difficult by these candidates.

Chemistry:
Candidates performed very well on **Question 15** and **Question 25**.

**Question 16** proved most difficult for the candidates.

Physics:
In the physics section **Question 35** caused difficulty to many candidates.

**Comments on specific questions**

**Question 1**

Many students got this question correct. Most candidates correctly identified that the cells lining the trachea have cilia. Many are under the misconception that red blood cells have nuclei.

**Question 2**

This question was generally answered well, some may have found it particularly easy. Candidates that did not answer this question correctly had chosen diffusion. Candidates should read the question very carefully and look for the key word (water) in the text.

**Question 4**

Whilst the majority of students correctly answered this question, many answered that a lack of vitamin C causes rickets. This is a common mistake and could be an area for improvement.

**Question 5**

Most candidates got this question correct, but some thought that bile is stored in the pancreas. This could be a misconception as to the role of the pancreas or a failure to identify the gall bladder in diagrams.

**Question 6**

Many candidates were under the impression that an increase in physical activity decreases the depth of breathing. Candidates need to be reminded that during exercise muscles respire more and as such require more oxygen. To supply this oxygen the rate and depth of breathing increases.

**Question 7**

Most candidates had identified the correct option. Where they had gone wrong some candidates had correctly identified one of the substrates or products in the answer (options **A** and **C**). Very few candidates had confused photosynthesis with respiration (option **C**).

**Question 9**

Whilst many got this question correct, some believe that auxin is produced at the site of the bend (b). Candidates should be reminded that auxin is produced in the shoot tip.

**Question 11**

This question was generally answered well. Where candidates had got this question wrong, they had chosen fertilization.

**Question 12**

This is essentially an applied question about diffusion. Many candidates had correctly identified **A**, but others had chosen **D** as their answer. This is incorrect as the nutrients do not travel across a partially permeable membrane via osmosis. Osmosis is the movement of water.

**Question 14**

Some of the more able candidates chose the incorrect **D** rather than the correct answer, **C**. They are required to describe and explain methods of separation and purification, including filtration.

**Question 15**

Candidates knew very well which substances are described as mixtures and which are elements.

**Question 16**

Candidates chose the incorrect **B** more often than the correct answer, **C**. They are expected to be able to explain the differences in melting point and boiling point of ionic and covalent compounds in terms of attractive forces.

**Question 17**

More able candidates chose the incorrect **A** rather than the correct answer, **B**. They are required to predict the products of the electrolysis of specified molten binary compounds, and to distinguish these from aqueous electrolytes.

**Question 20**

Candidates chose the incorrect **B** more often than the correct answer, **D**. They are required to know the tests and positive results for specified cations.

**Question 22**

More able candidates chose the incorrect **C** rather than the correct answer, **A**. They are required to identify representations of alloys from structural diagrams.

**Question 24**

More able candidates chose the incorrect **B** rather than the correct answer, **D**. They are expected to understand that when covalent substances melt, weak attractive forces between molecules are overcome rather than covalent bonds being broken.

**Question 25**

Candidates understood well why petroleum is described as a mixture.

**Question 27**

More able candidates chose the incorrect **B** rather than the correct answer, **D**. They are required to describe the cracking of larger alkane molecules and state the conditions required for this process.

**Question 28**

This question concerned speed-time graphs and was generally well answered. The incorrect option **B** was a popular choice however, attracting candidates who did not realise that the area under the graph line represented a distance of only 12 m.

**Questions 29 and 30**

A large majority of candidates was familiar with the concept of the effect of a gravitational field and could recall the equation for density.

**Question 31**

This was a rather more taxing question on kinetic energy, and was also well answered.

**Question 32**

Many candidates appeared to resort to guessing in this question on transfer of heat.

**Question 33**

Similar questions to this have appeared in past papers, but the majority of candidates failed to identify the amplitude and the wavelength of the wave.

**Question 35**

The use of a lens as a magnifying glass was not well understood, with the incorrect options **A** and **B** being considerably more popular than the correct option **C**.

**Question 36**

Slightly more than one in three candidates believed that sound travels at its greatest speed in a gas.

**Question 39**

A significant number of candidates incorrectly chose option **B** in this question on resistor combinations. Possibly their thinking was to average the values of the two resistors in parallel (3.0 Ω) then to add the value of the third resistor.

**Question 40**

In this question on fuse ratings option **C** was popular, this being the lower of the two values above the safe capacity of the lead, rather than the value just below it.

# COMBINED SCIENCE

**Paper 0653/31**
**Core Theory**

## Key messages

Candidates did well in this paper when they:

read the question carefully and understood what is required in the answer
referred to diagrams when requested in the question
used the number of marks allocated to a question as a guide for how much detail to include in the response
completed all responses when a list of answers is provided
understood the difference between breathing and respiration.

## General comments

There were some good scripts from candidates who had mastered all aspects of the syllabus, and had prepared well for this examination.

Candidates should ensure that their handwriting is legible so that candidates can score the maximum credit in their responses.

Candidates should include working in all calculations to enable credit to be given for a correct formula if an arithmetic mistake is made.

## Comments on specific questions

### Question 1

**(a)** Many candidates successfully identified the cell parts in this question. A minority of candidates named the layer of the leaf in which the cells are found. Candidates are reminded that the leaf is composed of cells and labelling of these was required.

**(b) (i) (ii)** Some candidates could identify the xylem and phloem. Candidates should be aware that the xylem and phloem are contained in the vascular bundle. Incorrect responses included labels in all parts of the leaf. Some candidates did not use a label line to indicate their answers, and wrote them directly on the diagram. In these cases, the X and P were difficult to see.

**(iii)** The function of the phloem was not widely known. Many candidates incorrectly stated that the main function of the phloem is to conduct minerals. Candidates are reminded that the xylem tissue conducts minerals.

**(c)** The word equation for respiration was generally well known.

**(d)** Some candidates understood what the question was asking and wrote acceptable answers as shown in the mark scheme. Many others interpreted the term *respiration* as breathing, and many responses included descriptions of the carbon dioxide exhaled during breathing being available for plants.

### Question 2

**(a)** This question was generally well answered.

**(b) (i)** A minority of candidates correctly stated that natural gas is the fossil fuel that contains large amounts of methane. Incorrect responses included coal and oil.

**(ii)** Some candidates wrote the correct formula for methane. Candidates are reminded that methane is a hydrocarbon, and only carbon and hydrogen appear in the formula.

**(iii)** A few candidates answered this question correctly. Many candidates were unfamiliar with this part of the syllabus.

**(iv)** Some candidates knew the products of complete combustion of a hydrocarbon to produce carbon dioxide and water. Some responses correctly stated that carbon dioxide is produced. Candidates are reminded that the hydrogen present in the hydrocarbon becomes oxidised to produce water and it is not one of the products of combustion.

**(c)** A small number of candidates correctly identified calcium carbonate. Careful reading of the information at the start of the question shows that three elements must be shown in the formula. Some candidates omitted at least one of these elements.

**(d)** A chemical test for water was generally not known. Some candidates gave responses such as boiling point and freezing point, but since these are physical properties, these responses did not address the question.

**Question 3**

**(a) (i)** The majority of candidates answered this question correctly. A few candidates wrote 'gravitational potential energy'. They are reminded that this is not a force.

**(ii)** Most of the candidates drew an arrow in the correct direction. Candidates should be aware that the arrow should touch the whale to show that the force is acting on the whale, rather than the water near to the whale.

**(iii)** A few candidates answered this question correctly. An object with constant speed has balanced forces acting on it. Therefore, force **S** is the same value as force **R**, **500 N**. Many candidates did a calculation which included the speed value of 5.0 km/hr.

**(iv)** Generally, well answered. Many candidates interpreted the separate effects of the horizontal and vertical forces to describe the two differences in the motion of the whale.

**(b) (i)** A few candidates scored full marks in this question. These candidates knew that both force and distance are needed to calculate the work done. Some candidates knew that the distance travelled was needed, with fewer writing force as well. Speed was the most common incorrect quantity given.

**(ii)** Many candidates successfully stated that the moving whale would have kinetic energy. Fewer knew that chemical energy in the whale was transferred into kinetic energy.

**(c)** This was generally well answered. Most candidates successfully used the speed = distance/time equation to obtain the correct answer of **1500 m/s**.

**Question 4**

**(a)** Most candidates were familiar with the diagram and some were able to score all four marks. Common errors for sperm duct included 'carries sperm towards the testes' and carries 'semen'.

Candidates should be aware that the sperms have other substances added by additional glands after they have left the sperm tube, to complete the composition of the semen.

A minority of candidates gained credit for identifying the urethra. Incorrect answers included penis, urine tube and fallopian tube.

Most candidates identified the testis correctly, and many candidates gave a correct definition for the scrotum.

**(b) (i)** Many candidates correctly interpreted the graph to say that the uterus lining becomes thinner. Candidates who identified this as the time of menstruation were also given credit.

**(ii)** Some candidates answered this correctly. Candidates had to refer to Fig. 4.2 to determine the time when the cycle repeats, in this case 30 days. Incorrect values given included 28, 35 and 7 days.

**(iii)** A few candidates appreciated the fact that the uterus lining builds up to prepare for implantation of a fertilised egg. Responses which were not acceptable included references to preparing for the next menstrual cycle.

**(c)** Candidates had to describe the fusion or joining of the egg cell with the sperm cell. Many candidates described the sperm cell meeting the egg cell as fertilisation. These responses were not accepted because many sperm cells meet the egg cell but only one sperm is successful in going into in the egg cell for fertilisation. The joining of the nuclei of the gametes was rarely stated.

**Question 5**

**(a) (i)** Most candidates obtained the two marks for this question. Incorrect responses included placing the metals in the reverse order of reactivity. Candidates are reminded that more reactive metals take a shorter time to produce 20 $cm^3$ of gas.

**(ii)** The point of this question was for candidates to change the experiment shown to increase the rate of the reaction. Many candidates successfully described acceptable changes of the variables. Responses which did not gain credit included 'the concentration of the acid' and 'the temperature' without saying how these variables should be changed to increase the rate of reaction.

Responses which did not contain enough detail included 'use more acid' and 'use a smaller piece of metal'.

**(b) (i)** Some candidates knew that hydrogen is produced when dilute hydrochloric acid react with metals. Incorrect responses included carbon dioxide and oxygen.

**(ii)** The majority of candidates successfully matched each gas with its correct test to gain full credit.

**(c)** A few candidates scored both marks in this question. Incorrect responses included descriptions of chemical properties.

**Question 6**

**(a) (i)** Many candidates scored full credit in this question, showing a good knowledge of the electromagnetic spectrum.

**(ii)** The dangers of exposure to ultraviolet radiation were generally well known. The most common answers gave reference to harm done to skin and eyes.

**(b) (i)** A few candidates gave the correct response. Other candidates should be aware that an electric current is the flow of charge. The most common incorrect response was 'flow of electricity'.

**(ii)** Most candidates did the calculation well and scored two marks. Fewer knew the correct unit, Ω.

Some candidates used an incorrect form of the equation, $R = V \times I$, instead of $R = V/I$. Therefore 1000 Ω was frequently seen instead of the correct answer **4000 Ω.**

**(c)** This question was very well answered. Most candidates described the possible hazard of operating electrical devices near water.

**Question 7**

**(a)** Many candidates were successful in identifying oxygen as the smallest molecule in the list.

**(b) (i)** Many candidates answered this question correctly. The colours required for the responses included the negative result with iodine for the presence of starch, which is brown. This was less widely known than the positive result with Benedict's solution for glucose.

**(ii)** Many candidates interpreted the results in Table 7.1 correctly to conclude that the starch molecules were still in the bag.

**(iii)** Due to the positive result with Benedict's solution recorded in Table 7.1, most candidates concluded that the glucose molecules had passed out of the bag and into the water. Further credit was gained when candidates described this movement of glucose molecules as diffusion.

**(iv)** The comparison of the sizes of molecules of glucose and starch was correctly stated by many candidates. This response required reference to the information about the bag, and evidence from the results table. Many candidates succeeded in drawing these parts together and gained full credit.

**(c)** Candidates had to choose a relevant substance that is carried by the plasma, which is not a dissolved nutrient. Some candidates gave an acceptable answer, with carbon dioxide and hormones most frequently seen.

**Question 8**

**(a)** This question was generally well answered. Incorrect responses included the correct numbers in the wrong order, or 27 written in either space.

**(b) (i)** Very few candidates knew that the method of extraction of aluminium is by electrolysis. Incorrect responses included heating, reduction and redox.

**(ii)** Ionic bonding in aluminium oxide was correctly stated by a minority of candidates. The most common errors stated were covalent or chemical bonds.

**(iii)** Candidates who were awarded credit explained that there is a limited amount of ore available. It is a finite resource that is conserved by recycling.

**(c)** There were very few correct answers given to this question. The knowledge that transition metals can form coloured compounds was not widely known. Common responses included 'copper is a metal, aluminium is not', and 'copper rusts and aluminium does not'.

**(d) (i)** The fact that carbon is used to reduce the copper oxide was known by very few candidates. There were many incorrect suggestions here, including the names of metals. The stem of the question clearly asks for a non-metallic element.

**(ii)** Many of the candidates answered this question correctly. Incorrect responses either provided no explanation as to why the copper oxide was reduced, or made statements such as 'the oxide was removed' instead of oxygen.

**Question 9**

**(a) (i)** A small number of candidates gained credit in this question. Careful reading of the stem was required here to ensure that an electrical property was given. The most common error was the statement that the wire should be a good thermal conductor.

**(ii)** Some candidates gained credit by explaining that the powder had to be a good thermal conductor so that the thermal energy produced by the heating coil could reach the metal tube and go through to the water. Other candidates stated that the powder had to be a good thermal conductor to prevent the resistance wire from overheating. These responses missed the point of the element, that the thermal energy had to go from the resistance wire to the water so that the water can heat up.

**(iii)** A few candidates scored full marks in this question. These candidates described convection, and gave further detail about the circulation of the water particles when they are heated. Incorrect responses named conduction as their method of heat transfer, or that electricity moved through the water.

**(b) (i)** The majority of candidates knew the symbol for the switch. Only a few knew the symbol for a fuse. The most common incorrect symbols drawn were a resistor, or a variable resistor.

**(ii)** Very few candidates obtained credit here. Many candidates did not know that the fuse wire is sensitive to the current passing through it, rather than the voltage. Therefore, the widely-seen answers such as 'the 3A fuse can't handle 240 volts' did not obtain credit.

# COMBINED SCIENCE

**Paper 0653/32**
**Core Theory**

## Key messages

Candidates did well in this paper when they:

read the question carefully and understood what is required in the answer
referred to diagrams when requested in the question
used the number of marks allocated to a question as a guide for how much detail to include in the response
knew the chemical test for copper(II) ions
understood the meaning of the word 'property'.

## General comments

There were some good scripts from candidates who had mastered all aspects of the syllabus, and had prepared well for this examination.

Candidates should ensure that their handwriting is legible so that candidates' can score the maximum credit in their responses.

Candidates should include working in all calculations to enable credit to be given for a correct formula if an arithmetic mistake is made.

## Comments on specific questions

### Question 1

**(a) (i)** The majority of candidates stated the correct two characteristics of living things. Errors commonly seen were digestion, and less frequently, photosynthesis.

**(ii)** Most candidates gained credit for the fact that animals eat food to gain their nutrition. Fewer candidates responded with 'photosynthesis' as the method of plant nutrition. Responses which did not gain credit for plant nutrition included 'through their roots', 'sunlight' and 'water'.

**(b) (i)** Most candidates scored in this question. Incorrect responses included a selection from the given characteristics given in Fig. 1.1.

**(ii)** The majority of candidates successfully completed the sentences. The most widely seen incorrect answer was the use of the word 'photosynthesis' instead of 'phototropism'. Also, several candidates wrote 'upwards' instead of 'downwards' for the direction of growth of the young radicle.

**(c)** There were several acceptable responses given to the effects of adrenaline on the body. Candidates should be aware of the specific effects of adrenaline required as shown in the syllabus. Therefore, statements such as 'it makes you more excited/happy/have faster reactions' and 'increase energy' were not awarded credit.

**Question 2**

**(a) (i)** Most candidates wrote the formula of sodium chloride correctly. Incorrect answers included word equations for the formation of sodium chloride from its elements, and incorrect use of the cases of the letters of the symbols, e.g. NaCL. Incorrect formulae included $NaCl_2$, NaC and NCl.

**(ii)** Candidates found this challenging. Many answers stated that the ionic bond forms between a metal and a non-metal, and the covalent bond forms between two non-metals, without mentioning electrons. These questions were not awarded credit. Candidates are reminded to read the question carefully so that their responses address what is being asked.

**(iii)** This question required an understanding of the terms *solvent, solute* and *solution*. Some candidates answered this correctly. Others are reminded that sodium chloride is the solute and aqueous sodium chloride is the solution.

**(b) (i)** A minority of candidates gained credit in this question. The production of new substances, in this case gases, indicate that a chemical change has taken place. Many of those candidates who wrote physical change seemed to be unfamiliar with the process of electrolysis, stating that no new substance is made, or that electrolysis could easily be reversed.

**(ii)** Candidates across the ability range were unfamiliar with the use of carbon to make the inert electrodes. Many metals were quoted, including iron and copper. Careful reading of the question would have excluded these as possible answers.

**(iii)** Approximately half of the candidates knew the correct names for the electrodes. Incorrect answers included naming the electrodes the wrong way round, or attempting to name the products of the electrolysis.

**(iv)** Chlorine and hydrogen were successfully identified by a minority of candidates. Incorrect gases quoted were carbon dioxide, oxygen and nitrogen.

**Question 3**

**(a)(i)** Most candidates across the ability range identified the sound wave successfully.

**(ii)** Many candidates gained credit in this question. Incorrect responses included the full range of waves given in the stem of the question, with infrared and visible light stated most frequently.

**(iii)** Many candidates correctly stated that ultraviolet radiation causes sunburn. The most common errors were infrared and visible light.

**(b)** Scripts gaining full marks in this question were rarely seen. Most candidates gained credit for the symbols for an ammeter and a voltmeter. Fewer candidates knew the correct symbol for the variable resistor. Many candidates did not place their voltmeter in parallel. Of those who did connect the voltmeter in parallel, some candidates placed it across other components, not the a.c. supply.

**(c)** The idea that the motor speed would increase the frequency of production of waves or decrease the wavelength, was correctly stated by some candidates. Incorrect responses included ‘bigger waves would be produced’ and ‘creates more waves (without mentioning a time period).

**Question 4**

**(a) (i)** Most candidates correctly concluded that the oil provided a barrier to oxygen reaching the banana slices and therefore prevented the banana from changing colour. Credit was lost by those candidates who did not use the information in Table 4.1 to state that the covering of oil resulted in the banana slice staying white and not changing colour.

**(ii)** Most candidates stated that boiling made the enzyme inactive, preventing the banana from going brown. Candidates who stated that boiling caused the enzyme to be killed were not awarded credit.

**(iii)** Candidates had to state that pH3 gives an acidic solution and this prevented the banana from going brown. Responses which did not interpret pH3 as an acid were not awarded credit.

**(b)** Many candidates knew the test with Benedict's solution to detect reducing sugar. A few of these candidates did not know the positive result.

**Question 5**

**(a) (i)** Generally, the higher-scoring candidates gave the correct answer gasoline as the fraction used as a fuel in cars. Common errors included petroleum and gas oil.

**(ii)** This question was answered correctly by approximately half of the candidates. Incorrect answers included gas oil and gasoline.

**(b) (i)** Candidates found this question challenging. Only a few wrote alkane or saturated. Many wrote methane, which did not gain the mark, because the question was asking for a more general term and not a specific example.

**(ii)** Some of the higher-scoring candidates completed the word equation successfully. Incorrect responses included hydrogen as one of the products. Candidates are reminded that the hydrogen in the hydrocarbon reacts with oxygen to produce water.

**(c) (i)** Most candidates found this question challenging. Compound X shows the characteristics of an alkene, an unsaturated hydrocarbon. The test with aqueous bromine confirmed this. There was no particular pattern of incorrect answers.

**(ii)** Candidates found this question challenging and were unfamiliar with addition polymerisation. Incorrect answers included physical polymerisation, fractional polymerisation and compound polymerisation.

**(d) (i)** The majority of candidates answered this question correctly. Incorrect diagrams included ones with four electrons in the first shell, and two in the outside shell.

**(ii)** Many candidates drew a correct dot-and-cross diagram. Incorrect responses included a single bond with no electrons drawn, and diagrams with two electrons coming from each hydrogen atom.

**(iii)** Some of the higher-scoring candidates scored credit in this question. Incorrect answers included explanations of bonding between two metals, or a metal and a non-metal.

**Question 6**

**(a)** The majority of candidates matched two out of the three temperatures correctly. The melting point of ice and room temperature were widely known. Few candidates identified the boiling point of liquid air. Most incorrect responses identified this as point F, 240 °C. Candidates are reminded that air is a gas at 0 °C, so it has to be cooled below this temperature to turn into a liquid.

**(b) (i)** Thermal of expansion of liquids with increasing temperature is the important property needed in this question. Many candidates did not understand the meaning of the word 'property', and just described the purpose of the thermometer.

**(ii)** Very few candidates scored credit in this question. As in **(b)(i)**, many candidates described the function of the digital thermometer, without suggesting which electrical property changes with temperature.

**(c) (i)** The transmission of energy from the Sun by the process of radiation was known by many candidates.

**(ii)** To answer this question correctly candidates had to identify convection in a different context. The medium referred to is gaseous, so the method of heat transfer is convection. Incorrect answers included 'conduction' and 'heat transfer'.

**Question 7**

**(a) (i)** Most candidates made correct statements about the unbalanced meal.

**(ii)** This question was generally well answered. Candidates provided a wide range of acceptable answers in this question. Many responses focused on a food which would provide vitamins or minerals.

**(b) (i)** Most candidates identified at least one polymer of glucose from the list. Full credit was scored by candidates towards the top of the ability range. Frequent incorrect responses included 'enzyme' and 'protein'. Both of these molecules are polymers, but of amino acids and not glucose.

**(ii)** The importance of chemical digestion was known by many candidates. These candidates knew it is necessary to make large molecules smaller so they can be absorbed. Some candidates lost credit by saying the importance of the small molecules is so they can be digested. The process of digestion is the breaking down of the large molecule into small molecules, and the movement of these small molecules into the bloodstream is called absorption.

**(iii)** Many candidates answered this correctly, stating the areas in the alimentary canal where chemical digestion takes place. Incorrect responses included the pancreas and salivary glands. Digestive enzymes are produced in both of these places, but are then transported into different areas of the alimentary canal where the chemical digestion takes place.

**Question 8**

**(a) (i)** Several candidates used their knowledge of displacement reactions to put the three metals in order of reactivity. Calcium must be more reactive than aluminium because it is not displaced by it. In turn the aluminium could displace iron, so it must be more reactive. The most frequent error was placing iron before aluminium.

**(ii)** The word equation was successfully completed by approximately half of the candidates. The reactants are given in the stem of the question, so their names are available for transfer into the first two boxes. Some candidates did not do this. The name of the product, iron, was given in the stem of the previous question and this was available to be added to the word equation. Candidates are reminded to read all the given information carefully.

**(iii)** A few candidates recognised that the aluminium is oxidised because it has gained oxygen. Responses that did not gain credit included answers which stated oxidised correctly but had incorrect or missing explanations, or responses which stated reduced.

**(b) (i)** Candidates who had seen this experiment knew that the mixture has to be heated strongly to start the reaction. A small number gave this response. There were many different incorrect responses, including 'add a catalyst', 'add water', add sodium hydroxide/hydrochloric acid'.

**(ii)** The tests for copper(II) ions were not known by many candidates. Incorrect responses included testing with limewater, and electrolysis.

**Question 9**

**(a) (i)** The frictional forces, identified by the letter **R**, were correctly identified by most candidates.

**(ii)** Some candidates scored credit in this question. When the truck is stationary, both the forward driving force **P** and the frictional forces **R** have a value of 0N. The frictional force resists horizontal motion so it is not acting when the truck is still. The vertical forces are not changed when the truck is stationary. Therefore, those candidates who wrote that **P** alone or **P**, **Q**, and **R** together have a value of 0N did not score.

**(b) (i)** Some candidates did the calculation correctly. The most common incorrect answer was 50N where the candidates had divided the 500 kg by 10, rather than multiplying it to give the correct answer of **5000N.**

**(ii)** Candidates needed to know that the box will only move if the forces on it are unbalanced. Therefore, force **U** has to be greater than the weight, **W**, if the box is to move upwards. Several candidates gained credit in this question.

**(iii)** Some candidates found this question challenging. The main point they had to make was that more work is done by lifting the box from the floor to the higher shelf than the lower shelf. This is because the force (weight of the box) is moved through a greater distance. Therefore, responses which stated that more force is needed to lift the box to the higher shelf did not gain credit.

**(c) (i)** To calculate the average speed the total distance was divided by the total time taken. Some candidates did not see that the total distance is given in the introduction of the question. Therefore, attempts to calculate the area under the graph were unnecessary, and in most cases, inaccurate. Many candidates gained full credit in this question. The correct answer was **3.75 m/s.**

**(ii)** Generally answered well. The candidates interpreted the graph and wrote that the speed of the truck was increasing.

**(iii)** Many candidates stated correctly that it is electrical energy which drives the motor. The electrical energy has come from the battery and flowed through wires to get to the motor. Inside the battery, the energy is stored as chemical (potential) energy and it is not until the circuit is connected and switched on that the chemical energy transfers to electrical energy.

# COMBINED SCIENCE

**Paper 0653/33**
**Core Theory**

## Key messages

Candidates did well in this paper when they:

read the question carefully and understood what is required in the answer
referred to diagrams when requested in the question
used the number of marks allocated to a question as a guide for how much detail to include in the response
filled in all blank spaces when there is a list of answers provided
did not write formulae when a word equation is requested
knew the chemical test for aqueous calcium ions, and the biuret test for protein.

## General comments

There were some good scripts from candidates who had mastered all aspects of the syllabus, and had prepared well for this examination.

Candidates should ensure that their handwriting is legible so that candidates can score the maximum credit in their responses.

Candidates should include working in all calculations to enable credit to be given for a correct formula if an arithmetic mistake is made.

## Comments on specific questions

### Question 1

**(a)** Many candidates identified the trachea and ribs correctly. Fewer candidates knew the bronchioles, with alveoli being the most common incorrect answer.

**(b)** Many candidates scored credit in this question by knowing that the concentration of carbon dioxide in exhaled air is greater than inhaled air and writing an acceptable answer. The most frequent incorrect responses included ones which gave a percentage of carbon dioxide of 2 per cent or less.

**(c) (i)** The majority of candidates gained partial credit by stating that the red blood cells are responsible for transporting oxygen. There was further credit available for stating that is the haemoglobin inside the red blood cells which carries oxygen. Some incorrect responses described the path of air in the gas exchange system. Others stated that oxygen is transported to organs in veins.

**(ii)** Very few candidates scored credit in this question. Some candidates wrote that oxygen is needed for respiration and therefore scored some credit. Rarely did any candidate state that respiration releases energy. There were numerous vague responses which were not good enough to gain any credit. Examples of these were ‘because you need oxygen to survive’, ‘in order to keep our systems working’, ‘all living things need a supply of oxygen’.

**(d)** Most candidates stated correctly that the rate of breathing increases during exercise. Only a small number wrote that breathing becomes deeper.

**Question 2**

**(a) (i)** Candidates had to say that a molecule consists of a group of atoms which are chemically combined. Though several candidates stated that there was a group of atoms very few went on to say that they are chemically combined.

**(ii)** Generally, well answered by the majority of candidates. Incorrect responses included gasification and condensation.

**(iii)** The majority candidates stated that there was no new substance formed so therefore the change was a physical one. Other candidates gained credit by reference to a change of state with no difference in the chemical composition of bromine.

**(b) (i)** This question was generally well answered by candidates of all abilities.

**(ii)** The majority of candidates scored at least partial credit in this question, with many gaining full marks. Incorrect answers included diagrams unchanged from the question and diagrams with the atoms as drawn in the question with arrows showing where electrons may move during the reaction.

**(iii)** A few candidates gained credit in this question. Some candidates were not aware of the fact that solid ionic compounds do not conduct electricity, but when they are melted they are able to conduct because the ions become mobile.

**(iv)** The higher-scoring candidates scored well in this question. Incorrect responses included 'ionic' and 'metallic' bonds.

**Question 3**

**(a) (i)** Candidates had to show the force arrow for friction acting in the opposite direction to the movement of a boy. Some candidates drew arrows facing the correct direction but very few of these actually touched the boy. These responses were not awarded credit. It was important for the arrow to touch the boy to show that the force was acing on him and not on the water close to him.

**(ii)** Many candidates gave the correct value for the frictional force. The boy was swimming at a constant speed, so therefore the forces were balanced and the value of the frictional force was the same as the forward swimming force. The most common error was when candidates stated a frictional force of less than 40N, explaining that the boy would not be able to move forward if the forces were equal.

**(b)** The majority of candidates successfully rearranged the speed = distance/time equation to do this calculation successfully. The correct answer was **31s**.

**(c)** Many candidates correctly interpreted the information shown by the graph to describe the motion of the swimmer. The answers had to describe both the periods of constant speed, and of deceleration. There was sufficient information for candidates to give a detailed description from the graph. Therefore, responses such as 'the swimmer's speed was decreasing' and 'he was swimming at a constant speed' did not gain full credit.

**(d) (i)** Candidates had to suggest that the harmful effects of X-rays would make them unsuitable for use in the timing of the race. Suggestions that X-rays could not penetrate water, or that they would just give a picture of bones were not accepted.

**(ii)** Many candidates wrote infrared radiation in the correct part of the electromagnetic spectrum.

**Question 4**

**(a) (i)** It was clear that not all candidates were familiar with the seven characteristics of living things as described in the syllabus. Of these, *movement* and *sensitivity* were the words required. Some of the responses which were not accepted were self-defence, survival skills and reflex action.

**(ii)** Having seen that the leaf closed when touched, most candidates could see that photosynthesis would be inhibited by the reduced area available to capture light.

**(b) (i)** The majority of candidates drew the organisms in the food chain in the correct order. Some candidates drew the arrows pointing in the wrong direction. Candidates are reminded that the arrows in a food chain show the direction of flow of energy from one organism to another.

**(ii)** Generally, well answered. The candidates successfully interpreted the trophic level descriptions to give an example of a carnivore and a herbivore.

**(c)** Very few candidates stated that the principal energy source of the food chain is the Sun. The light energy from the Sun enables photosynthesis to occur in the wheat, the producer. The chemical energy in the wheat is then available for the members higher up the food chain.

**Question 5**

**(a) (i)** The majority of candidates stated that the pH of the soil would increase to neutralise the soil. Some incorrect responses stated that decreased acidity decreased the pH value, or that the pH of the soil would increase to pH14.

**(ii)** Many candidates placed the names of the reactants in the correct boxes. Others wrote reactants that were not mentioned the question, for example calcium (metal), water, sulfur, carbon and oxygen. Candidates are reminded that the information about the reactants is contained in the stem of the question. Candidates are reminded to write word equations, and not symbolic equations, when requested.

**(iii)** The test for calcium ions in aqueous solution was generally not known.

**(b) (i)** A small number of candidates stated the importance of having excess copper oxide to ensure that all of the acid had reacted.

**(ii)** The use of filtration to separate the unreacted copper oxide from the solution was known by many candidates. Several responses referred to distillation. This was not acceptable because it would result in water being separated from the reaction mixture, and not the blue solution.

**(iii)** Many candidates gained credit in this question. The need to heat the solution was widely known. Responses stating that all the water is evaporated were not acceptable because this would produce the anhydrous form of copper sulfate.

**Question 6**

**(a)** The three missing words were written correctly in the spaces by the majority of candidates. One error which occurred frequently was the use of the word boils instead of evaporates for the first response. A liquid can only boil at its boiling point, which in the case of pure water is 100 °C.

**(b)** Most candidates correctly stated that the molecules would be closer together in the cylinder at high pressure. Fewer wrote that the speed of the gas molecules would be the same in the cylinder and in the room, because they are both at the same temperature.

**(c) (i)** An acceptable value for the lowest frequency for human hearing was given by many candidates. Some incorrect answers gave the higher threshold for human hearing. Others stated values in between the lower and higher thresholds.

Many candidates stated the correct unit, Hz, for frequency. ‘Decibels’ was written by some candidates. This unit is a measure of loudness of sound.

**(ii)** Knowledge of the upper threshold of human hearing was needed to answer this question. Candidates then had to suggest a frequency above this value. A few candidates made acceptable suggestions. Some answers given were below the lower threshold. Others were somewhere in between the lower and upper threshold.

**(d) (i)** Candidates found this question challenging. In order to produce a parallel beam of light the lamp should be at the focal point of the lens. There were many incorrect answers and several candidates did not attempt this question.

**(ii)** The ray diagram was done successfully by a few candidates. Some candidates drew two diverging rays from the light source, but they did not show them emerging from the lens. Candidates are reminded that rays of light should be drawn using a ruler and light rays should not change direction until they meet the lens.

**Question 7**

**(a)** The majority of candidates were familiar with the order of the stages of digestion, and the descriptions of the processes of digestion, therefore gaining full credit.

**(b)** Most candidates were unfamiliar with the role of the gall bladder for storing bile. Examples of widely-seen incorrect responses included 'to produce bile', 'to store urine' and 'to produce enzymes'.

**(c) (i)** Candidates had to describe a balanced diet as one which contains all the nutrients, and in the correct proportions for an individual's needs. Successful answers were expressed in a variety of different ways, but responses stating that a balanced diet should have equal amounts of each nutrient were not given credit.

**(ii)** This question was answered well by candidates. Some responses were general, for example, 'for growth and repair', and others were more specific, including 'to build up muscles' or 'to make enzymes. Both of these approaches to the question gained credit.

**(iii)** The higher-scoring candidates successfully recalled the chemical test for protein. Some of the other responses referred to The Benedict's test for reducing sugars or the starch test with iodine.

**Question 8**

**(a) (i)** A few candidates answered this question correctly. Incorrect answers included oxidation, exothermic and endothermic.

**(ii)** Generally answered well by most candidates. They understood that the rate of reaction would be slowed down, or may not take place at all if a lower temperature is used.

**(iii)** The important point that had to be made about argon was that it has a full outer shell of electrons. Therefore, responses just stating that argon is a noble gas did not explain why the element is unreactive. Very few candidates wrote the level of detail needed to gain credit.

**(b)** Several candidates explained that carbon is unable to displace aluminium from its compound because aluminium is more reactive than carbon. These candidates gained credit. Incorrect responses included the statement that aluminium is less reactive than carbon. Most of the lower-scoring candidates did not attempt this question.

**(c) (i)** A very small number knew the name of the aluminium ore, bauxite. Incorrect responses included aluminium ore and rocks.

**(ii)** The method of extraction of aluminium, electrolysis, was not known by the vast majority of candidates.

**(d)** Candidates found this question challenging. To answer this question successfully they had to use their knowledge of the physical characteristics of transition elements. Therefore, any reference to their chemical reactivities did not gain credit. Several candidates responded that both metals are good conductors of electricity, so were able to gain the mark for the similarity between the metals.

**(e)** Acceptable responses described the advantages of recycling in terms of protecting a finite resource. Candidates who were not awarded credit gave explanations in terms of economic considerations. The cost was excluded by the stem of the question.

**Question 9**

**(a) (i)** A small number of candidates were awarded the mark for this question. Candidates are reminded that the electromotive force (e.m.f.) of the battery is expressed in terms of volts, so responses lacking this unit were not awarded credit.

**(ii)** Some candidates gained credit by stating that the current produced by touching the electricity supply line is far greater than the current produced by touching the battery, and therefore would be fatal.

**(b) (i)** Many candidates successfully did the calculation using the equation $R = V/I$. Many of candidates who did not score did not recollect the equation correctly, with $R = V \times I$ seen frequently. The correct answer is **48 000Ω**.

**(ii)** Generally, well answered. Candidates recognised that the rubber material from which the gloves were made is an insulator.

**(c)** Some candidates scored credit in this question. Responses by successful candidates consisted of circuit diagrams which were clear and used the correct symbols. The most difficult part of the circuit was the inclusion of an additional branch to contain the motor and its own switch, and very few candidates did this. It was clear that many candidates were unfamiliar with the symbols used in electrical circuits. Knowledge of these symbols would have enabled these candidates to score some credit.

# COMBINED SCIENCE

**Paper 0653/41**
**Extended Theory**

## Key messages

Those 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 available marks to guide the detail required in their answers
ensured that their handwriting was legible so that correct answers gained the marks they deserved
ensured that they included working and relationships in questions involving calculations and that these were set out clearly enough for partial credit to be awarded even if the final answer was incorrect
successfully applied their knowledge to unfamiliar contexts e.g. **Questions 3(c)(i)** and **9(c)(i)**.

## General comments

Candidates often showed that they had prepared well for most sections of the syllabus and were familiar with the examination techniques required for success. The success of candidates in the three Science disciplines was similar although in some individual cases there was evidence that one or two of the Science disciplines were rather more familiar. As is often the case in this examination, candidates tended to do well in calculations testing various sections of the Physics syllabus. Questions that used unfamiliar contexts presented the greatest challenges to candidates and practice in these kinds of questions is always recommended. Some candidates obtained very low scores and these candidates may have been more suited to entry for the Core rather than Extension paper. Candidates usually wrote answers of appropriate length although colleagues should continue to stress that the number of marks and the space allocated for answers are guides to the length and detail required. There was no evidence that candidates were under any undue time pressure to complete the examination.

## Comments on specific questions

### Question 1

**(a) (i)** Final answer **6.64** per cent. Methods to calculate this increase were familiar to some of the candidates. Candidates who did not work through to the correct final answer but who set out their working clearly, gained partial credit for a correct step in the working.

**(ii)** Very many candidates were familiar with the molecular processes going on in osmosis and some very good answers were seen. The better answers used the term *water potential* correctly and avoided ambiguous references to concentration. Candidates needed to be very clear that if they used the word *concentration* then they needed to make it clear that they were referring to the concentration of water and not sucrose.

**(b)** Most candidates opted for one or other of the larger molecules in the list. The most popular answer was glucose.

**(c) (i)** Many candidates had learned the balanced equation for photosynthesis and both marks were very often awarded. Partial credit was less frequently gained since candidates had either learned the equation or had not.

**(ii)** Candidates should know that glucose is used in respiration to release energy or is stored as starch. Other valid uses of glucose were accepted. The more successful candidates avoided confusing the uses of glucose and proteins. Many lost credit for suggesting that glucose is used for growth or for plant food.

**Question 2**

**(a)** The most common correct answer referred to high temperature or heat. Candidates needed to avoid answers such as *a warm temperature* or *a suitable temperature*. Some candidates did not appear to be at all familiar either with the process of hydrocarbon cracking or the meaning of the term *condition* as used in the context of reaction conditions.

**(b) (i)** Provided candidates were clear about the structural difference between saturated and unsaturated hydrocarbons they had no difficulty identifying **A**, **B** and **E**. All three hydrocarbons had to be given before the mark was awarded. The most frequent mistake was to suggest **C** and **D**.

**(ii)** Usually those candidates who were successful in **part (i)** were also successful in this question. A larger number of candidates gained the mark for **part (ii)** than for **part (i)**.

**(iii)** All five of the compounds were required for this mark which was awarded to a relatively small number of candidates.

**(c)** Correct dot-and-cross diagrams of ethene were drawn by many candidates. A variety of styles of dot-and-cross diagrams are accepted provided they are clear. The better candidates drew their diagrams carefully so that the bonds were clearly shown. Very untidy diagrams that were too difficult to interpret did not gain credit. No credit was available on this occasion for molecular structures. Only partial credit was awarded if an incorrect number of electrons appeared on any of the atoms in the molecule, even if the covalent shared electrons were correctly shown.

**(d)** These marks were awarded to the relatively small number of candidates who had learned a proper definition of *homologous series*. Many candidates appeared to be unfamiliar with the term. Many others showed that they understood the concept and could state, for example, that alkanes and alkenes were in different series but they did not give a description in terms of a general chemical formula and similar chemical properties.

**Question 3**

**(a) (i)** The majority of candidates identified force P to be **14 000 N**.

**(ii)** The majority of candidates correctly calculated the mass of the whale to be **1400 kg.** The most common mistake was to multiply 14 000N by 10 N/kg.

**(b) (i)** Final answer **1.5 m/s**. This calculation was successfully completed by a large number of candidates who gained full credit. Some gained at least one mark by stating the relationship *speed = distance/time*.

**(ii)** Final answer **1 000 000** J. The use of the relationship *work = force × distance* was familiar to many candidates and both marks were frequently awarded. A very common mistake was to use 2.0 km rather than 2000 m in the calculation.

**(iii)** Final answer, assuming no errors in either **(a)(ii)** or **(b)(i)**, is **1575** J. The use of the relationship K.E. = ½ $mv^2$ was very familiar and errors carried forward from **(a)(ii)** and **(b)(i)** were allowed.

**(c) (i)** Candidates could simply state that sound travels faster in liquids compared to gases, or they could discuss the effect of the density difference between a liquid and a gas. Candidates needed to avoid talking about the vibration of sound particles.

**(ii)** Many candidates scored at least one mark for correctly stating the range of human hearing to be 20 Hz to 20 000 Hz. The second mark could be gained either by stating that at least some of the frequencies the whales can produce overlap with the range of human hearing or that the sounds from the whale would be heard by humans as high-pitched or squeaky. Candidates who found the words to express these ideas gained the available marks. Large numbers of candidates lost credit

because they discussed the range of frequencies that the whales could hear and/or the range of frequencies that humans can produce.

**Question 4**

**(a)** The presence of enzymes in the sperm at position **A** was not recognised by the majority of candidates, and the use of the term flagellum for **part B** was similarly uncommon. The most frequently seen answers were head and tail for which no mark was available. The term *acrosome* was seen a few times and accepted.

**(b) (i)** The better prepared candidates gained the mark for stating either oviduct or fallopian tube. The most frequently seen answers included ovary and uterus.

**(ii)** This was marked strictly and so candidates needed to avoid discussing hardening of egg walls or the formation of shells to prevent entry of a second sperm. Similarly, the idea that a membrane hardens or that the egg in some way closes up did not gain credit. Only a minority used the terminology in the syllabus and described the change in the jelly coating following the entry of the first sperm.

**(c) (i)** Both **parts A** and **B** were familiar to many candidates with umbilical cord being the more familiar. **A** common incorrect suggestion for **B** was uterus.

**(ii)** Amino acids and glucose were correctly identified by large numbers of candidates. White blood cells was a common incorrect suggestion.

**Question 5**

**(a) (i)** Many candidates showed that they understood ionic bonding in terms of electron loss and gain. Candidates who gained full credit realised that each oxygen atom gains two electrons. Some candidates seemed to be unfamiliar with the idea that a non-metal such as oxygen could and does gain more than one electron. The question encourages candidates to use diagrams to help their descriptions and many very clear drawings were often enough to show that both marks could be awarded. Candidates' answers sometimes contained wording more relevant to covalent bonding and this frequently meant that full credit could not be awarded.

**(ii)** Those candidates who successfully answered **part (i)** usually gave the correct chemical formula of sodium oxide. Candidates should be encouraged to explain the chemical formulae of ionic compounds in terms of balance of positive and negative charges on the ions. Other valid ways of explaining the formula are acceptable but candidates should avoid shortcut explanations such as *swap and drop* which does not gain credit in an examination of this type.

**(b)** The attractive force between positive and negative ions is an important final step in explaining ionic bonding. Most candidates seemed rather unfamiliar with this idea even when they had shown a very good grasp of electron transfer, and sometimes included a description of ionic charges in **(a)(i)**.

**(c)** Some candidates were familiar with this acid-base equation and gained at least one mark. Fewer could give at least three state symbols. The most frequent mistakes were to suggest the state symbol *(l) for* dilute hydrochloric acid, *(aq)* for water and *(s)* for sodium chloride. Credit for state symbols was not awarded if the equation contained incorrect chemical formulae.

**(d) (i)** The majority of candidates gained the mark for their estimates of the melting point of rubidium. Candidates should be advised that in questions like this there is always a fairly wide range of acceptable answers.

**(ii)** The only accepted explanation had to relate to the melting point trend *in Group 1 of the Periodic Table*. The mark was awarded provided candidates made it clear they were discussing the trend in the Periodic Table and not Table 5.1 in the question.

**(iii)** The reason for the failure of carbon to reduce Group 1 compounds in terms of relative reactivity was familiar to candidates mainly in the upper half of the mark range. Successful candidates avoided the simple statement *Group 1 metals are very reactive* which was not accepted.

**Question 6**

**(a) (i)** Final answer **100** J. This calculation was successfully completed by many of candidates mainly in the upper half of the mark range. A frequent mistake was to omit the time factor from the relationship E = V I t.

**(ii)** Final answer **0.05** C. The relationship Q = I t was not quite as familiar as the energy relationship in **(i)**. In some cases candidates obtained the numerical answer 0.05 but lost a mark for an incorrect or missing unit. Common mistaken units were *joules, volts, amps* and *watts.*

**(b)** Final answer **$1.6 \cdot 10^{15}$** Hz. Large numbers of candidates gained at least partial credit for stating the relationship *speed = frequency x wavelength*. Reasons for loss of credit included mistakes when rearranging the equation and arithmetic errors when attempting to evaluate $3 \cdot 10^{8} \div 184 \cdot 10^{-9}$.

**(c)** A simple reference to safety was all that was required here and many candidates scored the mark. Candidates needed to be a little careful in how they worded their answers. For example, credit was not given for an answer such as *so nobody can touch it.*

**Question 7**

**(a) (i)** The significant word in the question was *substance* which guided some candidates towards the required answer, haemoglobin. Large numbers of candidates suggested blood or red blood cells for which no credit was available.

**(ii)** Some excellent answers were seen which related the shortage of haemoglobin or red blood cells to oxygen deficiency and/or lower respiration. The idea that *iron gives energy and so low iron means low energy* was sometimes suggested. Candidates from the lower end of the mark range usually simply gave answers such as *they feel tired because they lack energy*.

**(b) (i)** The great majority of candidates gained both marks here, with most identifying various vegetables or fruits together with fibre, vitamins or minerals.

**(ii)** This proved to be quite a challenging question for many candidates, and full credit was not often awarded. There were two main difficulties. The first was in finding a way to express the idea that meals such as the one shown provide more energy than the body requires. The second was to answer the question in terms of energy rather than a named food such as fat or carbohydrate. Large numbers of candidates suggested that excess fat consumed goes unchanged into body fat of the consumer.

**(c) (i)** Many candidates had learned how to describe coronary heart disease. They were very familiar with the idea that blood vessels become blocked or narrowed by fat or plaque deposits. Off those who were familiar with CHD the main reason for loss of a mark was lack of precision about exactly which blood vessels are blocked. The better answers specified coronary artery. The variety of incorrect suggestions included *veins, blood vessels, heart valves* and *the heart* itself.

**(ii)** The required answer simply needed to refer to the high amounts of fat contained in the meal shown in the question. Many candidates repeated the answer they gave to **part (i)** without any reference to the meal.

**Question 8**

**(a)** Most candidates were familiar with deducing electronic structure and gained both marks. A small number simply stated the number *20* for which a mark could not be awarded unless the candidate made it clear that 20 referred to the number of electrons.

**(b) (i)** Candidates needed to make it very clear that the mass decreases because material is lost from the flask. So answers such as *carbon dioxide escapes* or *a gas is released* or *gas goes through the cotton wool* are all acceptable. Answers such as *gases are lighter than liquids* or *a gas is produced* are not precise enough in this case.

**(ii)** Candidates were very familiar with how to answer this question and many excellent answers were seen. Most candidates referred to increased kinetic energy and increased collision frequency. Fewer candidates than in previous years are losing marks for the simple statement *there are more collisions*.

**(iii)** This was correctly answered by many candidates. The most common reason for loss of a mark was that the graphs levelled off at different gas volumes.

**(c)** Many candidates correctly identified a suitable substance. Popular answers were *calcium oxide, calcium hydroxide and calcium.* Despite the wording in the question quite a few candidates suggested *calcium carbonate.* Any valid answer was accepted.

**Question 9**

**(a)** The great majority of candidates knew the boiling point of water.

**(b)** This simple series circuit was correctly drawn by large numbers of candidates. Many others scored one of the available marks for either a correct symbol for the fuse or for the switch. Candidates should be advised that the normal circuit symbol for a switch shows the switch in an open position. Switches drawn closed are sometimes not so obvious and may lose a mark. The most common incorrect symbols included a resistor and a variable resistor.

**(c) (i)** Candidates generally found it challenging to discuss how thermal energy is transferred in this context. Very often attempts to discuss molecular motion involved terms more relevant to fluids rather than solids. When vibration was mentioned it was important to make it clear that heat transfer occurs when vibrational motion is passed on. Only a very small number mentioned the transfer of thermal energy through metals in terms of delocalised electrons. Several candidates scored a mark for a reference to convection as the way that thermal energy disperses when transferred to the water.

**(ii)** Most candidates across the full range of abilities suggested carbon, stating that this would be suitable because of its high electrical conductivity.

**(iii)** The mark was awarded for the explanation provided the candidate had stated that the resistance would be lower. The best answers stated that resistance is inversely proportional to cross-sectional area although any reference to the wire being thicker was accepted. Many candidates thought that a larger cross-section would increase the resistance. Many others used inappropriate terms for the resistance change such as *worse* or *better* or *weaker*.

# COMBINED SCIENCE

**Paper 0653/42**
**Extended Theory**

## Key messages

Those candidates who scored well on this paper:

had prepared thoroughly for the examination, paying particular attention to the details of the knowledge and definitions that might be tested as set out in the syllabus
read the questions carefully and understood the importance of key words for example *specific situation* in **Question 7(c)**
ensured that their handwriting was legible enough to allow the Examiner to award as many marks as possible
ensured that they included working and relationships in questions involving calculations and that this was set out clearly enough for partial credit to be awarded where possible.

## General comments

The overall standard of candidates entered for this paper was good. Many candidates showed that they had prepared most sections of the syllabus thoroughly and had good examination techniques. Candidates tended to do equally well in the three Science disciplines. The number of candidates who obtained very low scores was relatively small and these candidates may have been better suited to entry for the Core rather than Extended paper. Candidates usually wrote answers of appropriate length although colleagues should continue to stress that the number of marks and the space allocated for answers are guides to the length and detail required. There was no evidence that candidates were under any undue time pressure to complete the examination.

## Comments on specific questions

### Question 1

**(a) (i)** The context in this question was understood by most candidates and large numbers gained both marks. It was not enough in the first box simply to state that the enzyme was untreated. Candidates needed to refer to the continuing activity of the enzyme, and a variety of ways of expressing this were accepted. Denaturing by high temperature was very familiar and very few candidates made the mistake of suggesting that the enzyme is killed

**(ii)** The key phrase in the question is *explain in detail.* The best answers explained that the enzyme molecule or the active site changes shape and then went on to describe how this prevents substrate molecules from fitting into the active site. Lower level answers did not include any molecular detail and simply stated that the enzyme is prevented from working.

**(b) (i)** The idea that gastric juice kills harmful microorganisms was far more familiar than the maintenance of pH so that stomach enzymes can function. Candidates had to say more than *gastric juice keeps the stomach acidic*. Several candidates suggested that the purpose of gastric juice was to denature any enzymes present. Only a minority of candidates scored both of these marks.

**(ii)** Candidates needed to be careful to avoid a vague general answer to this question. The word *dangerous* is used in the question and so the suggestion that *hydrochloric acid would be dangerous to use* had to be avoided. Many candidates made the vague statement that *hydrochloric acid would harm the body*. Answers that scored the mark referred to the corrosive nature of hydrochloric acid or explained that it would damage relevant parts of the alimentary canal, namely

the mouth, tongue or oesophagus. The suggestion that hydrochloric acid is poisonous did not gain credit.

**(c) (i)** Only a minority of candidates could name glycogen. Cellulose was also accepted. The variety of incorrect answers included, *sucrose, maltose, carbohydrate* and *starch* itself.

**(ii)** Many candidates were able to identify amino acids as the molecules making up proteins. A variety of incorrect suggestions were made although there were no particularly common mistakes. On this occasion it was decided to accept *peptides* (but not polypeptides).

**(iii)** The elements in proteins were familiar to many candidates. Many gave sulfur in addition to the four main elements. Some candidates gave only two or three of the main elements but all four were required before the mark was awarded. Some of the incorrect answers suggested compounds, most notably amino acids.

**Question 2**

**(a)** Most candidates knew how to describe a hydrocarbon. Candidates choosing to state that a *hydrocarbon contains hydrogen and carbon* had to include the word *only* before the mark was awarded.

**(b) (i)** Most candidates who scored this mark gave high temperature or heat. Vague answers such as *a suitable temperature* could not be accepted. Many candidates towards the lower end of the mark range seemed to be unfamiliar with the concept of reaction conditions and suggested the names of compounds.

**(ii)** Some excellent answers were seen from candidates who understood what happens to energy in endothermic reactions. The better candidates avoided stating things like *thermal energy creates chemical energy*. As a general precaution, candidates should be advised to avoid any suggestion of processes in Science creating energy.

**(iii)** Candidates towards the higher end of the mark range tended to be familiar with the test involving aqueous bromine and many scored both marks. Some reversed the results of bromine with saturated and unsaturated hydrocarbons, and a few others lost credit for using the term *clear* instead of *colourless*. Most candidates towards the lower end of the mark range seemed unfamiliar with his part of the Chemistry syllabus.

**(c) (i)** Many candidates drew a correct structure for propene. Most candidates gained one mark it if they linked three carbon atoms together. A common mistake was to draw two double bonds.

**(ii)** A large number of candidates did very well and produced a correctly balanced equation. It was too challenging for the majority of candidates towards the lower half of the mark range, most of whom did not identify oxygen as a reactant nor carbon dioxide and water as the products.

**Question 3**

**(a)** Most candidates identified **P**.

**(b)** Final answer **15 000** J. A large number of candidates successfully worked through to the final answer. Many made a mistake when finding the weight of the box and divided 500 kg by 10. This led to an answer of 150 for which partial credit was awarded. Overall this was very well answered.

**(c) (i)** Most candidates gained partial credit for recognising that the truck was slowing down. Full credit was awarded to those who recognised that the deceleration was not constant. A mark was not awarded if candidates stated that the motion was decreasing. Some candidates used phrases such as *the truck decelerates but at a non-constant speed.* There is potential ambiguity and so candidates should be encouraged to use the term *non-uniform*. A change in velocity is correctly described as an acceleration and so this term was an acceptable alternative to deceleration.

**(ii)** Final answer **240** m candidates were generally very familiar with calculating the area under a speed/time graph to find distance travelled. Partial credit was awarded if it was clear that the candidate had attempted to find the area under the graph. One incorrect answer seen frequently

was 290m which emerged from attempting to find the distance travelled in each leg of the journey using only *distance* = *speed* × *time*.

**(iii)** Final answer **18750** J. The use of the relationship KE = ½mv$^2$ was very familiar and large numbers scored both marks. Candidates towards the lower end of the mark range often lost credit by substituting 30 instead of finding the velocity at 30 seconds from the graph. Others correctly stated the formula for KE but then did not square the velocity.

**Question 4**

**(a) (i)** Most candidates identified process **X** as *combustion*. The most common mistakes were *respiration* and *evaporation*. Several candidates suggested *pollution* although no credit was available for this in this case.

**(ii)** The required answer, death, was only stated by a relatively few candidates. Most suggested *decomposition*. This was not accepted since that process occurs following process **Y**.

**(iii)** Candidates generally were very familiar with the reasons for carbon dioxide build-up following deforestation and large numbers of correct, well-expressed answers were seen. They key ideas that candidates needed to state were that trees absorb carbon dioxide during photosynthesis and so reduction in tree population reduces these processes. Some candidates discussed the increase in carbon dioxide when felled trees or undergrowth are burned. Ideas like this also gained credit. Some candidates towards the lower end of the mark range did not recognise what the question was asking and discussed global warming and its effects.

**(b)** This question produced the full range of possible marks. There were no obvious patterns in the mistakes although *death* instead of *growth* was often seen for the first term. Two marks which were frequently gained were *increased* and *decomposers*.

**Question 5**

**(a) (i)** The majority of candidates gained the mark for their estimates of the melting point of potassium. Candidates should be advised that in questions like this there is always a fairly wide range of acceptable answers.

**(ii)** The majority of candidates knew that rubidium is the more reactive metal.

**(iii)** The majority of candidates identified hydrogen. Frequently seen incorrect suggestions included oxygen, carbon dioxide and potassium hydroxide.

**(iv)** The best answers referred to the need to break the attraction between atoms. Many candidates wrote at length but did not really add anything significantly different to the simple idea that melting requires thermal energy. Credit was awarded if candidates discussed the increase in particle movement/kinetic energy which then resulted in separation of atoms. Answers that stated that thermal energy causes atoms to move further apart did not add quite enough to distinguish melting from thermal expansion.

**(b) (i)** Many candidates showed that they understood ionic bonding in terms of electron loss and gain. The question encourages candidates to use diagrams to help their descriptions and many very clear drawings were often enough to show that both marks could be awarded. Candidates' answers sometimes contained wording more relevant to covalent bonding and this frequently meant that full credit could not be awarded.

**(ii)** Some candidates successfully transferred their familiarity with the sodium chloride lattice to potassium chloride. There was a variety of incorrect attempts to draw the lattice and a relatively large number of candidates did not attempt the question.

**(iii)** The attractive force between positive and negative ions is an important final step in explaining ionic bonding. Candidates towards the upper end of the mark range often gained this mark but most candidates seemed rather unfamiliar with this idea even when they had shown a very good understanding of electron transfer.

**Question 6**

**(a)** This question tested the basic processes in convection but in an unusual context. A small number of candidates recognised this and did not become distracted into attempting over-complicated answers. It was anticipated that many candidates would answer this question terms of air rather than hot gases. This was accepted on this occasion. Despite this the essential ideas of hot gas having lower density and so rising were not seen very often.

**(b) (i)** Some exceptionally good answers were seen from large numbers of candidates who produced very well-organised, clear calculations scoring all three marks. The most common method candidates chose was the same as that shown in the mark scheme. A few candidates produced alternative and equally valid demonstrations of the time delay.

**(ii)** Final answer **$\underline{4.1 \cdot 10^{14}}$** Hz. Large numbers of candidates in the upper half of the mark range gained at least partial credit for stating the relationship *speed = frequency × wavelength.* Reasons for loss of credit included mistakes when rearranging the equation and arithmetic errors when attempting to evaluate $3 \cdot 10^{8} \div 7.4 \cdot 10^{-7}$.

**(c)** Most candidates knew a domestic use of infrared radiation and any valid example was accepted. The most popular answer was *TV remote*. The unqualified answer *television* did not gain the mark. One common mistake was the answer *microwave* presumably referring to a microwave oven.

**Question 7**

**(a)** Phototropism was well-known. The two most common mistakes were geotropism and photosynthesis.

**(b)** The majority of candidates gained at least partial credit for knowing that auxin is found in greater amounts on the shady side of the plant. The best answers referred to *cell elongation* and not *faster growth*. Only a very small number of candidates gained full credit by including the fact that auxin is produced at the plant tip.

**(c)** The important words in this question were *specific situation* and *increased by a large amount*. Candidates who identified situations such as being *frightened by a predator* or *riding a roller coaster* gained the mark. General answers such as *in a fight or flight situation* did not gain credit. Another common answer that did not gain the mark was *when an animal is in danger* since the answer needed to convey that the animal was aware of the danger. Many candidates suggested answers such as *when exercising* but this lacks the idea of a sudden increase in adrenalin by a large amount.

**(d)** Many candidates wrote extensive answers to both parts of this question, often showing good understanding of metabolic processes but regrettably not answering the question. All that was needed in the first part was the idea that increased breathing rate would increase the amount of oxygen taken into the body/blood. The second part required a simple statement that increased heart rate would increase the rate of supply of oxygen or glucose to the cells. Since the phrase *to increase the rate of respiration* appears in the question many of the quite detailed references to increased respiration rate could not be credited. Another reason why marks were not given was that candidates discussed increased heart rate supplying *more blood* or *more oxygen* rather than discussing the increased rate of supply.

**(e)** Many candidates were familiar with the uses of energy in the body and any valid answer was accepted. The simple answer *movement* was too vague and candidates needed to discuss use of energy in muscle, ideally referring to *muscle contraction*. Similarly, instead of the one-word answer *heat,* candidates should have referred to *maintaining body temperature*.

**Question 8**

**(a) (i)** Most candidates interpreted the chromatogram and correctly identified copper and nickel.

**(ii)** Final answer **$\underline{0.6}$**. The method used to calculate an Rf value from a chromatogram was familiar to some candidates. Partial credit was awarded if the candidate showed that they knew that the

progress of a particular spot is measured from the start line. Most candidates seemed to be unfamiliar with this part of the Chemistry syllabus.

**(b)** The great majority of candidates recognised that cobalt, copper and nickel are transition elements.

**(c) (i)** Candidates generally gained credit for identifying the ions travelling to the anode and cathode. They needed to be careful to state chloride and not chlorine. One mark was awarded if the ions were correctly identified but reversed.

**(ii)** The formula of copper(II) ions is given in **part (a)** of the question and the formula of chloride is one that candidates are expected to know. Many candidates were able to construct the formula $CuCl_2$. Common mistakes were Cu2C*l*, 2CuC*l*. In this case careless presentation, e.g. Cu $Cl^2$, was not accepted.

**Question 9**

**(a) (i)** Many candidates recognised variable resistor or rheostat. Two other popular suggestions were *resistor* and *battery*.

**(ii)** Although this was a fairly challenging circuit there was a variety of ways that candidates could gain at least partial credit. Some of the candidates near the top end of the mark range drew perfectly correct circuits, and most candidates gained at least one mark for drawing at least three correct circuit symbols. The majority attempted to draw a circuit with some components in parallel. If they did this they had a good chance of gaining a further mark for locating the two switches in the correct locations, which many did.

**(b) (i)** Final answer **252 watts (W)**. The use of $P = V I$ was familiar to large numbers of candidates who successfully worked through to the correct numerical answer. Many also converted two marks into three by correctly identifying the unit as watts. The most common incorrect unit was joules.

**(ii)** Many candidates deduced that the additional factor needed was the time of the journey. A wide variety of incorrect ideas were seen including answers such as *ammeter, voltmeter, distance* and *force.*

# COMBINED SCIENCE

**Paper 0653/43**
**Extended Theory**

## Key messages

Those candidates who scored well on this paper:

had prepared thoroughly for the examination, paying particular attention to the details of the knowledge and definitions that might be tested as set out in the syllabus
read the questions carefully and understood the importance of the instruction to *make use of information in a diagram to….* for example **Questions 1(a)** and **2(a)(ii)**
ensured that their handwriting was legible enough to allow the Examiner to award as many marks as possible
ensured that they included working and relationships in questions involving calculations and that this was set out clearly enough for partial credit to be awarded where possible.

## General comments

The general performance of candidates was similar to last year which in turn had seen an improvement from the previous year. Candidates often showed that they understood many sections of the syllabus and were familiar with the examination techniques required for success. In some cases, low scores were likely the result of inadequate preparation rather than any lack of ability. Evidence for this includes the observation that full credit for answers to advanced questions were seen from candidates right across the final mark range. Further evidence comes from the observation that answers that could not be rewarded were often expressed very well and showed some familiarity with the concepts being tested. A small number of candidates found many of the questions challenging and these candidates may have been more suited for entry for the core paper. Candidates tended to do equally well in the three Science disciplines. Questions that used unfamiliar contexts, such as **Question 6**, presented the greatest challenges to candidates, and practice in these kinds of questions is recommended. Candidates usually wrote answers of appropriate length although colleagues should continue to stress that the number of marks and the space allocated for answers are guides to the length and detail required. There was no evidence that candidates were under any undue time pressure to complete the examination.

## Comments on specific questions

### Question 1

**(a)** Most of the candidates recognised oxygen and carbon dioxide. Those candidates scoring both marks gave good reasons for their choices by referring to the decrease in oxygen and the increase in carbon dioxide. A small number correctly referred to respiration. A few candidates incorrectly suggested that gas **X** was oxygen because oxygen is the main gas in the air that is breathed in.

**(b)** Many candidates had learned the important features of alveoli and scored both marks, usually for referring to large surface area and thin walls. It was important that candidates avoided describing the alveoli themselves as thin or one cell thick. Some candidates described the function of alveoli rather than their features which unfortunately meant that their answer could not be rewarded.

**(c)** The best answers avoided the common mistake of suggesting that the hairs on the ciliated cells filter pathogens and dust from inhaled air. The best candidates understood that mucus from the goblet cells is responsible for trapping pathogens and that the mucus is removed from the airway by the cilia. Some excellent answers were seen from some, but the context of this question was completely unfamiliar to other candidates.

**(d)** Most candidates showed awareness of smoking-related diseases. References to cancer had to be specific and relevant to smoking rather than just the general word *cancer*. Any valid disease was accepted.

**Question 2**

**(a)(i)** Many candidates answered this question correctly. One frequently seen mistake was to draw the arrow showing the activation energy of the reverse reaction. The best candidates extended the line showing the reactant energy level and joined this to the maximum in the curve. Some other candidates drew their arrows so carelessly that the mark could not be awarded.

**(ii)** It was important that candidates followed the instruction in the question to use the information in the energy level diagram. Some simply described the general meaning of the word *endothermic* without reference to the relative energy levels shown in this particular case. Some candidates did attempt to use the diagram but their answers were not sufficiently clear. An example is *it is endo thermic because the energy level of the reactants increases.*

**(iii)** Most of the candidates that obtained this mark opted for heat or high temperature. These candidates avoid vague expressions such as *adequate temperature* or simply *temperature*. The conditions needed for cracking appeared to be completely unfamiliar to some candidates who made suggestions such as *presence of oxygen* or *hydrogen.*

**(b)** None of the candidates had learned a definition of homologous series and many appeared to be unfamiliar with the term. Some showed that they understood the concept and could state that alkanes and alkenes, for example, were in different series but they did not give a description in terms of a general chemical formula and similar chemical properties.

**(c)** Correct dot-and-cross diagrams of ethane were drawn by many candidates. A variety of styles of dot-and-cross diagrams are accepted provided they are clear. The better candidates drew their diagrams carefully so that the bonds were clearly shown. Very untidy diagrams that were too difficult to interpret did not gain credit. Only partial credit was awarded if an incorrect number of electrons appeared on any of the atoms in the molecule, even if the covalent shared electrons were correctly shown.

**(d)** The great majority of candidates showed good awareness of the risks to the environment of increasing atmospheric carbon dioxide. A common mistake in answer to this question is that the excess carbon dioxide in the environment will suffocate living things.

**(e)** Some correct balanced equations were seen. Many candidates seemed to be unfamiliar with the products of complete combustion of hydrocarbons.

**Question 3**

**(a)(i)** The best answers showed a neatly-drawn, horizontal arrow touching the swimmer and pointing in the direction of travel. Carelessly drawn arrows obviously not horizontal did not score the mark. The most frequently seen mistake was an arrow touching the swimmer's immersed arm and pointing in the opposite sense to the direction of travel.

**(ii)** Many candidates understood that there is a force acting on the swimmer that is equal and opposite to gravity. Some candidates were not awarded the mark because their answers lacked detail or clarity even though these candidates showed some understanding of the Physics involved. Examples of answers like these included *the swimmer has buoyancy* or *there is an upthrust* or *because of the density of the water.* A small number of candidates made the mistake of thinking that the force acting upwards on the swimmer must be greater than gravity.

**(b)(i)** A small number of candidates realised that the straight line on the graph indicated constant acceleration. Many more scored one mark for stating that the boy accelerated. Some did not mention speed at all and made suggestions involving the forces acting on the boy.

**(ii)** A small number of candidates discussed friction between the boy and the water or used the term water resistance to explain why the speed of the boy suddenly decreases. Most opted for a non-

scientific statement such as *because he hits the water.* Candidates should be advised that an answer like this which lacks any Scientific ideas is a risky choice and unlikely to gain credit.

**(iii)** Final answer **23.3** J. The use of the relationship KE = ½mv$^2$ was familiar to many candidates who scored both marks. Partial credit was awarded for correctly reading the speed of 0.88 m/s from the graph or for simply stating the KE equation. Candidates towards the lower end of the mark range seemed to be unfamiliar with calculations of kinetic energy.

**(iv)** Final answer **0.83** m/s. The majority of candidates had no difficulty with this calculation and the majority scored both marks.

**Question 4**

**(a) (i)** A small number of candidates had learned that magnesium is important for making chlorophyll. The majority of candidates gave the incorrect and very general answers for example *for growth* or *for a healthy plant.*

**(ii)** Despite most candidates not knowing that magnesium is important in chlorophyll, large numbers gained the mark for knowing that the leaves turn yellow. It was not enough simply to state that the plant loses colour. Any valid answer was accepted for example *photosynthesis will reduce*.

**(b)** Almost all of the candidates gained at least partial credit. There did not appear to be any particularly common mistakes although *death* was often written instead of *growth,* and *consumers* instead of *producers.*

**(c) (i)** Candidates generally understood that the cobalt chloride result was linked to water loss from the leaves. Only a very small number realised that the question concerned differential rate of transpiration from the underside and the top surface of the leaf. Those who had learned about transpiration simply described the process but no credit for this was available in this case. Of those candidates who had understood the aim of the experiment, some suggested that the increased transpiration rate from the underside of the leaf resulted from the underside being closer to the root system.

**(ii)** Candidates were far more successful in answering this question than **part (i)**. Many gained at least one mark by stating that the transpiration rate would be greater at higher temperature. A small number of good candidates went on to describe faster evaporation in terms of increased molecular kinetic energy

**Question 5**

**(a) (i)** Almost all of the candidates stated the correct numbers of protons and neutrons in the magnesium atom.

**(ii)** Most candidates correctly added the electrons to the shells of the magnesium atom.

**(b) (i)** Some good descriptions of melting were seen. The best answers discussed the decrease in inter-particle attractive forces which allowed particles to separate. Candidates needed to avoid answers that could just as easily be describing the expansion of a solid, for example *particles get further away from each other.*

**(ii)** Those candidates who were familiar with the process of electrolysis usually named the *cathode*. A few gave *anode* but it was clear that in many cases candidates appeared to be unfamiliar with this section of the Chemistry syllabus.

**(iii)** Some of the candidates who were familiar with electrolysis gained both marks. A small number were able to express their answer in terms of an electrode equation.

**(c) (i)** Many candidates identified magnesium chloride.

**(ii)** Candidates in the upper half of the mark range tended to be familiar with the limewater test for carbon dioxide. Many of the other candidates either suggested an incorrect test, usually the hydrogen test, or wrote answers that suggested they were unfamiliar with the concept of a chemical test.

**Question 6**

**(a) (i)** Many candidates gained two marks here. When only one mark was scored it was usually for realising that the separation of the molecules increases.

**(ii)** The candidates scoring this mark avoided stating that the *motion decreases*. Candidates had to make it clear that the speed of the molecules decreases. Some candidates suggested that the molecules move more quickly because they are being released from the pressure of the cylinder.

**(b)** The weather conditions it was hoped candidates would choose to discuss were temperature and wind speed. Answers referring to humidity also gained credit. Most candidates limited their answers to temperature. References to whether or not it was a sunny day were allowed as an implied reference to temperature. Candidates could score a mark for the simple statement that increased temperature increases the evaporation rate. A second mark was available for a similar statement referring to wind speed. Additional marks were awarded if explanations in terms of molecules of one or both weather conditions were given. A small number of candidates wrote excellent answers gaining three marks and many gained at least partial credit. Candidates who had learned how to describe evaporation in molecular terms did well in this question.

**(c) (i)** Final answer **1** m. Candidates needed to apply any knowledge they may have gained from working with oscilloscopes (in the laboratory or from a textbook) to this context. The successful candidates realised that the diagram does not contain the usual horizontal axis and so the amplitude of these water waves would be half of 2 m. A small number did score this mark. The most frequent suggestion was 2 m.

**(ii)** Final answer **0.2** Hz. Candidates needed to recall that frequency is the number of waves passing a point every second and can be calculated from frequency = 1 ÷ time between waves. A small number gained the mark.

**(iii)** Final answer **15** m. The use of the relationship $\lambda = v/f$ was familiar to some candidates. An error was allowed to be carried from **(ii)** to **(iii)** and this meant that quite a few candidates gained full credit.

**Question 7**

**(a)** Almost every candidate gained at least one mark for identifying substrate molecule **C**. Large numbers gained the second mark for stating that the substrate molecule must fit into the active site on the enzyme. Candidates needed to refer to *the active site* and not simply *the enzyme* for the second mark to be awarded.

**(b) (i)** Nearly every candidate correctly identified the optimum temperature to be 40 °C.

**(ii)** Most candidates knew that this question was testing their knowledge of enzyme denaturation and many gained at least one mark for using the term *denatured* correctly. The change in shape of the active site was familiar to many and the best answers went on to describe how the shape change destroyed the fit between active site and substrate. Some good answers were seen.

**(c)** Some candidates towards the top end of the mark range had learned how to define chemical digestion in terms of molecular breakdown. Many others wrote phrases such as *the breakdown of food into nutrients using chemicals in the body*.

**Question 8**

**(a)** This was answered well by many candidates. Frequent mistakes were to write *energy* instead of *electrons* and *electrons* instead of *charges*.

**(b) (i)** Final answer **4 320 000** J. This answer was obtained by candidates who remembered to convert the time factor from 1 hr to 3600 seconds before substituting into the expression for energy. Only a minority made the conversion. If candidates did not obtain the correct numerical answer but showed that they had converted the time to seconds then one mark was awarded.

**(ii)** Final answer **1500 C**. The relationship $Q = I\,t$ was familiar to many candidates who went on to score two or three marks. A common reason for loss of a mark was an incorrect unit, usually J or W.

**(c)** Many candidates were able to show the motor correctly connected. A frequent mistake was to connect the motor in series with the battery. Candidates should be advised that the normal circuit symbol for a switch shows the switch in an open position. Switches drawn closed are sometimes not so obvious and may lose a mark.

**Question 9**

**(a) (i)** Candidates needed to remember that the melting point of the alkali metals decreases down Group I. If candidates did not remember this trend then there was a risk that they would suggest a melting point for caesium greater that 39 °C, which many did. Candidates should be advised that in questions like this there is always a fairly wide range of acceptable answers and that they are not expected to know the accepted value.

**(ii)** Candidates towards the upper end of the mark range tended to know that the alkali metals increase in reactivity down the group. Many candidates at the other end of the mark range overlooked the word *trend* in the question and simply described the reaction between the metals and water.

**(b)** Candidates needed to compare the reactivity of the alkali metals and carbon. It was not enough simply to say that the alkali metals are very reactive.

**(c) (i)** Candidates needed to be quite definite and state that the group number and the number of outer electrons have the same value. Vague answers for example, *as the group number increases so does the number of outer electrons* did not score the mark. The best answers gave numerical examples but this was not essential in this case.

**(ii)** Candidates at the higher end of the mark range found various ways to express the idea that metallic character increases from left to right across a period. This feature of the Periodic Table was unfamiliar to candidates lower down the mark range.

# COMBINED SCIENCE

**Paper 0653/51**
**Practical Test**

## Key messages

Candidates do well in this paper when they read the questions carefully and answer exactly what is being asked.

Measurements should be recorded to the level of precision asked for in the question.

Candidates should take to care to ensure that they have sufficient time to attempt all the questions in the examination and not spend a disproportionate amount of time on one question.

## General comments

Some excellent answers were seen to all the questions on this paper, with candidates demonstrating a good understanding of practical science techniques.

A number of candidates made no attempt at **Question 2**. There was also some evidence that a few candidates may have run out of time before finishing the paper as answers to **Question 4** sometimes stopped abruptly partway through.

## Comments on specific questions

### Question 1

**(a) (i)** The first marking point in this question part required a clear, continuous outline of the apple and for the drawing to be sufficiently large to occupy at least half the space of the box, approximately. While a good number of candidates met both marking points a number of rather small diagrams were seen and also a number of candidates made their outlines 'feathery' rather than having a single clear outline. The second marking point required the inclusion of some detail of the apple core, which almost all candidates included.

**(ii)** This question part was testing candidates' ability to measure accurately using a ruler and record the measurement in millimetres. A few candidates were not able to convert centimetres to millimetres correctly. However the biggest weakness with this question was that very few candidates identified where they were measuring their width of apple. Candidates should mark on their drawing the width they are measuring and then record the measurement in millimetres.

**(iii)** Some candidates confidently worked out the magnification of their drawing, and usually quoted their answer to an appropriate number of significant figures, but weaker candidates misremembered the equation getting the two widths 'upside down' and the very weakest candidates were unable to recall even an incorrect version of the equation to use.

**(b) (i)** It was clear from Supervisors' results that some apples were giving a negative test for starch, while other apples showed patches of starch present. Candidates could therefore gain credit for either a positive or negative starch test. The question specifically asked for the colour after adding iodine and so candidates who wrote 'no change' did not gain credit unless they also referred to the colour of iodine solution. Almost all candidates knew the positive test results for Benedict's solution although a few weaker candidates recorded 'brown' for Benedict's which was not accepted as a positive result. A very small minority of candidates failed to write a colour for the Benedict's test here but then went on to give it in the next question part, showing that they had completed the test

correctly. It is important that candidates record test results clearly, where they are asked for, in order to gain credit.

**(ii)** To gain credit here candidate's conclusions about nutrient content needed to match the results they gave in **(b)(i)**. Many correctly identified the presence of reducing sugars, shown by the positive Benedict's result, but a number incorrectly recorded the iodine test as a protein test and so did not gain credit here.

**Question 2**

The best answers to this question followed the bullet points provided in the question, which ensured that candidates produced a complete plan. Full marks were available without mentioning every detail of a plan, but to gain full marks, candidates had to include at least one point from each section of the mark scheme. A number of candidates made no attempt at this question at all, suggesting a lack of familiarity with this style of question. All candidates who made an attempt at the question were able to gain some credit and some excellent answers were seen, with the very best gaining full marks.

Apparatus
Identifying suitable apparatus allowed some candidates to gain all 3 marks in this section, with many suggesting the use of a gas syringe. Suggestions to collect the gas in a balloon were accepted as reasonable suggestions. Similarly it was just as acceptable to suggest the sun as a source of light, as an artificial lamp.

Method and Variables
There were a variety of ways to gain credit for varying the brightness of light and while some candidates suggested making use of the amount of sunlight in different places or at different times of day, which were very simplistic and unquantifiable variations, others used artificial lamps and either varied their intensity or their distance from the plant. Many candidates were able to identify suitable variables to control and this was another section where stronger candidates gained multiple marks.

Measurements
Candidates who were able to come up with a plan almost always scored a mark in ***section C***, either by suggesting that the bubbles were counted or the amount of gas measured, often in a gas syringe. Stronger candidates were able to gain additional credit here for measuring the distance of the light as a quantitative way of varying intensity.

Processing results and making conclusions
This proved to be the section where candidates found it most difficult to gain credit. Many simply made a prediction of what would happen which did not gain any credit. A number of candidates made vague suggestions that they would 'draw a graph of the results and draw a conclusion' but these answers lacked the necessary detail to be creditworthy. Only the strongest candidates were able to suggest that they should look for a pattern relating volume of gas/bubbles per minute to brightness/intensity of light. Some candidates did gain credit in this section by stating clearly what graph should be drawn; volume/rate against intensity/distance.

**Question 3**

**(a)** The first mark here was gained by almost every candidate, for recording a full set of temperatures in Table 3.1. The second mark rewarded those who had carried out the experiment carefully and recorded the pattern of increasing and then decreasing temperatures. There was evidence here that some weak candidates were not able to record readings on the thermometer accurately, recording 55 degrees as 50.5 degrees, for example.

**(b) (i)** For the first mark here, candidates needed to label the y axis with label and unit and choose a linear scale that would allow the plotted points to cover at least half the grid. A significant number of candidates either put no label on the axis or left off the unit of temperature. A few candidates had not read through the question before choosing their scales and took them right up to the top of the grid for the last plotted point. If they had read through first and realised that they would be drawing lines beyond the highest points they could have chosen more suitable scales. Most candidates chose linear scales. For many candidates it would have been better to begin their scale above zero, at a temperature a little below their first reading.

The second mark here was for plotting points correctly. Candidates should use a sharp pencil to plot careful points either as a small dot or x. A number of candidates plotted in pen and then made corrections, which make the graph more difficult to read when they are in ink. Most candidates were able to plot their points from Table 1 correctly and gain credit here.

**(ii)** This mark was for making a good best-fit line judgement for the increasing and decreasing temperatures. Examiners were looking particularly at the decreasing temperatures and for a best-fit line well chosen to give a spread of points on either side of the line. Some candidates drew lines which left all points on or to one side of their line. Weaker candidates drew dot-to-dot lines through all the points on their graph.

**(iii)** Candidates who had drawn two best-fit lines were almost always able to gain credit here for reading the temperature at the intersection. For those that had not drawn best-fit lines, or those that had chosen scales where the best-fit lines met above the grid, it was not possible to gain credit here.

**(c)** To answer this part of the question, candidates needed to realise that the original 2 g of magnesium powder was an excess (as stated in the Method) and therefore the maximum temperature if 5 g magnesium is used will be the same. The strongest candidates were able to gain credit here, but many weaker candidates predicted a much higher temperature.

**(d) (i)** Again, the first mark here was for recording a full set of results and most candidates completed this task. Since the reaction with Zinc gives a much lower maximum temperature it was important that candidates stirred their mixture as indicated in the method. Those that did were able to record a lower maximum temperature which then started to decrease. A number of weaker candidates recorded temperatures that had not started to decrease by the end of the experiment and a few very weak candidates recorded initial temperatures which were significantly different from the first experiment, whereas Examiners expected the room temperature reading to be approximately the same in both experiments.

**(ii)** Candidates were asked to label the magnesium and Zinc lines. Those that clearly labelled both pairs of lines gained credit here. This could be done with a label to the line or the use of a key, which some candidates did, using dots and x's to indicate the different experiments. For the second mark here, candidates needed to have completed the task and achieved an intersection of the lines that was at or before the temperature began descending.

**(e)** A good number of candidates correctly linked the difference in maximum temperature to reactivity and gained credit here. Answers which said that magnesium reacts more strongly were insufficient to gain credit here.

**(f)** The question here specifically asked for an improvement to the apparatus and to gain credit candidates needed to say why their improvement would increase accuracy of results. Very few candidates identified the need to reduce loss of thermal energy from the apparatus. Credit was given to candidates who chose to replace apparatus with more precise measuring instruments as long as the answer was sufficiently detailed. 'Use a more precise thermometer' was insufficient, but 'use a thermometer that reads to 0.1 degrees as it is more precise' was credited. A number of candidates made vague suggestions about 'using a digital thermometer' which is not necessarily more precise. Another acceptable answer seen a few times was to use a pipette to give more precise measurement of copper sulfate solution.

**Question 4**

**(a) (i)** While many candidates gained credit here for giving a reasonable value to the required accuracy, a number of candidates did not give their answer to the required level of precision and so did not gain credit.

**(ii)** To gain credit here candidates needed to give a volume reading to the nearest 0.5 $cm^3$ and their answer needed to be within a reasonable range of the required volume. While many candidates measured a volume of close to 75 $cm^3$ quite a few of them only recorded the volume to the nearest 1 $cm^3$. A few candidates seemed confused by the instructions here. Candidates were asked to add approximately 75 $cm^3$ so that they did not need to spend extra time achieving an exact volume. Examiners did not need to see a value of 75.0 $cm^3$ exactly: a value somewhere between 70–80 $cm^3$ was quite acceptable.

**(iii)** Most candidates recorded a reasonable answer for the mass of the measuring cylinder and liquid L. A few weaker candidates performed a calculation to arrive at this value, which suggested that they had not understood the instructions.

**(iv)** The vast majority of candidates completed the calculation correctly.

**(v)** Most candidates were able to calculate the value for density of liquid L. There were a few weaker candidates who, having calculated $m_L$ and measured $V_L$ did not go on to complete this question part. Candidates could gain credit here even if they had given incorrect answers to earlier question parts.

**(b) (i)** While many candidates were able to provide a sensible mass for the test-tube, there were a few answers which matched the value for the mass of the measuring cylinder, suggesting that candidates had got confused in one part of this question or the other.

**(ii)** A good number of sensible answers were seen in this question part suggesting that candidates were able to measure the length and internal diameter of the test-tube. Very occasionally an answer for internal diameter was seen which was too large, and probably represented a measurement in millimetres rather than centimetres.

**(iii)** This calculation proved straightforward for almost all candidates.

**(iv)** Many candidates gained credit with correct calculations here, although in this question part a significant minority of candidates made rounding errors or gave an answer to only one significant figure. Answers should generally be given to a number of significant figures which matches the smallest number of significant figures given in the values used in the calculation. Examiners expected a minimum of two significant figures in this question part.

**(v)** Despite the difficulty in performing this instruction, many candidates recorded a sensible value for the length of the test-tube below the surface of the water. Where a candidate's answer here exceeded the value given in **(b)(ii)** for test-tube length, no credit could be given. Similarly answers that suggested only a small fraction (less than ¼) of the test-tube was submerged were not credible answers.

**(vl)** Examiners used this question part to reward candidates who had carried out method two carefully and thus arrived at a value within a reasonable range of the expected value for the density of the liquid.

**(c)** In this part of the question candidates were being asked to compare their two values for density of the liquid and say whether they agreed, within the limits of experimental accuracy. Some sensible comment about how close together or how far apart the two values were, was expected. Credit could be given whether or not the values were close to each other; what was important was how the candidates expressed their justification. Answers such as, 'yes, they agree because the values are close to each other' were just as acceptable as answers such as 'no, the values are too far apart to be considered in agreement'. A number of candidates made no attempt at this or the next question part, suggesting perhaps that they had run out of time at the end of the exam.

**(d)** A good number of candidates were able to identify a suitable practical difficulty, with many choosing to mention the difficulty in supporting the test-tube in an upright position without affecting the level submerged in the water. Again a number of candidates made no attempt at this question part suggesting perhaps that they had run out of time at the end of the exam.

# COMBINED SCIENCE

**Paper 0653/52**
**Practical Test**

## Key messages

## General comments

Candidates showed they were able to follow instructions to complete the tasks within the time set with few gaps or unanswered questions seen.

It is recommended that candidates read through the whole question first so that they can check what they are being asked before starting. The graph in **Question 1** needed a large enough scale for extrapolation which some candidates did not take into account. Using a measuring cylinder for the filtration in **Question 2** so that the volume of the filtrate could be measured was sometimes missed.
Candidates should make sure their answer is in the units that the question asks for.
Reading an unknown value from a graph and drawing apparatus are skills that candidates should be familiar with.
Centres are reminded that candidates should be familiar with any investigations referred to on the syllabus. These may still be demonstrated using video clips if centres are not able to set up practical equipment such as potometers.

## Comments on specific questions

### *Section A*

### Question 1

Candidates were generally able to obtain a full set of results which enabled them to progress and answer the whole question.

**(a)** A few candidates had used centimetres rather than millimetres and so did not get both marks.

**(b) (i)** Most candidates were able to describe the relationship of increased volumes leading to increased heights.

**(ii)** Whilst many candidates stated there was an increase, very few went on to say it would stay the same, suggesting they were not linking the idea of all a reagent being used up or the reaction being finished, and so not scoring any marks here.

**(iii)** Candidates generally attempted to answer this question but few were able to gain both marks. Accurate was given in the question and many candidates merely repeated this, which did not gain credit.

Some candidates suggested repeats but were unable to correctly explain why it would make it more accurate.

Leave longer was seen but often failed to explain that it allowed <u>all</u> of the precipitate to settle.

Candidates were not able to explain that a burette was more precise.

**(c) (i)** Candidates demonstrated good skills in choosing scales, labelling and plotting a graph**.** Nearly all made use of more than half the grid with linear scales that allowed easy plotting. Some did not allow enough room for the lines to be drawn. Others had scales that did not have a sensible value for 1 division to allow correct plotting and so did not gain that mark.

**(ii)** Straight lines needed to be drawn with a ruler to gain this mark, some candidates had clearly drawn it free-hand. Judgement for the lines was generally good.

**(iii)** Many candidates were not able to give a figure that was correct from their graph, but a value lower than the intersection and so lost this mark.

**(iv)** Some candidates described but did not explain what was happening, often just re-stating what was in the question. Many could see the precipitate was decreasing but few noticed that this was because it was dissolving**.**

**Question 2**

**(a) (i)** Candidates were generally able to state it allowed the results to be compared.

**(ii)** All of the alternatives were seen in responses with candidates demonstrating good knowledge regarding enzyme activity. A number of candidates talked about humidity or just 'in the same place', which did not gain a mark.

**(b) (i)** Most candidates were able to draw the measuring cylinder with the funnel. A few drew a test-tube or conical flask, which were not pieces of apparatus supplied. Diagrams were generally in pencil but a ruler was rarely used and the standard 2D format was not always seen. Some just had shading for the filter paper, this needs to be a single clear line and V shaped at the bottom. Labels were generally good.

**(ii)** Candidates were able to collect and measure both samples. There was evidence that some candidates had **A** and **B** reversed.

**Question 3**

Candidates generally made a good attempt at answering this question.

The bullet points in the question allowed them to structure their answers to gain marks. The full range of marks was awarded and some good labelled diagrams were seen.

The use or naming of a potometer was rarely seen which then made a suitable method of measuring the water loss more difficult but there were some good ideas that gained credit.

Safety precautions needed to be related to their investigation, not just general comments.

**Question 4**

The main reason for candidates not gaining marks was for incorrect rounding or too many significant figures used.

**(a) (i)** Candidates were generally able to record the mass to the nearest 0.01 g as the balance they used had this precision. Some who lost marks had clearly added much less than about 100 $cm^3$ water.

**(ii)** Candidates were usually able to correctly calculate the mass of the water**.**

**(iii)** Many candidates were not able to record the temperature to the nearest 0.5 °C, which required 1 decimal place to be quoted. Those with an extremely low value were penalised.

**(b) (i)** Candidates were generally able to record the mass of the ice cube to the nearest 0.01 g as the balance had this precision.

**(ii)** Most candidates were able to record the temperature and gain a mark here as the same precision as in **(a) (iii)** was not required.

**(iii)** Most candidates were able to gain the mark here, with the cube losing mass**.**

**(iv)** Good candidates were generally able to explain that this meant the water was all at the same temperature.

**(c) (i)** Precision was not required and most candidates were able to score the simple calculation mark here.

**(ii)** Candidates were able to use the formula provided correctly. Those who gave their answer to more than 3 significant figures were penalised, with few gaining the second mark.

**(d) (i)(ii)** Most candidates were able to use the formulae provided correctly. An error carried forward was allowed for **(d)(ii)**.

**(e)** Many candidates were able to link what they had seen to gain the mark here, with energy from air in the room or hands when handling the ice cube frequently seen.

# COMBINED SCIENCE

**Paper 0653/53**
**Practical Test**

## Key messages

Candidates do well in this paper when they read the questions carefully and answer exactly what is being asked.

Measurements should be recorded to the level of precision asked for in the question.

Candidates should take to care to ensure that they have sufficient time to attempt all the questions in the examination and not spend a disproportionate amount of time on one question.

## General comments

Some excellent answers were seen to all the questions on this paper, with candidates demonstrating a good understanding of practical science techniques.

A number of candidates made no attempt at **Question 2**. There was also some evidence that a few candidates may have run out of time before finishing the paper as answers to **Question 4** sometimes stopped abruptly partway through.

## Comments on specific questions

### Question 1

**(a) (i)** The first marking point in this question part required a clear, continuous outline of the apple and for the drawing to be sufficiently large to occupy at least half the space of the box, approximately. While a good number of candidates met both marking points a number of rather small diagrams were seen and also a number of candidates made their outlines 'feathery' rather than having a single clear outline. The second marking point required the inclusion of some detail of the apple core, which almost all candidates included.

**(ii)** This question part was testing candidates' ability to measure accurately using a ruler and record the measurement in millimetres. A few candidates were not able to convert centimetres to millimetres correctly. However the biggest weakness with this question was that very few candidates identified where they were measuring their width of apple. Candidates should mark on their drawing the width they are measuring and then record the measurement in millimetres.

**(iii)** Some candidates confidently worked out the magnification of their drawing, and usually quoted their answer to an appropriate number of significant figures, but weaker candidates misremembered the equation getting the two widths 'upside down' and the very weakest candidates were unable to recall even an incorrect version of the equation to use.

**(b) (i)** It was clear from Supervisors' results that some apples were giving a negative test for starch, while other apples showed patches of starch present. Candidates could therefore gain credit for either a positive or negative starch test. The question specifically asked for the colour after adding iodine and so candidates who wrote 'no change' did not gain credit unless they also referred to the colour of iodine solution. Almost all candidates knew the positive test results for Benedict's solution although a few weaker candidates recorded 'brown' for Benedict's which was not accepted as a positive result. A very small minority of candidates failed to write a colour for the Benedict's test here but then went on to give it in the next question part, showing that they had completed the test

correctly. It is important that candidates record test results clearly, where they are asked for, in order to gain credit.

**(ii)** To gain credit here candidate's conclusions about nutrient content needed to match the results they gave in **(b)(i)**. Many correctly identified the presence of reducing sugars, shown by the positive Benedict's result, but a number incorrectly recorded the iodine test as a protein test and so did not gain credit here.

**Question 2**

The best answers to this question followed the bullet points provided in the question, which ensured that candidates produced a complete plan. Full marks were available without mentioning every detail of a plan, but to gain full marks, candidates had to include at least one point from each section of the mark scheme. A number of candidates made no attempt at this question at all, suggesting a lack of familiarity with this style of question. All candidates who made an attempt at the question were able to gain some credit and some excellent answers were seen, with the very best gaining full marks.

Apparatus
Identifying suitable apparatus allowed some candidates to gain all 3 marks in this section, with many suggesting the use of a gas syringe. Suggestions to collect the gas in a balloon were accepted as reasonable suggestions. Similarly it was just as acceptable to suggest the sun as a source of light, as an artificial lamp.

Method and Variables
There were a variety of ways to gain credit for varying the brightness of light and while some candidates suggested making use of the amount of sunlight in different places or at different times of day, which were very simplistic and unquantifiable variations, others used artificial lamps and either varied their intensity or their distance from the plant. Many candidates were able to identify suitable variables to control and this was another section where stronger candidates gained multiple marks.

Measurements
Candidates who were able to come up with a plan almost always scored a mark in ***section C***, either by suggesting that the bubbles were counted or the amount of gas measured, often in a gas syringe. Stronger candidates were able to gain additional credit here for measuring the distance of the light as a quantitative way of varying intensity.

Processing results and making conclusions
This proved to be the section where candidates found it most difficult to gain credit. Many simply made a prediction of what would happen which did not gain any credit. A number of candidates made vague suggestions that they would 'draw a graph of the results and draw a conclusion' but these answers lacked the necessary detail to be creditworthy. Only the strongest candidates were able to suggest that they should look for a pattern relating volume of gas/bubbles per minute to brightness/intensity of light. Some candidates did gain credit in this section by stating clearly what graph should be drawn; volume/rate against intensity/distance.

**Question 3**

**(a)** The first mark here was gained by almost every candidate, for recording a full set of temperatures in Table 3.1. The second mark rewarded those who had carried out the experiment carefully and recorded the pattern of increasing and then decreasing temperatures. There was evidence here that some weak candidates were not able to record readings on the thermometer accurately, recording 55 degrees as 50.5 degrees, for example.

**(b) (i)** For the first mark here, candidates needed to label the y axis with label and unit and choose a linear scale that would allow the plotted points to cover at least half the grid. A significant number of candidates either put no label on the axis or left off the unit of temperature. A few candidates had not read through the question before choosing their scales and took them right up to the top of the grid for the last plotted point. If they had read through first and realised that they would be drawing lines beyond the highest points they could have chosen more suitable scales. Most candidates chose linear scales. For many candidates it would have been better to begin their scale above zero, at a temperature a little below their first reading.

The second mark here was for plotting points correctly. Candidates should use a sharp pencil to plot careful points either as a small dot or x. A number of candidates plotted in pen and then made corrections, which make the graph more difficult to read when they are in ink. Most candidates were able to plot their points from Table 1 correctly and gain credit here.

**(ii)** This mark was for making a good best-fit line judgement for the increasing and decreasing temperatures. Examiners were looking particularly at the decreasing temperatures and for a best-fit line well chosen to give a spread of points on either side of the line. Some candidates drew lines which left all points on or to one side of their line. Weaker candidates drew dot-to-dot lines through all the points on their graph.

**(iii)** Candidates who had drawn two best-fit lines were almost always able to gain credit here for reading the temperature at the intersection. For those that had not drawn best-fit lines, or those that had chosen scales where the best-fit lines met above the grid, it was not possible to gain credit here.

**(c)** To answer this part of the question, candidates needed to realise that the original 2 g of magnesium powder was an excess (as stated in the Method) and therefore the maximum temperature if 5 g magnesium is used will be the same. The strongest candidates were able to gain credit here, but many weaker candidates predicted a much higher temperature.

**(d) (i)** Again, the first mark here was for recording a full set of results and most candidates completed this task. Since the reaction with Zinc gives a much lower maximum temperature it was important that candidates stirred their mixture as indicated in the method. Those that did were able to record a lower maximum temperature which then started to decrease. A number of weaker candidates recorded temperatures that had not started to decrease by the end of the experiment and a few very weak candidates recorded initial temperatures which were significantly different from the first experiment, whereas Examiners expected the room temperature reading to be approximately the same in both experiments.

**(ii)** Candidates were asked to label the magnesium and Zinc lines. Those that clearly labelled both pairs of lines gained credit here. This could be done with a label to the line or the use of a key, which some candidates did, using dots and x's to indicate the different experiments. For the second mark here, candidates needed to have completed the task and achieved an intersection of the lines that was at or before the temperature began descending.

**(e)** A good number of candidates correctly linked the difference in maximum temperature to reactivity and gained credit here. Answers which said that magnesium reacts more strongly were insufficient to gain credit here.

**(f)** The question here specifically asked for an improvement to the apparatus and to gain credit candidates needed to say why their improvement would increase accuracy of results. Very few candidates identified the need to reduce loss of thermal energy from the apparatus. Credit was given to candidates who chose to replace apparatus with more precise measuring instruments as long as the answer was sufficiently detailed. 'Use a more precise thermometer' was insufficient, but 'use a thermometer that reads to 0.1 degrees as it is more precise' was credited. A number of candidates made vague suggestions about 'using a digital thermometer' which is not necessarily more precise. Another acceptable answer seen a few times was to use a pipette to give more precise measurement of copper sulfate solution.

**Question 4**

**(a) (i)** While many candidates gained credit here for giving a reasonable value to the required accuracy, a number of candidates did not give their answer to the required level of precision and so did not gain credit.

**(ii)** To gain credit here candidates needed to give a volume reading to the nearest 0.5 $cm^3$ and their answer needed to be within a reasonable range of the required volume. While many candidates measured a volume of close to 75 $cm^3$ quite a few of them only recorded the volume to the nearest 1 $cm^3$. A few candidates seemed confused by the instructions here. Candidates were asked to add approximately 75 $cm^3$ so that they did not need to spend extra time achieving an exact volume. Examiners did not need to see a value of 75.0 $cm^3$ exactly: a value somewhere between 70–80 $cm^3$ was quite acceptable.

**(iii)** Most candidates recorded a reasonable answer for the mass of the measuring cylinder and liquid L. A few weaker candidates performed a calculation to arrive at this value, which suggested that they had not understood the instructions.

**(iv)** The vast majority of candidates completed the calculation correctly.

**(v)** Most candidates were able to calculate the value for density of liquid L. There were a few weaker candidates who, having calculated $m_L$ and measured $V_L$ did not go on to complete this question part. Candidates could gain credit here even if they had given incorrect answers to earlier question parts.

**(b) (i)** While many candidates were able to provide a sensible mass for the test-tube, there were a few answers which matched the value for the mass of the measuring cylinder, suggesting that candidates had got confused in one part of this question or the other.

**(ii)** A good number of sensible answers were seen in this question part suggesting that candidates were able to measure the length and internal diameter of the test-tube. Very occasionally an answer for internal diameter was seen which was too large, and probably represented a measurement in millimetres rather than centimetres.

**(iii)** This calculation proved straightforward for almost all candidates.

**(iv)** Many candidates gained credit with correct calculations here, although in this question part a significant minority of candidates made rounding errors or gave an answer to only one significant figure. Answers should generally be given to a number of significant figures which matches the smallest number of significant figures given in the values used in the calculation. Examiners expected a minimum of two significant figures in this question part.

**(v)** Despite the difficulty in performing this instruction, many candidates recorded a sensible value for the length of the test-tube below the surface of the water. Where a candidate's answer here exceeded the value given in **(b)(ii)** for test-tube length, no credit could be given. Similarly answers that suggested only a small fraction (less than ¼) of the test-tube was submerged were not credible answers.

**(vl)** Examiners used this question part to reward candidates who had carried out method two carefully and thus arrived at a value within a reasonable range of the expected value for the density of the liquid.

**(c)** In this part of the question candidates were being asked to compare their two values for density of the liquid and say whether they agreed, within the limits of experimental accuracy. Some sensible comment about how close together or how far apart the two values were, was expected. Credit could be given whether or not the values were close to each other; what was important was how the candidates expressed their justification. Answers such as, 'yes, they agree because the values are close to each other' were just as acceptable as answers such as 'no, the values are too far apart to be considered in agreement'. A number of candidates made no attempt at this or the next question part, suggesting perhaps that they had run out of time at the end of the exam.

**(d)** A good number of candidates were able to identify a suitable practical difficulty, with many choosing to mention the difficulty in supporting the test-tube in an upright position without affecting the level submerged in the water. Again a number of candidates made no attempt at this question part suggesting perhaps that they had run out of time at the end of the exam.

# COMBINED SCIENCE

**Paper 0653/61**
**Alternative to Practical**

## Key messages

The following suggestions may support candidates to enhance and improve their marks on similar papers in future.

- Drawings from photographs should be made with continuous, smooth outlines, without shading and with due attention to show the main features of structure.
- When candidates are asked to add values to a table they need to judge the number of significant figures or decimal places based on the other entries in the table.
- When candidates are asked to record measurements from diagrams of apparatus, they should consider the number of decimal places. Either these will be indicated in the question or, in the case of apparatus such as a measuring cylinder or thermometer, it is usual to record values to 0.5 of the smallest graduation shown. This may require the use of a zero, such as 78.0 as an answer in **4(a)(i)**.
- In planning questions, candidates need to address all areas of the task to access the full mark range. They are guided in this by the bulleted list included in the task.

## General comments

Candidates generally showed a positive approach to the Alternative to Practical Paper, showing good time management leading to few unanswered questions or gaps.

Mathematical questions which demand substitution of values into formulae were well answered. Candidates showed a broad understanding of practical skills with marks being earned across the whole paper across the full variety of question types and tasks.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates earned at least one mark, usually for drawing an enlarged drawing. There was a further mark available for the quality of the drawing. The main features of the apple were the clear outline and the two pips in the core. Candidates who represented these earned the second mark. Some candidates drew feathered or broken outlines, included unnecessary shading which obscured the outline or did not show the pips in the centre. These shortcomings meant that a second mark was not always awarded.

**(ii)** Candidates need to take care to note the units the question states. The question asked for a measurement in millimetres. Answers given in centimetres did not earn a mark.

**(iii)** Most were able to calculate a correct magnification based on their own measurements. It was not necessary to report this magnification to more than 2 significant figures but candidates who did so were not penalised.

**(b)** There were three marks available for this test. Many candidates gave the reagent (Benedict's solution) the conditions required (heat) and the results of a positive test (the full range of colours for the presence of a reducing sugar at different concentrations was accepted). Some remembered that the positive result was 'brick red' but could not name the reagent. Incorrect reagents included iodine and biuret solution. Some candidates incorrectly gave the negative test result (blue) or an incorrect final colour (such as 'brown' or 'blue-black').

**Question 2**

Planning questions follow a similar format. Typically, candidates are asked to include details of apparatus, a method description, control of variables, safety, measurements, how to process results and how to use results to reach a conclusion. Reminders of this format are given in a bulleted list at the start of the question. Full marks require that all aspects of the task are addressed. Candidates who were careful to address each of these areas were able to earn all seven marks. Candidates who omit areas of the task are unable to earn all marks. It is strongly suggested that candidates take a few minutes to plan their answer to avoid an over-concentration on one aspect of the task to the exclusion of others.

Most candidates stated some apparatus needed for the investigation. Marks for apparatus may be earned from a fully labelled diagram. Some used sunlight as their light source, others used an artificial light source.

It is important that candidates state clearly which variables will be kept constant, which will be changed and which will be measured. Some answers gave a list of 'Variables' without stating clearly whether these would be kept constant or varied. Better answers stated clearly that it was important to control some variables such as volume of water, length of elodea and temperature. Most gave some indication that the light source needed to be varied, either by moving the lamp to different distances or by choosing different levels of shade from the Sun.

In order to fully process the results, some numerical measurements needed to be made. Many were clear that number of bubbles or volume of gas needed to be measured over a fixed time. Fewer made it clear how the independent or input variable was to be measured. Those who used the Sun usually did not develop a method of measuring the light intensity which could lead to a numerical treatment of results. Better answers suggested measuring the distance of a lamp from the water and elodea.

The final section, processing results and making conclusions, was often omitted. Some discussed the calculation of a rate by dividing number of bubbles by time, but few were able to discuss how this could be compared to any numerical value of the light intensity. Some suggested drawing graphs of distance of lamp against number of bubbles.

It should be noted that vague or non-specific safety precautions, such as 'wear goggles and gloves' were not credited. Safety precautions for a procedure need to be procedure specific, for example stating that the lamp is hot so should not be touched or identifying the need to be careful handling water near an electrical lamp.

**Question 3**

**(a)** In questions where candidates are asked to add values to a partially completed table, they need to judge the degree of precision by modelling their answer on the other values. Hence, 33.5 and 55.0 were the correct answers. No mark was given for 55.

**(b) (i)** Most candidates gave a linear scale, but some chose a scale so large that the highest values (60) were either at the limit or, in some cases outside the limit, of the available plotting area. This made subsequent questions difficult. Candidates are advised to consider a scale that is linear, covers at least half the grid but also does not exceed the limit of the available grid. Plots were usually correctly plotted.

**(ii)** Although most candidates earned a mark for the best fit lines, some candidates were not careful enough to ensure that the line was as close as possible to as many points as possible. The descending line was often drawn too low. Some candidates did not use a ruler for their lines, hence losing this mark.

**(iii)** Most were able to read a value from the graph. Those candidates who had chosen a scale which was too large, resulting in a 'cross' outside the limits of the graph grid were not awarded this mark.

**(c)** Only the most able candidates realised that using more magnesium would result in the same maximum temperature because it is not the limiting reagent. Most incorrectly suggested a higher temperature.

**(d) (i)** Most correctly read the thermometer to a precision of 0.5 °C.

**(ii)** In common with **(b)(ii)**, the most common reason for missing this mark was a lack of care to draw the lines of best fit as close as possible to most points. A relatively high proportion of candidate omitted this part question.

**(e)** Most candidates correctly stated that magnesium is more reactive than zinc.

**(f) (i)** Although many suggested correct alternatives to measure volume (such as a pipette or burette) some restated 'measuring cylinder' which was the apparatus already used in the existing method.

**(ii)** The question asked for an improvement to the apparatus used. More able candidates gave a clear statement that a lid or insulation was needed to minimise heat loss. However, common answers which did not earn a mark included vague references to 'doing repeats' or 'taking an average'. These ideas are not improvements to apparatus.

**Question 4**

**(a) (i)** Scales can typically be read to 0.5 of the main graduations on the piece of apparatus. In the case of this measuring cylinder, it is possible to judge to 0.5 $cm^3$. The correct reading should, therefore, be made to the appropriate degree of precision and recorded to one decimal place. Hence '78.0' was the acceptable correct answer. Many candidates who gave '78' did not, therefore, gain any credit.

**(ii)** Although most candidates appeared to know what parallax error was, they did not always express clearly how to avoid this error. Best answers referred to making readings with eye level perpendicular to the surface of the water. More poorly expressed answers stated vaguely that it is necessary to 'bend down' or 'place the measuring cylinder on flat surface'. These answers were not awarded any credit. Some confused parallax with the meniscus and stated that it is necessary to 'read from the bottom of the curve'.

**(iii)** In common with other questions, to earn a mark it was necessary to judge the precision of the answer with respect to the mass values given in the question. Some chose to round their value unnecessarily, although most gave the correct answer 86.69.

**(iv)** This question clearly asked candidates to give their answer to a suitable number of significant figures. This question, therefore, tested the candidate's ability to judge the number of significant figures that it would be appropriate to use and to round their answer accordingly. Correct answers to two or three significant figures were accepted. Those candidates who ignored this instruction lost one of the two available marks.

**(b) (i)** The question instructed candidates to record the mass value to the nearest 0.1 g. Most did so, but those who did not were not awarded credit.

**(ii)** Most, but not all, candidates were able to use the provided data and substitute values into the equation to calculate the volume from the provided formula. This question was well answered.

**(iii)** Again, substitution of values into the provided formula was well done by most candidates. Error carried forward was allowed for those who had made an earlier error in one of the previous questions.

**(iv)** This question asked candidates to measure in centimetres, to the nearest 0.1 cm. Most followed this instruction, although a few expressed answers incorrectly in millimetres. A common error was to measure the whole test-tube rather than the length of the portion below the water level, as the question asked.

**(v)** In common with other part questions, most candidates substituted values into the equation without a problem to earn a mark for the correct calculation of density.

**(c)** Candidates tended to say that the values did agree, even though correct values (1.11 and 1.4 $g/cm^3$) differed by well over 25%. Few stated that these were too far apart to be considered to be in agreement.

**(d) (i)** Some candidates correctly identified the main source of inaccuracy was due to the curve in the bottom of the test-tube. However, some rewrote the information in the question stating that the test-tube 'is not a perfect cylinder'. Such statements were not awarded credit.

**(ii)** The effect of the assumption that the test-tube is a perfect cylinder on the measured volume and density was not well understood. Many candidates left this part question blank.

# COMBINED SCIENCE

**Paper 0653/62**
**Alternative to Practical**

## Key messages

Degree of approximation remains an issue for many candidates, who are reminded that they must follow instructions when it is stipulated, or must follow an established pattern when entering values in a partly completed table.

When drawing graphs, linear scales must always be chosen which cover at least half the grid, and axes must be labelled fully, including units. Points should be plotted with a cross, and the line of best fit should be drawn with a ruler if linear, and if not then a smooth curve is required which is not point-to-point, feathery or too thick.

When approaching planning questions, candidates are strongly encouraged to read the guidelines as to what to include in their plans very carefully, and then, having written their plan, to refer to these guidelines again to make sure that all have been addressed.

## General comments

It was encouraging to note that candidates are reading questions more carefully in order to grasp fully the context and demand of a question, and are pacing themselves much better, as evidenced by fewer questions not being attempted.

Identifying sources of error in experimental procedure and suggesting methods of making a method more reliable or accurate remain relative weaknesses.

## Comments on specific questions

### Question 1

Candidates were required to consider the experimental procedure to investigate the effect of an enzyme on fruit.

**(a) (i)** Most candidates realised that the reason for using water along with pectinase was for comparison or as a control.

**(ii)** Temperature, masses and volumes were commonly the correct controlled variables, but a few candidates did not recognise that it was the same apple that was finely chopped in each beaker, thus erroneously suggesting that the type/shape/size of apple should be constant.

**(b) (i)** Nearly all candidates were familiar with the apparatus needed for filtration, but a few left a hole in the base of their filter paper, or forgot it completely.

**(ii)** 24.0 was required as the question asked for the volume to the nearest 0.5.

### Question 2

Candidates were asked to plan an experiment to compare transpiration in plants.

A few candidates included the use of a potometer, but the majority put bags around leaves or plants to collect the water released.

A labelled diagram was often helpful, and most candidates placed their plants in different conditions and controlled some variables.

General safety precautions such as wearing a lab coat are not specific enough in this case and are ignored by Examiners who are looking for a relevant precaution and the reason for its use.

Measurements were often made of weight loss/change in volume of water, and then a comparison of their results under the different conditions was expected, leading to a stated conclusion.

**Question 3**

Candidates were required to answer qualitative and quantitative questions concerning the precipitation reaction between two soluble salts.

**(a)** The vast majority of candidates could measure the heights accurately and, as the table demanded, to the nearest whole number.

**(b) (i)** Most candidates heeded the question, leading to fewer than usual reversals of axes, and nearly all chose a linear scale which was usually sensible and covered over half the paper. Points were plotted accurately by the vast majority of candidates, but a few forgot to label their axes entirely, or omitted the units.

**(ii)** It was insufficient here to account for an anomalous low height of precipitate by referring to misreading. Candidates were expected to realise that too little or impure sodium sulfate had been added.

**(iii)** Straight lines were usually ruler drawn, but some curves, which were also accepted, were less than smooth or too thick or too feathery.

**(iv)** The relationship between the variable must match their line of best-fit, so directly proportional was only credited if their straight line passed through the origin.

**(v)** Most candidates could read from their graph, but more than a few failed to indicate on the graph how their usually correct answer had been deduced.

**(vi)** Several candidates suggested that there would be no further increase, the reaction having finished, but others did not appreciate that by now the sodium sulfate was in excess, having reacted with all the barium nitrate.

**(c)** It was hoped that candidates would realise that volumes could be measured more easily in a syringe or burette, that they could reduce errors or anomalies by repeating the experiment, or they could avoid parallax error by reading at eye-level. Many candidates referred to stirring and many explanations referred to improving accuracy which was not credited as it was repeating the question.

**Question 4**

Candidates were asked to consider ice melting in a beaker of water.

**(a) (i)** Only a handful of candidates referred to the tare function on a balance, and only a minority realised that otherwise the mass of the empty cylinder needed to be subtracted from the mass when it contained water in order to deduce the mass of the water. There were some irrelevant references to density.

**(ii)** The majority of candidates correctly read the temperature to the stated required accuracy, and there was a mark available for those who chose 14 or 15, but not 14.0 or 15.0.

**(iii)** Reading to the nearest 0.01 g caused more of a problem with some candidates repeating the observed mass to the nearest 0.001 g and others over-approximating.

**(b) (i)** Several candidates realised that water was stirred to ensure it was all at the same temperature, but references to heat and melting the ice more quickly were not rare.

**(ii)** Candidates needed to relate the extra water to an erroneous mass measurement – several did so, but common answers such as to remove the water or the cube has water on it were not creditworthy.

**(c) (i)** An easy calculation which was achieved by nearly all candidates

**(ii)** Most candidates could substitute three numbers into a given formula correctly to evaluate the thermal energy lost by the water, but very few gave their answer to a suitable number of significant figures – here two were required since the lowest number of significant figures in the expression is also two.

**(d) (i)** An easy subtraction leading to success for the vast majority of candidates who quoted their answer to a minimum of three significant figures

**(ii)** An easy multiplication and a minimum of two significant figures were expected in the answer.

**(e)** Most candidates knew that the extra energy used in melting the ice-cube came from the air or the surroundings, but quite a few indicated a lack of understanding of the question by suggesting it came from the water.

# COMBINED SCIENCE

**Paper 0653/63**
**Alternative to Practical**

## General comments

Candidates generally showed a positive approach to the Alternative to Practical Paper, showing good time management leading to few unanswered questions or gaps.

Mathematical questions which demand substitution of values into formulae were well answered. Candidates showed a broad understanding of practical skills with marks being earned across the whole paper across the full variety of question types and tasks.

The following suggestions may support candidates to enhance and improve their marks on similar papers in future.

When candidates are asked to add values to a table they need to judge the number of decimal places or significant figures based on the other entries in the table.
When candidates are asked to record measurements from diagrams of apparatus they should consider the number of decimal places. Either these will be indicated in the question or, in the case of apparatus such as a measuring cylinder or thermometer, it is usual to record values to 0.5 of the smallest graduation shown. This may require the use of a zero, such as 93.0 as an answer in **3(a)(iii)**.
In planning questions, candidates need to address all areas of the task to access the full mark range. They are guided in this by the bulleted list included in the task.
When calculating values (for example in **Question 4(b)(iv)** to **(vi)**) candidates need to do more than record the value on their calculator and consider how best to present their answer.

## Comments on specific questions

### Question 1

**(a) (i)** Most candidates were able to show the air in tube B moving into the limewater and out of the tube. Responses in tube A were ignored.

**(ii)** Candidates did well with recalling the test for carbon dioxide. Some candidates used less specific descriptions such as ‘foggy’ or ‘opaque’ and these were not awarded.

**(iii)** Candidates struggled to recall the use of hydrogencarbonate indicator with most restating limewater.

**(iv)** Many candidates were able to provide safety precautions that related to this experiment. Marks were not awarded for general laboratory safety such as wearing goggles or tying hair back.

**(b) (i)** This was very poorly answered with most candidates unable to recall the relighting of a glowing splint as the test for oxygen. Several suggested a change in the limewater colour or modifying the experiment apparatus, whilst some suggested timing how long it takes a candle to go out.

**(ii)** There were two marks available for calculating a percentage reduction, with one mark for calculating the reduction alone (i.e. 20 – 15 = 5). Many candidates were confident in this calculation but some lost all marks for not showing any working out and giving an incorrect answer.

**Question 2**

**(a)** Candidates typically fell into one of two groups. They either clearly stated that a pulse should be taken for a minute or attempted to describe how to take a pulse. Some answers were too vague, e.g. 'count heart beats per minute' and needed to add a description of how that should be done (that is more specific that 'put a hand on the chest/wrist') A few candidates suggested using technology such as a smart watch or ECG and these were credited. However it is suggested students should have some experience of taking a pulse manually and be able to describe it.

**(b)** Planning questions follow a similar format. Typically, candidates are asked to include details of apparatus, a method description, control of variables, safety, measurements, how to process results and how to use results to reach a conclusion. A reminder of this format is given in a bulleted list at the start of the question. Full marks require that all aspects of the task are addressed. Candidates who were careful to address each of these areas were able to earn all six marks. Candidates who omit areas of the task are unable to earn all marks. It is strongly suggested that candidates take a few minutes to plan their answer to avoid an over-concentration on one aspect of the task to the exclusion of others.

Most candidates stated some apparatus needed for the investigation. Marks for apparatus may be earned from a fully labelled diagram. Most realised that they needed to use some form of timer.

It was important that candidates provided some details in the type and duration of exercise carried out in their method. The best answers included specific instructions such as running for 100 m, or performing jumping jacks for 2 minutes.

Most candidates realised that they needed to work out the pulse rate before exercising as well as afterwards but many did not realise that they needed to repeat this experiment to find the average time or that they needed to time how long it took for the pulse rate to return to normal. This meant that the controlled variables were often not stated. A common misconception was describing different intensities of exercise and then comparing the time taken for the pulse to return to normal.

It should be noted that vague or non-specific safety precautions, such as 'wear goggles and gloves' were not credited. Safety precautions for a procedure need to be procedure specific, for example stating that running shoes should be worn so there would be no slipping or staying hydrated in hot weather.

**Question 3**

**(a) (i)** Many candidates were unsure of how to collect gas in a measuring cylinder with several drawing diagrams where the delivery tube went into a bunged container. The best answers showed clearly how to collect the gas over water and provided at least one label.

**(ii)** Candidates were unable to recall the use of a gas syringe to obtain more accurate values. A few candidates suggested collecting the gas over water so they could read off the volume of gas. Candidates who did well on **(a)(i)** usually obtained this mark.

**(iii)** There were two marks available, one for each reading. Most candidates were able to gain one mark for 86.5 but several did not follow the pattern in the table for the second mark (93.0) with many incorrectly assuming that the value should end in 0.5.

**(b) (i)** Most candidates were able to gain full marks on this questions.. If marks were lost it was for not labelling the axis, or for incorrect units (e.g. m instead of min). Several candidates lost marks for using a non-linear y-axis, going from 0 to 45 without adding the discontinuity mark. This meant that they plotted their points on a non-linear scale and lost a second mark. It should be noted that the graph paper will fit the data provided using a simple linear scale and a discontinuity is rarely needed.

**(ii)** Although most candidates earned a mark for the best fit curve, some candidates were not careful enough to ensure that the line was as close as possible to as many points as possible. Some candidates did not include the point at (0,0) and so lost this mark. Candidates were not penalised for not including the final two points.

**(c)** Only the most able candidates realised that the curve had flattened out and were then able to state that the reaction was ending and suggest why. Weaker answers suggested that the reaction would continue increasing because of the pattern in the graph. These were usually the candidates that had ignored the last two data points in their curve for **(b)(ii)**.

**(d)** Most correctly drew a steeper line that either continued or ended higher than their plotted line.

**(e)** Very few candidates were able to explain why the reaction could not continue, with many ignoring the information in the question of the product being insoluble. This meant they were unable to visualise the product coating the marble chips.

**Question 4**

**(a) (i)** The majority of candidates were able to identify the lowest number in the correct column.

**(ii)** As in **(a)(i)**, most candidates were able to identify the correct column and the lowest number.

**(iii)** This question was also answered well. The most common mistake was ordering the metals from highest to lowest, or including all the materials rather than only the metals.

**(iv)** The relationship was typically described well with candidates able to summarise the relationship using comparatives such as higher and lower.

**(b) (i)** Most candidates were able to calculate the mass of the water to two decimal places and gained two marks. Weaker candidates were able to obtain one mark by showing their working out, even if their calculation was then recorded incorrectly. It is important that all candidates show how they have worked out their answer so credit can be given.

**(ii)** Most candidates could confidently state that the measuring cylinder should be dried before the mass was taken.

**(iii)** Scales can typically be read to 0.5 of the main graduations on the piece of apparatus. In the case of this measuring cylinder, it is possible to judge to 0.5 $cm^3$. The correct reading should, therefore, be made to the appropriate degree of precision and recorded to one decimal place. Hence '16.5' was the acceptable correct answer. Many candidates who gave '16' did not, therefore, gain any credit. A few candidates gave '18' as the answer and it is important that candidates think about whether their answer is reasonable (given that the reading was less than half way between 15 and 20).

**(iv)** This question clearly asked candidates to give their answer to a suitable number of significant figures. This question, therefore, tested the candidate's ability to judge the number of significant figures that it would be appropriate to use and to round their answer accordingly. Correct answers to two or three significant figures were accepted. Those candidates who ignored this instruction lost one of the two available marks.

**(v)** Most candidates were able to divide their answer from **(iv)** by 1000. Error carried forward was allowed. Several did no processing of the data and put $10^{-3}$ after their previous answer. Whilst this was credited, better answers that chose to use standard form manipulated the data and gave '$9.85 \cdot 10^{-4}$'.

**(vi)** Stronger candidates were able to convert the density using the information given in the question. However many candidates used their previous answer and placed '$\cdot 10^{-10}$' after it. These were often the candidates who had not understood how to process the data in part **(v)**. Too often results were given that started '10–e….' again showing candidates were simply repeating what their calculator showed rather than understanding the context.

**(c)** Candidates tended to say that the values did agree, even when their calculated value differed by more than 10%. Many candidates offered reasons for their value being very different and these related to possible errors in carrying out the method rather than simply stating that their result was not close to the given value.