COMBINED SCIENCE

Paper 0653/11
Multiple Choice (Core)

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

General comments

Chemistry

Question 19, **Question 24**, and **Question 27** proved most difficult for the candidates.

Physics

Physics **Questions 30**, **33**, **37** and particularly **36** proved most difficult for the candidates.

Comments on specific questions

Question 1

This question was correctly answered by most students who correctly identified the feature that makes plants a living organism.

Question 2

This question was correctly answered by most candidates. One in five candidates incorrectly thought that diffusion is against a concentration gradient.

Question 3

This question was correctly answered by most candidates. One in five candidates thought that the correct answer was **C**. Whilst they correctly identified the palisade and spongy mesophyll, they incorrectly thought that the vascular bundle was the cuticle.

Question 4

This question was correctly answered by most candidates. 20 per cent of candidates incorrectly thought that mineral salts were not absorbed into the bloodstream.

Question 5

Candidates struggled with this question. Most candidates incorrectly thought that digestion occurs throughout the digestive system.

Question 6

Candidates struggled with this question. Most candidates correctly identified that the vessel carrying blood from the heart was an artery (60 per cent), but which artery was carrying blood to the body was less well known.

Question 7

This question was correctly answered by most candidates. Where candidates answered incorrectly, most had simply reversed the correct answer.

Question 8

This question was correctly answered by most candidates. Where candidates answered incorrectly, they chose option **A**.

Question 9

Most students answered this question correctly.

Question 11

This question was correctly answered by most candidates. Students answering incorrectly mostly chose **C**.

Question 12

Most students answered this question correctly.

Question 13

This question was correctly answered by most candidates. Some candidates thought that cutting down trees led to a decrease in carbon dioxide levels.

Question 15

Candidates chose incorrect option **A** more often than correct answer **D**. Candidates are expected to be able to distinguish between elements and compounds in simple diagrammatic representations, recognising that some elements are monoatomic and some are diatomic.

Question 16

Candidates chose incorrect option **A** more often than correct answer **B**. Candidates are expected to understand the relationship between the number of protons, neutrons and electrons in an atom, and the overall charge, atomic number, mass number and identity of an element.

Question 19

Candidates chose incorrect options **C** and **D** more often than correct answer **B**. Candidates are expected to recognise the exothermic nature of the reaction by the initial temperature change, that the reaction stops when there is no more gas production, and that the temperature change is due to cooling alone.

Question 24

Candidates chose incorrect option **B** more often than correct answer **D**. Candidates are expected to know what alloys are and how the properties of alloys relate to the properties of their constituent metals.

Question 25

Candidates chose incorrect option **C** more often than correct answer **A**. Candidates are expected to know the method of extraction of both aluminium and copper, and the position of these metals, as well as zinc, in the reactivity series.

Question 26

Candidates chose incorrect option **B** more often than correct answer **A**. Candidates are expected to know that carbon monoxide is a pollutant, and that its presence indicates that the air sample is not clean.

Question 27

Candidates chose incorrect option **A** more often than correct answer **C**. Many candidates confused the elements present in a hydrocarbon, carbon and hydrogen, with the products of combustion of a hydrocarbon, carbon dioxide and water.

Question 28

This question on speed-time graphs caused relatively few problems and was well answered.

Question 30

In this question on density, slightly more than half the candidates opted for **B**, failing to rearrange the equation correctly.

Question 31

The topic here was power; although a large majority of candidates knew that the time taken was important, more believed that a longer, rather than a shorter time produces greater power.

Question 33

The arrangement of molecules in a liquid was not well known, with options **A**, **B** and **C** being roughly equally distributed.

Question 35

Many candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence. This led them to opt for **B** as the answer.

Question 36

This question about the position of the principal focus of a converging lens was often incorrectly answered. Most thought that option **B**, the optical centre of the lens, was correct, and many others chose **D**, the top of the image.

Question 37

Candidates were required to give the calculation used to determine the speed of sound. Nearly two-thirds failed to double the distance to 200 m, a classic mistake in this type of question, and this made option **C** very popular.

Question 40

Although generally quite well answered, some candidates incorrectly divided the resistance by the voltage to arrive at option **A**.

COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Physics

The physics questions causing the most difficulty were **Questions 31**, **36** and particularly **38**.

Comments on specific questions

Question 1

The most commonly chosen option was correct (**B**). Where candidates got the question wrong, answers were divided between the remaining options.

Question 2

This question was correctly answered by most candidates. Where candidates incorrectly answered, they remembered only part of the osmosis definition: either that it involved a partially permeable membrane or that it involved water.

Question 3

Candidates struggled with this question. Most thought that nitrates were used to make glucose.

Question 4

This question was correctly answered by most candidates. Of the wrong responses, most correctly identified the function of the tissue from its location but incorrectly named it.

Question 5

This question was correctly answered by most candidates. Wrong answers were evenly distributed across incorrect options.

Question 6

The most common response was the correct one, **D**. Wrong answers were evenly distributed across incorrect options.

Question 7

This question was correctly answered by most candidates. The most common incorrect option was **A**.

Question 9

This question was correctly answered by most candidates. Where candidates got the question wrong, they decided that the plant was growing away from the light.

Question 10

Candidates found this question difficult. Many candidates incorrectly chose option **C**. This may be because they misread the question, thinking that it was asking about asexual reproduction.

Question 11

The most common response was the correct one, **B**. Wrong answers were evenly distributed across incorrect options.

Question 12

This question was correctly answered by most candidates. Some candidates thought that the food web had only one herbivore.

Question 14

Candidates chose incorrect option **B** more often than correct answer **C**. Candidates are expected to distinguish between chemical changes and physical changes by whether new substances are made, or whether there is only a change of state with no new substance being made.

Question 25

Candidates chose incorrect option **C** more often than the correct answer **D**. Candidates are expected to recognise that copper oxide is reduced by carbon from this reaction equation, and that copper oxide, a base, is neutralised by an acid, rather than by a non-metallic element.

Question 27

Candidates chose incorrect option **C** more often than correct answer **A**.

Question 28

This question on use of a measuring cylinder was well answered.

Question 30

A significant number of candidates calculated the density of the metal by dividing mass by the length of one side of the cube, leading them to choose incorrect option **C**.

Question 31

The topic here was energy; many candidates did not appreciate that the load is stationary at its highest point, so it does not have kinetic energy. These candidates therefore chose incorrect option **C**.

Question 33

Option **A** and **B** were significant distractors for candidates uncertain about the differences between boiling and evaporation.

Question 35

Many candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence. This led them to opt for **B** as the answer.

Question 36

This question about the speed and frequencies of regions of the electromagnetic spectrum led to widespread guessing between **A** and **B**, with only around one third choosing the correct response **C**.

Question 37

Here candidates were required to give the calculation used to determine the speed of sound. Many failed to double the distance to 200 m, a classic mistake in this type of question, which made option **C** slightly more popular than answer **B**.

Question 38

Electrostatic charging was not well understood. Few candidates made the correct choice, with most believing that both electrons and protons move.

COMBINED SCIENCE

Paper 0653/13
Multiple Choice (Core)

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

General comments

Chemistry

Candidates performed very well on **Question 17**.

Question 14, **Question 24** and **Question 27** proved most difficult for the candidates.

Physics

Question 28 was particularly well answered, with **Questions 33**, **38** and particularly **29** and **36** causing the most difficulty.

Comments on specific questions

Question 1

The most chosen option was correct, **B**. Where candidates got the question wrong, options **A** and **D** were slightly favoured.

Question 2

This question was correctly answered by most candidates. Where candidates incorrectly answered, they remembered only part of the osmosis definition: either that it involved water or a partially permeable membrane.

Question 3

Candidates struggled with this question. Most thought that nitrates were used to make glucose.

Question 4

Candidates found this question difficult. Of those that incorrectly answered, most could not identify the tissue based on its location. Some forgot that the xylem also provides support to the plant.

Question 6

Candidates found this question difficult. The most chosen option was incorrect, **C**. Candidates need to recognise the difference between diffusion and ventilation.

Question 7

This question was correctly answered by most candidates. Where candidates answered incorrectly, they mostly chose option **A**.

Question 8

This question was correctly answered with students identifying the feature that makes plants living organisms.

Question 9

This question was correctly answered by most candidates. Where candidates got the question wrong, they decided that the plant was growing away from the light.

Question 10

This question was correctly answered by most candidates. Where candidates chose an incorrect answer, they chose option **C**. This may be because they misread the question, thinking that it was asking about asexual reproduction.

Question 11

With this question the most chosen option was correct, **B**. Where candidates got the question wrong, they thought that the ovaries were the site of fertilization.

Question 12

This question was correctly answered by most candidates. Some candidates thought that the food web had only one herbivore.

Question 14

Candidates chose incorrect option **D** more often than correct answer **C**. Candidates are expected to distinguish between chemical changes and physical changes by whether new substances are made, or whether there is only a change of state with no new substance being made.

Question 17

Candidates understood well how the formula of a compound identifies the number of atoms of each element contained within the compound.

Question 21

Some candidates chose incorrect option **C** rather than correct answer, **A**. Candidates are expected to know the products of the reactions between bases, including metal carbonates, and acids.

Question 23

Many candidates chose incorrect options **A** and **C**. Candidates need to recognise that noble gases are unreactive because they have full outer shells of electrons.

Question 24

Candidates chose incorrect option **C** more often than correct answer **D**. This question required candidates to know what alloys are, and how the properties of alloys relate to the properties of their constituent metals.

Question 27

Candidates chose incorrect option **C** more often than correct answer **A**. Candidates are expected to know the products of complete combustion of a hydrocarbon, and to be able to recognise the products' structures.

Question 28

This question on use of a measuring cylinder caused very few problems and was correctly answered by nearly all candidates.

Question 29

More than half the candidates calculated the density of the metal by simply dividing the mass by the length of one side of the cube, leading them to choose option **C**.

Question 31

The topic here was energy; many did not appreciate that the load is stationary at its highest point, so it does not have kinetic energy. These candidates therefore chose the incorrect option **C**.

Question 33

Some candidates opted for **A** or **B**, being uncertain about the differences between boiling and evaporation.

Question 34

The molecular description of solids and liquids was well known.

Question 35

A significant number of candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence. This led them to opt for **B** as the answer.

Question 36

This question about the speed and frequencies of regions of the electromagnetic spectrum led to many responses of **A** or **B**, with few choosing the correct response **C**.

Question 37

Here candidates were required to give the calculation used to determine the speed of sound. More than half failed to double the distance to 200 m, a classic mistake in this type of question, which this made option **C** slightly more popular than correct answer **B**.

Question 38

Electrostatic charging was not well understood. Relatively few candidates made the correct choice, with many believing that the process involves the movement of protons, either alone or with electrons.

COMBINED SCIENCE

Paper 0653/21
Multiple Choice (Extended)

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

General comments

Chemistry

Candidates performed very well on **Question 17**.

Physics

In the physics section, **Question 31** caused the least difficulty, with **Questions 38** and **40** proving the most problematic.

Comments on specific questions

Question 2

This question was correctly answered by most candidates. One in five candidates incorrectly thought that the answer was **C**. Whilst they correctly identified the palisade and spongy mesophyll, they thought that the vascular bundle was the cuticle.

Question 3

One third of candidates correctly answered this question. Two fifths thought that substance X was sugar. This could be because they incorrectly read the question: rather than answering what substance X was, they gave the result of the food test being used.

Question 5

This question was correctly answered by most candidates. However, nearly a third of the candidates incorrectly chose option **C**, which described a *single* circulatory system rather than a *double* circulatory system.

Question 6

This question was correctly answered by most candidates. Where candidates answered incorrectly, most had reversed the correct answer.

Question 7

This question was correctly answered by most candidates. Twenty percent of candidates incorrectly thought that aerobic respiration exchanges gases through the walls of the alveoli. Students need to know the difference between the respiratory system and respiration.

Question 10

This question was correctly answered by most candidates. However, many students incorrectly chose **C**. This may be because they misread the question, thinking that it was asking about asexual reproduction.

Question 11

The most chosen option was correct, **D**. However, many students correctly identified the structure of the stigma of wind- and insect-pollinated plants but failed to identify the features of the pollen.

Question 12

With this question the most chosen option was correct, **A**. The most popular incorrect option was **B**.

Question 13

Candidates struggled with this question. Whilst the correct answer was chosen by many, candidates went for option **B** in similar numbers.

Question 17

Candidates understood well how the formula of a compound identifies the number of atoms of each element contained within the compound.

Question 19

Candidates chose incorrect option **D** more often than correct answer **C**. Candidates are expected to be able to identify whether a reaction is exothermic or endothermic by using an energy level diagram. They are also expected to know that energy is required to break bonds, and that it is released when bonds are made.

Question 25

Most candidates chose either the correct answer, **A**, or the incorrect **B**. Candidates either did not recall that noble gases, including neon, are found in small amounts in clean air, or they did not understand that the presence of carbon monoxide means that a sample of air cannot be regarded as clean air.

Question 30

This question on the experimental determination of density by displacement was well answered and a large majority chose the correct option **A**.

Question 31

Here, non-renewable energy sources were well known, with few choosing incorrectly.

Question 35

Half of the candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence. This led them to opt for **B** as the answer.

Question 36

Although a large proportion of candidates understood that the current in the battery is equal to the sum of the currents in the branches, more than half of these also believed the same to be true for e.m.f., leading them to choose option **D**.

Question 37

Here candidates were required to give the calculation used to determine the speed of sound. Almost half of them failed to double the distance to 200 m, a classic mistake in this type of question, and this made option **C** popular.

Question 38

This question on factors affecting the resistance of a wire was not well answered. The most common mistake was to think that the effect of doubling the length is cancelled by halving the diameter, with these candidates therefore opting for **C**.

Question 40

The topic here was electrical energy; many failed to convert the time to seconds, leading to option **B** being chosen.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

Chemistry

Candidates performed very well on **Question 16**.

Physics

Question 28 caused the least difficulty, with **Question 38** proving problematic.

Comments on specific questions

Question 2

Most students correctly answered this question. Where students chose the incorrect answer, they thought that an adaptive feature of an egg cell is a flagellum.

Question 3

This was correctly answered by many candidates. Of those that incorrectly answered, most had correctly identified the function of the tissue from its location but had incorrectly named it.

Question 4

Whilst over a third of the candidates correctly answered this question, two fifths thought that substance X was sugar. This could be because they incorrectly read the question, and rather than answering what substance X was, they gave the result of the food test being used.

Question 5

Fifty per cent of the candidates correctly identified the aorta as the blood vessel with the highest pressure. Just over a quarter thought that the pulmonary vein was the vessel with the highest pressure.

Question 7

This question was correctly answered by most candidates. Twenty percent of candidates incorrectly thought that aerobic respiration exchanges gases through the walls of the alveoli. Candidates need to know the difference between the respiratory system and respiration.

Question 8

The most chosen option was correct, **C**. However, many candidates thought that nitrates were used to make glucose.

Question 9

This question was correctly answered by most candidates. However, many students incorrectly chose **C**. This may be because they misread the question, thinking that it was asking about asexual reproduction.

Question 11

Most students correctly answered this question. Where students chose the incorrect answer, they thought the placenta was to allow the mixing of the mother's blood with the blood of the fetus.

Question 12

Most students correctly answered this question. Where students chose the incorrect answer, they thought that the frog was on the second trophic level and was a secondary consumer.

Question 16

Candidates understood well how the formula of a compound identifies the number of atoms of each element contained within the compound.

Question 22

Candidates chose incorrect option **B** more often than correct answer **D**. Candidates are expected to know what alloys are, and how the properties of alloys relate to the properties of their constituent metals.

Question 23

Many candidates chose incorrect option **C**. This question required candidates to know that carbon *monoxide*, and not carbon *dioxide*, reduces iron oxide in the blast furnace, and that carbon monoxide is formed in the blast furnace through the reduction of carbon dioxide by carbon.

Question 28

This question on the use of a measuring cylinder was very well answered.

Question 30

A large majority of candidates knew that the graph starts as a straight line, but most of these then opted for **D**, which showed the line curving in the wrong direction after the limit of proportionality has been reached.

Question 31

The topic here was energy; many did not appreciate that the load is stationary at its highest point, so it does not have kinetic energy. These candidates therefore chose incorrect option **C**.

Question 35

A popular choice here was option **B**. These candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence.

Question 36

Here candidates were required to give the calculation used to determine the speed of sound. Almost one in three of them failed to double the distance to 200 m, a classic mistake in this type of question, and this made option **C** popular.

Question 38

This question on factors affecting the resistance of a wire was not very well answered. The most common mistake was to think that the effect of doubling the length is cancelled by halving the diameter, these candidates therefore opting for **C**.

COMBINED SCIENCE

Paper 0653/23
Multiple Choice (Extended)

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

General comments

Chemistry

Candidates performed very well on **Question 16**, **Question 19**, **Question 24** and **Question 25**.

Comments on specific questions

Question 1

This question was correctly answered by most students who identified the feature that makes plants living organisms.

Question 2

Most candidates answered this question correctly. Over a fifth of candidates incorrectly answered **C**, indicating that they did not think that ciliated cells were in the trachea.

Question 4

Whilst over half of the candidates correctly answered this question, some third of the candidates thought that substance X was sugar. This could be because they incorrectly read the question, and rather than answering what substance X was, they gave the result of the food test being used.

Question 6

This question was correctly answered by most candidates. A quarter of candidates incorrectly thought that aerobic respiration exchanges gases through the walls of the alveoli. Candidates need to know the difference between the respiratory system and respiration.

Question 9

This question was correctly answered by most candidates.

Question 12

This question was correctly answered by most candidates. Over a fifth of candidates incorrectly thought that the crab was on more than one trophic level.

Question 13

Most candidates answered this question correctly. Where candidates got the question wrong, options **A** and **D** were significant distractors.

Question 15

Candidates chose incorrect option **B** more often than correct answer **D**. Candidates are expected to know that water is a single compound, and that oxygen is an element.

Question 16

Candidates understood well how the formula of a compound identifies the number of atoms of each element contained within the compound.

Question 19

Candidates understood well how to identify an exothermic reaction from an energy level diagram. They also knew what energy transfer is associated with an exothermic reaction.

Question 25

Candidates knew well that carbon dioxide and methane cause an enhanced greenhouse effect when their concentrations in the atmosphere increase.

Question 30

The topic of this question was the extension of a spring. A large majority of candidates knew that the graph starts at the origin, but slightly more than half of these candidates then opted for **D**, which shows the line curving in the wrong direction after the limit of proportionality has been reached.

Question 31

The topic here was the reliability of energy resources, and this was very well understood.

Question 32

The molecular arrangement of a gas was well known.

Question 36

A popular choice here was option **B**. These candidates believed the angle given in the question, measured between the incident ray and the mirror, to be the angle of incidence.

Question 37

Here candidates were required to give the calculation used to determine the speed of sound. Slightly more than one in four of them failed to double the distance to 200 m, a classic mistake in this type of question, and this led them to choose option **C**.

Question 38

The most common mistake here was to think that the effect of doubling the length of the wire is cancelled by halving the diameter, these candidates therefore opting for **C**.

COMBINED SCIENCE

Paper 0653/31
Core Theory

Key messages

Candidates do well in this paper when they read the question carefully. Care should be taken to use all the information in the question stem and to ensure that the question is being answered exactly. For example, in **Question 4(b)**, careful reading of the question, which stated clearly that the plant was in the dark, should have pointed candidates towards a response other than phototropism.

Many candidates find it difficult to provide a clear explanation of terms given in the syllabus. Being able to provide a clear statement of the meaning of scientific terms is an important part of this course.

General comments

Some good responses were seen in this paper, with a number of candidates showing a sound understanding of the Core syllabus.

In questions involving calculations, candidates are advised to show all their working. Partial credit can be gained where candidates recall the correct formula, even if the numerical answer is incorrect. For example, in **Question 6(c)**, partial credit was given for stating the formula *speed* = *distance*/*time*.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified **B** and **C** as the plant cells in the figure.

(ii) Candidates were expected to identify the features exclusive to plant cells found in **B** and **C**. Many candidates correctly identified that **B** and **C** both had cell walls and a large vacuole. Credit was given to those candidates who named **B** as a root hair cell or **C** as a cell from a leaf, even though this level of detail was not required.

(iii) A good number of candidates recognised cell **A** as a white blood cell. To gain credit for the second mark candidates needed to use the correct term phagocytosis or give an accurate description of the process; e.g. engulfs pathogens. Candidates who gave vague responses such as ‘fights disease’ did not gain the second mark.

(b) (i) Stronger candidates recognised that the label line for **F** indicated plasma.

(ii) Many candidates gained both marks, knowing that glucose and oxygen move from the blood in the capillaries to the body cells.

(iii) A good number of correct answers. Weaker answers had ‘breathing’ instead of ‘respiration’ which is incorrect. Mouth and heart were common incorrect responses for lungs or alveoli.

Question 2

(a) (i) This question was testing candidates' knowledge of the trend in the periodic table from metallic to non-metallic character across a period. Very few candidates were able to state clearly that more metallic elements are found to the left of a period. Some were able to gain credit by recognising that **B** was a halogen and therefore a non-metal.

(ii) A good number of correct answers were seen here.

(b) Very few candidates gained full credit here. It was more common to see **D** recognised as Group VIII or a noble gas than to see **E** recognised as a transition metal.

(c) (i) A good number of candidates were able to complete the left-hand side of the word equation, but very few realised that water is a product. 'Oxygen' was a very frequent incorrect product. Candidates should be encouraged to complete word equations with words. Those who attempt to use chemical formulae often fail to gain credit by making mistakes in the formulae.

(ii) Very few candidates realised that excess copper oxide is added to ensure that all the sulfuric acid reacts.

(iii) A good number of candidates correctly recalled the ionic bond but fewer gave an explanation involving electrons, and some candidates talked about sharing of electrons in an ionic bond, which is incorrect.

Question 3

(a) Full marks were gained only by the strongest candidates. The most common correct answers seen were 'kinetic' energy of flowing water and 'electrical' energy in power lines. Many candidates incorrectly thought that it was 'thermal' energy of the turning turbine instead of 'kinetic'.

(b) (i) Many correct answers here.

(ii) Candidates gaining credit here almost always gained the previous mark as well. However, there were many incorrect answers seen here, often radio waves, but all other examples of electromagnetic waves were seen too.

(c) (i) This question required candidates to select the highest frequency wave, **C**, and then to explain why it had the highest pitch. An inability to express this clearly hampered many candidates. The answer needed to compare **C** with the other waves and say either 'more waves per unit time', or 'shorter wavelength' or 'higher frequency'. A number of candidates wrote, for example, 'it has a high frequency' which didn't differentiate it from **A** and **B**.

(ii) This question was also poorly answered for the same reasons as **(c)(i)**. A number of candidates thought **A** was the highest pitch and **C** the loudest. A few candidates gave names to the instruments rather than identifying the instrument by the letter in the figure.

(iii) Candidates needed to identify a value of frequency below the threshold for human hearing (20 Hz). Some allowance was made for candidates who gave phonetically spelt equivalents to Hertz.

(iv) Candidates struggled to explain themselves clearly here. The question required a statement that the value in **(c)(iii)** is below the threshold for normal human hearing. Candidates who gained credit here often did so by quoting the normal range of hearing for humans. A number of candidates left this answer space blank.

Question 4

(a) (i) A good number of candidates gained both marks here. The most common correct answers were photosynthesis and transport. A number of candidates gave the vague answer 'for growth' which lacked the precision necessary to gain credit.

(ii) Xylem and mesophyll were more often correctly remembered here than cortex. A few stronger candidates gave all three correct responses.

(b) Many candidates incorrectly cited phototropism here. A careful reading of the question showed that there was no light for the plant and so a different response must be at work. In this case, the plant was growing against gravity, showing gravitropism.

(c) (i) A good number of candidates continued the root growth downwards. Credit was not given for roots that continued in a straight line, showing no downward turn.

(ii) This was poorly answered with many candidates mistakenly linking the root growth to phototropism. The expected answer was a reference to the root responding to gravity.

(d) This question was answered well by the majority of candidates who correctly stated that without light photosynthesis would not take place.

Question 5

(a) (i) Many candidates correctly stated that the gas formed is hydrogen. A number of incorrect responses were seen, from otherwise strong candidates, including carbon dioxide, chlorine and even zinc chloride. This last answer suggests that these candidates did not read the question carefully enough, since zinc chloride is the salt formed, not the gas given off.

(ii) This was generally well answered. Candidates needed to realise that pH is a numerical value and so its change will be either to increase or decrease in value (or no change). Answers that talked about the pH becoming alkaline did not gain credit.

(iii) The vast majority of candidates knew and expressed clearly that increasing temperature speeds up the reaction.

(iv) Similar to **(a)(iii)** a good number of candidates realised that replacing the piece of zinc with powder would also speed up the reaction.

(b) (i) A good number of candidates stated that oxygen is lost during reduction. Some candidates simply defined the word reduction as meaning 'reducing something' rather than giving an explanation of the scientific term.

(ii) Candidates found it hard to explain the term endothermic. Those that gained credit here were able to state clearly that thermal energy is taken in during the reaction, or that thermal energy is absorbed from the surroundings. Weaker answers incorrectly gave the definition of an exothermic reaction.

(c) This was well-answered by most candidates, with a good number gaining full credit and very few candidates gaining no credit at all.

Question 6

(a) (i) This question was testing candidates' knowledge of the melting and boiling points of water. Most candidates correctly stated that Earth is the only planet from the Table where liquid water would be on the surface.

(ii) When a question asks candidates to use data, it is important to quote the relevant data in the answer. Candidates gained credit here in a variety of ways, most often by saying that at a temperature of –63 °C water would be frozen on Mars. The statement that the surface temperature (462 °C) on Venus was above the boiling point of water was given much less often. Candidates frequently said that water would evaporate on Venus, but since it will also evaporate on Earth this idea was not creditworthy.

(b) (i) Candidates were credited for recognising that thermal energy is transferred from the sun by radiation. Some candidates made no attempt at this question, and some others gave a list of methods of thermal energy transfer, including incorrect methods such as convection.

(ii) This question asked candidates to explain that radiation is the only method of thermal energy transfer that can take place without a medium. They could also state that there is no medium in space, but a statement that 'conduction happens in solids and convection in liquids' was insufficient to gain credit.

(c) Most candidates correctly recalled the formula *speed* = *distance*/*time*. For full credit, candidates needed to convert the time in days into time in hours. Some candidates gained only partial credit by quoting the distance as 940 km rather than 940 000 000 km.

(d) Candidates needed to complete the diagram to show rays emerging from the lens and converging. The point where the rays meet needs to be at the dry grass. Candidates should draw rays with a ruler to ensure straight lines. Weaker answers often showed rays that were not converging and did not meet anywhere on the diagram.

Question 7

(a) (i) Well answered by almost all candidates. Those not gaining full credit usually missed out the arrows or drew arrows in the wrong direction.

(ii) Candidates were being asked to recall the definition of a producer from the syllabus: an organism that makes its nutrients using energy from sunlight in photosynthesis. For full credit, both ideas, 'making its own food' and 'using sunlight or by photosynthesis' were required. Weaker answers often just stated that the producer is the start of the food chain.

(b) This question tested candidates' understanding of the importance of chemical digestion in breaking down insoluble molecules into soluble molecules that can be absorbed. To gain credit, answers needed to be about molecules and not just 'food'.

(c) (i) Many correct answers here with candidates either recognising that trees are producers in the food chain or that they provide shelter for animals in the food chain and in either case their removal disrupts the chain.

(ii) Almost all candidates were able to state a harmful effect of deforestation.

Question 8

(a) (i) It was good to see many candidates remembering the full name of this process and gaining credit for 'fractional distillation'.

(ii) Candidates needed to state that hydrocarbons are compounds made of carbon and hydrogen atoms only. Use of the word 'mixture' is incorrect. While some candidates correctly identified carbon and hydrogen, many did not state explicitly that only hydrogen and carbon make up a hydrocarbon.

(iii) Uses of naphtha were not well known by candidates. 'Making other chemicals' gained credit and other acceptable answers from candidates' general knowledge included 'making medicines' 'as a paint thinner' or 'as a cleaning agent'. A number of candidates gave examples from the syllabus of the uses of other fractions of petroleum, which did not gain credit.

(b) (i) Very few candidates were able to recall one of the two tests for water. Those candidates who did recall a correct test usually also recalled the correct result to gain full credit.

(ii) Candidates are expected to know that carbon monoxide is toxic or poisonous to humans. Some candidates gained credit with either of these terms. Other candidates were given credit for realising that carbon monoxide caused difficulties in breathing. Credit wasn't given for answers such as 'it kills you' (too vague) or 'causes cancer' (not a direct effect of carbon monoxide poisoning).

(iii) and (iv)
Candidates are expected to know that the composition of clean air is a mixture of 78% nitrogen, 21% oxygen and therefore 1% made up of other gases including carbon dioxide. In **(b)(iii)** any percentage less than or equal to 1% was given credit. In part **(b)(iv)** very few candidates were able to recall the percentages of nitrogen and oxygen even if they had given a creditworthy response in **(b)(iii)**. There was a lot of confusion about the composition of air.

Question 9

(a) Only the strongest candidates gained full credit with a correct symbol for a voltmeter connected in parallel with the cells. Candidates who could not remember the correct symbol still gained credit if they put a meter in the correct position, and other candidates also gained partial credit for including the correct symbol for a voltmeter located incorrectly in the circuit, usually in series with the heater and cells.

(b) A good number of candidates selected the correct fuse from the list. Some candidates chose the 10A fuse, which suggested that they did not know how to choose an appropriate fuse.
Candidates need to know that a fuse must allow the maximum current to flow without breaking, and so a fuse should have a value a little above the expected current in the circuit.

(c) Candidates were being asked to show how convection happens from the heater. While a number included several arrows showing the complete convection current, the minimum necessary was to show arrows going upwards from the heater. Some candidates did not gain credit because their diagrams included contradictory arrows, going down from the heater.

(d) While most candidates knew the correct symbol for a lamp, fewer were able to draw the symbol for a variable resistor. Fuses, fixed resistors and resistors with a diagonal line (but no arrow) were all seen. Most candidates gained some credit, but very few included all the elements necessary to gain full credit.

COMBINED SCIENCE

Paper 0653/32
Core Theory

Key messages

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

When candidates meet questions set in a context that they do not recognise it is important to try and use the scientific knowledge that they have learned. Often the answer required is quite a straightforward application of knowledge in the syllabus which candidates can miss by trying to overcomplicate their answer.

In several questions, candidates are asked for a type of something (see **Question 2(b)(i)** and **(ii), Question 8(b)(ii)** and **Question 9(a)** for example). This is not asking for a specific example but rather the general name for the type.

General comments

Some good responses were seen in this paper, with a number of candidates showing a sound understanding of the Core syllabus. In particular, calculations were done well by a large number of candidates.

Many candidates find it difficult to provide a clear explanation of terms given in the syllabus. Being able to provide a clear statement of the meaning of scientific terms is an important part of this course.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified **R** (cell membrane) and **S** (cytoplasm) as the plant cells in the figure. A common error was to label **R** as the cell wall. Some candidates were confused about the words chloroplast and cytoplasm, giving a label for **S** that was a hybrid of the two terms.

(ii) Many candidates gained both marks. A few candidates made no attempt at the question while others identified evidence in the figure which is common to plant and animal cells (e.g. nucleus), which did not gain credit.

(b) Candidates generally knew the word equation for photosynthesis well and gained full credit or were not able to recall either the reactants or products correctly. Candidates are expected to state that glucose is produced, and not the more general term carbohydrate, which refers to substances other than glucose as well. A small number of candidates produced the equation for respiration rather than photosynthesis.

(c) (i) and (ii)
Both very well answered.

(iii) To gain credit candidates needed to state that the number of snails would decrease and explain that this was due to a lack of food for them. There were very many good, clear answers. A few candidates explained that there was less food but neglected to state what would happen to the number of snails. It is important to read questions carefully and answer exactly what is being asked.

Question 2

(a) (i) Only the very strongest candidates correctly recalled that process **X** was cracking.

(ii) While a good number of candidates remembered that bromine was brown/orange/yellow, far fewer correctly recalled the colour change when it is mixed with an alkene. Candidates need to be aware that 'clear' is not equivalent to colourless. Solutions can be clear and coloured.

(iii) Very few candidates correctly recalled that poly(ethene) is formed by the addition polymerisation of ethene.

(b) (i) Stronger candidates correctly recalled the term hydrocarbon. A common incorrect answer here was 'carbon hydroxide'. Also, a number of candidates named methane, which is a specific hydrocarbon and not the name for the type of compound.

(ii) A good number of candidates gained credit for stating that carbon and hydrogen atoms have a covalent bond.

(iii) Many candidates were unsure of the products of complete combustion. The strongest candidates gained full credit stating carbon dioxide and water, but a huge variety of incorrect responses were seen and some candidates made no attempt at this question.

(iv) Many candidates were able to draw the structure of methane as a central carbon atom surrounded by four hydrogen atoms, but far fewer attempted the dot-and-cross diagram asked for in the question. Those who did draw a dot-and-cross diagram almost always did so correctly.

Question 3

(a) (i) A small number of candidates made no attempt at this question, but the majority of those who answered did so correctly, with an arrow touching the knob or spring and pointing to the right.

(ii) Forces can change an object's size, shape or motion. Many candidates recognised that force can change motion (e.g. by saying that forces make objects speed up), but some candidates gave two answers about motion and made no reference to other effects and so only gained partial credit.

(iii) The strongest candidates correctly recalled that both force and distance moved are needed to calculate the work done on an object. Some candidates remembered one of the two quantities, often force, but then gave an incorrect response for the second mark. Power and time were common incorrect responses.

(b) A good number of candidates gave two correct answers here. Weaker responses were more likely to only identify kinetic energy correctly.

(c) Candidates were generally good at doing calculations on this paper and many scored both marks here. Those who correctly recalled the formula usually went on to calculate the correct final answer.

Question 4

(a) (i) The majority of candidates were able to identify part **A** as a petal. The sepal, part **B**, was less well remembered, with a number of candidates calling **B** the stem or leaves.

(ii) This question proved to be very challenging for candidates and only the strongest gained even partial credit for recognising that the gametes (pollen and ovule) fuse. Very few candidates were specific in stating that it is the nuclei of the gametes which fuse. A lot of candidates gave an account of pollination and then simply finished by stating that fertilisation happens. Candidates need to read questions carefully so that they answer exactly the question that is being asked.

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Stigma and ovary were both popular correct answers for **(i)** and anther was the most common correct answer for **(ii).** Candidates giving the names of the gametes, ovule in **(i)** or pollen in **(ii)**, did not gain credit here. Generally, candidates recalled female reproductive parts more often if they only gained partial credit.

(c) (i) Very few candidates correctly identified the oviduct (or fallopian tube) as the place where fertilisation takes place in the human female reproductive system. Common incorrect answers included uterus and ovary. Some candidates answered as though the question was still about flowers, suggesting that they had not actually understood what the question was asking.

(ii) Less than half the candidates were able to name the fertilised egg as a zygote. There was a wide range of incorrect responses.

(iii) Candidates need to be encouraged to give a level of detail in their answers to reflect the number of marks awarded for a question. Here, 2 marks indicates that a more detailed answer than just 'uterus' is required for full credit. Stronger candidates were able to state clearly that the embryo continues its development in the lining or wall of the uterus.

Question 5

(a) (i) The vast majority of candidates were able to place all 3 labels in the correct place. A few candidates placed only electrolyte correctly.

(ii) Candidates were much less sure about the products of this reaction. A few candidates correctly identified hydrogen as a product. A number of candidates put 'chlorine' even though that was given in the question stem and two **other** products asked for.

(iii) Only a small number of candidates gave the test with damp litmus paper for chlorine. Those that remembered the test usually also remembered the correct result. Many candidates made no attempt to answer this question.

(b) This question was well answered by many candidates with a good number gaining full credit. A few candidates reversed the number of protons and neutrons. Where candidates gained partial credit, it was more often for remembering the number of protons. A number of candidates thought that the nucleon number, 23, given in the question was also the number of neutrons.

(c) A large number of candidates were able to complete the electron arrangement in a chlorine atom correctly. Strong candidates also completed the electron arrangement in the chloride ion. Candidates sometimes showed the chloride ion to have one fewer electron in its outer shell. Some candidates seemed to have misunderstood the figure and tried to show electrons moving from the chloride atom to the ion.

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(b) (i) Candidates were able to calculate to total resistance of the circuit with a good number gaining full marks. Where candidates did not get full credit, it was often for incorrectly recalling the unit of resistance.

(ii) This question asked candidates to choose the most suitable fuse for the hair dryer. A fuse needs to have a larger rating than the expected current. However, it is designed to break if the current flowing is too large. Candidates needed to use the information in the question in order to choose the first fuse rating above 3A (i.e. the 5A fuse).

(c) (i) A significant number of candidates realised that the hair dries due to the evaporation of the water. A common incorrect response was ‘thermal energy’, which is not a process.

(ii) Candidates found it much harder to describe the process of evaporation. To gain credit they needed to state that the more energetic, or faster moving, molecules escape from the surface of the water.

(iii) Very few candidates realised that this question was about the evaporation of water leaving the remaining water, in contact with the head, cooler. A lot of answers imagined a comparison between the head feeling warmer when the hairdryer was switched on and colder when it was switched off, but this is not what the question was asking.

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(a) This is another question where candidates were asked to give the type of charge rather than the name of particular charges. A large number of candidates correctly stated that the types of charge are positive and negative.

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(e) (i) Once again candidates are generally able to perform simple calculations correctly. A large number gained full credit here for recalling that speed = distance/time and that this could be rearranged to find the distance of 1650 m.

(ii) The last question on the paper was well-answered by a large number of candidates who were able to express clearly that light travels faster than sound.

COMBINED SCIENCE

Paper 0653/33
Core Theory

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COMBINED SCIENCE

Paper 0653/41
Extended Theory

Key messages

Those candidates who scored well on this paper ensured that:

- they had read the questions carefully and used the number of marks available for each question as a guide to how much detail to include
- *(for biology)* they gave detailed information about the use of glucose in plants, they could describe the factors affecting the rate of transpiration through a leaf, and they had learned a clear definition of the term *ecosystem*
- *(for chemistry)* they understood the meaning of the term *reaction conditions* in the context of industrial cracking, they could describe the process of electron gain in the discharge of copper ions in electrolysis, and they had learned the test for aqueous copper ions using sodium hydroxide solution
- *(for physics)* they were able to use the relationship $P = V \times I$ to calculate electrical power, they avoided vague or unscientific suggestions about the advantages and disadvantages of hydroelectric power generation, they successfully used the relationship $v = \lambda f$ in calculating a wavelength, and they knew that satellite communication to and from the Earth is carried on microwaves.

General comments

- Some good scripts were seen from candidates who had mastered most parts of the syllabus, who were very well-prepared for examinations of this type, and who presented answers in a well-organised manner. Some of the candidates who were less successful might have been better suited for entry to the core paper.
- Some questions tested the ability of candidates to apply their knowledge and understanding of science to describe and explain contexts that may be unfamiliar. Candidates often find these questions challenging and examination practice of this type of question is encouraged.
- Performance across the three science disciplines was quite well balanced, although in this paper there was evidence that the candidates may have found physics to be slightly more challenging. There was no evidence that candidates had difficulty in finishing the paper in the time allowed.
- Candidates should write their answers legibly to ensure that examiners award as many marks as possible. A number of scripts in this examination were very difficult to read because letters were incorrectly formed.
- Candidates generally showed their working in questions requiring calculation and this is to be encouraged.

Comments on specific questions

Question 1

(a) The differences in structure between plant cells and red blood cells had been learned very well. A common mistake was to label a chloroplast as chlorophyll. Candidates selecting cell wall gained the mark, provided that the label line did not reach the cell membrane.

(b) Candidates who gained this mark made it clear that the function of root hairs was water *absorption* and not just water *transport*. Candidates discussing nutrients and minerals needed to ensure that they also mentioned water. This part of the biology syllabus was well-known.

(c) (i) The function of the flagellum to facilitate sperm movement was very familiar. References to *sperms swimming* were frequently seen and accepted.

(ii) Successful candidates had learned the important adaptation of sperm in carrying enzymes used to penetrate the egg cell. The one-word answer *enzymes* does not convey enough information. An alternative answer that gained credit referred to the large numbers of energy-providing mitochondria. Answers that were not accepted included descriptions of a sperm's pointed shape.

(d) (i) The correct answer *glucose* was often given. All of the distractor answers were suggested with carbon dioxide and glycogen being the most common.

(ii) Three correct selections were frequently made showing that this part of the syllabus had been learned very well. Common mistakes included the reversal of haemoglobin and red blood cells and the substitution of diffusion with osmosis.

(iii) Although the word *walls* appears in the question, it was essential that candidates included it in their answers. Candidates who gained credit therefore referred to *thin capillary walls* rather than *thin capillaries*. Alternative answers suggesting permeability were accepted provided they also specified the capillary walls.

Question 2

(a) Candidates were very familiar with covalent bonding in a water molecule. The second mark was awarded to candidates who explained, in terms of non-metallic elements, why the bond is covalent. Descriptions of shared electrons without reference to non-metallic elements were not accepted.

(b) (i) Candidates gaining this mark usually specified high temperature and the need for a catalyst. Candidates needed to avoid the one-word answers *temperature* and *pressure* and vague suggestions such as *a suitable temperature*. This part of the syllabus was familiar to many candidates although some of the incorrect ideas suggested that candidates may not have understood the instruction to state *reaction conditions*.

(ii) The mark for successful completion of this balanced equation was frequently awarded.

(c) (i) The general form of a dot-and-cross bonding diagram was very familiar. The correct diagram for carbon dioxide was not seen as often as expected given that carbon dioxide is one of the named examples that candidates are expected to have learned. The candidates that gained partial credit tended to show the shared pairs of electrons in the double bonds but omitted non-bonding electrons on the oxygen atoms or added extra electrons to the carbon atom.

(ii) The link between atmospheric carbon dioxide and global warming was very familiar. Hardly any candidates made unqualified reference to the greenhouse effect. An alternative answer that gained the mark discussed a possible increase in the rate of photosynthesis.

Question 3

(a) (i) The correct answer *lake surface* was often stated. The most common answers that were not accepted were *water* and *dam*.

(ii) This mark was very often awarded. The most common incorrect suggestion referred to the power lines to the house.

(b) Answers that gained credit avoided statements that were either too general, too short term or simply untrue. Examples of advantages that gained credit included direct references to the absence of carbon dioxide emissions, and the avoidance of atmospheric pollution by combustion products of fossil fuel. Examples of suggested advantages that did not gain credit included *environmentally friendly, no need for fossil fuel, never runs out*. Examples of disadvantages that gained credit included *can damage water ecosystems, can destroy habitats when large areas are flooded.* Examples of disadvantages not gaining credit included *kills fish, causes visual pollution, noise when the dam is constructed.*

(c) (i) Candidates needed to recognise that this question simply required recall of the speed of light and a correct unit, which is normally given as 3×10^8 m/s. Some candidates demonstrated that they had learned this constant by using it in the following question, yet they were not awarded this mark because they were distracted by the value of frequency given: common mistakes included 6×10^8 , 600 and 3×10^8 MHz.

(ii) Use of the relationship $v = \lambda f$ is often tested and the correct final answer of **0.5 m** was obtained by candidates across the mark range. An error from part **(c)(i)** could be carried forward and this often resulted in candidates gaining both marks. Candidates gained one mark if they correctly stated the relationship even if other parts of the calculation were incorrect. This is an example of the value of showing all working. When candidates did not recall the relationship correctly no marks could be awarded.

(iii) The correct answer, *microwaves*, was not very familiar. The most frequently seen suggestion was *radio waves*.

(d) Candidates who gained both marks stated that sound is transferred through the vibration of particles, or air molecules in this case. A mark was awarded when candidates described the nature of the vibration either as a longitudinal wave or in terms of rarefactions and compressions. In some cases, the required information was shown in a clear, labelled diagram. Many answers were awarded partial credit, though other answers made very general statements that contained no scientific information.

Question 4

(a) (i) The balanced equation for photosynthesis had been learned very well.

(ii) Both marks were gained when candidates avoided vague references to energy and identified relevant larger molecules that are built from glucose. Answers concerning energy that gained a mark included reference to respiration or phrases such as *to release energy* or *to supply energy.* A mark was not awarded for the answers *energy* or *for energy*. References to the production of molecules such as proteins or cellulose were accepted as alternatives for starch. Other answers that did not gain credit included *for plant growth, as plant food* and *stored as energy.*

(b) (i) The palisade mesophyll layer **B** was frequently recognised. The most common mistake was to suggest layer **A**.

(ii) To gain one mark, candidates had to state that most of the chloroplasts are present in layer **B**, rather than simply that layer **B** contained chloroplasts. A second mark was awarded to candidates who made it clear that photosynthesis occurs within chloroplasts. Credit was not awarded for answers that discussed the details of photosynthesis without mentioning either chloroplasts or chlorophyll.

(c) Candidates very often showed that they understood the reason for the reduced transpiration rate in humid air, and any wording that conveyed the idea clearly enough was accepted. Correct use of the term *diffusion* gained at least one mark, as did the simple idea that increased humidity meant that the concentration of water (vapour) in the air was greater. Candidates needed to avoid statements which implied that increased humidity in air surrounding the leaf meant that the concentration of water inside and outside the leaf had become the same. In general, finding the words to describe the idea of a reduced water potential gradient proved challenging.

Question 5

(a) The syllabus specifies that key characteristics of transition metals include high melting point, high density and catalysis. Alternative answers that were accepted for this question included a reference to reactivity, the idea of variable oxidation state and the colour of the metal itself. The mark for this question was awarded less frequently than expected. The most common type of answer that was not awarded a mark was a metallic property that is common to both copper and aluminium.

(b) (i) Cathode was very frequently identified.

(ii) The two marks were for describing the ideas that electrons are gained by the copper ions and that the ion is electrically neutralised. Some candidates gained both marks by writing a correct electrode equation. There was evidence that the electrode processes in electrolysis had been partially learned, and marks were sometimes lost by suggesting that the copper ions lost electrons or by giving descriptions of the way that ions form from atoms. In this case, credit was not awarded for reference to reduction unless electrons were included in the answer.

(c) (i) The correct response, *carbon*, was frequently stated. The most common incorrect suggestion was copper although all of the other substances in the equation were seen.

(ii) The correct idea that aluminium is more reactive than carbon was very frequently seen. The answers '*aluminium is reactive'* or '*aluminium is more reactive than copper'* were not accepted.

(d) The use of sodium hydroxide solution to identify aqueous copper ions was unfamiliar. Some candidates suggested the alternative answer of using aqueous ammonia. A small number of candidates suggested using the flame test although the correct flame colour for copper was often missed. Electrolysis was frequently suggested but was not accepted. There was evidence that many candidates had to guess the answer, and a wide variety of incorrect suggestions was seen. A significant number of candidates made no attempt to answer this question.

Question 6

(a) The question required candidates to recognise the relative size of numbers given in standard form. The correct answer, Earth, was seen a little more frequently than the most likely distractor, Venus.

(b) The relationship *density = mass/volume* was very familiar and three or two marks were frequently awarded. Candidates who gained only two marks either made arithmetic mistakes handling the numbers in standard form or suggested incorrect units. Full marks were awarded for any consistent combination of numerical answer and units.

(c) The correct answer *Earth* was very frequently given. Candidates who gained the second mark used information from the table of data and correctly made the comparative statement that the Earth has the *highest* gravitational field strength. Suggestions such as *Earth has a high gravitational field* did not gain credit. The answer that the Earth has the highest mass was a much less popular answer and some candidates could not be awarded the second mark because they stated that the Earth has the highest weight.

(d) The answer to this question required candidates to use information that was not included in the table of data and consequently this mark was awarded very infrequently. The most popular suggestions were that Mercury has no atmosphere or that Mercury was either too close or too far away from the sun.

(e) The idea that Venus has a higher atmospheric pressure than the Earth was very frequently stated, but the mark was only awarded when candidates went on to say that this meant that the particles in the atmosphere were more concentrated. General statements about higher density either of the atmosphere or particles did not gain credit because the question directs candidates to consider the arrangement of particles. The second mark was awarded infrequently, and it was often suggested that the lower gravity on Venus was important.

Question 7

(a) (i) Successful candidates had learned a standard definition of the term *ecosystem*. Many candidates had a feel for the meaning of the term and any wording that unambiguously included all of the key features gained credit. Common reasons why credit was not awarded included referring only to living organisms, referring to a population rather than a community, and, most commonly, not referring to the interaction between organisms and environment. One common mistake was to limit the idea of interaction to predator/prey relationships.

(ii) Two marks were often awarded for this question. The term *solar* is not accepted as an alternative for light. Other incorrect answers included *heat* and *the sun's* instead of light, and *heat* and *the producer's/consumer's* instead of chemical. Candidates should be advised that answers to questions like this should be types of energy.

(b) Credit was often awarded for excretion and respiration. The wording in the question asks for ways that energy is lost from each of the trophic levels. This means that candidates' suggestions must be correct for producers and consumers, so references to urine, for example, were not accepted. A common mistake was to describe causes for inefficient energy transfer between trophic levels.

(c) Most candidates gained full credit for their answers. There were not many common mistakes but one which was seen a few times was the idea that if the producers disappear then the primary consumers will become producers.

Question 8

(a) (i) The wide range of estimated temperature allowed in this question meant that most candidates gained the mark.

(ii) Most candidates used the wording in the table to arrive at the correct answer.

(b) (i) A minority of candidates wrote the correct formula RbOH. The suggestions OHRb and Rb^+OH^- were accepted. There were many incorrect suggestions, most of which contained mistakes in the subscripts or included incorrect electrical charges.

(ii) Full marks for this question were quite often awarded. Candidates were allowed a pH value in the range 8 to 14, but no credit was given for the answers *high* or >7. There was a variety of acceptable wording for the second mark including *because hydroxides are basic.* When candidates suggested a pH value below seven, an error was allowed to be carried forward if they stated that the solution was acidic.

(c) The award of three marks was relatively infrequent although large numbers of candidates gained at least one mark for identifying that rubidium hydroxide is ionic and/or water is covalent. Candidates needed to relate the attractive forces between either ions in rubidium hydroxide and/or molecules in water with the relative amounts of thermal energy needed to separate these particles. This relationship was often generally described and so gained at least one mark. Full marks relied on candidates specifying that the attractive forces between *ions* are much stronger than weaker intermolecular forces between *molecules*.

(d) Candidates often gained both of these marks. It was important that they specified that *thermal* energy (heat) was the type of energy released. Candidates should be advised to avoid suggesting that exothermic reactions *produce* energy. It should always be emphasised to candidates that, in answers to science examination questions, energy is transformed or transferred and not created or destroyed.

Question 9

(a) (i) Candidates towards the upper end of the mark range were familiar with the relationship for the combined resistance of two resistors in parallel. These candidates usually gained two or three marks. When a mark was missed it was often because candidates did not complete the final step of the calculation to obtain R from $1/R$. The most common mistake was the calculation of the combined resistance of $R_2 + R_3$ to give $9\,\Omega$. The final answer for the combined resistance of all three resistors was **10Ω**. although an error from the first calculation could be carried forward.

(ii) The correct answer **0.9**(A) was often stated. A variety of incorrect answers was produced by candidates carrying out arithmetic operations other than subtraction on the two values of current stated in the question.

(iii) Candidates who stated the correct answer in part **(a)(ii)** did not always provide the correct explanation in part **(a)(iii)**. Candidates needed to explain that the current shown on the ammeter is the sum of currents in the two branches. The idea that both parallel branches would carry the same current was often suggested.

(iv) The small number of candidates who explained that this question concerned electromotive force gained the mark. A few others suggested that with the switch open there were no resistances 'using up' energy from the battery. Any sensible attempt like this gained credit.

(b) The relationship $P = V \times I$ was used by a relatively small number of candidates who worked through to the correct answer **405 (W)**. The most common mistake was to use Ohm's Law to calculate $I \times R$.

COMBINED SCIENCE

Paper 0653/42
Extended Theory

Key messages

Those candidates who scored well on this paper ensured that:

- they had read the questions carefully and used the number of marks available for each question as a guide to how much detail to include;
- *(for biology)* they had learned the details of the way carbon monoxide reduces the oxygen carrying ability of haemoglobin, the role of nitrate ions in plant nutrition and that lipase digests fat molecules to form fatty acids;
- *(for chemistry)* they had learned that the ore of aluminium is called bauxite, they could describe the molecular processes occurring during electrolysis to form aluminium atoms, and they were able to describe in terms of bonding and molecular forces why sodium chloride has a higher melting point than chlorine;
- *(for physics)* they could describe the effect on current through and potential difference across a motor when a resistor in series is connected, and they understood that a material becomes electrically charged when electrons are lost or gained;

General comments

- Some good scripts were seen from candidates who had mastered most parts of the syllabus, who were very well-prepared for examinations of this type, and who presented answers in a well-organised manner. Some of the candidates who were less successful might have been better suited for entry to the core paper.
- Some questions tested the ability of candidates to apply their knowledge and understanding of science to describe and explain contexts that may be unfamiliar. Candidates often find these questions challenging and examination practice of this type of question is encouraged.
- Performance across the three science disciplines was quite well balanced. There was no evidence that candidates had difficulty in finishing the paper in the time allowed.
- Candidates should show their working in questions requiring calculation and write their answers legibly to ensure that examiners can award as many marks as possible.

Comments on specific questions

Question 1

(a) (i) This question presented few problems and most candidates correctly calculated **0.9(dm^3)** from the graphs.

(ii) Successful candidates realised that in 12 seconds two extra breaths are taken so in 60 seconds there would be 60/12 times this number. The final answer was **10** breaths per minute. Partial credit was awarded for each of the steps in the calculation. Many candidates became lost in the mathematics and a wide variety of incorrect approaches was seen.

(b) Candidates needed to explain that an increased respiration rate would lead to an increase in blood carbon dioxide level. Candidates towards the higher end of the mark range tended to gain both marks. Candidates did not need to specify aerobic respiration but if they suggested anaerobic respiration then the mark was not awarded. There were two kinds of common mistake made by candidates who suggested that the carbon dioxide level would decrease: some suggested that exercise caused increased rate of breathing and so more oxygen and carbon dioxide would be taken in; others suggested that since the body would need more oxygen this would reduce the ability of blood to carry carbon dioxide.

(c) The detailed action of carbon monoxide was familiar to a minority of candidates. Candidates needed to take care to state that carbon monoxide combined with haemoglobin. It was not enough simply to state that carbon monoxide entered the blood or red blood cells. Candidates also needed to avoid suggesting that if carbon monoxide is present then no oxygen at all is transported in the blood. Some candidates suggested that carbon monoxide would destroy cilia and lead to lung infection.

(d) The connection between cigarette tar and lung cancer was very familiar and most candidates were awarded this mark. Other correct alternative answers the were accepted included bronchitis, emphysema and COPD. Candidates should have avoided asthma and CHD.

Question 2

(a) (i) The mark for recognising that the molecules at **A** and **B** would be hydrocarbons was quite often awarded. Candidates needed to describe a similarity of molecules rather than the products obtained at **A** and **B**. This meant that answers such as *both have boiling points below 400 °C* or *fraction **A** and fraction **B** are both found in petroleum* or *both are fuels* did not gain credit.

(ii) This mark was often awarded and the majority of candidates who gained the mark opted for the difference in molecular size. Candidates needed to describe a difference between the molecules rather than the products obtained at **A** and **B**. This meant that answers describing bulk properties such as boiling point or density could not be accepted.

(b) (i) A much greater number of candidates than in previous years had learned an accurate definition of homologous series and so gained both marks. Candidates should be advised to specify the same or similar **chemical** properties and to avoid suggesting that homologues have the same physical properties or that they have the same chemical formula.

(ii) The structure diagram of propane was very familiar and most candidates gained both marks.

(c) (i) Large numbers of candidates produced a correctly balanced equation for the complete combustion of propane. One mistake which occurred a few times was that candidates omitted oxygen from the reactant side of the equation.

(ii) The link between atmospheric carbon dioxide and global warming was very familiar. Hardly any candidates made unqualified reference to the greenhouse effect. An alternative answer that was accepted discussed a possible increase in the rate of photosynthesis.

(iii) The general form of a dot-and-cross bonding diagram was familiar. The correct diagram for carbon dioxide was not seen as often as expected given that carbon dioxide is one of the syllabus examples that candidates should learn. Candidates who gained partial credit tended to show the shared pairs of electrons in the double bonds but then suggested incorrect numbers of non-bonding electrons on the oxygen atoms or added extra electrons to the carbon atom.

Question 3

(a) (i) Some candidates had learned a simple statement of Hooke's Law either in words or as the formula. Candidates should learn to specify that it is the *extension* and not the length of the spring that is proportional to the force or load. Many candidates described the meaning of elastic limit which is the answer to a different question.

(ii) Successful candidates were able to apply the ideas in Hooke's Law and worked through the simple proportion sum to calculate the final answer **3.0(N)**. Partial credit was awarded to some candidates who calculated the extension to be 0.04 cm.

(iii) The use of the relationship *work = force x distance* was very familiar and large numbers of candidates applied it correctly to obtain the final answer **0.011(J)**. The most common mistake was to divide force by distance. Candidates should be advised to notice the number of significant figures in the question data and ensure that their numerical answers have at least the same precision. This means that the answer 0.01J was not accepted.

(b) (i) It was clear that large numbers of candidates were familiar with this type of calculation and many were awarded full marks for obtaining the final answer **1.6(m)**. A common reason for the loss of one mark was that candidates used 125g rather than 0.125kg in the calculation of the height reached.

(ii) Only a minority of candidates referred to air resistance. A wide variety of incorrect suggestions was seen. Examples of misconceptions include the ideas that gravity was "still acting" or that the kinetic energy was somehow insufficient.

Question 4

(a) (i) Most candidates correctly labelled the nucleus and the cell membrane in the root hair cell. The most common mistakes were that the cytoplasm or the vacuole membrane were labelled as the cell membrane.

(ii) Most candidates were awarded at least partial credit for stating that the root hair cell has a large surface area. The idea that the hair cell is long and thin was accepted as an alternative. The candidates who gained the second mark made it clear that a large surface area increases the **rate** or efficiency of water absorption. The answer *to absorb more water* was not accepted.

(b) (i) The importance of nitrates in the making of amino acids was familiar to only a few candidates. The non-specific answers *for growth* or *to keep the plant healthy* were often suggested but did not gain credit.

(ii) The passage of nitrate ions through the xylem was familiar to some candidates who gained at least one mark. The first stage through the root cortex was known by only a very small number, and many substituted phloem for xylem. The stem was mentioned by only a relatively small number.

(c) (i) Health problems caused by vitamin D deficiency were familiar to large numbers of candidates and any correct suggestion gained credit. The most common incorrect answers were related to vitamin C deficiency. Some candidates could not be awarded credit because they described the benefits of vitamin D.

(ii) Candidates generally knew suitable food types that provide vitamin D, with the most popular being milk and alternative answers being fish or fish oil. The most common mistake once again related to vitamin C and in this case an error was not carried forward from **(c)(i).**

Question 5

(a) (i) Bauxite was rather unfamiliar to candidates across the whole mark range. Candidates need to be aware of the names of the natural resources that appear in the syllabus. The most common answers that did not gain credit included aluminium oxide and aluminium ore. Some candidates seemed to be very unfamiliar with this part of the syllabus and made suggestions that did not relate to aluminium.

(ii) The correct formula Al^{3+} was frequently seen. Many candidates attempted an alternative chemical formula to the one shown for aluminium oxide in the question and others stated an incorrect ionic charge.

(iii) The processes occurring in the electrolysis of molten aluminium oxide were quite familiar mainly to candidates in the upper half of the mark range. The most common type of mistake was reversal either of anode for cathode or electron loss for electron gain. In this case, the term *reduction* on its own without reference specifically to electrons did not gain a mark. In a several cases, candidates lost credit because they interchanged the terms *atoms* and *ions*.

(iv) The correct idea that aluminium is more reactive than carbon was very frequently seen. The answers, *carbon is unreactive* or *aluminium is reactive* or *aluminium is more reactive than copper,* were not accepted.

(b) The mark for stating that aluminium alloys are stronger than pure aluminium was very frequently awarded. The vague term *more durable* did not gain credit and any reference to rusting could not be accepted as an alternative to corrosion. Other answers that were not accepted included alloys are harder, have different melting points and have lower density.

Question 6

(a) The use of the relationship $P = I \times V$ was familiar, and many candidates correctly calculated the current through the hairdryer when working normally to be 3.1(A). Only a small number of candidates could explain why a 5A fuse would be a suitable replacement in this context. A simple general description of the need for a fuse was not enough. They needed to state either that if the fuse was rated lower than 3.1A then it would cut off the current in normal use or that the fuse needs to be a little higher than 3.1 but not so high that the dryer could be damaged.

(b) At least one mark was awarded to large numbers of candidates who showed that they recognised the circuit symbol for a resistor. In order to gain the remaining marks, candidates needed to explain that inclusion of the resistor would decrease the voltage dropped across the motor and so decrease the current through it. A number of candidates gained the mark for stating that the current would be reduced. Many candidates referred to a reduction in potential difference, but they did not specify that this reduced potential difference would be across the motor. There was a tendency for some candidates to discuss ‘faster’ or ‘slower’ current, and candidates should be advised to avoid this way of describing current.

(c) Candidates who gained two marks specified that thermal energy would increase the kinetic energy of the water molecules and that those with most energy would then escape. A few candidates explained that, by blowing air, escaped water molecules would be carried away more efficiently. The majority of candidates had learned a molecular explanation of evaporation and gained at least partial credit.

Question 7

(a) (i) Only a small number of candidates towards the higher end of the mark range gained full marks for this question. These candidates specified that lipase acts on the fats in the milk and that this reaction produces fatty acids. It was not enough to state that lipase acted *on the milk*. The production of fatty acids was unfamiliar to most candidates, and many attempted to explain the increased acidity by suggesting that lipase must be an acid or that the mixture somehow knows it has to be acidic because that would be optimum for lipase.

(ii) Two marks were often awarded for this question because many candidates had learned a proper definition of chemical digestion. It was important that candidates referred to the breakdown of large food **molecules** and not just the breakdown of food.

(iii) The majority of candidates correctly stated pancreas or parts of the small intestine. The two most common answers that were not accepted were stomach and liver. Gastric lipase was not specified which is why stomach was not accepted on this occasion.

(b) The details of enzyme denaturation were fairly familiar and the majority of candidates gained at least partial credit. Most candidates realised that boiling prevents the enzyme from functioning, but they needed to state a more detailed answer than simply *the enzyme stops working.* Many candidates understood that boiling would destroy the shape of the molecule / active site, and the most successful candidates could state that this prevents binding with the substrate.

(c) Wording was very important here and unlike **(a)(ii)** it was important that candidates avoided discussing the breakdown of molecules and referred instead to breaking large pieces of food into smaller pieces. The second mark was awarded if candidates stated either that only a physical process was involved or that no chemical changes occurred.

Question 8

(a) (i) The great majority of candidates correctly stated the number of electrons to be 85.

(ii) Most candidates correctly stated that astatine atoms have seven outer electrons because astatine is in Group VII of the Periodic Table. One mistake which occurred several times was caused by candidates attempting to apply the rules for electron numbers in shells of elements up to calcium. Distributing 85 electrons into a very large number of shells each containing eight electrons leaves three in the assumed outer shell and so candidates allocated astatine into Group 3.

(iii) The mark for KAt was very frequently awarded. The alternative answers AtK and K^+At^- were accepted. Mistakes usually occurred as incorrect subscripts and/or incorrect ionic charges.

(b) (i) Candidates usually obtained one mark for stating that thermal energy is released in an exothermic reaction. The second mark for a correct discussion about energy changes during bond breaking and bond making was awarded to a small number of candidates towards the upper end of the mark range. Some candidates attempted to describe bond making and breaking but often suggested that bond making and bond breaking both *required* energy.

(ii) Many candidates had learned how to draw the lattice arrangement of ions in sodium chloride. There were no particularly common mistakes. This lattice is the only one named in the syllabus and candidates should be advised to learn it thoroughly.

(iii) This proved to be challenging for candidates across the mark range. The most commonly awarded mark was for identifying that sodium chloride is ionic and/or chlorine is covalent. Candidates could gain a mark by comparing strong attractive forces in sodium chloride with weak intermolecular forces in chlorine. Candidates needed to be careful to specify attractive forces **between** molecules in chlorine and avoid the word *bonds*. Credit was also available for describing the connection between strength of attractive forces and the thermal energy required to separate the particles. A variety of incorrect suggestions was seen including the idea that sodium chloride has a high melting point because it is a compound and chlorine is only an element.

Question 9

(a) A large number of candidates filled in all the missing parts of the electromagnetic spectrum instead of just UV and visible as instructed. The evidence from the answers to this question, however, showed that the EMS had been very well learned.

(b) The use of the relationship *distance = speed x time* was very familiar and large numbers of candidates worked through to the correct final answer **3300(m)**. The most common mistake was to divide the speed by the time.

(c) Many candidates were familiar with the relationship $Q = I \times t$ and correctly applied it to obtain the final answer **1.5 coulombs**. The most common mistakes were to divide the current by the time and to state incorrect units, usually either J or W.

(d) (i) The idea that the static charge is the result of electron transfer was very unfamiliar and this mark was infrequently awarded. A very wide variety of incorrect suggestions was seen, some of which had nothing to do with electricity.

(ii) The context of this question was new and both of the parts were marked together. Quite a few candidates obtained one mark for realising that a person's hair becomes electrically charged. Answers such as *this is all due to static* were not detailed enough.

COMBINED SCIENCE

Paper 0653/43
Extended Theory

Key messages

Candidates should always read the question carefully. Questions where this was especially important were **2(a)**, knowledge of the formula of methanol, **3(c)(i)**, only calculating the distance between 0s and 150s, and **7(a)(iii)**, focusing the answer on the transfer of energy from the milk to the bottle and then through the glass bottle. Some candidates did not gain credit because they were not responding to the question as it was written.

Candidates must be thoroughly familiar with the syllabus, including recent changes.

General comments

There were some excellent scripts from candidates who demonstrated sound knowledge of the syllabus across the three science disciplines. These candidates demonstrated good examination technique.

Most candidates scored well in straightforward recall questions. Others were less successful in responding to questions set in an unfamiliar situation. These questions require the application of scientific knowledge and understanding in a new context.

Candidates made sensible use of the space provided for their responses on the paper, and there was no evidence that they ran out of time.

It is recommended that this report is read in conjunction with the examination paper and the published mark scheme.

Comments on specific questions

Question 1

(a) (i) Some candidates correctly identified process **X**, fossilisation. Unacceptable responses included death and decay, processes which occur at a much faster rate. Fossilisation takes place over millions of years.

Most candidates identified **Y**, the process of animals eating green plants. Digestion was seen on several scripts. This response was not awarded credit because digestion takes place within the animal after the transfer of chemical energy by eating.

(ii) The majority of candidates stated the correct answer, green plants.

(iii) A few candidates wrote the correct answer, starch. Glucose was the most frequently-seen incorrect answer. Although glucose contains carbon, and is the product of photosynthesis, it is converted into starch for the storage of energy.

(b) There were some excellent responses to this question showing that candidates understood that removal of trees reduces the production of oxygen by photosynthesis. Fewer responses explained that the chemical reaction of combustion uses up oxygen when the trees are burnt. Both of these factors contribute to the reduction of oxygen in the atmosphere.

Question 2

(a) (i) Most candidates gained full credit in this question, either by stating that there is oxygen present or by explaining that the molecule does not only contain hydrogen and carbon. Candidates are reminded that the OH group is not ionic and therefore cannot be described as a hydroxide group.

(ii) There were some excellent dot-and-cross diagrams drawn by the higher-scoring candidates. Some candidates did the bonding correctly but omitted the lone pairs of electrons in the oxygen atom. Some responses by lower-scoring candidates did not add any extra atoms to the three on the question paper. The formula is stated at the beginning of the question.

(b) (i) Most candidates wrote global warming as their response and gained credit. The **enhanced** greenhouse effect and specific consequences of global warming were accepted, but responses referring to acid rain or the ozone layer were not credited.

(ii) The balanced symbol equation was written correctly by the higher-scoring candidates. Only partial credit was given when the balancing was either incorrect or missing. Other candidates omitted the oxygen as a reactant, or gave a word equation.

Question 3

(a) (i) Candidates of all abilities found this question challenging. The eye has to be close to the magnifying glass to obtain a clear magnified image.

(ii) A minority of candidates stated correctly that a virtual image cannot be formed on a screen, unlike a real image.

(b) The correct words were written in the spaces by the majority of candidates. The most frequently-seen incorrect answer was frequency instead of amplitude in the second sentence.

(c) (i) Many candidates obtained the distance correctly by calculating the required area under the graph. Other candidates attempted to calculate the whole area. A common error was seen in the calculation for the distance covered in the first 10 seconds of the journey: candidates used the calculation 10×0.8 but then omitted to divide it by 2. When added to the area of the rectangle for the rest of the distance, this gave a total of 120 m. The correct answer was **116 m**.

(ii) Many higher-scoring candidates identified the different shapes of the graph as periods of constant and non-constant acceleration. Some candidates used the word speed instead of rate, e.g. ‘Between 0 and 10 seconds the girl is accelerating at a constant speed’. Another common error was when candidates just stated that the girl was speeding up during the first 10 seconds, and slowing down during the last 30 seconds, with no further descriptions of the rates of acceleration and deceleration.

(d) Most candidates gained full credit in this question. The correct answer was **20 000 J**.

Question 4

(a) The definition of an enzyme was known by many candidates. Candidates should be aware that enzymes are **biological** catalysts and also that they are **proteins**. These properties distinguish enzymes from other catalysts, for example heavy metals in chemical processes.

(b) (i) The boxes were matched successfully by the majority of candidates, who demonstrated their knowledge of chemical digestion.

(ii) One area where protease is secreted was widely known. The most common incorrect answer was the large intestine. Candidates are reminded that the main function of the large intestine is to absorb water.

(c) There were some excellent responses to this question, showing a good understanding of the effect of high temperatures on the activity of enzymes. Some lower-scoring candidates described the effect of increasing temperature in terms of more frequent collisions resulting in a faster rate of reaction, instead of realising that the temperature of 70 °C is a lot higher than body temperature and the digestive enzyme will be denatured.

(d) The functions of hydrochloric acid in the stomach were known by most candidates. These were, as described by the specification, to provide a suitable pH for enzymes and to kill bacteria. Therefore, responses referring to dissolving food, or breaking food into small pieces did not gain credit. The phrase ‘to get rid of bacteria’ was not accepted; the bacteria would still be present, but dead.

Question 5

(a) (i) The majority of candidates answered this question correctly, giving the answer 8. The most frequently-seen incorrect answer was 18. This is the number of elements in period 4.

(ii) The decreasing metallic character of elements from left to right across the period was well answered by most candidates.

(b) (i) Most candidates gave a correct description of the bleaching action of damp litmus paper by chlorine. Other candidates just described a colour change to red but then did not continue to say that the colour is bleached, so credit was lost by them. A few candidates gave the chemical test for a chloride. This response did not gain credit.

(ii) The killing of bacteria by chlorine was known by the majority of candidates.

(c) This question addressed displacement reactions of halogens. Many candidates did not know the colour change during the reaction. Aqueous potassium bromide is colourless, and when chlorine gas is bubbled through, there is a colour change to orange as bromine is released. Many candidates knew that a displacement reaction had taken place but their explanation confused bromine with bromide. Statements such as ‘chlorine is more reactive than bromide’ and ‘the chlorine displaces the bromide’ were not awarded credit. Candidates should be aware that the element is bromine and the salt in the ionic compound is a bromide.

(d)(i) The majority of candidates gave the correct answer, the anode.

(ii) A chloride ion is negatively charged because it has gained an electron when the ionic compound was originally formed. Therefore, the electron has to be removed to obtain the element. This is done at the anode, where one electron per ion is lost. Many candidates stated that one electron is lost and therefore gained full credit. Some candidates did not state the number of electrons lost, and a few candidates stated that electrons were gained by the chloride ions.

(iii) The name of the metal, potassium, was given by most candidates.

Question 6

(a)(i) The diagram was interpreted correctly by many candidates who identified the two separate destinations of blood after leaving the heart. Some candidates stated that the human circulation is a double circulation because the blood goes through the heart twice. This statement was not given credit unless it was made clear that the blood goes through the heart twice for every full circulation of the body.

(ii) The responses in this question had to be comparative. An example of an acceptable answer is 'There is more carbon dioxide in **P** than in **Q**', whereas '**P** contains carbon dioxide' is not accepted. There is no information about the amount of carbon dioxide in **Q**.

(b)(i) The majority of candidates stated the correct answer, the phloem. Incorrect answers included xylem or, in a few cases, phylem.

(ii) The need for food resources to travel to the roots, which cannot photosynthesise, was well explained by candidates of all abilities.

(iii) The higher-scoring candidates did well in this question. They provided good explanations about the decrease in concentration gradient of water vapour between the inside and the outside of the leaf. Some candidates confused humidity with temperature. Other candidates incorrectly attributed the decrease in transpiration rate to the closing of the stomata.

(iv) Most candidates correctly stated one other function of xylem, support. Those responses which referred to conducting water or minerals through the plant were excluded by the introduction to the question, so they were not awarded credit.

Question 7

(a)(i) The higher-scoring candidates gave accurate descriptions of the process of evaporation of water molecules and how this results in the temperature of the cooler decreasing. It was important that the (kinetic) energy of the water molecules was discussed.

(ii) This question was challenging for all candidates. Responses had to take into account the collisions between the molecules of the surrounding air and the increased transfer of their kinetic energy to the molecules of water on the cooler.

(iii) The kinetic energy had to be transferred from the milk to the glass bottle by collision of milk molecules with glass molecules, and then the energy is conducted through the glass by passing vibrations from molecule to molecule. Some candidates described conduction of heat through the milk towards the bottle rather than conduction through the bottle.

(b) Higher-scoring candidates interpreted the information and used the equation $P = I V$ to calculate the current in the freezer both during the day and during the night. They then had to say which fuse was suitable to use at these times. Some candidates omitted to say this. Lower-scoring candidates were not familiar with the equation and its application.

Answers: daytime current **7.5 A needs a 10 A fuse**, night-time current **0.33 A needs a 1 A fuse.**

Question 8

(a) (i) Candidates who did well in this question explained that the closer proximity of the acid particles would make collisions between the acid particles and magnesium atoms more likely.

(ii) The vast majority of candidates identified either the temperature or the surface area of the magnesium as variables that would affect the rate of the reaction. To gain credit the candidate had to indicate how the variable would be changed. Therefore, an increase of temperature or the surface area of magnesium were acceptable. Just mention of the variables alone was not sufficient to gain credit.

(iii) Candidates across all ability ranges found this question challenging. The main point that candidates had to make was that the amount of energy required to break the bonds of the reactants was less than the amount of energy given out when the bonds of the products are formed. The excess energy is then released as heat. Many candidates stated incorrectly that energy is given out when bonds break.

(b) Most candidates answered this question correctly, making reference to the fact that magnesium is more reactive than carbon so cannot be used in the blast furnace.

Question 9

(a) The higher-scoring candidates interpreted the information to complete the circuit diagram correctly. Candidates are reminded that the correct circuit symbols should be used in responses: lamps cannot have a connecting wire running through, and open switches must have a space visible.

(b) There were two methods of calculating this answer. The sum of the two current values gives the total current in the main circuit, 3 A. The total voltage across the parallel circuit is $8 \times 1.5 = 12$ V. Therefore, an Ohm's Law calculation gives the **total resistance of 4 Ω.**

The other method is to calculate the resistance of each bulb individually using the 12 V and the current flowing through them. Then the use of $1/R_t = 1/R_1 + 1/R_2$ produces the same answer.

A common error seen in these calculations was failure to invert the answer at the end of the calculation.

Some candidates used 1.5 V in their calculation instead of 12 V.

COMBINED SCIENCE

Paper 0653/51
Practical Test

Key messages

When describing observations, candidates need to make a positive observation with sufficient detail: for example, writing 'no change' is insufficient for the observation 'colourless solution'.

In the planning question, candidates need to address all areas of the task to gain full marks. Candidates should be guided by the bulleted list included in the task. Candidates should take care to avoid vague phrases such as 'measure the *amount* of' and instead specify the quantities they will measure such as *mass* or *volume*.

Candidates need to read questions and follow instructions carefully; for example, candidates are often asked to record a measurement to a specific number of significant figures, or they may be given a notice in the question stem that a graph scale does not need to start at zero.

Graphs appear on all practical papers. Candidates need to:

- choose scales so that their plots occupy more than half the available grid
- ensure that axes are labelled with units
- plot points neatly and carefully
- draw smooth, single lines of best fit with an even spread of data points above and below the line.

General comments

Most candidates had a positive approach to the Practical Paper, carried out the experiments carefully, and attempted all the questions. A significant minority of candidates made no attempt at the planning question, **Question 3**.

Where candidates have difficulty in completing a practical task, they should be encouraged to continue with the rest of the question: subsequent parts of the question may not depend upon the earlier practical task and marks can still be gained.

Comments on specific questions

Question 1

(a) (i) Candidates were asked to calculate the final percentage concentration of salt solution in test-tube **B**. They needed to realise that if a volume of salt solution is mixed with an equal volume of water, the percentage concentration of the salt solution halves. Many candidates correctly calculated the value as 7.5 per cent or rounded to the nearest whole number 8, with both of these answers gaining credit. Rounding the answer down to 7 per cent was incorrect and did not gain credit.

(ii) Three marks were available for the results in Table 1.1. Almost all candidates gained credit for recording the time taken for the X to become visible in all four test-tubes. A good number of candidates gained credit for following the instruction to record their times in whole seconds.

(iii) Candidates were asked to explain why the recorded time was an estimate. There was evidence that some candidates found this difficult to express, but a good number managed to convey the idea that judging the end point is difficult to do or subjective. Another acceptable answer was recognising that pepsin had been added at different times to each test-tube and the stopwatch started only after the last addition. An answer that only stated 'human error' was too imprecise to gain credit here.

(iv) Candidates were asked to use their results to place the test-tubes in order of fastest-to-clear to slowest-to-clear and almost all candidates were able to do this correctly using their own data from Table 1.1.

(v) Many candidates recognised that the test-tube without pepsin (**D**) was included as a control to see whether it was the pepsin in the other test-tubes that caused the milk to clear. Some responses stated that it was to see whether salt solution had an effect alone. As both **C** and **D** contain no salt solution, this is incorrect.

(vi) Candidates could gain credit here by recognising that a water-bath maintained the test-tubes at a constant temperature or suggesting that use of the water-bath provided the optimum temperature for enzyme activity. Most candidates gained credit with one of these answers. 'To control the temperature' was accepted as a weaker expression of maintaining the same temperature. Answers that simply stated 'to heat the test-tubes' or 'so that the enzymes react' were insufficient because the enzymes will react without the water-bath and there are other ways of heating test-tubes that do not control the final temperature.

(b) In this part of the question, candidates were expected to look back at their results, identify which result gave the shortest time (the peak value), and then suggest percentage concentrations of salt solution above and below that peak value. This proved challenging, with only a few candidates gaining full credit. A number of candidates did suggest at least one suitable additional value of percentage salt concentration. The question specifically asked for additional values and so answers that only stated 'use more concentrated salt solution' were too vague to gain credit.

(c) In this last part of the question, a good number of candidates were able to recall that Biuret reagent is used to test for protein and gives a lilac/purple positive result.

Question 2

(a) (i) Candidates were asked to test two unknown chemicals, **E** and **F**, with universal indicator and record the pH of each solution. Almost all candidates identified **F** as an alkali with a pH of 12–14. Most candidates identified **E** as an acid with a pH of 1 or 2. A small number of candidates incorrectly identified **E** as having pH 11 or 12, perhaps by testing **F** first and then using a contaminated glass rod.

(ii) A good number of candidates correctly described the test with a lighted splint which gives a 'pop' in the presence of hydrogen. Some responses only stated 'the pop test' which was insufficient on its own. A few candidates wrote about testing with a glowing splint, confusing the hydrogen test with the test for oxygen gas.

(iii) Almost all candidates correctly observed a white precipitate when dilute nitric acid and then aqueous barium nitrate were added to solution **E**. Answers to the second observation (dilute nitric acid followed by aqueous silver nitrate added to **E**) were less precise, with a number of candidates choosing to state 'no change' rather than the observation that it 'produces a colourless solution'. An alternative observation for this second test was to state that 'no precipitate is formed'.

(b) Only a few candidates combined the results of the tests in **(a)(i)** and **(a)(iii)** to conclude that **E** was sulfuric acid. Credit was also given for recognising that **E** must contain a sulfate as this showed the correct interpretation of the test in **(a)(iii)**.

Question 3

This question produced a wide range of answers from candidates, with a good number giving detailed plans that gained most or all of the marks. The best responses used the bullet points in the question to structure the plan. A significant minority of candidates made no attempt to answer this question.

The main reason candidates scored lower marks in this question was for omission of some aspect of the question. Details of how to compare results were frequently missing, and planned measurements were often too vague to gain credit. The other reason for lower marks was choosing the wrong technique. Distilling the water suggested candidates thought it was important to collect the *water* rather than the salt. Not filtering the water before evaporating meant that both soluble and insoluble salts would be measured.

Apparatus

Many candidates gained multiple marks in this section, with most naming a suitable container for the sea water, and a Bunsen burner or other appropriate device for heating. Use of weighing scales or a measuring cylinder both gained additional marks here. Mention of both a filter funnel and filter paper was required for a mark. Candidates often gained apparatus marks from labelled diagrams.

Method

A good number of candidates gained credit here, with most realising that they needed to heat the water so that it would evaporate. A number of responses omitted the step of filtering the sea water to remove any insoluble salts before heating. A very small number of candidates mistakenly planned to measure the insoluble salts, and so they filtered the sea water but did not evaporate the filtrate.

Candidates needed to explain how a safety precaution was relevant to this specific plan and connect the precaution to the hazard. Answers such as ‘wear goggles’ were too vague. Candidates who wrote ‘wear goggles to stop sea water going in eyes’ or ‘use gloves to handle hot apparatus’ did gain credit.

Measurements and control

Candidates needed to be specific about the measurements: ‘measure the *mass* of salts’ or ‘measure the *volume* of water’ gained credit, but ‘measure the *amount* of…’ was too vague. Multiple marks were gained by candidates who explained clearly how to measure the mass of dissolved salts by first weighing the empty container and then weighing the same container with the salts left after evaporating the water. Many candidates gained credit for stating that the same volume of each type of sea water must be used.

Processing and use of results

This was the section where candidates found it hardest to gain credit. They needed to compare the *mass* of salts extracted in the different samples and clearly state this. Candidates who suggested repeating each experiment multiple times gained credit if they then planned to calculate the average mass of salts from each type of sea water.

Question 4

(a) (i) The vast majority of candidates were able to gain this mark for recording a temperature to two significant figures.

(ii) Almost all candidates recorded all the temperature readings for the cup with the lid. A few candidates did not wait for the thermometer to stop rising as instructed in the question and so did not have the pattern of temperature decreasing with time for full credit.

(b) (i) Candidates were awarded marks here for the care with which they undertook the experiment, so the first mark was for having starting temperatures above 60 °C, and the second mark was awarded for temperatures which showed a greater decrease in temperature for the cup without a lid. A good number of candidates were able to gain both these marks.

(ii) This mark was only gained by a minority of candidates. Common errors were to record the symbol as C^0 or to record a numerical value of temperature, with or without the unit.

(c) A total of 5 marks was available for drawing the graph in this part.

Axes
Most candidates were able to plot the axes correctly with temperature on the vertical axis. A number incorrectly recorded the unit of time as 's' instead of 'min'; 'm' was not accepted for minutes as this is the abbreviation for metres.

Scales
Candidates needed to choose scales that allowed their plots to occupy a minimum of half the grid provided in each direction. The question advised candidates that they did not need to start the vertical axis at zero. However, many candidates did choose to begin temperature at zero which meant that the plotted points occupied only a small proportion of the grid.

Plots
Candidates needed to use small neat plots, either an 'x' or a small dot. Large blobs that filled a whole small square were not accurate enough to gain credit. Most candidates plotted enough points neatly and correctly to gain this mark.

Smooth best-fit lines/curves
Candidates were given credit for either best-fit straight lines or curves. When drawing a best-fit straight line, candidates should take care to ensure that there is an equal spread of points on either side of the line. A line that has all the points to one side is not the best-fit straight line. For those candidates who chose to draw a curve, it was important that the curve was a smooth, neat, single line rather than several, feathered lines.

Labels
The last mark on the graph was gained by the majority of candidates, who clearly indicated which line was for each cup in the experiment. A few candidates used different colours or symbols for the different cups but did not provide any key to identify which plots belonged to which cup.

(d) Candidates were asked here for one similarity and one difference in the way that the temperature *changed* with time in the two experiments. Many candidates gained credit for recognising that in both experiments the temperature decreased with time. A few candidates did not gain credit because they talked about the cups having the same starting or finishing temperature, which is not a *change*. A good number of candidates used either the table or their graph to explain that the cup without the lid had a faster decrease in temperature than the cup with a lid.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

- It is recommended that candidates read through the whole question first before starting to answer.
- Candidates should make sure their answer is in the units that the question asks for.
- The drawing of a biological specimen is a skill that candidates should practise during their course. Outlines of specimens should be clear and continuous, not feathery or broken, with any internal detail taken into account. Shading is not required.
- The planning question is a completely separate, stand-alone question and is not related to any of the other questions on the paper.
- Candidates can expect to draw a graph. They therefore need to be able to select a suitable linear scale with axes the correct way around.
- Centres are reminded that candidates should be familiar with any investigations and mathematical requirements referred to on the syllabus. Many investigations can still be demonstrated by the teacher or via video clips if centres are not able to set up the practical equipment.

General comments

Candidates showed a positive approach to the paper with **Question 1** generally being fully answered. **Questions 2** and **3** were the most challenging but candidates showed they had time to answer **Question 4**.

Comments on specific questions

Question 1

(a) (b) Candidates were able to provide thermometer readings to the same number of decimal places within the table.

(c) (i) A common mistake was not having the values totalling the initial 10 cm^3 measured.

(ii) Some candidates averaged the rows rather than the column for volume of iodine solution *added*.

(d) Candidates who carried out the task correctly with fruit juice **A** were able to reproduce this with fruit juice **B**.

(e) Some candidates did not read the question carefully enough and responded about how much iodine was added, or referred to starch rather than the relative concentrations of vitamin C. Those that commented on the relative concentrations were nearly always able to gain the mark.

(f) (i) Many candidates were able to calculate the correct concentration and give their answer to the correct number of significant figures to score both marks. Candidates that did the calculation incorrectly were still able to gain a mark for the correct number of significant figures.

(ii) Many candidates were able to identify the use of a burette. A number of candidates talked about DCPIP or doing more repeats without further qualification, which did not gain credit.

(g) Nearly all candidates were able to give a full circle shape which was larger than the picture, with just occasionally only a segment of the orange being drawn. Many candidates showed attention to detail by having the correct number of segments and an indication of the pith between the segments. Some omitted one or both of these so did not gain full marks.

Question 2

(a) (i) Candidates were generally able to describe the correct colour of the powders.

(ii) (iii) Most candidates were able to correctly describe a positive result for carbon dioxide and then link that to the identification of a carbonate as a result.

(b) (i) Many candidates were not able to get both parts correct to gain the mark.

(ii) A range of colours was seen, with some candidates demonstrating correct performance of a flame test.

(iii) Candidates were able to refer to the notes on qualitative analysis and convert a correct flame test observation to identify copper as the cation.

Question 3

Candidates found this a challenging question. Candidates should use the bullet points in the question to help structure their answer. To gain full marks, candidates need to score at least one mark from each section.

Candidates that produced clear, labelled diagrams could easily get at least 2 apparatus marks and 1 method mark straight away. A number of candidates incorrectly tried to seal a beaker with a bung.

A common error in the method was to use a fixed period of time and then attempt to calculate a rate of gas loss, and to suggest that the fizzy drink that was quickest to lose carbon dioxide gas contained the least volume of gas, rather than heating or leaving until all the carbon dioxide gas was lost. Only a few responses stated the need to measure the volume of gas produced. Some candidates used the loss-of-mass method, which was credited, while others suggested that the volume of the fizzy drink would reduce when the drink went flat, which was not correct.

Many candidates stated they would use the same volume or amount of fizzy drink to gain a control mark.

Bubbling the gas into limewater was commonly seen. This would not give a comparison, only a qualitative confirmation that carbon dioxide was present, which was already confirmed in the question. A quantitative method was needed by collecting and measuring the volume of the gas evolved to provide data to support a conclusion.

Candidates found stating how they would process the results the most challenging part of the question, and responses often failed to explain how the volume of gas collected or the reduction in mass supported the conclusion given.

Question 4

(a) (i) (ii) Many candidates were able to measure the time for 10 oscillations and routinely matched the number of decimal places in their answers.

(iii) Candidates could generally change the pendulum length to obtain a full set of results.

(iv) Only a few candidates grasped the idea that the oscillations needed to be timed from a set point, the most obvious point being as the pendulum passes directly in front of the retort stand.

(v) Candidates found this a challenging idea to grasp and describe. Few were able to link this to the human error in recording oscillations, particularly for a single oscillation, which they could see from their results was only about 1 or 2 seconds. This meant most candidates were then unable to go on to explain how this would be an improvement by reducing the uncertainty or spreading it over more oscillations.

(vi) Candidates found this part challenging. The question explained that the period was the time for one complete oscillation and so in fact only a simple calculation was required to determine this from their time for 10 oscillations.

(vii) Candidates who were able to calculate the period in **(vi)** were usually able to square their answer to gain the mark here.

(b) (i) Some candidates did not have a linear scale from zero, with 0 –20–25–30 sometimes seen. A number of candidates chose a scale that was too small for the grid provided. Candidates with a correct set of axes were able to demonstrate correct plotting.

(ii) Most candidates did not recognise the proportional relationship and only stated that the longer the pendulum, the longer T^2 was.

COMBINED SCIENCE

Paper 0653/53
Practical Test

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A good number of candidates gained credit here, with most realising that they needed to heat the water so that it would evaporate. A number of responses omitted the step of filtering the sea water to remove any insoluble salts before heating. A very small number of candidates mistakenly planned to measure the insoluble salts, and so they filtered the sea water but did not evaporate the filtrate.

Candidates needed to explain how a safety precaution was relevant to this specific plan and connect the precaution to the hazard. Answers such as ‘wear goggles’ were too vague. Candidates who wrote ‘wear goggles to stop sea water going in eyes’ or ‘use gloves to handle hot apparatus’ did gain credit.

Measurements and control

Candidates needed to be specific about the measurements: ‘measure the *mass* of salts’ or ‘measure the *volume* of water’ gained credit, but ‘measure the *amount* of…’ was too vague. Multiple marks were gained by candidates who explained clearly how to measure the mass of dissolved salts by first weighing the empty container and then weighing the same container with the salts left after evaporating the water. Many candidates gained credit for stating that the same volume of each type of sea water must be used.

Processing and use of results

This was the section where candidates found it hardest to gain credit. They needed to compare the *mass* of salts extracted in the different samples and clearly state this. Candidates who suggested repeating each experiment multiple times gained credit if they then planned to calculate the average mass of salts from each type of sea water.

Question 4

(a) (i) The vast majority of candidates were able to gain this mark for recording a temperature to two significant figures.

(ii) Almost all candidates recorded all the temperature readings for the cup with the lid. A few candidates did not wait for the thermometer to stop rising as instructed in the question and so did not have the pattern of temperature decreasing with time for full credit.

(b) (i) Candidates were awarded marks here for the care with which they undertook the experiment, so the first mark was for having starting temperatures above 60 °C, and the second mark was awarded for temperatures which showed a greater decrease in temperature for the cup without a lid. A good number of candidates were able to gain both these marks.

(ii) This mark was only gained by a minority of candidates. Common errors were to record the symbol as C^0 or to record a numerical value of temperature, with or without the unit.

(c) A total of 5 marks was available for drawing the graph in this part.

Axes
Most candidates were able to plot the axes correctly with temperature on the vertical axis. A number incorrectly recorded the unit of time as 's' instead of 'min'; 'm' was not accepted for minutes as this is the abbreviation for metres.

Scales
Candidates needed to choose scales that allowed their plots to occupy a minimum of half the grid provided in each direction. The question advised candidates that they did not need to start the vertical axis at zero. However, many candidates did choose to begin temperature at zero which meant that the plotted points occupied only a small proportion of the grid.

Plots
Candidates needed to use small neat plots, either an 'x' or a small dot. Large blobs that filled a whole small square were not accurate enough to gain credit. Most candidates plotted enough points neatly and correctly to gain this mark.

Smooth best-fit lines/curves
Candidates were given credit for either best-fit straight lines or curves. When drawing a best-fit straight line, candidates should take care to ensure that there is an equal spread of points on either side of the line. A line that has all the points to one side is not the best-fit straight line. For those candidates who chose to draw a curve, it was important that the curve was a smooth, neat, single line rather than several, feathered lines.

Labels
The last mark on the graph was gained by the majority of candidates, who clearly indicated which line was for each cup in the experiment. A few candidates used different colours or symbols for the different cups but did not provide any key to identify which plots belonged to which cup.

(d) Candidates were asked here for one similarity and one difference in the way that the temperature *changed* with time in the two experiments. Many candidates gained credit for recognising that in both experiments the temperature decreased with time. A few candidates did not gain credit because they talked about the cups having the same starting or finishing temperature, which is not a *change*. A good number of candidates used either the table or their graph to explain that the cup without the lid had a faster decrease in temperature than the cup with a lid.

COMBINED SCIENCE

Paper 0653/61
Alternative to Practical

Key messages

- Candidates need to be able to draw simple set-ups for common laboratory techniques such as testing a reaction mixture with limewater, filtration and evaporation. Diagrams need to be clear, with apparatus shown sealed or open as necessary, and without additional bungs or outlets. Diagrams should be labelled to show the most important pieces of apparatus.
- The practical paper, Paper 5, provides analysis notes at the back of the paper. These are not available to candidates during the examination for Paper 6. However, they are useful for revision and during learning. It is suggested that these are provided to candidates before the examination and it is recommended that candidates learn the tests and results for the ions and gases listed in the syllabus and on these notes. **Question 2** of this paper showed that some candidates could not recall the main tests and their results.
- When candidates are asked to add values to a table, they need to judge the required 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. These will either 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 half the smallest graduation shown. This may require the use of a zero, such as the answer of 78.0 to question **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. Candidates should take care to avoid vague phrases such as 'measure *amount* of' and instead specify the quantities they will measure such as *mass* or *volume*.
- Graphs appear on all practical papers. Candidates need to choose scales to occupy more than half the grid, ensure that axes are labelled with units, plot points carefully, and draw considered, finely drawn lines of best fit. Candidates also need to follow instructions relating to labelling lines or drawing interpolation lines to show how they have read values from the graph.

General comments

Candidates generally showed a positive approach to the Alternative to Practical Paper. Most questions were fully answered. The most omissions and gaps were seen in **Question 2**.

Comments on specific questions

Question 1

(a) (i) Candidates found this question difficult, perhaps because only one concentration was 'modelled' in the table. Many candidates left this part blank.

(ii) Almost all candidates correctly recorded the times in seconds for test-tubes **A** and **B**. The conversion of minutes to seconds was more difficult, but most recorded **C** correctly as 120 s, rather than 2 minutes. Many candidates knew the mathematical symbol for 'greater than' and gave a correct reading of >300 for the last box. A common unnecessary addition was to include units in the body of the table. If the column heading includes units, they are not needed next to numbers.

(iii) Almost all candidates correctly interpreted the table to give a correct order of rate of clearing for the milk. An error carried forward was applied for candidates who had entered incorrect times in their table.

(iv) Most candidates gave the correct response that **D** was a control or was required to see if water alone had an effect on the milk. Some incorrect responses stated that **D** was to see whether salt solution alone had an effect; however, both **C** and **D** contained no salt solution.

(v) A range of answers was accepted, including ideas about maintaining a constant temperature or to provide an appropriate temperature for the enzyme. Some candidates stated that a water-bath 'heats up the test-tubes'. This alone was not accepted, as there are many other methods of heating the test-tubes. The use of the water bath specifically controls the final temperature, which other methods do not.

(b) The question asked about *percentages*. It was relatively common to see that candidates had included *volumes* of salt solution instead, leading to answers such as 3 and 4 cm^3. The main idea tested here was that the rate of milk-clearing is fastest at 7.5 per cent (**B**) and so, to increase accuracy, values close to and either side of this value would need to be tested. This idea was very challenging. Values between 0 and 15 per cent were not often given. More commonly, candidates listed only values much higher than 15 per cent, which would extend the range tested but would not increase the accuracy of the outcome of the experiment.

(c) Some candidates knew the Biuret test. Some knew the positive and negative test results relating to colour. However, few knew all three. Phonetic spelling such as 'burets' was accepted. The correct colour change for incorrect reagents was also accepted, as candidates could recall the colour change but were unsure about the reagent. A common incorrect choice was Benedict's.

Question 2

(a) (i) Where a question asks for a 'type' of substance, the actual name is not required. This question only needed 'acid' and 'alkali' for (1) mark. Many candidates attempted to name the substances. Some inverted the order.

(ii) Candidates did not generally know how to test a reaction mixture with limewater. Common errors included:

- adding the limewater directly to the reaction mixture in the same test tube
- drawing a delivery tube directly from the liquid in the reaction, with no bung shown
- where a second test tube of limewater was shown, the delivery tube into it was not entering the limewater
- a bung placed at the mouth of the limewater tube (so no gas transfer would occur)
- the delivery tube drawn with an outlet halfway along the tube (commonly seen when testing exhaled gases with limewater).

It was very rare to see a set-up which would give a positive limewater result.

(iii) Most candidates identified 'hydrogen' as the gas. 'Carbon dioxide' was the most common incorrect answer.

(iv) Most of the remaining parts of **Question 2** were either left unanswered or resulted in very few marks for candidates. Candidates could not recall the details of the analysis tests from the syllabus. It is suggested that the analysis notes on the back of Paper 5 are used by candidates in their preparation for Paper 6. Answers given in this part of **Question 2** were usually incorrect. Most answers were not anions. Lists of cations or compounds were often seen.

(v) As this question depended on the answer to the previous one, almost all candidates either left this question blank or gave an incorrect response. Compounds such as ammonia, sodium hydroxide and sodium chloride were all frequently seen.

(b) Again, this question was not often attempted. 'Iron(II)' was the most common incorrect response. The idea that **F** was a test reagent itself (sodium hydroxide or aqueous ammonia) was a difficult idea and most candidates did not realise its identity.

(c) Copper ions, or any other metal ions that give a coloured precipitate, can be used to identify sodium hydroxide or aqueous ammonia. Most suggested using pH paper. This was not awarded a mark. In common with most part questions testing knowledge of the analysis tests, this question was usually left blank.

Question 3

Some common approaches to planning questions are more likely to lead to higher marks. It is recommended that candidates:

- take care to address every bullet point in the question
  Candidates who tick off or cross out aspects of the question as they answer them are more likely to address all aspects of the question. Weaker responses commonly only address one or two aspects of the question, allowing access to only some of the available marks.

- draw a labelled diagram
  Apparatus marks (such as for filter funnel, filter paper, evaporating basin, Bunsen burner) may be earned directly from labels on diagrams. Diagrams without labels are not awarded any credit. Candidates need to practise drawing diagrams for common procedures so that they can draw them clearly, with labels and without errors.

- list apparatus and describe procedures clearly
  It is therefore important that candidates list their apparatus and describe their procedures clearly.

- specify the measurements they will make
  'Measure the *amount* of….' is not given marks. The mark scheme requires that candidates specify 'measure the *volume* of…' or 'measure the *mass* of…'.

- address the results and conclusion bullets.
  Candidates often omitted any description of how they would process their results. It was common to see answers such as 'see which has the biggest amount of salt'. The best responses gave details such as 'Measure the mass of the salt using a balance. The seawater that gives the highest mass reading contains the most salt.'

Responses gaining higher marks typically listed apparatus, provided labelled diagrams, discussed the measurements to be made, stated how to control the volumes of water, and gave a clear outline of how the final masses of solid salts would be measured and compared to identify which seawater initially contained the most salt. Strong responses also described specific safety precautions in the context of the task such as 'wear goggles to prevent any salt spitting out during evaporation from getting into your eye'.

The main reason for lower marks was omission of some aspect of the question. However, some common errors included:

- errors in diagrams such as filter funnels without filter paper or diagrams without labels
- presenting techniques in the wrong sequence such as evaporating the water without removing the insoluble particles by filtration first or filtering after heating
- choice of inappropriate techniques and apparatus such as distillation apparatus - distillation implied that candidates had not understood that it was important to collect the salt, rather than the water, at the end of the process
- giving a technique to measure rate of water loss such as by measuring mass lost over a short time interval such as 2 minutes, rather than evaporation of *all* the water
- stating vague safety precautions such as 'wear goggles and gloves' which were not related to the specific safety issues.

Question 4

(a) (i) Most, but not all, candidates correctly judged the decimal places to give 78.0 as the temperature.

(ii) Candidates appeared to misunderstand what was needed. Although most gave °C as the correct unit in the table, many attempted to write numerical values in this box.

(iii) The correct answer, 65.5, was usually given.

(iv) Line-of-sight readings was given as the correct answer by many candidates. Other acceptable answers were seen such as ensuring the bulb of the thermometer was centred in the liquid. However, many candidates stated, 'repeat it' or 'repeat it and take an average'. These answers were not accepted. When asked how to use a piece of apparatus, candidates need to choose a precaution specific to the piece of apparatus.

(b) (i) This question was challenging because two sets of values needed to be entered on a single graph scale. The question also required candidates to choose a suitable scale for their graph. It is important that the scale is chosen so that the points plotted (in this case ranging from 65.5 to 78.0) occupy more than half the available vertical space. Many graphs with inappropriately small scales were seen. It is not necessary to start every graph at zero. Some candidates presented axes with non-linear scales.

Axes must be labelled with correct units. Many responses omitted labels, omitted units or gave incorrect units (m for minutes was not accepted, as this is the SI abbreviation for metres).

Most candidates plotted enough points correctly to be given (1) mark for plotting.

(ii) The instructions were to draw separate lines of best fit and to label these lines. It was relatively common that candidates did not label the lines. A line of best fit may also be drawn as a curve where appropriate. In drawing a line, candidates need to use a single, fine line, without any feathering, gaps or doubled areas. Candidates should consider the line of best fit carefully so that, if all values do not exactly fit on the line, a similar number occur on either side.

(c) (i) The question asked about temperature *changes*. The best responses stated that both experiments showed a decrease in temperature but the cup without the lid showed a faster decrease. Responses that stated 'they both start at 78.0' did not describe a temperature *change*.

(ii) This is another common question type. Most candidates were able to give a correct reading, although some chose the incorrect line (the question asked for the temperature with a lid). However, the instruction to 'show on your graph how you arrived at your answer' was often ignored. The best responses displayed clear interpolation, with lines drawn from the time axis to the plotted graph and then from the plotted graph to the temperature axis.

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Paper 0653/62
Alternative to Practical

Key messages

- The analysis notes provided to candidates for the practical paper, paper 5, are not provided to candidates for paper 6. These are a very useful source of information for preparation for paper 6 and it is recommended they are used during teaching and for revision. **Question 2** scores could have been improved by candidates being able to recall the information for basic tests.
- It is recommended that candidates read through the whole question first before starting.
- Candidates should make sure their answer is in the units that the question asks for.
- The drawing of apparatus or a biological specimen is a skill that candidates should practise during their course. There was a drawing of a specimen for **Question 1** and apparatus for **Question 2**. Outlines of specimens should be clear and continuous, not feathery, and any internal detail taken into account. Shading is not required. Apparatus diagrams should use a ruler where appropriate and be labelled with the main parts and any chemicals.
- The planning question is a completely separate stand-alone question and is not related to any of the other questions on the paper.
- Candidates can expect to draw a graph. They therefore need to be able to select a suitable linear scale which allows a big enough graph with the axes the correct way round.
- Centres are reminded that candidates should be familiar with any investigations referred to on the syllabus. Many can still be demonstrated by the teacher or via video clips if centres are not able to set up the practical equipment.

General comments

Candidates showed a positive approach to the paper with **Question 1** generally being fully answered. **Questions 2** and **3** were the most challenging but candidates showed they had time to carry on and answer **Question 4**.

Comments on specific questions

Question 1

(a) (i) (ii) Most candidates were able to provide thermometer readings to the correct number of decimal places.

(iii) Some candidates averaged the rows and not the column for the volume of iodine that was needed.

(b) (i) Nearly all candidates included the outlier to score only 1 mark here.

(c) Quite a few candidates did not read the question carefully enough and talked about how much iodine was added, or referred to starch, rather than the relative concentrations of vitamin C. Those that commented on the relative concentrations were nearly always able to gain the mark.

(d) (i) Many candidates were able to calculate the correct concentration and give their answer to the correct number of significant figures to score both marks. A number of candidates who had done the calculation incorrectly were still able to gain a mark for the correct number of significant figures.

(ii) There was some confusion with burette and biuret. Some candidates merely re-stated measuring cylinder, which was the apparatus originally used in the question.

(e) Nearly all the candidates were able to give a full circle shape which was larger than the picture, with just occasionally only a segment of the orange being drawn. Many candidates showed attention to detail by having the correct number of segments and an indication of the pith between the segments. Some omitted one or both of these and so did not gain full marks.

(f) Many candidates were well prepared and knew the correct testing reagent, although the full range of food testing reagents was seen across the entries.

Question 2

(a) (i) A number of candidates missed the clue that the gas was bubbled through limewater, which requires a delivery tube. Other common mistakes were no bung on the test tube being heated, or the inclusion of a bung on the test-tube containing the limewater. Some did not draw a test-tube despite this being stated in the question.

(ii)(iii) Most candidates were able to identify the gas as carbon dioxide, but many were not able to then link that to the identification of a carbonate as a result.

(b) There was evidence of confusion over the term 'anion', and some candidates had not read through the scenario carefully, giving different responses for **G**, **E** and **F**, some containing both anions and cations. Higher-scoring candidates were able to correctly identify copper.

(c) Copper sulfate was the most commonly correct response. A number of candidates gave copper carbonate rather than copper oxide.

Question 3

Candidates should use the bullet points in the question to help them structure their answer. To gain full marks, candidates need to score at least one mark from each section. Those that gave clear labelled diagrams often gained at least 2 apparatus marks and 1 method mark for this. A number of candidates incorrectly tried to seal a beaker with a bung. A common error in the method was to use a set time and then to try to calculate a rate or suggest the quickest drink to lose the gas contained the least, rather than heating or leaving until all the gas was gone. Only a few stated measuring the volume of gas produced. Some candidates used a mass-loss method, which was credited, while others suggested the volume of the fizzy drink would reduce when the drink went flat, which was not correct.

Many candidates stated they would use the same volume or amount of fizzy drink to gain a control mark.

Bubbling the gas into limewater was commonly seen. This would not give a comparison, only a qualitative confirmation that carbon dioxide was present, which was already confirmed in the question. A quantitative method was needed by collecting and measuring the volume of the gas evolved to provide data to support a conclusion.

Candidates found stating how they would process the results the most challenging part and often failed to explain how the volume of gas collected or mass reduction would support their conclusion.

Question 4

(a) (i) (ii) Many candidates were able to correctly measure the length of the pendulum and then multiply this to the correct value from the scale given. Some did not routinely match the decimal places in their answer to those already given in the table.

(b) (i) Most candidates were able to read the stop-clocks and round the figures correctly to match the number of decimal places already used in the table**.**

(ii) Most candidates were able to correctly calculate the average for their two values.

(iii) Candidates could generally calculate these values correctly.

(c) (i) Few candidates grasped the idea that the oscillations needed to be timed from a set point – the most obvious being as the pendulum passes directly in front of the retort stand.

(ii) Candidates found this a challenging idea to understand and describe. A few were able to link this to the human error in recording oscillations, particularly for a single oscillation, which they could see from the table was only about 1 second. However, hardly any were then able to go on to explain this would be an improvement by reducing the percentage uncertainty.

(d) (i) Many candidates did not have a linear scale from zero. Often 0 –20–25–30 was seen. A number chose a scale that was too small for the grid provided. Most candidates were able to demonstrate correct plotting from a correct set of axes.

(ii) Most candidates did not realise it was a proportional relationship, and only stated the longer the pendulum the longer T^2.

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Key messages

- Candidates need to be able to draw simple set-ups for common laboratory techniques such as testing a reaction mixture with limewater, filtration and evaporation. Diagrams need to be clear, with apparatus shown sealed or open as necessary, and without additional bungs or outlets. Diagrams should be labelled to show the most important pieces of apparatus.
- The practical paper, Paper 5, provides analysis notes at the back of the paper. These are not available to candidates during the examination for Paper 6. However, they are useful for revision and during learning. It is suggested that these are provided to candidates before the examination and it is recommended that candidates learn the tests and results for the ions and gases listed in the syllabus and on these notes. **Question 2** of this paper showed that some candidates could not recall the main tests and their results.
- When candidates are asked to add values to a table, they need to judge the required number of significant figures or decimal places based on the other entries in the table.
- 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. Candidates should take care to avoid vague phrases such as 'measure *amount* of' and instead specify the quantities they will measure such as *mass* or *volume*.
- Graphs appear on all practical papers. Candidates need to choose scales to occupy more than half the grid, ensure that axes are labelled with units, plot points carefully, and draw considered, finely drawn lines of best fit.

General comments

Candidates generally showed a positive approach to the Alternative to Practical Paper. Most questions were fully answered. The most omissions and gaps were seen in **Question 2**.

Comments on specific questions

Question 1

(a) (i) Candidates found this question difficult, with few stating that it was important for *all* of the potato tissue to be in contact with the sugar solution.

(ii) Almost all candidates correctly measured the final lengths as 55 and 52 mm.

(iii) Almost all candidates correctly calculated the change in mass as –5 and –8. An error carried forward was applied for candidates who had entered incorrect lengths in their table.

(iv) Most candidates correctly calculated the average change in length to be –6.5.

(v) Most candidates correctly used the equation provided and calculated the percentage change as 18 per cent. The most common mistake was not using the results for 0.1 mol/dm^3 sugar solution.

(b) (i) Many candidates were able to explain clearly that water was entering the potato and increasing its length. A common mistake was to suggest that the sugar was moving. Strong responses further explained why the water was moving, showing good biological knowledge.

(ii) Strong responses again demonstrated good biological knowledge by stating that the *concentrations* of sugar or water were equal inside and outside the potato. The most common error was to suggest that the *amounts* were the same. Candidates should use specific terms and avoid vague words such as 'amount'.

(c) (i) The majority of candidates were able to suggest a sugar concentration of higher than 0.1 mol/dm^3 and lower than 0.3 mol/dm^3.

(ii) Almost all candidates were able to score marks here. The most common error was to omit 'initial' when talking about the diameter or length of the potato, or to suggest that the 'amount' of potato should be kept the same. Strong responses included temperature and time.

(d) Most candidates were able to recall iodine as the test for starch, with many also recalling blue-black as a positive result. A small number of candidates did not score the second mark as they omitted to give the negative result as a colour. These candidates usually responded with 'no change'. Candidates need to be aware of the colours for both positive and negative results. A few candidates confused this test with testing a leaf for starch and included details on how to decolourise a leaf with ethanol before adding iodine to show the presence of starch. Whilst these extra details were ignored in this answer, candidates need to read the question carefully to ensure they are describing the correct procedure in the context of the question.

Question 2

(a) (i) Most candidates were able to correctly describe the test for hydrogen as using a lit splint and observing a resulting popping sound. The most common mistake was to describe use of a glowing splint, which would not ignite the hydrogen gas.

(ii) Few candidates were able to identify both sodium hydroxide and sodium. Candidates were unable to recall the details of the analysis tests from the syllabus. It is suggested that the analysis notes on the back of Paper 5 are used by candidates in their preparation for Paper 6.

(iii) Most candidates gave an incorrect response to this question. A range of ions could have been used as an alternative to identify sodium hydroxide.

(b) (i) Candidates did not generally know how to test a reaction mixture with limewater (solution **H**). Common errors included:

- adding the limewater directly to the reaction mixture in the same test tube
- drawing a delivery tube directly from the liquid in the reaction, with no bung shown
- where a second test tube of limewater was shown, the delivery tube into it was not entering the limewater
- a bung placed at the mouth of the limewater tube (so no gas transfer would occur)
- delivery tubes drawn as a single line rather than as a tube that something could travel through.
- apparatus and chemicals being unlabelled.

It was very rare to see a set-up which would give a positive limewater result.

(ii) Several candidates were able to identify solution **H** as limewater. A few candidates correctly gave calcium hydroxide as their answer, which was also credited. However, the chemical name was often given incorrectly, and candidates are encouraged to use the term 'limewater' in their answers. The most common error was to identify the solution as carbon dioxide.

(iii) Few candidates were able to identify the solid **F** as calcium.

Question 3

Some common approaches to planning questions are more likely to lead to higher marks. It is recommended that candidates:

- take care to address every bullet point in the question
  Candidates who tick off or cross out aspects of the question as they answer them are more likely to address all aspects of the question. Weaker responses commonly only address one or two aspects of the question, allowing access to only some of the available marks.

- draw a labelled diagram
  Apparatus marks (such as for a gas syringe, measuring cylinder and stopwatch) may be earned directly from labels on diagrams. Diagrams without labels are not awarded any credit. Candidates need to practise drawing diagrams for common procedures so that they can draw them clearly, with labels and without errors. A labelled diagram showing the gas being collected over water or into a gas syringe was given credit.

- list apparatus and describe procedures clearly
  It is therefore important that candidates list their apparatus and describe their procedures clearly.

- specify the measurements they will make
  'Measure the *amount* of….' is not given marks. The mark scheme requires that candidates specify 'measure the *volume* of…' or 'measure the *mass* of…'. When measuring a rate, a reading of time should be taken.

- address the results and conclusion bullets.
  Candidates often omitted any description of how they would process their results, for example, by giving unqualified statements such as 'see which was the fastest'.

Responses gaining higher marks typically listed apparatus, provided labelled diagrams, discussed the measurements to be made, stated how to control the volumes of hydrogen peroxide and the mass of the catalyst, timed how long it would take to collect a fixed volume of gas or measured the volume of gas collected in a fixed time, and gave a clear statement that connected the conclusion of best catalyst to the measurements taken. Strong responses also described specific safety precautions in the context of the task such as 'wear goggles to avoid the hydrogen peroxide getting into your eyes'.

The main reason for lower marks was omission of some aspect of the question. However, some common errors included:

- not using a stopwatch to measure time
- using non-specific words such as 'amount' to describe how much hydrogen peroxide to use
- measuring a volume of the solid catalyst
- counting the number of bubbles produced, which is impossible to do due to the speed of the reaction
- timing how long it would take to relight a glowing splint
- stating vague safety precautions such as 'wear goggles and gloves' which were not related to the specific safety issues.

Question 4

(a) Most, but not all, candidates correctly judged the decimal places to give 0.30 (m) as the distance.

(b) The majority of candidates were able to calculate the average force and follow the pattern in the table, giving 0.77 (N) as their answer.

(c) (i) This question was challenging because the distance values did not increase in regular increments of 0.10 m. This meant that some candidates presented axes with non-linear scales. Several candidates converted the distance values to centimetres but failed to put this unit in their axis label. A common error was to put an additional distance value on the x axis, between 0 and 0.10, of 0.5 (rather than 0.05).

Axes must be labelled with correct units. Many answers omitted labels, omitted units or gave incorrect units (n was not credited as the abbreviation for Newtons).

Most candidates plotted enough points correctly to be given (1) mark for plotting.

(ii) Candidates correctly identified that the line of best fit should be drawn as a curve. In drawing a line, candidates need to use a single, fine line, without any feathering, gaps or doubled areas. It is recommended that candidates use a pencil to draw their lines, as often they were not able to correct a mistakenly drawn line, leading to feathering and doubled areas.

(d) Most candidates were able to state that the force decreases as distance from the hinge increases. Few were awarded the second mark for stating that the change in force is greater at smaller distances.

(e) (i) Whilst most candidates were able to identify that newton meter **C** had an insufficient range for the experiment readings, very few were able to suggest that the resolution was the problem on newton meter **A**. Many candidates referred to accuracy or simply stated that **A** was too big, and **C** was too small.

(ii) A clear line should have been marked on newton meter **B** at 1.8 N. Many candidates missed this question out or drew a line for the average force at d = 0.25 m, rather than for experiment **1** as the question required. Lines that were too thick and covered multiple divisions on the newton meter did not score.

(f) Practical difficulties need to relate to the equipment being used. Strong responses referred to the difficulty of pulling the newton meter smoothly, rather than the lack of strength of the candidate or the stiffness of the hinges.