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Paper 0654/11
Multiple Choice (Core)

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

General comments

The paper was not very well answered. There was some evidence of guessing between two answers on many questions. **Question 36** was found to be very challenging.

Candidates performed very well on **Questions 1**, **12**, **14** and **Question 16**.

Comments on specific questions

Question 2

Candidates were asked what had happened to cells when placed in a concentrated glucose solution. Although about a third of them correctly stated that water left the cells by osmosis, an equal number thought glucose had entered by osmosis.

Question 7

Although many candidates correctly identified the pulmonary artery as the blood vessel leading to the lungs, a significant number stated that it was the pulmonary vein.

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Question 8

Only about a third of the candidates correctly answered this question on processes using energy, a similar number thought that diffusion rather than cell division required energy.

Question 9

Nearly half the candidates correctly stated the order that an impulse passes through the neurones during a reflex action. However, about a third confused the relay and motor neurones.

Question 10

This question showed evidence of guessing.

Question 11

Nearly half the candidates correctly interpreted this Punnett square showing a heterozygous cross; the rest were fairly equally divided between the other three answers.

Question 14

Candidates easily identified apparatus used in an experiment to measure the rate of a reaction.

Question 16

Candidates knew the dot-and-cross diagram for a water molecule very well.

Question 18

Candidates chose the incorrect options **A** and **D** more often than the correct answer, **B**. They are expected to know the electrode products, using inert electrodes, in the electrolysis of concentrated aqueous sodium chloride.

Question 22

There was evidence that many candidates had guessed at the answer. They are required to classify oxides as either acidic or basic, related to metallic and non-metallic character.

Question 23

There was evidence that many candidates had guessed at the answer. They should know the test for Group I metals and for Group VII elements and use these to identify Group I halides.

Question 26

There was evidence that many candidates had guessed at the answer. They are expected to know that cobalt(II) chloride paper is used in a test for the presence of water.

Question 27

There was evidence that many candidates had guessed at the answer. They are required to know the products of the complete combustion of ethanol.

Question 30

In this question on potential and kinetic energy, the incorrect option **A** was frequently chosen, especially by candidates who performed less well overall. These candidates did not understand that energy is transferred in overcoming air resistance.

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Question 31

One in three of the candidates thought that power could be calculated without knowing the time taken, leading them to opt for **B**.

Question 33

The topic of this question was refraction of light; some candidates appeared to have resorted to guessing, with all options being popular.

Question 34

Many candidates were aware that gamma rays and radio waves are at opposite ends of the electromagnetic spectrum, but a significant number confused frequency with wavelength and chose option **A**.

Question 35

A very large majority of candidates knew that the force between P and Q would be attractive, but a sizeable number of them believed that P must gain electrons to become positively charged, leading them to opt for **A**.

Question 36

This question was poorly answered, with options **A** and **B** each being much more commonly chosen than the correct option **C**. Candidates choosing **A** did not notice that the currents were all given in milliamps. Those opting for **B** made the same mistake, but also incorrectly rearranged the equation so that they divided resistance by voltage.

Question 37

All candidates found this question on current and voltage difficult. Although many were aware that the voltmeter reading would remain the same, a common mistake was to believe that the ammeter reading would decrease. It is accepted that, depending on where the third resistor is added, the ammeter reading could stay the same but, of the options available, only **D** can be correct.

Question 40

In this question, option **C** (being half of the total time of 10 years for all the readings shown) was as popular as the correct option **B**. This suggests a common lack of understanding of the concept of half-life.

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Paper 0654/12
Multiple Choice (Core)

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

General comments

Questions 9 and **12**, on adrenaline secretion and trophic levels were well answered. Candidates performed very well on **Questions 18** and **32**.

Questions 15, **17**, **22**, **23**, **25**, **35 to 40** proved most difficult for the candidates.

Comments on specific questions

Question 7

Slightly less than half the candidates correctly answered this question on water transport in plants.

Question 11

This question asked for the ratio of offspring when a heterozygous dominant flower was crossed with a homozygous recessive. Over half the candidates wrongly stated that 75% of the offspring would show the dominant characteristic, rather than the correct 50%.

Question 13

There was evidence of guessing in this question on the carbon cycle, with a large number of candidates thinking that fossilisation would increase the level of carbon dioxide in the air.

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Question 15

There was evidence that many candidates had guessed at the answer. They should be able to identify physical and chemical changes and understand the differences between them.

Question 16

Many candidates chose option **C** rather than the correct answer. Candidates are expected to be able to identify the separate elements represented within a formula.

Question 17

Candidates chose options **A** and **D** more often than the correct answer. They are required to identify the electrode products, using inert electrodes, in the electrolysis of dilute sulfuric acid.

Question 18

Candidates understood very well endothermic and exothermic changes.

Question 19

Many candidates chose option **A** rather than the correct answer. They are expected to be able to make relevant deductions about experiments concerned with rate of reaction.

Question 20

There was evidence that many candidates had guessed at the answer. Option **B** was a common incorrect choice. They are required to describe the characteristic properties of acids, including their effect on metals.

Question 21

There was evidence that many candidates had guessed at the answer. They are expected to know the tests for the gases and ions listed, and to know which of these tests do and do not produce precipitates.

Question 22

Candidates chose options **B** and **C** more often than the correct answer. They are required to know the properties of the elements in Group VII of the Periodic Table.

Question 23

Candidates chose option **A** more often than the correct answer. They should know that iron oxide can be reduced by heating with carbon.

Question 24

Candidates chose option **B** more often than the correct answer. They are expected to know that clean air contains 21% oxygen and how to convert a volume of oxygen to a volume of clean air.

Question 25

Candidates chose options **A**, **B** and **C** more often than the correct answer. They are required to know the uses of limestone as described in the specification.

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Question 28

A common mistake was to calculate mass by multiplying weight by gravitational field strength, rather than dividing, leading to option **D**.

Question 29

Some candidates opted for **A**. These candidates did not notice the lower position of the centre of mass in option **D**.

Question 30

It was widely known that the magnitude of the force is needed to calculate the amount of work done, but a significant number of candidates believed that it was not necessary to know the distance moved as well (option **B**).

Question 32

Change of state caused few problems in this very well-answered question.

Question 33

Option **C** was quite popular; this showed a sensible direction for the flow of water but did not take account of where the heat was being applied.

Question 34

Many candidates were unfamiliar with the definition of wavelength, believing that there were three wavelengths between points X and Y.

Question 35

There was evidence of widespread guessing in this question about voltage, resistance and current. Options **C** (adding the current and resistance values) and **D** (dividing resistance by current) were more commonly chosen than the correct option **A**.

Question 36

Two incorrect options, **A** and **D**, were as popular as the correct option, with option **B** attracting half of all candidates. Clearly there was widespread confusion about resistance and currents in parallel circuits.

Question 37

In this question on a suitable position for a fuse in a circuit, few candidates obtained the correct answer, with all three incorrect options being much more popular, suggesting guessing.

Question 38

Magnetic field patterns and directions were not well known. The majority of candidates did not notice the current direction, therefore choosing option **C**. The correct option was the least popular choice of the four options.

Question 39

Many candidates were confused about the structure of the nucleus, with slightly fewer than one in three choosing the correct option. Many thought that $A - Z$ represented the number of protons.

Question 40

This question on half-life was found very challenging for most candidates. Options **A** (one quarter of the length of time given) and **C** (half of the length of time given) were far more popular than the correct answer.

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Paper 0654/13
Multiple Choice (Core)

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	C	11	B	21	B	31	C
2	B	12	D	22	D	32	B
3	A	13	B	23	D	33	A
4	D	14	B	24	C	34	C
5	C	15	A	25	D	35	A
6	D	16	A	26	D	36	C
7	D	17	B	27	C	37	D
8	A	18	B	28	B	38	D
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General comments

Questions 9 and **12**, on adrenaline secretion and trophic levels were well answered. Candidates performed very well on **Questions 18** and **32**.

Questions 15, **17**, **22**, **25**, **36, 37 and 40** proved most difficult for the candidates.

Comments on specific questions

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Less than half the candidates correctly answered this question on water transport in plants.

Question 11

This question asked for the ratio of offspring when a heterozygous dominant flower was crossed with a homozygous recessive. Over half the candidates wrongly stated that 75% of the offspring would show the dominant characteristic, rather than the correct 50%.

Question 13

There was evidence of guessing in this question on the carbon cycle, with a large number of candidates thinking that fossilisation would increase the level of carbon dioxide in the air.

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There was evidence that many candidates had guessed at the answer. They should be able to identify physical and chemical changes and understand the differences between them.

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Candidates chose option **C** as often as the correct answer. Candidates are expected to be able to identify the separate elements represented within a formula.

Question 17

Candidates chose options **A** and **D** more often than the correct answer. They are required to identify the electrode products, using inert electrodes, in the electrolysis of dilute sulfuric acid.

Question 18

Candidates understood very well endothermic and exothermic changes.

Question 19

Option **A** and **B** were almost as popular as the correct answer. Candidates are expected to be able to make relevant deductions about experiments concerned with rate of reaction.

Question 20

There was evidence that many candidates had guessed at the answer. Option **C** and **D** were common incorrect choices. Candidates are required to describe the characteristic properties of acids, including their effect on metals.

Question 21

There was evidence that many candidates had guessed at the answer. They are expected to know the tests for the gases and ions listed, and to know which of these tests do and do not produce precipitates.

Question 22

Candidates chose options **B** and **C** as often as the correct answer. They are required to know the properties of the elements in Group VII of the Periodic Table.

Question 23

Many candidates knew that iron oxide can be reduced by heating with carbon.

Question 24

Candidates chose options **A** and **B** as often as the correct answer. They are expected to know that clean air contains 21% oxygen and how to convert a volume of oxygen to a volume of clean air.

Question 25

Candidates chose options **A** and **B** more often than the correct answer. They are required to know the uses of limestone as described in the specification.

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Question 28

A common mistake was to calculate mass by multiplying weight by gravitational field strength, rather than dividing, leading to option **D**.

Question 29

Many candidates opted for **C**. These candidates did not notice the lower position of the centre of mass in option **D**.

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It was widely known that the magnitude of the force is needed to calculate the amount of work done, but a significant number of candidates believed that it was not necessary to know the distance moved as well (option **B**).

Question 32

Change of state caused few problems in this very well-answered question.

Question 33

Option **C** was quite popular; this showed a sensible direction for the flow of water but did not take account of where the heat was being applied.

Question 34

Many candidates were unfamiliar with the definition of wavelength, believing that there were three wavelengths between points X and Y.

Question 35

There was evidence of widespread guessing in this question about voltage, resistance and current. Options **C** (adding the current and resistance values) and **D** (dividing resistance by current) were often chosen rather than the correct option **A**.

Question 36

All incorrect options were as popular as the correct option **C**. There was widespread confusion about resistance and currents in parallel circuits.

Question 37

In this question on a suitable position for a fuse in a circuit, very few candidate responses were correct, with all three incorrect options being much more popular, suggesting guessing.

Question 38

Magnetic field patterns and directions were not well known. Many candidates did not notice the current direction, therefore choosing option **C**.

Question 39

Many candidates were confused about the structure of the nucleus. Many thought that $A - Z$ represented the number of protons.

Question 40

This question on half-life was found very challenging for most candidates. Options **A** (one quarter of the length of time given) and **C** (half of the length of time given) were far more popular than the correct answer.

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Paper 0654/21
Multiple Choice (Extended)

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

General comments

There was some evidence of guessing between two or more answers on several questions. No questions proved to be particularly easy for the candidates.

Questions 15, **21**, **24**, **27 29**, **34**, **36, 38** and **39** proved most difficult for the candidates.

Comments on specific questions

Question 1

This question on characteristics of living organisms was very well answered.

Question 2

This question asked candidates which part of the gas exchange system had ciliated columnar epithelium. Nearly half the candidates stated that this was the alveoli, rather than the trachea. A few hazarded a guess at the diaphragm.

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Question 6

When asked to identify on a diagram of a villus where amino acids and fats are absorbed, candidates showed evidence of guessing, with a slightly higher proportion of them choosing the correct answer, which included naming the structure and identifying the substance absorbed. They were particularly poor at knowing which substance was absorbed by the lacteal or capillary.

Question 9

The candidates appeared to have guessed between two answers, unfortunately, most of them making the wrong choice of pupil reflex, rather than accommodation, for the change in the lens when focusing on near and far objects.

Question 11

Candidates had to interpret a pedigree diagram and choose how many cattle were heterozygous for an allele. It appears that many of them simply counted the number of cattle showing the dominant characteristic. Less than a quarter of candidates realised that one of these cattle could have been either heterozygous or homozygous.

Question 12

Candidates were unsure of the definition of an ecosystem, with nearly half of them believing that it was a food chain.

Question 14

Candidates chose options **A** and **B** more often than the correct answer. They are expected to be able to describe and explain methods of separation and purification, including distillation.

Question 15

Candidates chose option **B** more often than the correct answer. They should be able to suggest appropriate apparatus for the measurement of volume.

Question 21

Candidates chose option **C** more often than the correct answer. They are required to describe the preparation, separation and purification of salts using techniques described in the specification.

Question 23

Candidates chose option **C** more often than the correct answer. They can be expected to predict the properties of elements other than chlorine, bromine an iodine, in Group VII.

Question 24

Candidates chose option **D** more often than the correct answer. They should be able to describe the methods of extraction metals from their ores that are listed in the specification.

Question 25

There was evidence that many candidates had guessed at the answer. They are required to describe chemical tests for water, including the use of copper(II) sulfate and cobalt(II) chloride.

Question 27

There was evidence that many candidates had guessed at the answer. They are expected to know the structures of the polymers poly(ethene) and nylon, including the linkage between the monomers.

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Question 29

In this question on stretching a spring, almost half the candidates opted for option **D**, this being the final length range given in the table, rather than the length range at which the extension stopped being proportional to the force applied.

Question 30

Although quite well answered, a significant number of candidates opted for option **A**. This is obtained by multiplying the weight of each child by the distance to the pivot of the other child, then equating these false values for their moments.

Question 31

The topic here was energy resources. Slightly more candidates opted for option **D** than the correct option, thinking that the source of energy for nuclear fuel is the Sun.

Question 32

A large majority of candidates chose the correct statement in this question about states of matter.

Question 33

It was widely known in which direction the ray refracts, but slightly more than a quarter of candidates chose option **A** and thought that the speed decreases when light moves from glass into air.

Question 34

This question showed that many candidates were unaware that all electromagnetic waves travel at the same speed in a vacuum. More than six out of ten believed that gamma rays are faster than microwaves.

Question 36

This question on factors affecting the resistance of a wire was poorly answered. A large number of candidates opted for option **C**, not realising that the effects of the two changes cancel.

Question 38

There was evidence of guessing in this question on fuses. Options **A** and **D** were almost as commonly chosen as the correct option.

Question 39

Approaching half of the candidates opted for option **A**, thinking that the transformer reduces the voltage and the current by the same factor.

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Paper 0654/22
Multiple Choice (Extended)

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

General comments

The paper was generally very well answered. No questions proved to be particularly difficult. Candidates were particularly confident on the subjects of photosynthesis, blood composition and function, the effects of physical activity and trophic levels. Candidates performed very well on **Questions 17**, **26**, **28** and **32**. Candidates found **Questions 18** and **36** most difficult.

Comments on specific questions

Question 9

A significant number of candidates opted for the incorrect option **D**, involving a phototropic response. It is important to read the question carefully. The question stated the plant was in complete darkness.

Question 10

While almost all candidates were confident that fertilisation occurs in the oviduct and leads to the formation of a zygote, about a third of them believed that the zygote then underwent meiosis rather than mitosis.

Question 11

Only about half of candidates opted for the correct answer. Many candidates chose the incorrect options **A** or **D**.

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Question 17

Candidates understood very well the changes involved in endothermic reactions.

Question 18

Candidates chose option **D** more often than the correct answer. They are expected to be able to make comparisons of the accuracy of different types of apparatus that can be used to measure the amount of gas that is produced in an investigation.

Question 26

Candidates knew very well the uses of the named fractions obtained from petroleum.

Question 28

The effect on weight of changing gravitational field strength was widely understood.

Question 30

A sizeable proportion of candidates who performed less well overall used the distance moved along the slope instead of the vertical height change in the equation gravitational potential energy = *mgh*, leading them to choose incorrect option **D**.

Question 32

A large majority of candidates found little difficulty in answering this question on the thermal transfer of energy.

Question 33

The topic here was refraction of light. Candidates who performed less well overall tended to overlook, or did not understand, the fact that the angle of incidence was greater than the critical angle, so there would not be a refracted ray. This led them to choose incorrect option **B**.

Question 36

In this question on resistors in series, two incorrect options were quite popular. To arrive at option **B**, candidates assumed that both resistors must have the same p.d. across them. Ignoring the p.d. across the left-hand resistor led to option **C**.

Question 37

The popularity of option **C** showed that almost one in three candidates forgot to change the time from minutes into seconds; this is a common mistake.

Question 39

Candidates who performed less well overall tended to opt for option **B**, believing that the transformer reduces both the current and the voltage.

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Paper 0654/23
Multiple Choice (Extended)

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

General comments

The paper was generally very well answered, with candidates being particularly confident on the subjects of characteristics of living organisms, plant and animal nutrition, structure of an insect pollinated flower and artificial selection. No questions proved to be particularly easy for the candidates.

Questions 30, **34**, **37** and **39** were found to be the most difficult.

Comments on specific questions

Question 4

This question asked about the effect of pH on an enzyme-controlled reaction. While almost all candidates correctly identified the optimum pH and knew that at a high pH the shape of the active site changed, they were equally divided on whether molecules moved faster at a higher pH or not, suggesting they are confusing pH and temperature.

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Question 7

This question required candidates to interpret a diagram of a biennial plant which uses its root as a storage system over winter. Although just over half the candidates answered this question about sources and sinks correctly, nearly as many got the two confused.

Question 18

Candidates chose option **A** more often than the correct answer. They are expected to be able to deduce for which reactions the apparatus is appropriate for the measurement of time and volume of gases.

Question 22

Candidates chose option **B** more often than the correct answer. They are required to describe the halogens, chlorine, bromine and iodine in Group VII, as a collection of diatomic non-metals showing a trend in colour and physical state.

Question 27

Many candidates chose option **B** rather than the correct answer. They are expected to be able to describe the properties of ethene in terms of addition reactions with bromine, hydrogen and steam.

Question 28

The topic here was density. Many candidates who performed less well overall opted for option **A**; this being the densest material, rather than the least.

Question 29

This question on moments led to two incorrect options being popular. Option **A** was found by using 3.0m as the distance to the pivot for the force applied. Multiplying the weight of the rock by the distance from the person to the pivot, then dividing the result by the distance of the rock to the pivot, produces option **C**.

Question 30

As many candidates thought that coal did not have the Sun as its energy source as did those who correctly identified geothermal resources. Water waves were also often chosen as not relying on energy from the Sun.

Question 33

A large majority of candidates was aware that the speed of the light wave decreases as it enters glass, but a majority of those in this group also believed that the wavelength does not change, leading them to choose the option **B**.

Question 34

In this question about a converging lens, many candidates appeared to resort to guessing. Option **C** was almost as popular as the correct option and option **B** was more popular.

Question 35

It was very widely known that the temperature of the lamp filament increases with increasing current, but more than half of the candidates knowing this also thought that the resistance of the lamp filament decreases (option **C**).

Question 36

Although the correct option was chosen more often than the other options, an appreciable number chose option **D**, either by not reading the question carefully or confusing parallel with series arrangements.

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Question 37

Fuses were not well understood, with options **B**, **C** and **D** all being popular choices.

Question 38

Most candidates could identify the correct direction for the magnetic field lines (options **A** and **B**), but many of these failed to notice that the distances between the lines in **B** were equal, whereas they should increase with distance from the wire (option **A**).

Question 39

Guessing was evident for candidates answering this question on the electric motor. Options **A**, **B** and **C** were all popular, with the correct option being the least commonly chosen of these three.

Question 40

It was well known that γ-rays pass straight through a magnetic field undeviated, but a majority of those knowing this could not determine the direction of deflection of the β-particles and therefore chose option **B**.

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Paper 0654/31
Theory (Core)

Key messages

- Candidates had a good understanding of what the questions were asking.
- A good standard of scientific knowledge was displayed by many candidates. Some clear and accurate responses were seen.
- Calculations were often done well with working shown.

General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on every question and on the paper as a whole. Candidates generally gained some credit on all questions. Few gained no credit on any question but very few gained full credit on any question. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

Some candidates only gained some of the credit available due to their responses not answering the question completely. In these cases, candidates should be reminded to read the stimulus material and each question carefully and complete all the instructions contained within the question to be able to access the maximum marks available.

There was a noticeable increase in the number of candidates who gave no response to many questions.

A number of candidates continue to cross out a correct answer and replace it with an incorrect answer.

Any formula quoted should be in a standard form and use recognisable symbols.

There was no evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

(a) (i) Most candidates knew the parts of the *Euglena* responsible for excretion and sensitivity. A few candidates misunderstood the question and described the different characteristics.

(ii) Most candidates were able to state one other characteristic of living organisms as either respiration, growth or reproduction.

(iii) Many candidates correctly identified chloroplasts as the part that *Euglena* have in common with plant cells but not animal cells.

(b) The functions of the cell wall in plant cells were well known.

(c) (i) This was not answered well by most candidates. Many gave the name of a carbohydrate and others only suggested one or two of the elements found in all carbohydrates.

(ii) Both glycogen and starch were well known, although few candidates identified both.

Question 2

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(a) (i) Many candidates incorrectly suggested that either N_2 or O_2 were the compounds found in natural gas.

(ii) Cl_2 was the most popular and correct response for an element that bleaches damp litmus. Popular incorrect suggestions were NaCl and $MgCl_2$.

(iii) O_2 was usually suggested as the element that makes up 21% of clean air. N_2 was the only common incorrect response.

(iv) NaCl was often correctly suggested as a compound containing an ion with a 1+ charge. $MgCl_2$ was a common error.

(v) NH_3 was rarely identified as the gas made by displacement from an ammonium salt.

(b) (i) Few candidates were able to explain that the decrease in mass during the experiment was due to the loss of carbon dioxide gas. Many candidates incorrectly suggested that the decrease in mass was caused by the reactants being used up or dissolving.

(ii) Some candidates correctly suggested increasing the temperature of the acid or increasing the concentration of the acid. Some forgot to state increasing.

(iii) Water and carbon dioxide were well known as the other products of the reaction. Carbon and hydrogen were frequently suggested.

(c) Crystallisation was not well known as the separation technique. Filtration, electrolysis and distillation were frequently suggested.

Question 3

(a) (i) Many candidates demonstrated good data handling skills on the question. 30 000 m / s was the popular correct answer.

(ii) The correct answer of 20 s was usually stated.

(iii) The force that causes the meteorite to slow down through the Earth's atmosphere was not well known. Gravity was the commonest incorrect suggestion. The correct response of friction or air resistance was rarely suggested.

(b) (i) Many candidates correctly determined the mass of the meteorite as 3.3×10^7 kg. A number of candidates multiplied by 10 instead of dividing by 10.

(ii) The calculation was completed correctly by many candidates but few candidates stated correct units.

(c) Very few candidates were able to describe another method of magnetisation. A few vaguely mentioned passing electricity through it or wrapping some wire around the piece of iron. There was also some confusion with electrostatic charging.

(d) (i) There were many combinations of acceptable words used by the candidates.

(ii) Many correct answers were given. Common incorrect responses were 54 and 56 neutrons.

Question 4

(a) (i) Many candidates correctly determined the percentage decrease in number of infections as 39.3.

(ii) Many correct reasons for the decrease in the number of new infections were suggested. One common error was to suggest using contraceptives rather than using condoms or barrier contraception.

(iii) A virus was well known as the type of organism that causes HIV.

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(b) (i) Most candidates could identify the white blood cell as **D** and the red blood cell as **A**. A common error was to suggest that the function of platelets is to prevent blood clotting.

(ii) Few candidates suggested measuring anything and only a few knew that magnification equals image size divided by actual size.

Question 5

(a) (i) There were very few candidates who did not place the metals in the correct order of reactivity.

(ii) Most candidates correctly identified either potassium or lithium as a metal from Table 5.1 that is found in Group I of the Periodic Table. A few candidates suggested other Group I metals.

(iii) Copper was well known as a transition element.

(b) (i) There was some confusion between endothermic reactions and exothermic reactions. Few candidates mentioned a temperature decrease.

(ii) Few candidates were able to describe why copper oxide is described as a basic oxide. Correct responses here mentioned either that copper oxide is a metal oxide or that copper oxide reacts with an acid to produce a salt and water.

(c) Many candidates completed one of the missing words about electrolysis; few candidates could give two.

(d) (i) This question was not well answered. Many candidates did not give a comparative response. For example, they stated that brass was strong rather than stronger.

(ii) This question was not well answered. Few candidates were able to explain that brass is a mixture or that mixtures have a melting point range.

Question 6

(a) (i) Many candidates correctly determined the magnitude of the resultant force but many did not correctly show the direction of the resultant force.

(ii) Few candidates were able to describe the motion of the truck as accelerating or moving faster.

(b) (i) This question was not well answered. Most candidates were able to draw the correct symbol for a lamp, but few were able to show two lamps connected in parallel. Few candidates were able to draw the correct symbol for a fuse.

(ii) Few candidates gave a correct response to this question. Very few suggested that both the lamps get the full voltage or that the lamps are brighter. A few correctly explained that if one of the lamps stops working or breaks, the other lamp would still work.

(iii) The idea that a fuse protects the circuit was quite well known, but few candidates explained that the fuse melts due to a large current flowing in the circuit.

Question 7

(a) Most candidates identified the correct definition of inheritance as the transmission of genetic information from generation to generation.

(b) (i) Most candidates gain some credit for this question. There were no common incorrect answers.

(ii) Most candidates completed the genetic diagram correctly but did not calculate the likelihood of the offspring having a wrinkled shape as 25%. The most popular answer was 75%.

(c) Few candidates were able to list the three structures in order of size.

Question 8

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(a) (i) Condensation and freezing were well known as the two changes of state.

(ii) Some candidates managed to identify boiling as a physical change. Fewer candidates were able give a reason. A physical change is able to be reversed and no new substances are formed.

(b) (i) Many candidates were able show at least one pair of bonding electrons but few were able to complete the dot-and-cross diagram correctly.

(ii) Covalent bonding in a water molecule was well known.

(c) Many vague answers were given. There was some confusion about whether filtration removes insoluble or soluble substances from water. The purpose of chlorination is to kill bacteria.

(d) Many candidates correctly balanced the equation for the reaction between hydrogen and oxygen.

Question 9

(a) (i) Some candidates managed to continue the ray of light as far as the lens and some managed to show it passing the principal focus **F** onto the screen.

(ii) Few candidates showed the size and position of the image on the screen.

(iii) Few candidates identified point **F** as the principal focus or focal point.

(b) (i) Few candidates knew the maximum audible frequency for a healthy human ear.

(ii) Few candidates understood what is meant by the frequency of a wave.

(c) (i) Many candidates used resistance = p.d. × current rather than resistance = p.d. ÷ current.

(ii) Many different responses were credited here. The most popular response was skin cancer.

Question 10

(a) (i) Gravitropism was not well known as the tropic response. Phototropism was frequently suggested.

(ii) Many different responses were credited here. A popular response was photosynthesis.

(iii) The root hair cell was not well known as the part of the plant that absorbs water from the soil.

(iv) Xylem vessels were well known as the vessels that transport water from the roots to the leaves in a plant.

(b) Magnesium was not well known as the main mineral ion required for the synthesis of chlorophyll.

(c) Most candidates correctly identified at least one correct statement about plants but few identified all three correct statements.

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Question 11

(a) (i) Some candidates correctly deduced the total number of atoms in a molecule of ethene as six. Two and four were popular incorrect answers.

(ii) The formula of ethene was correctly stated as C_2H_4 by many candidates. A number of candidates attempted to give the general formula for an alkene.

(iii) Many candidates correctly described an unsaturated hydrocarbon molecule as containing a carbon-carbon double bond.

(iv) The chemical test for an unsaturated hydrocarbon using aqueous bromine was not well known.

(b) (i) Some candidates knew that the two products of the complete combustion of ethene are carbon dioxide and water. Popular incorrect products suggested were carbon, hydrogen and oxygen.

(ii) Cracking was not known by many candidates as the process used to break down the larger molecules in petroleum.

(iii) A few candidates were able to describe the polymerisation of ethene molecules in terms of the monomer units joining together.

Question 12

(a) Many candidates knew the correct equation to use but were unable to complete the calculation using the powers of ten quoted in the question. Few candidates realised that there was also a unit conversion required in their calculation.

(b) Most candidates were able to identify X-rays as region **L**.

(c) This question was not well answered. Few candidates mentioned that space is a vacuum nor the necessity for a medium for conduction and convection.

(d) (i) Quite a few candidates included coal or natural gas in their responses.

(ii) Quite a few candidates included geothermal in their responses.

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CO-ORDINATED SCIENCES

Paper 0654/32
Theory (Core)

Key messages

- Candidates had a good understanding of what the questions were asking.
- A good standard of scientific knowledge was displayed by many candidates. Some clear and accurate responses were seen
- Calculations were often done well with working shown.

General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on every question and on the paper as a whole. Candidates generally gained some credit on all questions. Few gained no credit on any question but very few gained full credit on any question. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

Some candidates only gained some of the credit available due to their responses not answering the question completely. In these cases, candidates should be reminded to read the stimulus material and each question carefully and complete all the instructions contained within the question to be able to access the maximum marks available.

There was a noticeable increase in the number of candidates who gave no response to many questions.

A number of candidates continue to cross out a correct answer and replace it with an incorrect answer.

Any formula quoted should be in a standard form and use recognisable symbols.

There was no evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

(a) (i) Most candidates could identify one part. Many candidates suggested the prostate gland rather than the urethra for the part that carries urine and semen.

(ii) Many candidates confused the prostate gland with the bladder.

(b) (i) Many candidates suggested that the name of the female gamete in humans is ‘ovary’.

(ii) Some candidates misunderstood the question and gave 0.05 mm as their response.

(c) (i) Few candidates were able to state the word equation for aerobic respiration correctly, although oxygen and carbon dioxide were frequently seen somewhere in the equation.

(ii) Most candidates correctly suggested that energy is needed for cell division and movement.

(d) Few candidates were able to describe the process of fertilisation as the fusion of the nuclei from a male gamete and a female gamete in the oviduct.

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Question 2

(a) (i) Many candidates incorrectly suggested that either ethanol or chlorine are used as a chemical test for water.

(ii) Ethanol was usually correctly stated.

(iii) Most candidates correctly identified aluminium as the substance used in aircraft parts.

(iv) Sulfur was often correctly suggested as the substance used in the manufacture of sulfuric acid.

(v) Chlorine was often correctly suggested as the substance used in the treatment of the water supply.

(vi) Limestone was usually correctly suggested as the substance used in the treatment of acidic soil.

(b) (i) Many candidates determined that the total number of atoms in one molecule of sulfuric acid is seven. Six was a common mistake.

(ii) Many candidates determined that the total number of elements found in one molecule of sulfuric acid is three.

(c) (i) Hydrogen was well known as one of the products of the reaction. Magnesium sulfate was less well known.

(ii) Filtration was well known as the separation technique used to remove any unreacted solid magnesium from the reaction mixture.

Question 3

(a) (i) This question was not well answered. Both infrared and ultraviolet were frequently written in the wrong places.

(ii) Very few candidates realised that the speed of infrared waves is the same as that of ultraviolet waves.

(b) Few candidates were able to state that an echo is a reflection of a sound wave.

(c) (i) Few candidates identified point **F** as the principal focus or focal point.

(ii) Few candidates were able continue ray 2 parallel to the principal axis and intersecting with ray 1. Consequently, they were unable to draw and label the image formed.

(d) Many candidates demonstrated good data handling skills to determine the average speed of the camera as 30 m / s.

Question 4

(a) Many candidates drew three lines from **X** and three lines from **Y** instead of three lines in total.

(b) Most candidates suggested that the function of phloem is to transport minerals rather than dissolved sugars.

(c) (i) Few candidates knew that nitrate ions are needed to synthesise amino acids. A common misconception was that nitrate ions contain amino acids and proteins.

(ii) Chlorophyll was not well known as the substance containing magnesium ions that is required for photosynthesis.

(d) Many candidates did not know the requirements for photosynthesis. Carbon dioxide was frequently omitted or replaced with oxygen.

Question 5

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(a) (i) Most candidates were able to construct the word equation. Some candidates unsuccessfully attempted to give a fully balanced symbol equation.

(ii) Many incorrect or vague explanations were given. Candidates needed to explain that hydrogen and chlorine are both non-metals or that the electrons in the bond are shared.

(iii) Many candidates drew clear dot-and-cross diagrams to show the arrangement of outer-shell electrons in a molecule of hydrogen chloride. Some candidates drew all three shells for chlorine.

(iv) This question was not well answered and few candidates referred to universal indicator.

(v) This question was well answered.

(b) (i) Many candidates performed well. A common error was to suggest that iodine is a liquid at 20 °C.

(ii) The halogens were well known as the name given to Group VII of the Periodic Table.

(iii) Many incorrect or vague explanations were given. Candidates needed to explain that chlorine, bromine and iodine all have seven electrons in their outer shell

Question 6

(a) (i) Few candidates knew that α-particles are helium nuclei. Proton was frequently suggested.

(ii) Some candidates correctly placed the three radiations in order of their ionising ability. Some candidates reversed the order. Others chose one of the other possible combinations.

(iii) More candidates chose α-particles rather than γ-rays.

(b) (i) This question was well answered.

(ii) Many candidates gave a value greater than 20 000 Hz.

(c) Very few candidates were able to explain why the evaporation of ethanol causes the doctor's skin to cool. They needed to explain that when the most energetic molecules escape from the surface, the temperature of the remaining ethanol molecules is lowered.

Question 7

(a) (i) This question was well answered with many candidates gaining full credit.

(ii) Most candidates correctly identified temperature as another factor that affects the activity of enzymes.

(b) Most candidates could identify either catalysts or proteins.

(c) Many candidates could identify where two of the process occur. Ingestion seemed to be the most difficult.

(d) Few candidates were able to describe a similarity between absorption and assimilation. A suitable similarity is that both involve the movement of digested food molecules or soluble nutrients.

Question 8

(a) (i) The idea that copper ore is a finite resource was not well known.

(ii) Many candidates described the difference in the separation rather than differences in the arrangement and motion of the atoms. Many candidates did not make it clear in their responses whether they were describing the atoms in molten copper or the atoms in solid copper.

(b) (i) Anode was a more popular response than cathode, the correct response. Many candidates did not answer this question.

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(ii) Few correct suggestions were given. Many candidates did not answer this question.

(iii) Many candidates identified one word that was not correct but few identified both.

Question 9

(a) A majority of candidates gained full marks on this question.

(b) (i) A majority of candidates gained full marks on this question.

(ii) Many candidates gave the correct response of 100 °C.

(c) (i) Few candidates were able to explain that Table 9.1 shows that energy is conserved in the processes because all the output percentages add up to 100%.

(ii) Few candidates were able to explain that the power station is not efficient because the useful energy output is only 25%.

(d) (i) This question was not well answered. Many candidates confused the series circuit with the parallel circuit. A number of candidates did not attempt this question.

(ii) A number of correct advantages were given by the candidates.

Question 10

(a) (i) Many candidates showed good data handling skills on the first two parts of this question but found the descriptions of continuous variation and phenotype more difficult.

(ii) Height was the common correct response for an example of continuous variation in humans.

(b) This question was well answered by many candidates.

(c) (i) Few candidates were able to define an allele as a version of a gene.

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Question 11

(a) (i) Many candidates correctly stated the number of neutrons in a carbon atom as six. However, many candidates incorrectly suggested that a hydrogen atom has one neutron.

(ii) Many candidates correctly stated the number of electrons in a carbon atom as six.

(b) (i) Many candidates knew that an unsaturated hydrocarbon contains a carbon–carbon double bond.

(ii) Few candidates were able to state that the aqueous bromine remains orange with a saturated hydrocarbon.

(c) (i) The purpose of a catalyst was well known.

(ii) There was some confusion between endothermic reactions and exothermic reactions. Few candidates mentioned a temperature decrease.

(d) (i) Many candidates suggested methane as another greenhouse gas.

(ii) Many candidates correctly identified oxygen as the gas in the air that reacts with hydrocarbons during combustion. However, a number of candidates suggested nitrogen or hydrogen.

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Question 12

(a) (i) Some candidates were able to show the movement of the warmed air around the classroom using three arrows. Some candidates were only able to draw one arrow.

(ii) Convection was known as the method of thermal energy transfer by some candidates, A number of candidates did not answer this question.

(b) (i) The Celsius scale was well known as the temperature scale used on the thermometer. A number of candidates misunderstood the question and gave the answer 29 °C.

(ii) Mercury and alcohol were well known as liquids that are used in thermometers.

(iii) Few candidates were able to state that volume is the physical property of the liquid that varies with temperature in the thermometer.

(c) (i) Many candidates were able to explain that sound cannot travel through a vacuum because there is no medium.

(ii) Few candidates gained any credit on this question.

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CO-ORDINATED SCIENCES

Paper 0654/33
Theory (Core)

Key messages

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General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on every question and on the paper as a whole. Candidates generally gained some credit on all questions. Few gained no credit on any question but very few gained full credit on any question. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

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(iii) Few candidates were able to state that volume is the physical property of the liquid that varies with temperature in the thermometer.

(c) (i) Many candidates were able to explain that sound cannot travel through a vacuum because there is no medium.

(ii) Few candidates gained any credit on this question.

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CO-ORDINATED SCIENCES

Paper 0654/41
Theory (Extended)

Key messages

- Candidates should read the stimulus material carefully and follow the guidance given. Questions with command words that require candidates, for example to, state, identify, outline, complete, show, calculate, explain, describe, construct and determine all require different types of responses. Some questions also required candidates to use information from figures, for example, **Question 1(a)** where candidates needed to state the letter rather than the name of the part of the alimentary canal; **Question 10(a)** where candidates needed to explain why the growth of surface producers increases using the information in the graph rather than using their knowledge about eutrophication and **Question 11(e)** where candidates needed to use the diagram of metallic bonding to explain why metals conduct electricity rather than use their knowledge about metals being electrical conductors and non-metals being electrical insulators.

- Credit was sometimes not awarded because candidates had not answered all aspects of the question using the required terminology. This was evident in **Question 1(b)** where many candidates did not name the enzyme secreted by **B**, amylase, but named a substance, saliva, instead; **Question 2(e)** where candidates were required to complete and balance the equations for the Contact Process but where candidates only used chemical symbols and did not attempt to balance the second equation with the number 2, and **Question 8(d)** where candidates were required to use ideas about collisions between particles but many candidates only stated that the reaction would increase as there is more energy at a higher temperature, completely ignoring the instruction about collisions between particles.

- Candidates should try to match their answers with the number of marks available for that part of the question. A question worth 3 marks will require 3 separate marking points. For example, **Question 1(d)** where candidates were required to outline the different roles of bile in digestion for 4 marks - many candidates just outlined one role of bile in digestion and then concentrated on this one role, usually emulsification, by describing the process of emulsification in detail. Also, **Question 5(b)**, where candidates were asked to state what is meant by an isotope for 3 marks - many candidates just wrote about an isotope being an element with the same proton number. Candidates should attempt all questions even if they only know one part of the answer, for example, **Question 6(a)(i)** which required candidates to place one tick in each row of the table; some candidates only ticked one of the rows.

- When completing calculations, candidates need to state the expressions or formulae required before attempting the calculation, to rearrange the equation as required and to show all their working. These types of questions were answered much better than in previous years and even if full credit was not achieved for the final answer, some credit was still awarded for the equation and any correct steps in the calculation.

- Candidates should use correct scientific terminology and scientific language when describing phenomenon and have a good understanding of the definitions and specific scientific terms used in the syllabus. This was particular important in **Question 2(d)(i)** where burning of fossil fuels or combustion of fossil fuels was required rather than just burning or combustion; **Question 2(d)(ii)** where candidates needed to state acid rain rather than just pollution; **Question 4(c)** where many candidates stated that less energy is produced rather than less energy is released; **Question 5(a)** where shells of electrons or orbits of electrons were required but many candidates wrote about circles of electrons and layers of electrons; **Question 7(a)(iv)** where osmosis was the expected answer but many candidates just wrote diffusion, and **Question 7(b)(i)** where mitosis was the expected answer but many candidates wrote meiosis, nuclear division and cell division.

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General comments

A high standard of vocabulary, legibility and scientific knowledge was displayed by the majority of candidates. The use of scientific knowledge and scientific terminology was usually good. Some candidates gave incomplete responses to questions that required an explanation and this prevented them from achieving full credit for a question. Candidates appeared to have sufficient time to complete the question paper.

Most candidates completed the required calculations throughout the question paper and these calculations were attempted in a logical manner with clear steps including the use of expressions, formulae and units when required. Some candidates had difficulty rearranging equations and using standard form. Some candidates also had difficulty with balancing chemical equations. Areas of weakness included the role of bile, equations in the Contact Process, anaerobic respiration and anaerobic respiration, explanations for processes in physics, nuclear equations and electrolysis.

Comments on specific questions

Question 1

(a) Most candidates identified **A** as the part where mechanical digestion occurs. Fewer candidates identified the correct letters for the part that contains villi, the part that produces bile and the part that produces insulin. **E** was often seen for the part that contains villi and **G** was usually given for either the part that produces bile or the part that produces insulin.

(b) Candidates found this question challenging and usually did not identify the name of the enzyme secreted by **B**. These candidates named saliva and described the functions of saliva. Some candidates who identified the name of the enzyme as amylase also went on to describe the actions of saliva or wrote vague answers about digesting food. Candidates that described the breakdown of starch generally gave maltose or glucose as the product.

(c) The majority of candidates stated the names of two different types of teeth. The most common types of teeth were incisors and molars.

(d) Candidates found this question challenging. Many candidates knew that there was a link between bile and the liver, so they just described the functions of the liver, for example, deamination or breakdown of toxins. Other candidates thought that bile had a general role in digestion, for example, breaking down food molecules or acting as an enzyme. These responses were often intermingled with the correct responses of emulsification or neutralisation. Few candidates gave further details about how emulsification or neutralisation helped to increase the rate of digestion.

Question 2

(a) The majority of candidates correctly linked the state of matter to the arrangement and movement of particles.

(b) The majority of candidates identified the mixture as **B** and gave the reason that mixtures melt over a range of temperatures. A few candidates identified **C** as being a mixture as it has the highest melting point or **D** as it has the lowest melting point. A few candidates wrote about boiling points rather than melting points.

(c) The majority of candidates identified the gas as ammonia and gave the reason that ammonia has the lowest relative molecular mass. A few candidates explained that ammonia has a small relative molecular mass rather than the lowest relative molecular mass; this answer was not comparative. A few candidates identified sulfur dioxide because it has the highest concentration of particles or is the denser gas.

(d) (i) The majority of candidates just gave vague answers, for example, by pollution or by cars or by factories. Good answers included by the combustion of fossil fuels containing sulfur or during the eruption of volcanoes.

(ii) Some candidates gave acid rain as their answer, but a significant number of candidates stated global warming or climate change.

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(e) Candidates found this question challenging. The most common correct answers were H_2SO_4 in the second equation and H_2O in the third equation. The space for the number 2 to balance the first equation was often left blank.

Question 3

(a) (i) The majority of candidates were able to show that the volume of the cylinder of graphite was 1.95 cm^3. A few candidates did not recognise that 0.3 cm^2 is an area and used this in the calculation as either the radius or the diameter.

(ii) The majority of candidates correctly calculated the density by first stating the equation, then substituting the values into the equation before calculating the density of graphite. A few candidates incorrectly rounded the final answer to 2.2 or 2.25 g / cm^3. A significant number of candidates multiplied the mass by the volume rather than dividing the mass by the volume.

(b) (i) The majority of candidates stated that the reading shown on the voltmeter was 1.5 V. A few candidates halved this value giving 0.75 V.

(ii) The majority of candidates correctly calculated the resistance by first stating the equation, then substituting the values into the equation before calculating the resistance of the cylinder of graphite. A few candidates multiplied the ammeter reading and the voltmeter reading.

(iii) Candidates found this question challenging. Many candidates did not give an answer in quantitative terms but just gave general trends. The question stated that the new cylinder of graphite has double the length so candidates should use this information in their answer by stating that this doubles the resistance. The question also stated that the new cylinder of graphite has double the cross-sectional area so candidates should use this information in their answer by stating that this halves the resistance. There were a few candidates who thought that as the current and voltage were unchanged then the resistance would be unchanged or that as the material was the same the resistance would be unchanged.

(c) Candidates found this question challenging. Many candidates did not describe the main method of thermal transfer in solids but just stated that the transfer was by conduction or used vague terms such as energy passing from one particle to another particle. Some candidates did describe the idea that atoms in a solid are vibrating but very few included the idea that the vibrations are passed from one atom to another atom. Few candidates described the transfer by free electrons.

Question 4

(a) The majority of candidates identified the heart rate increases to a maximum or 190 bpm and that the oxygen required for aerobic respiration is transported by haemoglobin in red blood cells. Some candidates thought that oxygen was transported by blood in red blood cells or by blood vessels in red blood cells. Fewer candidates identified that the body required more energy for muscular contraction with many candidates writing about requiring more energy for muscular respiration, muscular endurance or muscular mass.

(b) Candidates found this question about completing the balanced chemical equation for aerobic respiration challenging. Many candidates just wrote the word equation or wrote the word 'energy' as one of the products. Some candidates recognised CO_2 and H_2O as the products but did not balance the equation. The formula for glucose $C_6H_{12}O_6$ was often incorrectly written as CH_2O or the attempt at balancing the O_2 was as $2O_2$.

(c) Candidates usually stated that anaerobic respiration produces lactic acid or causes an oxygen debt. Fewer candidates described less energy being released with many of these candidates incorrectly stating that less energy is made or less energy is produced or more energy is used or more carbon dioxide is released.

(d) (i) The majority of candidates explained that valves in veins prevent the backflow of blood, but fewer candidates linked this to the idea that blood is transported under lower pressure in the veins compared to in the arteries. Many candidates described the direction of blood flow in veins and in arteries and that there is also a difference in the oxygenation of blood - these types of responses did not answer the question.

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(ii) The majority of candidates stated the name of the main artery that transports blood away from the heart as the aorta or as the pulmonary artery.

(e) The majority of candidates stated the name of the two plant vessels specialised for transport as phloem and xylem. Common incorrect answers included root hair cells, arteries, veins and capillaries.

Question 5

(a) The majority of candidates gave the answer of protons in the central nucleus of an atom. Fewer candidates gave the answer of neutrons in the central nucleus of an atom with many giving electrons as their answer. Electrons being in shells surrounding the nucleus was not as well-known, with answers such as ions, electrons, atoms and charge seen.

(b) Most candidates described isotopes as having the same proton number. A few of these candidates then also described isotopes as having a different number of neutrons. However, few candidates described an isotope as being atoms of the same element.

(c) The majority of candidates completed the dot-and-cross diagram showing a double bond with two dots and two crosses in the overlap area of the two circles. Some candidates then went on to complete the rest of the diagram with four dots on the rest of one circle and four crosses on the rest of the other circle. However, some candidates incorrectly completed the diagram with six dots on the rest of one circle and six crosses on the rest of the other circle. A few candidates completed the dot-and-cross diagram to show just a single bond by using one dot and one cross in the overlap area of the two circles.

(d) There was an error in question 5d. The command for Question 5(d) asked candidates to 'Describe the way the sulfur and oxygen bond in the structure of silicon(IV) oxide'. The command should have asked candidates to 'Describe the way the silicon and oxygen bond in the structure of silicon(IV) oxide. This has been corrected in the published version of the paper. Full marks have been awarded to all candidates for this question to make sure that no candidates were disadvantaged.

Question 6

(a) (i) In this question candidates were required to place a tick in each row to show the effect on the properties of frequency, speed and wavelength for light as the light travels from air to glass. The majority of candidates indicated that the wavelength of light decreases. Some candidates also indicated that the speed of light decreases. Fewer candidates stated that the frequency of light remained the same.

(ii) Candidates found this question about calculating the angle of refraction challenging. The majority of candidates just divided 53 by 1.5 or divided 1.5 by 53. Candidates that stated the equation, $n = \sin i \div \sin r$, usually then completed the calculation giving 32.2° as their answer.

(b) The majority of candidates stated the equation, $Q = It$, re-arranged this equation to give $t = Q \div I$ before substituting the values and giving the final answer of 5500 s. Some candidates incorrectly rearranged the equation to give $t = QI$.

(c) Candidates found this question challenging. The majority of candidates wrote about slip rings, the different components of motors, current being transferred or just copied out the part of the question about the current being alternating.

Question 7

(a) (i) The majority of candidates calculated the percentage change in the length of the potato cylinder in the 0.40 mol / dm^3 sucrose solution as 2.0%.

(ii) The majority of candidates gave the incorrect answer as 1.0 mol / dm^3 for the concentration of sucrose solution that gives the smallest water potential gradient. This is the smallest concentration

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but not the smallest percentage change in the length of the potato cylinder, which is +1.0 and so giving the correct answer of 0.6 mol / dm^3.

(iii) The majority of candidates gave the correct answer of 0.2 mol / dm^3 for the concentration of sucrose solution that results in the potato cells with the greatest turgor pressure.

(iv) Approximately half the candidates gave the answer of osmosis but many candidates either did not attempt this question or gave answers such as diffusion, active transport or growth.

(b) (i) The majority of candidates gave the incorrect answers of meiosis, cell division, nuclear division, haploid division or a method such as grafting.

(ii) The majority of candidates recognised that the offspring would be genetically identical although some candidates only described the offspring as being similar or lacking variation rather than being similar genetically or lacking genetic variation. Many candidates also just repeated the question, unable to survive changes in the environment, without giving the idea that the offspring lacked the ability to adapt.

(iii) The majority of candidates gave the answer of either carbon dioxide or water but rarely both. Common incorrect raw materials included air, sunlight, chlorophyll, warmth and soil.

Question 8

(a) Candidates often made minor mistakes when constructing the balanced symbol equation for this reaction. Some candidates mixed the reactants and the products, used Zn_2, used 2 Zn with 2 $2HNO_3$, omitted H_2 or used $ZnNO_3$.

(b) (i) Candidates found this question challenging with many stating that reaction X uses a higher concentration of nitric acid. Other candidates stated that reaction Y uses a higher concentration of nitric acid because more gas was produced in the reaction rather than the reaction finishing sooner.

(ii) The majority of candidates did not determine the average rate of reaction during the first 50 seconds correctly. Many of these candidates multiplied 50 and 16 to give an answer of 800 cm^3 / s or subtracted 16 from 50 to give an answer of 34 cm^3 / s or 50 divided by 16 to give an answer of 3.125 cm^3 / s.

(c) Candidates found this calculation to find the mass of 46 cm^3 of hydrogen gas challenging. Some candidates were able to convert 46 cm^3 into 0.046 dm^3 but other candidates converted 46 cm^3 into 46000 dm^3. Some candidates did not convert the cm^3 into dm^3 but were able to calculate the mass as 3.8 g.

(d) The majority of candidates explained that the reaction will be faster because the particles had more energy. Fewer candidates also explained that the frequency of collision of molecules is higher or there were more collisions per second. Many candidates just wrote about more collisions but not about the frequency of collisions increasing.

Question 9

(a) (i) Candidates found this question about using the correct nuclide notation to complete the decay equation for tritium challenging. Some candidates gave the correct nuclide notation for the beta particle, but some candidates assigned the 0 and −1 the wrong way around or gave 1 or +1 rather than −1.

(ii) Candidates found this question about calculating the time taken for 87.5% of the sample to decay very challenging. A common incorrect answer was to multiply 12.3 by 2 to give 24.6 and then multiply this by 87.5 ÷ 100 to give 21.5 years.

(b) (i) The majority of candidates stated the equation *distance* = *speed* × *time* or that distance = $2.0 \times 10^8 \times 3.5 \times 10^{-10}$. Fewer candidates gave the correct answer of 0.070 m with many candidates finding standard form calculations difficult. Some candidates tried to use the equation as *distance* = *speed* ÷ *time*.

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(ii) Candidates found this question about calculating the mass of a beta particle very challenging. A few candidates stated the equation kinetic energy = $\frac{1}{2}mv^2$ but then usually forgot to square the velocity or found the standard form too difficult.

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Question 10

(a) The majority of candidates identified the increase in nitrates as part of the descriptions of the trends shown in the graph, Fig. 10.1, but very few candidates linked this to the production of proteins or amino acids. Many candidates just described the process of eutrophication rather than using the information given in the graph, Fig. 10.1.

(b) The majority of candidates were able to describe the reduction in light intensity as being the reason why the number of underwater producers in the lake decreases during eutrophication. Fewer candidates then linked this reduction in light intensity to a reduction in the rate of photosynthesis. Many candidates just described the process of eutrophication or gave a description about the trends given in the graph, Fig. 10.1.

(c) Candidates found this question challenging with a wide range of incorrect answers seen, including algae and fish.

Question 11

(a) Candidates found this question about calculating the maximum mass of aluminium extracted from aluminium oxide challenging. A few candidates correctly calculated the relative molecular mass of Al_2O_3 as 102 but some candidates instead calculated the relative molecular mass of 2 Al_2 as 108 by multiplying 27 by 4.

(b) Candidates found this question about explaining if the reaction is oxidation or reduction challenging. Many candidates thought the reaction was reduction because electrons were gained. Other candidates thought the reaction was oxidation because electrons were gained or because the oxygen molecule had lost electrons rather than the oxide ion.

(c) Candidates found this question about constructing the ionic half-equation for the reaction at the anode very challenging. Many candidates included oxygen or hydrogen in their ionic half-equations.

(d) Candidates often had the idea that the reactivity of aluminium was important and often explained it in terms of aluminium being more reactive than iron rather than aluminium being more reactive relative to carbon. Some candidates thought it related to melting point as electrolysis only happens in liquids.

(e) The majority of candidates performed poorly on this question about using Fig. 11.1 to explain why metals conduct electricity. A few candidates explained that there were free electrons or delocalised electrons, but many incorrectly explained that the free electrons were positive, that ions move through the solid or that current is transferred by rubbing.

Question 12

(a) (i) The majority of candidates gave incorrect answers of gravitational potential energy or chemical energy as their response to the sentence completion about the kinetic energy of the car being transferred to the surroundings.

(ii) The majority of candidates did not calculate the area under the graph to determine the distance. Some candidates stated the equation $W = Fd$ or multiplied 2500 by 27.

(b) The majority of candidates calculated the moment of the force about the pivot.

(c) (i) The majority of candidates calculated the potential difference across the lamp. Some candidates divided the current by the power.

(ii) The majority of candidates either had evidence of using the equation $f = v \div \lambda$ or the correct unit of frequency as the Hz. However, many of these candidates did not use the velocity 3×10^8 m / s. Few candidates gave the correct answer of 4.0×10^{14} m with many candidates finding standard form calculations difficult. Many candidates gave the unit of frequency as m / s or seconds or Hz / s.

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CO-ORDINATED SCIENCES

Paper 0654/42
Theory (Extended)

Key messages

- Candidates should read the stimulus material carefully and follow the guidance given. Questions with command words that require candidates, for example to identify, describe, state, calculate, explain, draw, sketch, complete, suggest and construct all require different types of responses. **Question 11(d)** required candidates to use ideas about the bonding in sodium chloride and in chlorine and attractive forces - candidates should use all these ideas in their answers. Some questions had further instructions, for example, **Question 3(c)**, where candidates were told they may include a labelled diagram to aid their description. Therefore, if a diagram is drawn it must be a labelled diagram to gain credit.

- Credit was sometimes not awarded because candidates has not answered all aspects of the question using the required terminology. This was evident in **Question 3(b)** where candidates sketched a graph showing a sinusoidal waveform but did not consider that the wind turbine was turning at a constant speed so the sinusoidal waveform had to have a constant time period and amplitude; **Question 4(a)** where candidates were required to state the balanced symbol equation for photosynthesis but where some candidates wrote the word equation or did not balance the symbol equation; **Question 4(e)** where candidates were required to name the cells but many candidates named organelles or substance rather than cells.

- Candidates should try to match their answers with the number of marks available for that part of the question. A question worth 3 marks will require 3 separate marking points. For example, **Question 8(d)(ii)** which was worth 3 marks, where candidates were required to look at the reaction profiles for the three reactions and select and explain which reaction would be the most suitable. Many candidates just suggested the reaction and gave just one point for the explanation rather than two different points. Also **Question 9(c)(i)** where candidates were required to explain what is observed when the two plastic sheets are moved closer to each other for 2 marks. Many candidates did not state what was being observed and only wrote about like charges repelling. Candidates should attempt all questions even if they only know one part of the answer, for example, **Question 1(a)(i)** which required candidates to identify structures on the simplified diagram of the circulatory system in horses. Some candidates left the answer spaces blank rather than suggesting a possible answer for the name of a blood vessel or the name of an organ.

- When completing calculations, candidates need to state the expressions or formulae required before attempting the calculation, to rearrange the equation as required and to show all their working. These types of questions were answered much better than in previous years and even if full credit was not awarded for the final answer, some credit was still awarded for the equation and any correct steps in the calculation.

- Candidates should use correct scientific terminology and scientific language when describing phenomenon and have a good understanding of the definitions and specific scientific terms used in the syllabus. This was particularly important in **Question 5(a)(iii)** where addition polymerisation was required rather than just addition or polymerisation; **Question 5(a)(v)** where candidates were required to state two similarities between members of a homologous series. The answers needed to be specific to similar chemical properties rather than just properties and then specific to the same general formula rather than the same formula. In **Question 7(b)** candidates needed to state mitosis is used for asexual reproduction rather than just reproduction and in **Question 12(b)(i)** where candidates were required to compare the motion and arrangement of atoms in solids and liquids, but some candidates only wrote about solids become liquids when they are heated as the atoms have more kinetic energy.

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General comments

A high standard of vocabulary, legibility and scientific knowledge was displayed by the majority of candidates. The use of scientific knowledge and scientific terminology was usually good. Some candidates gave incomplete responses to questions that required an explanation and this prevented them from achieving full credit. Candidates appeared to have sufficient time to complete the question paper.

Most candidates completed the required calculations throughout the question paper and these calculations were attempted in a logical manner with clear steps including the use of expressions and formulae when required. Some candidates had difficulty rearranging equations and using standard form. Some candidates also had difficulty with balancing chemical equations. Areas of weakness included the transformer, oscillations and energy transfer in a longitudinal wave, carbohydrate functions in plants, refractive index, cell division and electrolysis.

Comments on specific questions

Question 1

(a) (i) Most candidates identified **X** as the pulmonary artery on the simplified diagram of the circulatory system in horses. Some candidates identified **X** as the pulmonary vein. Fewer candidates identified **Z** as the vena cava, with many candidates identifying **Z** as just a vein or the aorta. **Y** was usually identified as the liver rather than the kidney.

(ii) Most candidates described that horses have a double circulatory system because the blood enters the heart twice during one complete circulation. Some candidates then described one part of this circulation goes just to the lungs and the other part of this circulation goes just to the body. A few candidates just concentrated on one part of the circulation being oxygenated and the other part of the circulation being deoxygenated without mentioning the body or the lungs. Other candidates thought there was a double circulatory system because there were two arteries and two veins.

(b) (i) This question required candidates to state two blood groups in humans. Approximately half of all candidates stated A and O or A and B. The other half of all candidates achieved no credit for answers such as positive and negative, red blood cells and white blood cells or oxygenated and deoxygenated.

(ii) The majority of candidates identified the correct functions of white blood cells as antibody production and phagocytosis. A few candidates also thought that white blood cells had a function in blood clotting.

(c) (i) The majority of candidates correctly calculated how many times thicker an artery wall is than a capillary wall as 2000. A few candidates just subtracted 0.0005 from 1.0000 to give 0.9995.

(ii) The majority of candidates were able to explain one of the reasons for the difference in thickness of wall for an artery and a capillary as being because the artery wall needs to be thicker to withstand high blood pressure. Few candidates explained that the capillary wall is thinner to provide a short diffusion distance. Some candidates thought that the capillary wall is thinner to increase the rate of diffusion rather than decrease the diffusion distance.

Question 2

(a) The majority of candidates identified two chemical reactions that make carbon dioxide as respiration and thermal decomposition of calcium carbonate. A few candidates incorrectly identified the reaction between an alkali metal and water as making carbon dioxide.

(b) The majority of candidates described increased concentrations of carbon dioxide causing either climate change or global warming. Fewer candidates explained that carbon dioxide is a greenhouse gas.

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(c) This question about explaining why oxides, such as carbon dioxide, can be classified as acidic was challenging. The majority of candidates put a ring around amphoteric so did not gain any credit. Candidates that did put a ring around acidic usually explained that carbon is a non-metal and that non-metal oxides are acidic.

(d) (i) The majority of candidates stated that the type of chemical bonding in a molecule of carbon dioxide is covalent. A few candidates thought it was ionic.

(ii) The majority of candidates completed the dot-and-cross diagram showing a double bond with two dots and two crosses in the overlap areas between the three circles, one circle in the middle for carbon and the two outer circles for oxygen. Some candidates then went on to complete the rest of the diagram with four dots or four crosses on each circle of oxygen only. However, some candidates incorrectly completed the diagram with four dots or crosses on the circle for carbon. A few candidates completed the dot-and-cross diagram to show just a single bond by using one dot and one cross in the overlap areas between the three circles.

Question 3

(a) The majority of candidates stated one advantage of generating electricity using wind turbines as it does not contribute to global warming, or it is renewable.

(b) The majority of candidates sketched a graph showing a sinusoidal waveform that had a constant time period and amplitude. A few candidates sketched a sinusoidal waveform that had a non-constant time period but a constant amplitude. Other candidates just sketched a graph with a straight line.

(c) This question about describing the construction of a basic step-up transformer was challenging. Most candidates included a diagram, but this diagram was not always labelled. The incorrect diagrams included a motor, an electrical circuit containing a voltmeter, ammeter and resistor, a wind turbine or a power station connected via a box labelled transformer to overhead power lines. Candidates that performed well included a labelled diagram of a transformer showing an iron core, two coils wrapped around the same core and the number of turns on the primary less than the number of turns on the secondary. A few candidates did not label the primary and secondary coils on the diagram.

(d) The majority of candidates calculated the force exerted by the wind on each turbine blade. These candidates showed evidence of $F = P \times A$ or 7200×90 followed by the correct answer of 650 000 (N).

(e) (i) The majority of candidates stated the minimum frequency of sound which can be heard by a healthy human ear as 20 Hz.

(ii) This question about describing, in terms of oscillations and energy transfer, what is meant by a longitudinal wave, was challenging. Many candidates gave incomplete descriptions, for example, when the direction of vibration of particles is parallel to the wave, or a wave that oscillates in the direction of the energy transfer.

Question 4

(a) The majority of candidates stated the correct balanced symbol equation for photosynthesis. Some candidates just wrote the word equation. Some candidates recognised CO_2 and H_2O as the reactants but did not balance the equation. The formula for glucose $C_6H_{12}O_6$ was sometimes incorrectly written as $C_6H_{12}O_2$.

(b) The majority of candidates completed all the gaps in the sentences to describe and explain the graph in Fig. 4.1. The most common incorrect answers were particle collisions instead of successful, effective or frequent collisions in the second sentence and surface of enzyme or shape of enzyme or active surface of enzyme or active spot of enzyme instead of active site of enzyme in sentence four.

(c) The majority of candidates completed the sentence to describe the transfer of energy during photosynthesis using light and chemical (potential) energy as their answers.

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(d) Candidates found this question challenging. Candidates were expected to state the names of the carbohydrates that plants use for storage and for transport. Many candidates gave the answers of glucose or glycogen or protein or energy for storage and glucose for transport.

(e) This question required candidates to state the name of the cells in the leaf that are adapted for efficient photosynthesis. Many candidates gave incorrect answers including chloroplasts or chlorophyll. The name of the cells adapted for absorption of water from the soil was usually correct as root hair cells, although a few candidates did name these cells as just root cells.

Question 5

(a) (i) The majority of candidates selected **D** as the compound which is ethene. **A** was a common incorrect answer.

(ii) The majority of candidates selected **D** as the compound which is an unsaturated hydrocarbon. **A** was a common incorrect answer.

(iii) Candidates found it challenging to state the type of reaction that takes place when compound **B** is made from compound **D**. Many candidates stated it was cracking, polymerisation or an addition reaction rather than addition polymerisation.

(iv) Candidates found this question challenging. The question required candidates to describe how compound **C** is made from compound **D**. Many candidates described adding water rather than the addition of steam. The use of a catalyst was rarely seen in answers. Some candidates named fermentation and anaerobic respiration as the processes required. Some candidates just described the need for the carbon-to-carbon double bond to be broken to form compound **C**.

(v) Candidates found it challenging to state two similarities between members of a homologous series. Many candidates gave vague answers about having similar properties rather than having similar chemical properties and vague answers about similar structures or the same chemical group rather than the same general formula. Other candidates wrote about having a name that has the same ending, for example, with the letters 'ane'.

(b) (i) The majority of candidates described how to deduce that carbon is in Group IV by the Fig. 5.2 showing that there are 4 electrons in the outer shell. A few candidates thought that carbon had 6 valence electrons.

(ii) The majority of candidates completed Fig. 5.3 to show a different isotope from that shown in Fig. 5.2. Candidates usually added 6p and 7n or 8n in the centre of the circles and added 2 electrons in the inner shell and four electrons in the outer shell. The most common errors were to add extra electrons to the outer shell or not draw any electrons.

Question 6

(a) (i) The majority of candidates correctly calculated the speed of light in water. These candidates usually stated the equation $v = f\lambda$ or $(5.0 \times 10^{14}) \times (4.5 \times 10^{-7})$ to give the answer of 2.25×10^{8} m / s.

(ii) Candidates found this question about calculating the refractive index of water challenging. The majority of candidates incorrectly stated the equation $n = \sin i \div \sin r$ or divided 2.25×10^{8} by 2000, the depth, to give 112 500 as the answer on the answer line.

(b) (i) The majority of candidates correctly calculated the kinetic energy of the angler fish by first quoting the equation kinetic energy = $\frac{1}{2}mv^2$ before giving the answer of 0.1694 J. A few candidates forgot to square the velocity.

(ii) The most common errors were to name force **A** as gravity or mass rather than weight in the first sentence and then direction or velocity or force rather than acceleration in the third sentence.

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Question 7

(a) (i) Approximately half of all candidates identified the actual number of chromosomes in cell **A** as 24 and in cell **B** as 12. Other candidates usually identified the actual number of chromosomes in cell **A** as 46 and in cell **B** as 23 or in cell **A** as 4 and in cell **B** as 2.

(ii) Approximately half of all candidates gave haploid as the name of the type of cells represented by cell **B** in Fig. 7.1. Other candidates usually gave answers of diploid or sex cells or daughter cells.

(iii) This question about the process occurring at stage 1 in Fig. 7.1 was challenging. Many candidates gave answers about the chromosomes cloning, chromosomes fusing together, chromosomes combining, cells multiplying or nuclear division.

(iv) Candidates found this question challenging. The question required candidates to state the name of the type of nucleus in the parental cell in Fig. 7.1. Common incorrect answers included haploid, DNA, genes, gametes, parent nuclei and single cell.

(v) This question about describing the arrangement of chromosomes in the parental cell in Fig. 7.1 was challenging. There were a wide variety of answers including spaced out, separated, single, isolated, random, unpaired and in the centre of the cell.

(b) This question required candidates to state two uses of mitosis. Most candidates gave the answer of asexual reproduction. Other correct answers seen included for growth and for repair. Some candidates thought that uses of mitosis included cell division, creating new organisms, sexual reproduction, fusion and making zygotes.

Question 8

(a) The majority of candidates correctly stated that conditions **A** would give the fastest rate of reaction.

(b) The majority of candidates were able to calculate the mass of 1.2 dm^3 of carbon dioxide gas. These candidates carefully set out their calculations to first calculate the M_r of CO_2 as 12 +16 + 16 = 44, then the moles of CO_2 as 0.05 and finally the mass of CO_2 as 2.2 g. A few candidates were only able to calculate the M_r of CO_2 and then multiplied 44 by 24 before dividing by 1.2 to give an answer of 880 g.

(c) The majority of candidates stated that an exothermic reaction is a reaction in which energy is given out to the surroundings.

(d) (i) Candidates found this question about what is meant by activation energy challenging. Some candidates stated that it is the energy required for the reaction to take place, but many did not then state it was the minimum amount of energy required for the reaction to take place. Incorrect responses included the amount of energy it takes for reactants to get ready, the difference between the initial energy and the higher energy, the energy released before the reaction and the energy that activates the reaction.

(ii) Candidates found this question about the most suitable reaction to use in the self-heating cans challenging. Candidates were required to look at the reaction profiles for the three reactions and select and explain which reaction would be the most suitable. Many candidates selected reaction **Z** with the explanation that it was endothermic. Other candidates selected **Y** as the other reactions gave out too much energy. Candidates that correctly selected reaction **X** usually only explained that **X** has a low activation energy than or that **X** gives out heat but did not compare these to **Y**.

Question 9

(a) (i) Most candidates gave the temperature as 41, 42, 43 or 45 °C. Their explanations usually did not include information about the rate of conduction or the rate of cooling and just explained how they chose the number to be between 1.0 cm of insulation and 3.0 cm of insulation, which is not an explanation.

(ii) Candidates found this question challenging. The description in the question was about a thermocouple but most candidates gave answers including circuit, series, parallel and thermistor.

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(b) The majority of candidates were able to calculate the resistance of the kettle. These candidates provided evidence of $I = P \div V$ or $1800 \div 240$ to give 7.5 A. Then evidence of $R = V \div I$ or $240 \div 7.5$ to give the answer of 32 Ω. Their calculations were usually well set out within the answer space for the question. A significant number of candidates stopped their calculations early and gave 7.5 Ω as their final answer.

(c) (i) Most candidates explained that positive charges repel. These candidates did not usually state that the observation was that the plastic sheets move away from each other.

(ii) Candidates found this question about how a plastic sheet can become positively charged challenging. Most candidates described that the plastic sheet needs to be rubbed but fewer mentioned the transfer of electrons from the plastic sheet or to the surface it is rubbing against. Many candidates wrote about positive ions and negative ions moving or being formed, about putting a charged object next to the plastic sheet to attract the electrons or just that there are more electrons than protons.

Question 10

(a) This question about identifying the parts labelled on a diagram of human skin was challenging. Most candidates identified **B** as a sweat gland, but few candidates identified **C** as fatty tissue and even fewer identified **A** as the erector muscle. **A** was often identified as just a muscle, a nerve or hair cell and **C** identified as tissue, plasma, epidermis and capillaries.

(b) This question was challenging and candidates performed poorly. Candidates were required to describe the role of the blood vessels in maintaining a constant internal body temperature when external temperature increases. Candidates wrote about blood vessels moving to the surface of the skin; heat being lost from the blood but no mention of more heat being lost; blood flowing in the skin but no mention of more blood flow to the capillaries at surface of the skin; blood moving faster; the meaning of homeostasis and excretion of sweat and evaporation of water to cause cooling. A few candidates described vasodilation or blood vessels expanding. Some candidates thought that the capillaries expand rather than the arterioles.

(c) Approximately half of all candidates stated the name of the type of feedback used to maintain a constant internal body temperature as negative feedback. Common incorrect answers included homeostasis, reflex, vasoconstriction and sweating.

Question 11

(a) The majority of candidates completed the sentence about electrolysis with the word ionic. Fewer candidates also completed the sentence with the word molten. Common incorrect responses for molten included dilute, dissolved and heated.

(b) Candidates found this question requiring the completion of the sentence about the electrolysis of a binary salt challenging. Many candidates gave the answer of cation and anion or positive and negative or ion and salt or sodium and chloride.

(c) (i) The majority of candidates could not explain chlorine gas being made at the anode during electrolysis is an example of oxidation. Many candidates gave answers that included it gains electrons, chlorine loses electrons rather than chloride loses electrons, chlorine is oxidised, chlorine becomes neutral.

(ii) This question about constructing the ionic half-equation for the formation of the product at the cathode was very challenging. Most candidates gave the answers $Na^+ + e^- \rightarrow Na$ or $H^+ + e^- \rightarrow H$.

(d) The majority of candidates explained the difference in the melting points of sodium chloride and chlorine as being because sodium chloride has ionic bonding. Fewer candidates mentioned that chlorine has covalent bonding. The answer about chlorine having weak intermolecular forces or sodium chloride having strong electrostatic forces between oppositely charged ions was rarely seen. Incorrect answers included sodium chloride has stronger bonds; sodium chloride is less reactive; in sodium chloride the particles are in a fixed position and there are more frequent collisions in chlorine.

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Question 12

(a) (i) The majority of candidates stated the type of ionising radiation emitted as alpha. A few candidates incorrectly stated that it was gamma radiation.

(ii) Approximately half of all candidates gained credit for this question about calculating the time taken for the activity to decrease to 85 counts per minute. These candidates first stated that there were 3 half-lives or divided 680 by 2, then 340 by 2 and then 170 by 2 to show 3 half-lives. Finally, they multiplied 140 by 3 to give 420 days. A common incorrect answer was 17.5 days where the candidate had multiplied 140 by 85 and then divided this answer by 680.

(b) (i) Approximately half of all candidates did not gain any credit for this question. The question required candidates to explain, in terms of the motion and arrangement of atoms, why a fixed mass of solid polonium will occupy a smaller volume than the same mass of liquid polonium. Candidates were expected to write about the differences in the motion and arrangement of atoms in a solid compared to a liquid. Some candidates only explained this in terms of the motion of the atoms and others in terms of the arrangement of the atoms. Some candidates only wrote about solids and some only about liquids and so did not provide a comparison.

(ii) The majority of candidates calculated the volume occupied by 235 g of solid polonium. These candidates used the equation $V = m \div \rho$ or $235 \div 9.4$ to give the answer of 25 cm^3.

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Paper 0654/43
Theory (Extended)

Key messages

- Successful candidates were well prepared for the examination.
- Candidates are reminded to use the number of marks available as a guide to the level of detail required and time spent on the question. A good guideline is approximately one minute for each mark available.
- Learning definitions of keywords in the specification is always very useful. This was particularly applicable to **Questions 2(a)**, **9(b)(ii)** and **10(b)(i)**.
- Candidates should be reminded to read the stimulus material and each question carefully and follow all the instructions given in the question to be able to access the maximum credit available. Sometimes candidates 'fixate' on one or two words and miss the point of the question.

General comments

In calculation questions, candidates should always quote the formula being used and show all steps in working. Numerical answers should be to an appropriate number of significant figures and include units where required. Most of the physics calculation questions were answered correctly.

Some areas of the syllabus were better known than others. Candidates should be reminded to revise all the material detailed in the syllabus. A useful tool is to use the syllabus as a revision aid and encourage candidates to go through the syllabus ensuring that they have covered each learning objective in their exam preparation.

All questions should be attempted. Particular attention should be paid to questions that involve annotating a diagram, where an answer line is not typically provided, as these can be easily missed.

Comments on specific questions

Question 1

(a) (i) The majority of candidates could identify both parts. The most common errors were rib cage, rings of cartilage and lung.

(ii) Many candidates performed well on this question. Thin membrane or cell wall was suggested by a few candidates rather than just 'thin'. The most common correct answers were 'large surface area' and 'thin'.

(iii) Most correctly identified this as a goblet cell, although a few gave other suggestions such as ciliated cell, alveolus and epithelial cell.

(b) (i) Almost all candidates gave the correct response of 25 breathes per minute.

(ii) There were many fully correct responses. A few candidates placed more than two ticks in the boxes, a case of not following the instructions given in the question. A few ticked 'decrease in oxygen use' or 'increase in water intake'.

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Question 2

(a) Almost all identified **D** and many also recognised the presence of an oxygen atom. A few responses were vague; 'contains hydrogen and carbon' is true, but 'only' is missing. Other compounds also contain hydrogen and carbon.

(b) Almost all candidates correctly stated **A**.

(c) Some candidates suggested using ethanol as a fuel even though the question had already stated **D** is a fuel. A number thought ethanol was used for road surfacing. Other fairly common incorrect responses were 'alcohol', 'bread making' and 'fertiliser'. Other correct answers such as alcoholic drinks and hand sanitiser were credited.

(d) Correct answers mainly focused on the lack of double bonds with a few stating 'contains only single bonds'. The important word 'only' was occasionally left out.

(e) The most common errors were: hydrogen as a product, a hydrocarbon as a product, no products shown (in a few cases), carbon as product and insufficient oxygen.

(f) There were many fully correct diagrams. A common error was extension bonds not being long enough to pass through the brackets. Other fairly frequent errors were inclusion of a double bond, missing brackets and extra hydrogen atoms.

(g) Candidates found this challenging and confused responses were often seen. Some candidates stated the formation of water in condensation polymerisation. There was a general understanding that addition polymerisation involves one type of monomer whereas condensation polymerisation involves two monomers.

Question 3

(a) (i) Many candidates made no attempt at the symbol for a thermistor but still correctly identified the voltmeter and ammeter. Most of the thermistor symbols given were incorrect, such as those for a resistor, light bulb or a variable resistor.

(ii) Calculations were usually correct but sometimes the units were incorrect, such as J, V and A. A few candidates did an incorrect calculation but gave the correct units.

(b) There were only a small number of fully correct responses. A small but significant number of candidates gave reversed answers, such as 'resistance increases' and 'power decreases'. It was common to miss the idea of constant voltage or reference to $P = IV$.

(c) A few candidates interpreted the graph as a speed/time graph and so missed the point of the question. Most omitted the idea of a straight line passing through the origin. Many recognised the idea of proportionality.

Question 4

(a) It was unusual for candidates to identify both **Y** and **Z**, although many identify the root hair cell. Common errors were: 'plant cell', 'root cell', 'xylem' and 'mesophyll cell'.

(b) A lot of vague responses such as 'at the top of the plant' or 'contains chloroplasts' (missing the idea of many/lots of chloroplasts). It was more common for candidates to only gain credit for 'many chloroplasts'.

(c) Many candidates seemed confused by this question, often referring to photosynthesis or gas exchange. Some said 'the process is slower' without naming the process. Many of those who stated 'evaporation' did not give an explanation.

(d) **'**Concentration' was often used instead of 'water potential'. A number of candidates did not gain any credit for this question giving answers such as: 'gravitational', 'force', 'xylem' or 'stem'.

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Question 5

(a) Many correct responses. It was quite common to see the 'non-gaseous' suggestion calcium chloride.

(b) The majority of candidates answered this correctly. It was sometimes missed with a non-zero start and/or the second value greater than 20 seconds.

(c) It was unusual to gain full credit as most candidates did not convert cm^3 to dm^3 but show a method. A small number of candidates gave the final answer as 1/480 but it is expected that candidates should calculate the final answer.

(d) The most common error was one of omission with no mention of activation energy.

(e) Only a very small number achieved full credit, often due to using a double headed arrow to show the energy change of the reaction. The indication for activation energy was sometimes vague with arrows not going from the reactants to the top of the 'hump'.

Question 6

(a) Very few scored all three marks but many scored two. Most did not realise there were four springs so did not divide the force by four to find the force per spring giving a final answer of 30.8 instead of 25.7 (cm).

(b) (i) Almost all suggested a correct frequency.

(ii) Many fully correct responses were seen. Fairly common incorrect answers included: 'oscillations', 'perpendicular', 'vibrations' and 'extensions'.

(iii) Most candidates used an incorrect time value. Most candidates understood that the time taken to reach the crack was half that for the signal to return the detector.

Question 7

(a) (i) There were few fully correct responses. The lacteal was often mistaken as being part of the lungs, villus or capillary. Those who gave 'lacteal' were often vague or incorrect about its function: 'absorbs glucose', absorbs nutrients', 'absorbs food' or 'transports oxygen'.

(ii) Some candidates stated thin cells or just 'thin' so did not gain credit for 'thin walls'. Some completely missed the point of the question suggesting answers related to structural support. Only a small number gained full credit.

(b) (i) Almost everyone correctly described one way the shape of the villi is different.

(ii) There was a lot of confusion here and candidates often linked this to ciliated cells. Many correctly stated 'decreased surface area' but quite often did not make the connection with nutrient absorption.

(c) (i) Most correctly stated one disease but there were a few incorrect suggestions such as scurvy and a small number of 'no response'.

(ii) Many correct responses were seen, although a few seemed confused between 'burette' and 'biuret'.

(d) Many candidates did not seem to understand the concepts of mechanical and/or chemical digestion. Most did not realise that chemical digestion also occurs in the mouth.

Question 8

(a) Many fully correct responses were seen. A fairly common error was omitting the positive sign for the proton charge. A few gave –1 as the mass of the electron.

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(b) A number of incorrect responses were seen. Some candidates ticked the correct box but then negated this by ticking a second box.

(c) Many candidates correctly referred to 'free or delocalised electrons' but omitted the fact that these electrons can move. A significant number missed the point completely suggesting ideas such as an ionic structure, strong/weak bonds or referring to the layered structure of graphite but no mention of electrons.

(d) (i) A number of fully correct responses were seen. Some incorrectly used the atomic mass instead of number of neutrons. Some did not realise that the only difference was the number of neutrons.

(ii) Very few could explain why the isotopes have the same chemical properties. Most gave a definition of an isotope, which did not answer the question.

(e) A few ticked the correct box then added another tick, so negating the mark.

Question 9

(a) (i) This was generally well answered but there were a significant number who misinterpreted the graph as a velocity–time graph. However, some of these still correctly recognised the car was 'stationary/at rest after 20s'.

(ii) Almost all stated the correct time.

(iii) Many candidates performed well here. The formula was usually correctly stated but then not used correctly or incorrectly used to calculate the speed.

(b) (i) Only a relatively small number of candidates answered this correctly due to vague answers and not using one of the key phrases 'incident ray' or 'angle of incidence'. Many answers were unrelated to the question such as 'it is transparent', 'the light is going straight' and 'the refractive index does not change'.

(ii) Very few correct responses were seen due to the lack of the key terms 'TIR/total internal reflection' and 'angle of incidence'.

Question 10

(a) This question confused many candidates with responses such as: 'space to grow', 'space for water' and 'carbon dioxide for photosynthesis'. A large number of candidates appeared not to realise the first process is germination which requires oxygen.

(b) (i) Most gave the correct response, although a few suggested geotropism.

(ii) Many understood that auxin is produced in the tip but did not relate this to lack of cell elongation.

(c) Many correct responses were seen, although a few suggested 'natural selection'.

(d) (i) There were a significant number of 'no responses' and a relatively small number of fully correct responses were seen. Many candidates correctly labelled the wrong structure, such as petals. Some indicated the correct part but with the wrong name.

(ii) Many correct responses were given, usually referring to the large petals. It was unusual to see any of the other acceptable answers. Some suggested, incorrectly, colourful petals.

(e) Many described 'yellow leaves', although some missed also stated other colours. Only a small number linked the absence of magnesium to the lack of chlorophyll.

Question 11

(a) (i) Most suggested reaction with sodium for the extraction of magnesium but some still correctly stated magnesium is more reactive than carbon or vice-versa. Fully correct response were a rarity.

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(ii) Most candidates completely missed the point of this question and did not link reactivity to how easily electrons are lost. With responses such as 'sodium has a lower boiling point', 'sodium has a +1 charge and magnesium has a +2 charge', 'sodium is higher in the reactivity series' and 'sodium is in Group I'.

(b) Many candidates answered this correctly. The M_r of carbon dioxide was usually correct.

(c) A significant number of 'no responses' were seen. Quite a few candidates had no idea how to tackle this question and it was rare to see a fully correct response. The most common correct part was for calculation of the moles of iron oxide. A few determined the moles of iron oxide and aluminium. Candidates were, in general, unable to make the link between the numbers of moles when trying to explain why aluminium was the limiting reagent with vague comments such as 'aluminium is more reactive' and 'there is less aluminium than iron'. Some candidates made no attempt to calculate moles.

(d) Most did not mention ions or atoms when trying to explain the oxidation and reduction processes in the equation. Some could define oxidation and reduction in terms of electrons. There were only a small number of fully correct responses.

(e) Many correct responses were given, although some got 'oxidises' and 'reduces' the wrong way round.

Question 12

(a) (i) Many random responses were seen such as 'condensation' and 'boiler'. It was quite common to name one of the pieces of equipment shown in the diagram.

(ii) There were very few correct responses. It appeared that many candidates were unclear on which energy sources are and are not derived from the Sun.

(b) (i) Most referred to collisions with the walls but very few mentioned the idea of a force being exerted on the walls. Many candidates went off on a tangent, describing what happens to the particles as the temperature increases.

(ii) Most candidates could state what happens to the pressure of the steam. A small number suggested an increase in volume.

(c) (i) Candidates found this challenging and many confused responses were given. Very few candidates included either of the key phrases (changing magnetic field and induced p.d.). This suggests most candidates were lacking knowledge and understanding of how the a.c. generator works.

(ii) A significant number of candidates gained no credit for this question. It was quite common to see incorrect values used incorrectly with a calculation of 75% of 3600.

(d) Many fully correct responses were seen. Common errors included having the number for Th and/or α upside down and omitting one or more of the numbers.

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Paper 0654/51
Practical Test 51

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

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Paper 0654/52
Practical Test

Key messages

- Candidates were generally quite well prepared for this examination and were familiar with several experimental techniques.
- Answers to the planning question were often brief and lacking in detail.
- Candidates found interpreting and evaluating experiments challenging.
- It is advisable for candidates to read the questions carefully to ensure they have answered all of what is being asked. This will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques and were quite careful in their experimenting. The standard of graph drawing was generally high although candidates need to remember a line of best fit needs to be a single line.

It would be helpful for the planning question for candidates to practice organising experimental procedures and measurements in their practical work in lessons.

Candidates found interpreting and evaluating experimental methods difficult such as **Question 3(d)**, a reason why the delivery tube was removed before stopping heating and **Question 6(g)**, why one method was done before another. Undertaking practical work in lessons aimed at these skills would help with this.

Candidates appeared to have sufficient time to complete the paper as only some of the more demanding questions were omitted.

Comments on specific questions

Question 1

(a) (i) Many candidates drew a table with rows and columns. Headings were often incomplete usually with units missing. A common error was height in cm.

(ii) Most candidates recorded the heights in mm. The most common error was to give the measurements in cm.

(iii) Many candidates appreciated that as concentration increased, the height increased; the more common error was to link incorrect variables not mentioned in the question. Few candidates appreciated that as concentration doubled so the height doubled, hence the variables were proportional.

(iv) Identifying or excluding anomalous results was not well known. Common non-creditworthy responses included to check the results to see if the results are right. Accuracy was a common incorrect response.

(v) Many candidates appreciated the reason for mixing the yeast. To activate the yeast was a common incorrect response.

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(vi) More successful candidates appreciated that the contamination would be from the other solutions. Contamination alone was not sufficient to be creditworthy

(vii) Many candidates gave a correct difficulty. The ruler moving was a common incorrect response.

(viii) Gas syringe was quite well known although some candidates omitted gas. Other apparatus included measuring cylinder with no mention of collecting over water, test-tube and beaker.

(b) Some candidates deduced the values correctly. Volumes given often did not add to 10 cm^3 and tended to be random rather than showing a common theme. A significant number omitted this question.

Question 2

Candidates were generally well prepared for the planning question. Some addressed the bullet points and gave a logical description of the investigation. The whole range of marks was seen and some candidates gave detailed answers.

Listing apparatus may be useful but is not creditworthy until it is used in the method. A significant number used a specific volume of mouthwash and saliva but did not include the apparatus for measuring it and many used litmus to test for pH.

The method needs to be workable and in such detail that another person would be able to perform the same method safely. The solution of saliva was given in the plan but many candidates used their own saliva and a small number suggested placing the indicator into their mouth, followed by eating, using mouthwash and then using the indicator again in the mouth; this method was not creditworthy.

Volumes of mouthwash were often not measured; amount is insufficient. Many candidates did not use a variety of volumes of mouthwash or did not measure the volume of saliva used. Of those that used universal indicator, few candidates used a pH colour chart to determine the pH. The most successful candidates repeated for five different volumes of mouthwash and also repeated each volume more than once. Where repeats had been undertaken, averaging was insufficient – the reason for averaging needed to be explained. Many candidates thought either heating the saliva was required or that the mixture needed to be timed and the pH taken at intervals.

Many candidates controlled the volume of mouthwash. Control of volume of saliva was quite well known.

Candidates continue to find processing results and drawing conclusions challenging. Citing a conclusion or prediction from previous knowledge, or simply looking for a pattern in the results was not creditworthy. The use of the results to formulate a conclusion for the details of their investigation was required – for example, look to see when the volume of mouthwash is increased does the pH of the mixture increase, decrease or stay the same. If a graph was to be drawn, then the quantities on each axes needed to be specified and the relationship could then be determined from the shape of the graph – for example, a straight line with a positive gradient would mean a linear relationship between the mouthwash and pH of saliva.

Question 3

(a) (i) Most candidates did the experiment carefully, recording accurate colours for all of the substances. Common errors in colours were before heating: blue for the colour of copper carbonate, red for the colour of iron carbonate and after heating: red or brown for iron carbonate.

Most candidates recorded the times for all four substances in seconds. The most successful had the times in the correct order. The times of some candidates did not match with the order of the Supervisor's results.

(ii) Many candidates gave the correct colour. Yellow and grey were common incorrect responses.

(b) Many candidates calculated the rates correctly. Significant figures were not well understood and often values with three decimal places (four significant figures) were given.

(c) More successful candidates interpreted the results and gave the correct order of reactivity. The most common error was to reverse the order. Reversing the middle two metals was also a common error.

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(d) Very few candidates gained credit for this and a significant number omitted the question. Incorrect responses included: it would explode or burst, carbon dioxide would escape, limewater would splash, reaction would carry on and reaction would stop.

(e) More successful candidates gave a correct improvement, usually measuring the gas with a gas syringe, weighing the metal carbonates or using the same volume of limewater. Many repeated and averaged, although the question prevented this. Common incorrect responses included use different solutions, use more metal carbonates, increase the heat, use a larger mass and heat for a longer time.

Question 4

(a) Most candidates did the experiment carefully recording voltages in the correct order. The most common error was not to have 0 for copper and some did not give the voltages to the same number of decimal places.

(b) Most candidates gave the metals in the correct order. The most common error was to reverse the order.

(c) Candidates found this extremely difficult with few correct responses. Many chose question **3**. Those that chose question **4** did not usually give a valid reason; the most common incorrect responses being it is more accurate or the vague comment, does not depend on human error.

Question 5

(a) Almost all candidates recorded an appropriate value for I. Some gave a value that was higher than 0.5 A or with only one decimal place.

(b) Almost all candidates recorded an appropriate value for V.

(c) Most candidates recorded all values in an increasing order. A small number had the values decreasing.

(d) More successful candidates gave a valid practical reason. Incorrect responses included the current is constantly changing, the distances being different and the ruler not starting from 0.

(e) (i) The standard of graph drawing was generally good. Common incorrect responses included non-linear scales and scales where the plotted points used too little of the grid. Plotting of the points was good except where scales were awkward and required the use of a calculator. A significant number omitted the graph.

(ii) Many candidates drew a good line of best fit. Others were feathery, non-continuous or of changing gradient.

(f) (i) The lines of many candidates intercepted the axis and the value recorded correctly. Some lines were inverted and so the axis was not intercepted. Some found reading their own scale difficult.

(ii) Most candidates with values from **(a)** and **(f)(i)** calculated the value of r correctly. A small number inverted the division of added the numbers.

(g) Candidates found this very difficult and some omitted the question. Most either said the values were within 10% as they were close or were not within 10% as the values were too far apart, neither of which were creditworthy as a calculation was required.

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Question 6

(a) The large majority of candidates recorded the reading correctly. The most common errors were to include one or two decimal places in the value.

(b) Most candidates recorded both values appropriately.

(c) The majority of candidates calculated density correctly. Whilst almost all candidates showed correct substitution of the numbers into the equation, some could not calculate the value correctly.

(d) Candidates found this difficult. The most common incorrect responses were reading the level below the meniscus or from the meniscus rather than to the bottom of the meniscus. Other non-creditworthy responses included reading directly, straight on and parallel. It is worth noting that when reading perpendicular or at eye level this needs to be to the reading on the scale. Placing the measuring cylinder on a flat surface was not creditworthy.

(e) (i) Almost all candidates gave an appropriate mass. A small number did not record their value to the nearest gram.

(ii) Almost all candidates gave appropriate volumes.

(f) The vast majority of candidates calculated the density correctly and many had a value within 10% of the value of density in **(c)**. A small number had values which were not within 10% of **(c)**.

(g) Almost none of the candidates appreciated that the measuring cylinder would be wet when its dry mass was measured to calculate the first density. The value is needed for method 2 for accuracy and it is a controlled variable.

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Paper 0654/53
Practical Test

Key messages

- Candidates were generally quite well prepared for this examination and were familiar with several experimental techniques.
- Answers to the planning question were often brief and lacking in detail.
- Candidates found interpreting and evaluating experiments challenging.
- It is advisable for candidates to read the questions carefully to ensure they have answered all of what is being asked. This will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques and were quite careful in their experimenting. The standard of graph drawing was generally high although candidates need to remember a line of best fit needs to be a single line.

It would be helpful for the planning question for candidates to practice organising experimental procedures and measurements in their practical work in lessons.

Candidates found interpreting and evaluating experimental methods difficult such as **Question 3(d)**, a reason why the delivery tube was removed before stopping heating and **Question 6(g)**, why one method was done before another. Undertaking practical work in lessons aimed at these skills would help with this.

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Comments on specific questions

Question 1

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(ii) Most candidates recorded the heights in mm. The most common error was to give the measurements in cm.

(iii) Many candidates appreciated that as concentration increased, the height increased; the more common error was to link incorrect variables not mentioned in the question. Few candidates appreciated that as concentration doubled so the height doubled, hence the variables were proportional.

(iv) Identifying or excluding anomalous results was not well known. Common non-creditworthy responses included to check the results to see if the results are right. Accuracy was a common incorrect response.

(v) Many candidates appreciated the reason for mixing the yeast. To activate the yeast was a common incorrect response.

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(vi) More successful candidates appreciated that the contamination would be from the other solutions. Contamination alone was not sufficient to be creditworthy

(vii) Many candidates gave a correct difficulty. The ruler moving was a common incorrect response.

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Volumes of mouthwash were often not measured; amount is insufficient. Many candidates did not use a variety of volumes of mouthwash or did not measure the volume of saliva used. Of those that used universal indicator, few candidates used a pH colour chart to determine the pH. The most successful candidates repeated for five different volumes of mouthwash and also repeated each volume more than once. Where repeats had been undertaken, averaging was insufficient – the reason for averaging needed to be explained. Many candidates thought either heating the saliva was required or that the mixture needed to be timed and the pH taken at intervals.

Many candidates controlled the volume of mouthwash. Control of volume of saliva was quite well known.

Candidates continue to find processing results and drawing conclusions challenging. Citing a conclusion or prediction from previous knowledge, or simply looking for a pattern in the results was not creditworthy. The use of the results to formulate a conclusion for the details of their investigation was required – for example, look to see when the volume of mouthwash is increased does the pH of the mixture increase, decrease or stay the same. If a graph was to be drawn, then the quantities on each axes needed to be specified and the relationship could then be determined from the shape of the graph – for example, a straight line with a positive gradient would mean a linear relationship between the mouthwash and pH of saliva.

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(b) Many candidates calculated the rates correctly. Significant figures were not well understood and often values with three decimal places (four significant figures) were given.

(c) More successful candidates interpreted the results and gave the correct order of reactivity. The most common error was to reverse the order. Reversing the middle two metals was also a common error.

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(d) Very few candidates gained credit for this and a significant number omitted the question. Incorrect responses included: it would explode or burst, carbon dioxide would escape, limewater would splash, reaction would carry on and reaction would stop.

(e) More successful candidates gave a correct improvement, usually measuring the gas with a gas syringe, weighing the metal carbonates or using the same volume of limewater. Many repeated and averaged, although the question prevented this. Common incorrect responses included use different solutions, use more metal carbonates, increase the heat, use a larger mass and heat for a longer time.

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Question 5

(a) Almost all candidates recorded an appropriate value for I. Some gave a value that was higher than 0.5 A or with only one decimal place.

(b) Almost all candidates recorded an appropriate value for V.

(c) Most candidates recorded all values in an increasing order. A small number had the values decreasing.

(d) More successful candidates gave a valid practical reason. Incorrect responses included the current is constantly changing, the distances being different and the ruler not starting from 0.

(e) (i) The standard of graph drawing was generally good. Common incorrect responses included non-linear scales and scales where the plotted points used too little of the grid. Plotting of the points was good except where scales were awkward and required the use of a calculator. A significant number omitted the graph.

(ii) Many candidates drew a good line of best fit. Others were feathery, non-continuous or of changing gradient.

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(a) The large majority of candidates recorded the reading correctly. The most common errors were to include one or two decimal places in the value.

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(c) The majority of candidates calculated density correctly. Whilst almost all candidates showed correct substitution of the numbers into the equation, some could not calculate the value correctly.

(d) Candidates found this difficult. The most common incorrect responses were reading the level below the meniscus or from the meniscus rather than to the bottom of the meniscus. Other non-creditworthy responses included reading directly, straight on and parallel. It is worth noting that when reading perpendicular or at eye level this needs to be to the reading on the scale. Placing the measuring cylinder on a flat surface was not creditworthy.

(e) (i) Almost all candidates gave an appropriate mass. A small number did not record their value to the nearest gram.

(ii) Almost all candidates gave appropriate volumes.

(f) The vast majority of candidates calculated the density correctly and many had a value within 10% of the value of density in **(c)**. A small number had values which were not within 10% of **(c)**.

(g) Almost none of the candidates appreciated that the measuring cylinder would be wet when its dry mass was measured to calculate the first density. The value is needed for method 2 for accuracy and it is a controlled variable.

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Paper 0654/61
Alternative to Practical

Key messages

- Candidates were quite well prepared for this examination and were familiar with some experimental techniques.
- Answers to the planning question were often brief, missing key substances and salient points.
- Qualitative analysis tests were not well known. It is advisable for candidates to have undertaken such practical work.
- Candidates need to read questions carefully to ensure they have answered what is being asked, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question such as **Question 1(a)(ii)** where the measurements should have been in mm.

General comments

Candidates generally demonstrated an understanding of basic practical knowledge and techniques.

The standard of graph drawing was poor with axes unlabelled and lines of best fit taking into account anomalous points.

Candidates found interpreting and evaluating experimental methods difficult such as **Question 3(a)(iii)**, a reason why the delivery tube was removed before stopping heating and **Question 7(g)**, why one method was done before another. Undertaking practical work in lessons would help with this and also in the description of methods required by the planning question. Several of these style questions were omitted by candidates or candidates performed poorly.

Candidates appeared to have sufficient time to complete the paper.

Comments on specific questions

Question 1

(a) (i) Candidates found drawing a table for the results quite challenging. Many drew a basic structure of a table with rows and columns. Headings were often incomplete with name or units missing, with some choosing incorrect headings. A common error was height in cm. Some candidates confused table with graph and so attempted to draw a graph. A significant number omitted the question.

(ii) Many candidates measured the heights carefully and gave their answer in mm. Common errors included heading the column in one unit but giving the measurements in another, values being either 10 or 100 times too large and giving the percentage rather than the height. A significant number omitted the question.

(iii) Many candidates appreciated that as concentration increased the height increased; the more common error was to link incorrect variables not mentioned in the question. Few candidates appreciated that as concentration doubled so the height doubled hence the variables were proportional.

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(iv) Many candidates followed the trend in the results and realised that the foam would overflow the test-tube. Common errors included the reaction would not happen and the solution is too concentrated.

(v) Candidates found this challenging. The most common response was measuring cylinder without quoting a suitable size such as 5 cm^3 or 10 cm^3. Other common incorrect responses included test-tube, beaker and dropper. If a pipette is used to measure volume, it needs to be a volumetric or graduated pipette.

(vi) Identifying or excluding anomalous results was not well known. Common non-creditworthy responses included to check the results and see if the results are right. Accuracy was a common incorrect response.

(vii) This proved to be very challenging. Incorrect responses included this includes the length of the solution as well, *h* is smaller so more accurate or easier to measure, a subtraction would be needed, *H* does not change and the top is uneven.

(viii) Gas syringe was quite well known although some candidates omitted gas. Other apparatus included burette or measuring cylinder with no mention of collecting over water, test-tube, beaker, pipette and conical flask. A significant number omitted the question.

(b) Candidates found this very difficult with one quarter omitting the question. Answers usually did not add to 10 cm^3 and tended to be random rather than showing a common theme.

Question 2

Candidates were generally quite well prepared for the planning question. Some addressed the bullet points and gave a logical description of the investigation. A significant number omitted the question. The whole range of marks was seen and some candidates gave detailed answers.

Listing apparatus may be useful but is not creditworthy until it is used in the method. A significant number used a specific volume of mouthwash and saliva but did not include the apparatus for measuring it and a large number used litmus to test for pH.

The method needs to be workable and in such detail that another person would be able to perform the same method safely. The solution of saliva was given in the plan but many candidates used their own saliva or placed an indicator into their mouth, followed by eating, using mouthwash and then using the indicator again in the mouth; this method was not creditworthy.

Volumes of mouthwash were often not measured – amount is insufficient. Many candidates did not use a variety of volumes of mouthwash or did not measure the volume of saliva used. Of those that used universal indicator, almost no candidates used a pH colour chart to determine the pH. Most successful candidates repeated for five different volumes of mouthwash and also repeated each volume more than once. Where repeats had been undertaken, averaging was insufficient – the reason for averaging needed to be explained. Many candidates thought either heating the saliva was required or that the mixture needed to be timed and the pH taken at intervals.

Many candidates controlled the volume of mouthwash. Control of volume of saliva was quite well known.

Candidates continue to find processing results and drawing conclusions challenging. Citing a conclusion or prediction from previous knowledge, or simply looking for a pattern in the results was not creditworthy. The use of the results to formulate a conclusion for the details of their investigation was required – for example, look to see when the volume of mouthwash is increased does the pH of the mixture increase, decrease or stay the same. If a graph was to be drawn, then the quantities on each axes needed to be specified and the relationship could then be determined from the shape of the graph – for example, a straight line with a positive gradient would mean a linear relationship between the mouthwash and pH of saliva.

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Question 3

(a) (i) Many candidates recorded the times to the nearest second. Rounding proved to be an issue, with many citing 27, as did converting minutes and second to minutes. A significant number wrote the readings as they appeared on the stop-watches.

(ii) Reasons of using a hard glass test-tube were quite well known. Common non-creditworthy responses included better conduction of heat, holding the heat better and withstanding the heat. More accurate was also seen often.

(iii) Very few candidates gained credit and a significant number omitted the question. Incorrect responses included: it would explode or burst, carbon dioxide would escape, limewater would splash, reaction would carry on and reaction would stop.

(iv) Candidates found this difficult and a significant number omitted the question. The link between some of the powder not reacting and the colours of the two compounds given in the question was frequently not made. Non-creditworthy responses included not all of the copper carbonate reacts, there is residue left in the test-tube, it is all black and observes the colour change.

(b) (i) Many candidates calculated the average time correctly. Averages were often given as just the sum of the two numbers. A significant number omitted the question.

(ii) More successful candidates calculated the rates correctly. Significant figures were not well understood and often values with three decimal places (four significant figures) were given. A significant number omitted the question.

(c) More successful candidates interpreted the results and gave the correct order of reactivity. The most common error was to reverse the order. Reversing the middle two metals was also a common error.

(d) Candidates found this very difficult and a significant number omitted the question. Many answered the different question about use of a blue flame in flame tests so colour of the flame is not masked rather than applying to the experiment being undertaken.

(e) Candidates found this very difficult and a significant number omitted the question. Many repeated and averaged despite the question specifying not to. Common incorrect responses included use different solutions, use more metal carbonates, increase the heat, use a larger mass and heat for a longer time.

Question 4

(a) Almost no candidates appreciated that this would be a short circuit or would produce no voltage or current. The most common response was the two metals reacting with each other and causing an issue such as a large current or a large voltage. Other common incorrect responses included causes a fire, a swap or share of electrons and electrolysis would not happen.

(b) Most candidates gave the correct order of the metals; a few were inverted. The reason proved more difficult with many giving a snapshot such as the most reactive is at the top or the least reactive is at the bottom rather than the trend.

(c) Candidates found this extremely difficult with few correct responses. Many chose question **3**. Those that chose question **4** did not usually give a valid reason. The most common incorrect responses being it is more accurate or the vague comment, does not depend on human error.

Question 5

Qualitative analysis was not well known. Copper chloride, **J**, was the most known, with iron(II) chloride, **L**, next; few knew zinc chloride, **K**. Where the correct solution was chosen, the reason was usually correct. A significant number omitted the question.

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Question 6

(a) The majority of candidates recorded the current correctly. Common incorrect responses included 0.8 and 1.6 A.

(b) The majority of candidates recorded the voltage correctly. Common incorrect responses included 0.60, 0.55, 0.56 and 0.75 V. A significant number omitted the question.

(c) Candidates found this challenging. Many candidates discussed stopping electrocution, allowing the meters to reset or for accuracy.

(d) Many candidates correctly chose the anomaly, but few could describe the error of reversing the numbers. Many linked this to their answer to **(c)** by citing not resetting the meters or there is still electricity in the circuit. Parallax, human and zero errors were all common incorrect responses.

(e) (i) The drawing of the graph caused candidates a number of issues. The axes were frequently not labelled, particularly with the unit and were often reversed. The scales were often non-linear, sometimes the readings in the table and frequently covered too little of the grid.

(ii) Candidates found drawing the best-fit line difficult. Many included the anomalous point or drew a curve or did both. Some drew lines which were nowhere near the points, multiple lines or non-continuous lines. A significant number omitted the question.

(f) (i) A great many lines did not intercept the vertical axis and so the values quoted were often incorrectly the lowest in the Table. Many could not read their own scale and gave an incorrect reading and almost a quarter of candidates omitted the question.

(ii) The majority of those that had values for **(a)** and **(f)(i)** calculated *r* correctly. A common incorrect response was quoting the value from **(a)**. Others included adding the values, subtracting the values and inverting the division. Just over a quarter of candidates omitted the question.

(g) Candidates found this very difficult with over a third omitting the question. Most either said the values were within 10% as they were close or were not within 10% as the values were too far apart, neither of which were creditworthy as a calculation was required.

Question 7

(a) The large majority of candidates recorded the reading correctly.

(b) Most candidates recorded the volume correctly. 60.4 cm^3 was a common incorrect response.

(c) The majority of candidates calculated density correctly. The most common error was 192.91 or 193 g / cm^3 where candidates divided 134 by 64 and subtracted their answer from 195.

(d) Candidates found this difficult. The most common incorrect response was reading the level below the meniscus rather than to the bottom of the meniscus. Other non-creditworthy responses included reading directly, straight on and parallel. It is worth noting that when reading perpendicular or at eye level, this needs to be to the reading on the scale. Placing the measuring cylinder on a flat surface was not creditworthy.

(e) Almost all candidates gave a correct volume.

(f) The vast majority of candidates calculated the density correctly.

(g) Almost none of the candidates appreciated that the measuring cylinder would be wet when its dry mass was measured to calculate the first density. The value is needed for method 2 for accuracy and it is a controlled variable.

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Paper 0654/62
Alternative to Practical

Key messages

- Candidates were generally well prepared for this examination and were familiar with several experimental techniques. Answers to the planning question were often detailed and logical.
- Candidates tended to give generic answers rather than those specific to the experiment being discussed.
- Interpreting and evaluating experiments proved challenging.
- Candidates need to read questions carefully to ensure they have answered all of what is being asked, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated a good understanding of basic practical knowledge and techniques. The standard of graph drawing was high, although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line which does not take into account any anomalous points.

Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results and also to describe methods such as those required by the planning question.

Candidates appeared to have sufficient time to complete the paper as only some of the more demanding questions were omitted

Comments on specific questions

Question 1

(a) The standard of drawing was high. The outline was occasionally feathery or had gaps in it. A small number of drawings were too small or did not have the serrated edge in the top half. Diagrams of this type should not be shaded.

(b) (i) Most candidates measured the length correctly. Common errors included 38, 40.2, 4.2 and 420 mm.

(ii) The majority of candidates drew a line and measured it correctly. A significant number of candidates did not draw the line and so any measurement given could not gain credit.

(iii) The majority of candidates calculated the magnification correctly. A small number inverted the division. Many did not give their answer to two significant figures often giving two decimal places. Rounding was an issue for some candidates.

(c) Most candidates described one visible difference and the more successful also described a difference. Incorrect responses included both from carnivores, both canines, both curved and one has a longer root.

Question 2

(a) (i) Many candidates used universal indicator, incorrect responses included litmus, measuring paper and indicator unqualified by name. Few appreciated that the colour obtained needs to be compared

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with the colour chart in order to ascertain the pH. Non-creditworthy responses included listing the colours for acid and alkali or simply looking at the colour to estimate pH.

(ii) The majority of candidates drew two lines in the correct places. A small number drew lines which were too short or at pH 5 or 6. A significant number omitted the question.

(iii) Many candidates explained that the pH was lower than 5.5 more frequently and the more successful also explained that the teeth spent longer below pH 5.5 or that **C** went to a lower pH. Some gave vague answers such as pH fluctuated more or repeated the information given at the beginning of the question and discussed dental decay and plaque with no reference to Fig. 2.1.

(b) Many candidates appreciated at least one reason for the difference. Non-creditworthy responses included the enzyme pH differs, there is more or less saliva, food consumed with no link to it being different, illness, temperature change, pH changes and enzyme activity is different on different days.

(c) Candidates found this challenging. Many appreciated that Benedict's solution was needed and some stated that heat was also required. Very few candidates described sampling the mixture at regular intervals and testing these samples with Benedict's solution such that the colour change observed would indicate the various concentrations of reducing sugars. Many attempted a continuous process where everything was put into a test-tube at once and the colour observed, often with no reference to time. Some incorrectly used iodine to test for the reduction of starch. A significant number omitted the question.

Question 3

(a) (i) Almost all candidates recorded the temperature correctly. Incorrect responses included 52.5 and 53 cm^3.

(ii) Candidates found this challenging. Many gave vague non-creditworthy responses such as letting the temperature become even or to heat the syringe. Incorrect responses included letting the reaction finish, so no air escapes, heating up the water and for accuracy.

(iii) Candidates found this difficult. The most popular incorrect response was that the plastic would melt. Other responses included glass does not conduct heat or is an insulator and glass can withstand high temperatures.

(iv) Most candidates recorded 52.5 °C correctly; there were a small number of 53.5 °C. Candidates are expected to look at the data provided in tables and match the number of decimal places of a reading to them; here, 61 °C was a very popular non-creditworthy response.

(b) (i) The standard of graph drawing was generally good. Some candidates reversed the axes and a significant number omitted the label and/or the unit on the axes. A small number gave non-linear axes and some gave the values in the table as their scale. A small number did not use at least half of the grid. Plotting of the points was good except where scales were awkward and required the use of a calculator.

(ii) The majority of candidates circled the anomalous point. A significant number omitted the question.

(iii) Over half of candidates drew a straight line of best ft. Some drew multiple lines, non-continuous lines or did not use a ruler. A significant number included the chosen anomalous point in their line.

(iv) The majority of candidates gave a correct relationship. Proportionality was not well understood as a significant number thought the line showed proportionality. A straight line of positive gradient which goes through the origin shows proportionality of the variables; here, the straight line did not go through the origin.

(v) Most candidates gave a correct value from their graph. Where the scale on the axis was awkward, candidates were unable to read their scale accurately.

(c) Candidates found this challenging. Common incorrect responses included out of the range of the graph, cannot be plotted, too high and the syringe breaks.

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Question 4

(a) The test for hydrogen was quite well known. Squeaky pop test is insufficiently described and many candidates used a glowing splint.

(b) More successful candidates realised the solution was limewater. Common incorrect responses included sodium hydroxide, calcium carbonate and zinc. A significant number omitted the question.

(c) The flame test method was not well known. Many candidates heated the solution in a test-tube or beaker, used a spoon, cotton wool, spatula, tongs or clamp to put the solution into the flame or put the sample into a Bunsen rather than into a flame. Spraying solution into the flame is not a safe procedure.

(d) (i) The test for carbon dioxide was well known. Some candidates thought an emulsion was made rather than a precipitate and some used litmus.

(ii) Candidates did not recall this well and many omitted the question. Incorrect responses included chloride, calcium and calcium carbonate.

(iii) Almost half of the candidates recalled the test for chloride ions. Incorrect responses included sodium hydroxide, the test for chlorine gas, bleaching litmus paper, electrolysis and nitric acid alone. A significant number omitted the question.

Question 5

(a) (i) The majority of candidates gave the correct symbol and parallel connection. Common errors included connecting the voltmeter in series and putting a line thought the meter.

(ii) Almost all candidates recorded 2.9 V. The ammeter caused more issues with 0.81 and 0.84 A being common incorrect responses.

(b) (i) Just over half calculated and recorded the value correctly. The value given in the table was to two significant figures; the most common error was to record their calculated value to too many significant figures.

(ii) The unit of resistance was well known. R was the most common incorrect response.

(c) (i) Just over half of candidates gave a correct reason. Incorrect responses included electrocution, allowing the meters to reset or for accuracy.

(ii) Almost all candidates calculated the resistance correctly.

(d) (i) The current remaining constant was quite well known. Incorrect responses included increases and they are proportional.

(ii) The relationship was quite well known. Common incorrect responses included increases unqualified and as current increases so resistance increases.

(e) The terms were well known. Common incorrect responses included serial, in line and continuous for series and perpendicular for parallel.

(f) Many candidates drew a correct circuit. Some drew the voltmeter in series.

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Question 6

Candidates were generally well prepared for the planning question. Many addressed the bullet points and gave a logical description of the investigation. A very small number omitted the question. The whole range of marks was seen and some candidates gave detailed answers.

Listing the apparatus may be useful but the apparatus is not creditworthy until it is used in the method. A significant number did not name the apparatus they used to measure length and time; scale is insufficient for a ruler since most measuring instruments include a scale.

The method described needs to be workable and in such detail that another person would be able to perform the same experiment; candidates often gave a good basic method. Many candidates timed one oscillation; timing multiple oscillations and dividing by the number of oscillations is a much more accurate method of determining the period. Few candidates repeated the measurements to identify and exclude any anomalies or repeated for five different lengths despite often drawing a graph as part of their processing of the results.

Many candidates drew a table with length and time; few included units. A significant number did not include a table in their plan.

Control variables were well known. Common errors included: controlling the length of the pendulum.

Candidates continue to find processing results and drawing conclusions challenging. Citing a conclusion or prediction from previous knowledge, or simply looking for a pattern in the results was not creditworthy. The use of the results to formulate a conclusion for the details of their investigation was required – for example, look to see if increasing the length of the pendulum increased, decreased or made no difference to its period. If a graph was to be drawn, the quantities on each axes needed to be specified and the relationship could then be determined from the shape of the graph – for example, a straight line though the origin would mean the variables were proportional.

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Paper 0654/63
Alternative to Practical

Key messages

- Candidates were generally well prepared for this examination and were familiar with several experimental techniques. Answers to the planning question were quite often detailed.
- Candidates tended to give generic answers rather than those specific to the experiment being discussed.
- Interpreting and evaluating experiments proved challenging.
- Recording readings on pieces of apparatus were often accurate. Care needs to be taken with decimal places.
- Candidates need to read questions carefully to ensure they answer the question being asked.

General comments

Candidates generally demonstrated a good understanding of basic practical knowledge and techniques. The standard of graph drawing was high, although candidates need to remember that a line of best fit needs to be a single line.

Food tests were generally well known.

Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results and also to describe methods such as those required by the planning question. Qualitative analysis tests were not well known; it is advisable for candidates to have practised these.

Candidates appeared to have sufficient time to complete the paper as only some of the more demanding questions were omitted.

Comments on specific questions

Question 1

(a) (i) Almost all candidates recorded the masses correctly to the nearest gram. The most common error was to record the full balance readings.

(ii) Almost all candidate calculated the change in mass correctly.

(iii) Candidates found this challenging with few discussing surface area. Popular non-creditworthy responses included to be fair, can compare, otherwise wrong results and not accurate.

(iv) Many candidates appreciated that liquid on the outside of the test-tube would add to the mass being measured. Some rewrote the question, removed water from in the potato or did not mention mass.

(v) Just over half of candidates deduced that water had entered the cell. Some thought the sugar had moved into the potato and some discussed movement by osmosis, but did not specify a direction.

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(b) (i) The standard of graph drawing was generally high. Some candidates omitted the labels for the axes or the unit on the mass axis. A small number gave non-linear axes and some gave the values in the table as their scale. A small number did not use at least half of the grid. Plotting of the points was good.

(ii) Over half of candidates drew a reasonable curve. Some drew feathery or multiple lines, non-continuous lines or a straight line.

(c) (i) The majority of candidates determined the concentration from their graph accurately; fewer showed their working on the graph, which was expected to be lines showing the value.

(ii) Half of the candidates either knew there was no net overall movement of water or the solutions inside and outside of the potato were of equal concentration. Some went further and used theory to explain this referring to either concentration gradient or water potential gradient. Non-creditworthy responses included discussing either no water going in or coming out rather than discussing both, where the line is zero and between 2 and 4. A significant number omitted the question.

Question 2

(a) The colours were well known with the positive test colours better known than the original colours of the test reagents. Common incorrect responses included: for iodine: blue and purple for a positive result and colourless, blue and purple for the original colour; for Benedict's solution: colourless and green for the original colour and purple or blue for a positive result; for biuret solution: orange, brown, white, purple and yellow for both results. Some candidates incorrectly gave no change for the negative results.

(b) The conclusions were well deduced. Some candidates gave what was contained and omitted what the tests showed were not contained, discussed sugar rather than reducing sugar and included fats/lipids. It is worth noting that Benedict's solution does not test for any one sugar e.g. glucose but is a general test for all reducing sugars.

Question 3

(a) (i) Candidates found this quite challenging. Incorrect responses included accuracy, high kinetic energy of particles, still reacting and safety of not burning.

(ii) The question asked for volumes to the nearest 0.5 cm^3 and so the recorded value needed to end with either .0 or .5. Common incorrect responses were 79 for 78.5 and 65 for 65.0.

(iii) Almost all candidates subtracted their values correctly.

(iv) Almost all candidates calculated the percentage correctly. A small number did not multiply by 100.

(b) Candidates found this challenging. Incorrect responses included: more air, repeats, less air and air from a different place.

(c) More successful candidates knew that oxygen is needed to support burning. Many candidates confused the test for oxygen and thought the lighted splint would relight or that the splint should be blown out to be glowing and would then relight, or that it would not relight or that the splint would pop.

(d) The test was not well known. Common incorrect responses included silver nitrate, flame test, nitric acid, acid, distillation and electrolysis. Those that used sodium hydroxide often gave the colour with no precipitate or a red precipitate. A large number of candidates omitted the question.

(e) Candidates found this very challenging. Many thought that either the limewater or oxygen would take the place of the carbon dioxide or that there was no reaction.

(f) The test for water was not well known. Many incorrect colours were seen such as black, red and green with common incorrect responses including colourless to blue, colourless to pink, blue to pink, pink to blue and blue to white. A significant number omitted the question.

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(g) Candidates found this quite challenging. The most common response was **1** and **2**; **4** was rarely seen. Many candidates appreciated that tube **1** contained no air but thought tube **2** contained no air or water.

Question 4

Candidates were generally well prepared for the planning question. Many addressed the bullet points and gave a logical description of the investigation. A small number omitted the question. The whole range of marks was seen and some candidates gave detailed answers.

A results table and diagram were not required but more successful candidates included one or both.

Listing the apparatus may be useful but the apparatus is not creditworthy until it is used in the method. Many candidates did not name the apparatus they were using; scale is insufficient for balance since most measuring instruments include a scale.

The method needs to be workable and in such detail that another person would be able to perform the same experiment. Many candidates added iron to water containing salt and indicator **X** but incorrectly left their experiment for several days before looking to see of the indicator had changed colour. Some candidates did not use the indicator at all but looked for signs of rust after several days. In addition, at least two different masses of salt needed to be used. A significant number used the percentage concentration of salt solution, which was not creditworthy as the question asked for the relationship between mass of salt and time for rusting.

Safety issues need three aspects to be addressed, the protection worn, what part of the body it is protecting and what it is protecting against. Candidates are improving in their responses, but non-creditworthy response usually only addressed two of these three factors.

Where repeats had been undertaken, averaging was insufficient – the reason for averaging needed to be explained. Some candidates used five different masses of salt so that a graph of the results could be drawn.

Control variables were well known. Some candidates controlled the mass of salt because they thought knowing the various different masses of salt was controlling it.

Candidates continue to find processing results and drawing conclusions challenging. Citing a conclusion or prediction from previous knowledge is not creditworthy. The use of the results to formulate a conclusion for the details of their investigation was required to formulate the conclusion – for example, look to see if increasing the mass of salt increased, decreased or did not affect the time for rusting to occur. If a graph was to be drawn, then the quantities on each axes needed to be specified. The shape of the graph could then be used e.g. a straight line through the origin would mean the variables were proportional.

Question 5

(a) (i) The majority of candidates measured the distance correctly. Some confused **(a)(ii)** and gave a value that was six times too large. Common incorrect responses included 4, 10, 60 and 62 cm.

(ii) The majority of candidates gave a correct distance. The most common error was to divide **(a)(i)** by 6.

(iii) Candidates found this very difficult and a significant number omitted the question. Common incorrect responses included refraction, reflection, dark room, projection and focus.

(b) Many candidates calculated the value correctly. Some used 103 instead of their answer to **(a)(ii)**.

(c) The majority of candidates calculated the value correctly. Some found the calculation difficult.

(d) Most candidates calculated the average correctly, however, rounding and significant figures proved difficult for some.

(e) The majority of candidates drew the image correctly. A small number drew the image upright or the same size or larger.

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(f) Candidates found explaining this difficult. Many repeated the question stem by saying it was easier to see. Other non-creditworthy responses included easier to focus and there is no light.

Question 6

(a) (i) Most candidates recorded the temperature correctly. The most common incorrect response was 83.5 °C.

(ii) Candidates found this challenging. Incorrect responses included gives time to read, accuracy, water changes temperature, water cools down and to get even temperature in the water.

(iii) Candidates found this a little difficult with many discussing using a digital thermometer, timing exactly or not rounding the values. It is worth noting that when reading perpendicular or at eye level this needs to be to the reading on the scale.

(b) (i) The vast majority of candidates subtracted the correct two values. A common incorrect response was choosing only the first minute, hence 5.5.

(ii) The vast majority of candidates calculated the rate correctly. Some divided by 120.

(c) The majority of candidates calculated the rate for the final two minutes. The most common incorrect response was calculating the rate for the last minute; where the calculation was shown an error carried forward mark was able to be awarded.

(d) Candidates found this very challenging and only a small number stated a conclusion linking rate to temperature to the water. Most formed a conclusion in terms of time, such as the rate was faster at the start, the rate slowed down with time and so did not gain credit.

(e) (i) Most candidates calculated the decrease in temperature correctly. Common incorrect responses included 5 and 12.7.

(ii) Almost half of the candidates used their answer to **(e)(i)** coupled with the decreasing rate of cooling to estimate the temperature of the water correctly. Many candidates did not appreciate the slowing rate of cooling and so subtracted **(e)(i)** from the temperature reading at 5 minutes giving 39.5, which was incorrect.

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