CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice

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

General comments (Biology)

Candidates were prepared quite well for this paper.

Comments on Specific Questions

Question 2

Nearly all of the candidates answered this question correctly

Question 6

This question tested a candidate's knowledge on the relative energy provision of fats and proteins. The more able candidates knew that the answer is fats, but over a third believed that proteins provide the most energy.

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Question 7

Many of the candidates answered that urea passes directly from a cell into the small intestine. Candidates needed to consider how urea is transported from a cell.

Question 12

Candidates need to be aware that it is carbon *dioxide* that is the greenhouse gas, not carbon *monoxide*..

General comments (Chemistry)

Candidates need to be able to recall the chemical tests and their results in order to be able to deduce the nature of unknown substances.

Comments on Specific Questions

Question 15

Candidates were required to make a deduction using a simplified representation of the Periodic Table, which caused little difficulty.

Question 16

Candidates needed to recall the products of a syllabus-specified electrolysis; a significant portion chose the distractor 'hydrogen and sulfur dioxide'.

Question 17

Most candidates answered this correctly, but a significant proportion thought that an exothermic reaction is one in which the temperature of the mixture decreases.

Question 19

Candidates were required to identify the reaction between hydrogen and oxygen as both combustion *and* oxidation.

Question 21

Candidates need to know the nature and results of the chemical tests in order to be able to produce the detective work that this sort of question requires. The change of litmus from red to blue is the positive result of the ammonia test. The only anion that could produce ammonia is option **C**, nitrate. Many candidates found this question challenging.

Question 26

Although most candidates knew that lime is used for the neutralisation of industrial waste, a significant number thought that it was manufactured by reduction, rather than by thermal decomposition.

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General comments (Physics)

Candidates performed best on **Question 36** and found **Question 39** the most difficult.

Comments on Specific Questions

Question 29

This question concerned mass and weight. A majority of less able candidates, and a fair proportion of more able ones, opted for distractor B. This could be because they related mass to volume rather than to weight, or that they believed that the two columns must contain different choices, which is not necessarily the case.

Question 30

Many weaker candidates chose the correct value for the missing force but thought that it acted forwards, failing to take into account the fact that the resultant force was zero.

Question 35

A popular distractor in this question on refraction was **C**. Candidates need to be reminded to check carefully whether a light ray is passing into a more dense or a less dense substance.

Question 39

Most candidates were unaware that the way to increase the current was to connect the 20Ω resistor in parallel with the 10Ω one. All the distractors were popular, especially B and C.

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Paper 0654/12
Multiple Choice

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

General comments (Biology)

The biology section of the paper was tackled most competently by candidates. Only one question presented serious difficulties, and that was because the answer related to a structural feature of a cell that, perhaps understandably, proved relatively unfamiliar.

Comments on Specific Questions

Question 1

Candidates needed to realise that there is a membrane surrounding the vacuole in a plant cell. The label line from the '**A**' very carefully leads to the cell wall surrounding the cell, not the membrane.

Question 3

A high proportion of candidates recognised the shape of the graph showing the effect of temperature on enzyme activity.

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Question 5

Many of the candidates answered that urea passes directly from a cell into the small intestine. Candidates needed to consider how urea is transported from a cell.

Question 7

A significant number of the weaker candidates did not appreciate that respiration provides the energy required in the maintenance of body temperature.

Question 13

A high proportion of candidates knew that photosynthesis removes carbon dioxide from the atmosphere.

General Comments (Chemistry)

Candidates need to ensure that they read question stems carefully in order to absorb all of the information given in them.

Comments on Specific Questions

Question 15

This was the question that was answered correctly by most candidates, indicating that candidates have a good understanding of the prediction of chemical properties from position in the periodic table.

Question 16

Candidates needed to recall the products of a syllabus-specified electrolysis; a significant portion chose the distractor ‘hydrogen and sulfur dioxide’.

Question 17

The key to answering this question was to realise that the reaction is completed very quickly. This was signalled with the word ‘immediately’ in the stem and only the initial rise in temperature can be attributed to energetic changes resulting from the reaction. The subsequent cooling is as a result of the dissipation of the energy released by the initial reaction.

Question 19

Candidates were required to identify the reaction between hydrogen and oxygen as both combustion *and* oxidation.

Question 26

This was another question answered correctly by the large majority of the candidates, indicating that candidates are familiar with the nature of cracking.

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General comments (Physics)

Candidates performed best on **Questions 28**, **32** and, particularly, **Question 36**. The most difficult was found to be **Question 37.**

Comments on Specific Questions

Question 29

This question concerned density, and a majority of less able candidates opted for distractor A. Candidates possibly confused *mass* with *density* and therefore chose the smallest block as having the least mass.

Question 30

Many weaker candidates chose the correct value for the missing force but thought that it acted forwards, failing to take into account the fact that the resultant force was zero.

Question 35

Almost one in three less able candidates knew that the image was inverted, but failed to appreciate that it would be formed where the refracted rays crossed, and therefore would be enlarged.

Question 36

Very few responses were incorrect to this question on sound and a vacuum.

Question 37

In this question about making a permanent magnet more candidates chose option C (iron) than the correct option D (steel). Possibly they saw a reference to a magnetising coil, and failed to read that a permanent magnet was being made.

Question 39

Although two thirds of candidates knew that the current in a series circuit is the same at all points, a significant number did not.

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Paper 0654/13
Multiple Choice

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

General comments (Biology)

Some of the biology question proved challenging, but careful thought before answering might have resolved some of the problems that candidates encountered.

Comments on Specific Questions

Question 1

Many of the candidates believe that sexual reproduction is exhibited by all living things.

Question 6

The most popular wrong answer was the cuticle – a structure that is devoid of cells.

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Question 7

Many of the candidates answered that urea passes directly from a cell into the small intestine. Candidates needed to consider how urea is transported from a cell.

Question 10

There was apparently a problem with linking adrenaline with the liver as a target organ. Candidates need to be aware of the part played by adrenalin and the liver in increasing blood glucose concentration.

Question 11

Candidates needed to appreciate the significance of the term *zygote* in this question. Candidates should be aware that it is not sufficient that a sperm reach an ovum for fertilization to take place; the sperm needs to enter and fuse with the ovum to form a zygote for fertilization to take place.

General Comments (Chemistry)

Candidates need to be able to recall the chemical tests and their results in order to be able to deduce the nature of unknown substances.

Comments on Specific Questions

Question 17

Candidates seem to have confused the intake of externally applied heat energy, leading to a temperature rise, with endothermic changes leading to temperature decrease.

Question 19.

Candidates were required to identify the reaction between hydrogen and oxygen as both combustion *and* oxidation.

Question 21

Candidates need to know the nature and results of the chemical tests in order to be able to produce the detective work that this sort of question requires. The change of litmus from red to blue is the positive result of the ammonia test. The only anion that could produce ammonia is option **C**, nitrate. Many candidates found this question challenging.

Question 22 Some of the more able candidates think that fluorine is inert enough to provide a non-reactive atmosphere for high temperature welding process.

Question 24. Candidates were required to deduce the order of reactivity of five metals from pictorial representations of reactions; a large proportion of the candidates managed to do this.

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General comments (Physics)

Candidates found some of the questions challenging.

Comments on Specific Questions

Question 30

Almost half of the weaker candidates chose the correct value for the missing force but thought that it acted forwards, failing to take into account the fact that the resultant force was zero.

Question 32

Candidates found this question challenging. Candidates are very familiar with pictorial representations of the three states of matter, but they need to be familiar with verbal descriptions as well.

Question 33

Weaker candidates appeared to guess in response to this question on transfer of thermal energy.

Question 34

Wave refraction was the subject here. Only a few candidates answered this correctly, suggesting that candidates are not familiar with the reasons why waves refract when entering a different medium (shallower water, in this case).

Question 35

Although refraction is involved in dispersion of white light, the question asked for the name of the splitting effect, and a very large proportion of candidates either did not know this or failed to read the question carefully.

Question 36

Most candidates knew that an echo is caused by reflection of sound waves, but fewer were aware that sound waves are longitudinal.

Question 37

This question about magnetism was very challenging for a large number of candidates, including the more able.

Question 38

Fuses are generally well understood, although weaker candidates found this question challenging.

Question 39

Only approximately 10% of candidates knew that two resistors in parallel would have a total resistance less than the smaller of the two resistors in the parallel arrangement. The great majority believed that the values should be added, as if the resistors were in series.

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Paper 0654/21

Core Theory

Key Messages

A general improvement was noted, with more candidates seen showing clear working, using the correct units, and giving formulae using the correct abbreviations as listed in the syllabus.

General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on most questions. Candidates generally scored on all questions. Few gained no marks on any question, but very few gained full marks on any question. Although it appeared that candidates often knew the answers to the questions, their answers were sometimes vague. Performance depended not only on scientific knowledge, but on the ability of the candidates to understand the question and express themselves clearly.

Any formula quoted should be in a standard form and use recognisable symbols. Formulae consisting of units should be avoided. Similarly, formulae consisting of a mixture of words, symbols and units should also be avoided.

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

Comments on specific questions

Question 1

(a) Many candidates gained a mark for stating that that the trapped air was a good insulator. Many candidates gave less detail and simply stated that the fibre layer was an insulator.

(b) Many candidates gained one mark for either referring to friction or describing friction. Fewer gained a second mark for describing the transfer of electrons.

(c) (i) Skin cancer was well known as a possible danger of exposure to ultraviolet radiation.

(ii) Most candidates were able to identify an electromagnetic wave and give a use. The most common responses were for radio waves and microwaves. A number of candidates suggested infra-red radiation, but the associated use was often too vague. Heat alone was insufficient.

Question 2

(a) (i) Many candidates knew exothermic. A number incorrectly suggested endothermic.

(ii) Sometimes the candidates simply stated that the point **E** was when the line started to go down. There needed to be a reference to the temperature decreasing.

(iii) This was well answered with many candidates correctly stating 3 minutes. A common error was to quote the time at the end of the line, which was 6.8 minutes.

(iv) Many candidates appreciated that the reaction would be faster, but the idea of there being a greater concentration of acid particles and hence a greater collision frequency was not well understood.

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(v) There were many vague answers for this part, such as *it will get faster*, without clearly linking this to an increase in temperature.

(b) A number of candidates suggested magnesium chloride as the gas given off, but more suggested carbon dioxide and the correct test with limewater.

(c) The mark scheme required a response of no temperature change. Many candidates gave an answer of lower temperature. Candidates should be aware that copper does not react with dilute hydrochloric acid.

Question 3

(a) (i) Most candidates gained some marks here, but few gained more than three marks. Candidates needed to be able to differentiate between bronchus and bronchiole. Many candidates struggled to spell correctly bronchus, bronchiole and alveoli.

(ii) This was not well known although a few candidates gained a mark by stating that it was structure **E**.

(b) (i) Few candidates gained the mark here. There were a number of candidates who drew too many arrows.

(ii) Most candidates found this part extremely difficult. Most failed to work out what the apparatus was showing. Most candidates stated the difference between the two samples as inhaled and exhaled air rather than referring to the content of the air.

(iii) In view of the confusion in **(b)(ii)** it was difficult for many candidates to make sense of this part. Many candidates simply stated that bubbles would be seen, which was insufficient. Many other candidates reversed the observations.

(iv) Despite the difficulties of the previous parts of this question, many candidates made some sensible reference to carbon dioxide.

Question 4

(a) (i) A number of candidates referred incorrectly to elements containing only one atom rather than one type of atom. Many correctly referred to the presence of elements in the Periodic Table.

(ii) This was not well answered. Correct answers usually related to bonding or fixed chemical formula.

(b) (i) The correct answer of 21 was well known. The most common incorrect answer was 3, where the candidates were writing down the number of elements.

(ii) The idea of purity and the consequences of an impure product were not well known.

(c) (i) This was well answered by many candidates, but some included the presence of electrons in their answer.

(ii) There was some confusion in this part as to the meaning of the term *nucleon number*. A number of candidates suggested that as there was no gravity in space this would affect the nucleon number.

(iii) This was quite well answered with many candidates able to explain that caesium would react with air or a gas in the air, but would not be able to react with argon, because argon was very unreactive.

Question 5

(a) Most candidates were able to gain full marks here. The most common error was to link thermal energy to the electric drill.

(b) This was quite well answered. Common errors were to draw the ray as a straight line from outside to inside and only refracting at the second surface or to leave out the ray of light through the prism.

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(c) Most candidates correctly stated the value of the angle as 60°. Fewer were able to identify it as the angle of reflection. A number of candidates referred to it as an acute angle.

(d) (i) Many candidates drew a perfectly correct circuit diagram. Common errors were to draw three lamps rather than three cells or to use the wrong symbol for a cell. A few candidates drew a parallel circuit instead of a series circuit.

(ii) Many candidates correctly drew the voltmeter in parallel with the lamp. A number of candidates incorrectly drew a V inside a square box rather than a circle.

(iii) Many candidates completed the calculation successfully, displaying good data handling skills. Many formulae were poorly written with candidates using their own symbols or using a mixture of symbols, units and words. Any formulae quoted should be in a standard form and use recognisable symbols. Alternatively, it is acceptable to write the formulae in words.

Question 6

(a) Some candidates correctly linked nitrates to plant growth. Fewer linked magnesium to photosynthesis.

(b) (i) Many candidates gained two marks here. Candidates were able to state that over the first 20 days the two fields were the same. Candidates were also able to state that over the next 100 days the plants in field **A** grew higher. Few candidates were able to describe differences in growth patterns shown on the graph.

(ii) This was well answered with many candidates showing good data handling skills.

(iii) Many responses were often specific to field **A** and field **B**, but not linked to fertiliser use.

(c) Water was well known. Carbon dioxide was less often referred to. Sunlight was often incorrectly suggested.

Question 7

(a) (i) Air or atmosphere was not very often identified. Some candidates incorrectly suggested nitrogen oxide.

(ii) Few candidates were able to deduce that gas **A** was natural gas and explain this deduction.

(iii) Carbon monoxide was not well known. Many candidates suggested either carbon dioxide or carbon.

(iv) Most candidates gained at least one mark for drawing a carbon-carbon bond in their structure. Fewer were able to draw a correct structure. Many were unable to name the hydrocarbon.

(b) (i) Water was often identified as a reactant, but few candidates were able to identify ethane as the other reactant. Common wrong answers were alcohol and alkane.

(ii) This was well known.

Question 8

(a) (i) Many candidates identified temperature as a condition. Fewer identified oxygen. Many incorrectly suggested either carbon dioxide or light.

(ii) This was quite well answered, although a number of candidates failed to link their prediction to water.

(b) (i) This was well known.

(ii) Many candidates correctly explained that the seeds would not be eaten. Few candidates were able to describe the advantage of this to the plant.

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Question 9

(a) (i) Many candidates correctly identified the two processes. Common errors were to place the two processes the wrong way round or to identify radiation as one of the processes.

(ii) The differences between the magnetic properties of iron and steel were not well known.

(iii) This calculation proved to be difficult for some candidates. Candidates needed to successfully rearrange a well known formula and appreciate that they needed to convert 0.8 kg to 800 g.

(b) Few candidates were able to give both descriptions required. Most explained that the particles were close together or touching. Few described the random arrangement of the particles.

(c) Many candidates correctly stated one of the quantities. Few knew both.

Question 10

(a) (i) Reflex was not well known. There were a number of candidates who did not answer this part.

(ii) Most candidates were able to answer this correctly.

(b) (i) (ii) Very few candidates were able to identify either of the nerve cells correctly.

(c) This was well known.

Question 11

(a) Copper and chlorine were usually correct for **P** and **Q**. Few candidates identified either hydrogen or oxygen for **R** and **S**.

(b) (i) This was quite well answered. Most candidates were able to show the electrodes connected to the power supply. Many candidates showed the fork and copper electrode dipping into the electrolyte. Some candidates showed the fork connected to the negative connection.

(ii) A number of candidates did not explain that the mass of the fork had increased because of the extra mass of the copper plating. Instead they stated that the mass had increased by 0.1 g. This was not an explanation.

(c) Few candidates identified either of the two properties that were typical of transition metals.

Question 12

(a) Coal, petroleum and natural gas were all well known as fossil fuels. A common misconception was to state one of the fractions obtained from petroleum.

(b) This was well answered.

(c) Many candidates gained at least one mark. Many suggested using less electricity or petrol, but did not explain how less could be used.

Question 13

(a) (i) Most candidates gained at least one mark. There was no single common error.

(ii) Few candidates understood that the forces needed to be equal and opposite. Many incorrectly explained that force **B** would have to greater than force **D** if the boat was moving forward.

(b) (i) Many candidates failed to realise that the distance travelled was 240 m and not 120 m.

(ii) The human range of audible frequencies was not well known. Many candidates gave a very small range, such as from 4 Hz to 100 Hz.

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(iii) Many candidates knew that ultrasound waves were outside the human audible range. Fewer explained that ultrasound waves have a frequency above the human audible range.

(c) Many candidates gained at least one mark here. Some candidates lost marks by giving multiple letters for each answer.

(d) (i) Many candidates described energy changes rather than how the motion of the waves could be converted into electrical energy. This required candidates to use the terms *turbine* and *generator*.

(ii) This was quite well answered.

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Paper 0654/22

Core Theory

Key Messages

A general improvement was noted, with more candidates seen showing clear working, using the correct units, and giving formulae using the correct abbreviations as listed in the syllabus.

General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on most questions. Candidates generally scored on all questions. Few gained no marks on any question, but very few gained full marks on any question. Although it appeared that candidates often knew the answers to the questions, their answers were sometimes vague. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

Any formula quoted should be in a standard form and use recognisable symbols. Formulae consisting of units should be avoided. Similarly formulae consisting of a mixture of words, symbols and units should also be avoided.

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

Comments on specific questions

Question 1

(a) Some candidates had a reasonable knowledge of the difference between mass and weight. Fewer candidates were able to express their ideas clearly enough for them to be able to gain full credit. Some responses included the idea that mass remains unchanged, whereas weight changes with differences in gravitational field strength. These responses gained credit. To gain credit for explaining the meaning of the term weight, candidates needed to refer to the gravitational force pulling on an object, rather than just the gravity. Many candidates also referred to mass as being how heavy an object is rather than a measure of the amount of matter. A large number of candidates confused mass with weight. Many candidates thought that the mass of an object was also its volume or its density.

(b) (i) (ii) The vast majority of candidates were able to gain some marks on this part. Fewer gained full marks. Some candidates confused kinetic energy with potential energy. Many candidates quoted gravitational energy for **(b)(ii)**.

(c) (i) This was well answered with many candidates gaining both marks.

(ii) Many candidates understood the idea of the forces being opposite, but few were able to explain that they were equal.

(d) (i) Many candidates stated that the section is a straight line. This was not sufficient. The description needed to include the idea that the line was horizontal.

(ii) This was well answered.

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Question 2

(a) All three responses were well known. A number of candidates misread the question and described colour changes for universal indicator.

(b) (i) (ii) Both of these parts were well known.

(c) (i) Limewater was well known, although a number of candidates suggested carbon dioxide.

(ii) Candidates who answered **(c)(i)** correctly generally answered this part correctly too.

(iii) Both answers were quite well known although few candidates correctly gave both.

(iv) Many correct alternative answers were offered. Some candidates were vague in their descriptions of increasing the surface area by crushing the calcium carbonate to a powder.

Question 3

(a) Nearly all candidates completed Fig. 3.1, with most gaining at least partial credit. Some candidates demonstrated a misconception between breathing and respiration. Some candidates also used the term *decomposition* rather than *combustion* to describe the last process from fossil fuels to carbon dioxide.

(b) Candidates that attempted this question sometimes drew a correct arrow between plants and animals. Some candidates connected plants and animals, but showed the wrong direction for the carbon transfer. A significant number of candidates chose not to answer this question.

(c) Most candidates were able to identify that more photosynthesis occurred during the spring and summer. The more able candidates referred to decay in the autumn. Many candidates gave the loss of leaves during the autumn, resulting in less photosynthesis, as an explanation. This was also credited. Some candidates did not refer to photosynthesis in their responses preventing them from achieving full credit.

(d) This question was generally answered well with some candidates stating that carbon dioxide is used in photosynthesis and that deforestation would result in less photosynthesis and less carbon dioxide removed from the atmosphere.

Question 4

(a) Some candidates scored well on this part. A few candidates only stated one element per box, which prevented them from gaining full credit. A few candidates wrote the names of the elements rather than the symbols. A few candidates wrote down the wrong symbol for a particular element.

(b) (i) Many candidates gave the correct answer (13), but a common incorrect answer was 12.

(ii) The correct answers silicon and calcium were often given. Candidates were asked to write down the names of the elements. A number of candidates wrote down the symbols and consequently did not gain full credit for their answer.

(c) (i) Only about half of the candidates suggested potassium fluoride, but the majority of these correctly suggested that ionic bonding requires a metal and a non-metal.

(ii) Many candidates knew that the fluorine atom would gain an electron. A number of candidates incorrectly suggested that the fluorine atom would lose an electron.

Question 5

(a) (i) The vast majority of candidates correctly identified 1955, with a few candidates suggesting 1995.

(ii) The vast majority of candidates were able to correctly calculate the yield increase as 330 g / cm^3.

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(b) (i) This part was not well answered. A number of candidates seemed confused by the term *yield*. Others tried to describe the genetic modification of crops. A few candidates gained one mark for suggesting that the highest yielding crops were chosen.

(ii) Many candidates gained some marks here by correctly identifying better use of fertilisers, better irrigation, better soil quality or better weather. However, too many candidates gave very vague answers such as temperature or water.

(c) There were many vague answers here referring to natural disasters and bad weather. Specific ideas were needed, such as drought or flooding.

(d) Only taste and resistance to pests or disease were suggested by candidates.

Question 6

(a) This part was quite well answered, with candidates gaining credit for referring to friction and the transfer of electrons. Descriptions of friction were also accepted.

(b) (i) This was not well answered. The circuit symbol for a switch was not well known. Many candidates drew a series circuit. Most candidates managed to position the switch to control both lamps.

(ii) The idea that there was still a complete circuit for the second lamp was not well known. A common response was the reason of it being a parallel circuit. This was not credited

(iii) Many candidates showed good data handling skills here and were able to calculate the current as 6 A. Marks were often lost for using formulae consisting of a mixture of words, symbols and units.

(c) (i) Many candidates knew that the sound would become quieter. A number of candidates confused amplitude with frequency and suggested that the pitch of the sound would change.

(ii) Candidates found this very difficult. A few managed to draw explanatory diagrams to show the difference. Many candidates confused longitudinal waves with transverse waves.

Question 7

(a) The ovaries were well known as the part of the female reproductive system in which the female gametes are produced.

(b) (i) Oviduct or fallopian tube were also well known.

(ii) Most candidates were able to give an explanation as to why infertility would result from the oviduct becoming blocked.

(c) (i) A few candidates were able to gain maximum marks here by quoting the general definition given in the syllabus. Many candidates assumed that they needed to describe hormones related to reproduction or adolescence and failed to gain any credit.

(ii) Many candidates identified the ovary as the part that produces hormones.

Question 8

(a) (i) (ii) Most candidates correctly calculated the percentage of oxygen in the Earth's crust. Fewer were able to quote accurate values for the percentages of nitrogen and oxygen in the Earth's atmosphere.

(b) (i) Reduction was quite well known. Use of the term *deoxidation* should be discouraged.

(ii) Some candidates could state the meaning of cathode, but few were able to describe electrolysis or state what an electrolyte contains.

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(c) (i) Malleability was not well known. Many candidates just gave a general property of metals such as good electrical conductor, which did not answer the question.

(ii) Some candidates failed to suggest other properties of aluminium that make it a suitable material to wrap around food during cooking. Instead, they gave general properties of metals.

Question 9

(a) (i) In general, the calculation was done well. A number of candidates are still using the triangle consisting of three variables as a substitute for a formula. The idea of using the triangle consisting of three variables is a valuable tool to answering calculation questions, but is not acceptable as a formula. A number of candidates generated the wrong formula using such a triangle.

(ii) Most candidates gained credit for stating that either the maximum human audible frequency was 20 000 Hz or that 50 000 Hz was too high a frequency for humans to hear. A few suggested, incorrectly, that 50 000 Hz was too low a frequency for humans to hear.

(b) Few candidates did this well. The ray drawn needed to go from the dolphin's head to the surface. Refraction needed to be shown on the surface and the ray needed to continue and enter the eye. A number of candidates produced a ray of light that deviated the wrong way. A number of candidates failed to start their first line anywhere near the dolphins head.

(c) (i) Many candidates simply repeated the question and gave an answer that did not include the word *temperature*.

(ii) Many candidates were able to make at least one valid point here. Some candidates were confused between evaporation and boiling.

(d) (i) (ii) These parts were poorly answered. Two ideas were required for each mark and in many cases candidates only gave one idea. There was some confusion with candidates describing properties of the liquid rather than describing the particles. For example a liquid has no fixed shape or takes up shape of the container was not accepted, but the particles in a liquid have no fixed positions would have been accepted. In the case of the gas, some candidates suggested that particles were in random motion rather than randomly arranged.

Question 10

(a) (i) (ii) These parts were answered well. The most common mistakes were to refer to a root cell rather than root hair cell in **(a)(i)** and to refer to cell membrane rather than cell wall in **(a)(ii)**.

(b) Answers for this question often included a vague reference to the absorption of nutrients. Candidates should be reminded that the correct term required was *mineral ions*. Candidates who stated the absorption of a named mineral ion were credited.

(c) (i) (ii) Transpiration was well known in **(c)(i)** although a number of candidates suggested evaporation. Leaf was well known in **(c)(ii)**.

(d) Many correct suggestions were seen with many candidates gaining credit for either photosynthesis, turgor or growth. Fewer candidates suggested water was required for transport. Some candidates described the use of water to keep the plant hydrated. This response did not gain credit.

Question 11

(a) (i) Cracking was well known, but a number of candidates suggested fractional distillation or polymerisation.

(ii) This question was answered quite well, with many candidates being able to make a reference to the double bond present in an alkene. Quite a few candidates identified the hydrocarbon as an alkane.

(iii) Some candidates were able to describe the decolourisation of a solution of bromine. Many reversed the colour change suggesting that the bromine solution would change from colourless to orange.

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(b) (i) Few candidates recognised the process as polymerisation.

(ii) Most candidates found this difficult. Some ignored the instruction to use a letter **G** in a circle as the symbol for hydrocarbon **G**. Many just showed one or two molecules linked. Candidates needed to link at least four hydrocarbons together in a simple chain to gain the mark. A number attempted to construct very complex three dimensional structures.

(iii) Few candidates were able to gain any marks here. Most candidates failed to see that the question was asking them explain what a hydrocarbon was.

Question 12

(a) Incisor was well known

(b) Many candidates showed a good understanding of the structures and functions of the two different teeth in the question. Many gained full marks.

(c) Many candidates gained at least one mark. Making the food easier to swallow was the most popular answer.

(d) Candidates knew that regular brushing of teeth removed plaque, bacteria and food remnants. Few referred to the neutralisation of acids.

(e) Methods of preventing tooth decay were well known.

Question 13

(a) (i) The nature of ionising radiation was not well understood. Many candidates suggested that it was harmless radiation. Few gave a correct definition.

(ii) This was quite well answered. Many candidates were able to explain that X-rays were harmful to humans or that repeated exposure to X-rays was harmful or that the metal screen would stop X-rays from penetrating.

(iii) Many candidates gained one mark here, but few gained both marks. Many attempted to fill in the whole of the electromagnetic spectrum. Some candidates placed X-rays in two boxes and gamma rays in two boxes.

(b) (i) Candidates needed to continue the ray through the fibre with angles of reflection approximately correct. The ray needed to reflect at the wall of the fibre and not pass through the fibre wall before reflecting. Many candidates managed to do this.

(ii) The idea of total internal reflection was not well known. Few candidates were able describe it.

(c) A variety of responses were seen. However, the majority of candidates identified the correct statements. A minority of candidates chose to only tick only one or all three boxes, which did not gain any credit.

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Paper 0654/23

Core Theory

Key Messages

Many candidates benefited from using the correct abbreviations as listed in the syllabus, quoting formulae, showing their working and giving the correct units. General areas of strength are calculations and interpreting graphs. However, there are still many topics where candidates have limited understanding.

General comments

Most candidates attempted all the questions. Many candidates answered some of the questions well. There was a good range of marks on most questions. Candidates generally scored on all questions. Few gained no marks on any question, but very few gained full marks on any question. Although it appeared that candidates often knew the answers to the questions, their answers were sometimes too vague to be awarded credit.

In some questions, the performance depended not only on scientific knowledge, but on the ability of the candidates to understand the question and express themselves clearly.

Any formula quoted should be in a standard form and use recognisable symbols. Formulae consisting of units should be avoided. Similarly, formulae consisting of a mixture of words, symbols and units should also be avoided.

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

Comments on specific questions

Question 1

(a) Many candidates gained a mark for identifying element **C** as a noble gas. Fewer candidates were able to add the correct information about reactivity and electrical conduction.

(b) Some candidates were able to state that the proton number of the element is used to place the element in the Periodic Table.

(c) (i) Many candidates demonstrated an understanding of nucleon numbers.

(ii) The term isotope was well known.

(d) (i) Very few candidates identified hydrogen as the gas given off.

(ii) Very few candidates were able to explain that the pH of the solution increased due to an alkali being produced.

(iii) Few candidates were able to apply their knowledge of the reactivity of elements in Group I of the Periodic Table to answer this question. Many candidates chose not to answer this part.

Question 2

(a) (i) Most candidates understood the idea of a series circuit, however, some were unable to use the correct circuit symbols.

(ii) The calculation was completed correctly by many candidates showing good data handling skills.

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(iii) Only a small number of candidates were able to deduce the combined resistance of the two lamps in series.

(b) (i) (ii) Angle of incidence and angle of reflection were both quite well known.

(iii) This part was quite well answered.

Question 3

(a) (i) (ii) Almost all candidates were able to work out the year when the number of new HIV infections was greatest. However, very few were able to suggest why the actual number of new HIV infections may have been greater than this.

(b) The candidates showed a very good understanding of the methods by which HIV can be transmitted within a population.

(c) (i) Many candidates were able to state that the number of new HIV infections decreased between 2006 and 2010. Fewer were able to make a quantitative comment.

(ii) Many candidates were able to give one or two reasons for the decrease in new infections.

Question 4

(a) (i) Electrons were well known as the charged particles.

(ii) Many candidates gave a good explanation and gained at least one mark. A few candidates thought that the balloons would attract each other.

(b) (i) Many candidates knew that the sound waves were reflected. A common response was ‘bounce off’, which should be discouraged as it is not a technical term.

(ii) The calculation was completed correctly by many candidates displaying good data handling skills.

(c) Candidates found this part very difficult. The unfamiliar situation seemed to confuse many candidates. Few were even able to suggest that gases contract when cooled.

(d) (i) This was not well understood although some candidates were able to explain that there was a resultant upward force.

(ii) This straightforward calculation was carried out quite well.

Question 5

(a) This part was not answered well. Few candidates even suggested heating. Many candidates attempted to explain how sodium chloride crystals could be obtained from a salt water lake.

(b) (i) Many candidates did not understand what they were being asked to do. Consequently many did not answer this part.

(ii) Few candidates were able to explain why strong bonds form between sodium ions and chloride ions.

(c) (i) (ii) Few candidates were able to identify the process as electrolysis, whereas many knew the difference between a cathode and anode.

(iii) Few candidates were able to identify the gas as hydrogen.

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Question 6

(a) (i) Transpiration was not well known.

(ii) Very few candidates were able to identify the place inside the leaf where water evaporates.

(iii) Stomata were not well known.

(iv) This part was well answered, with many candidates referring to high temperature or arid conditions.

(b) (i) The palisade cells were known to some candidates as the cells in which most photosynthesis occurs. Few candidates were able to explain their answer in terms of the presence of many chloroplasts.

(ii) Entry of carbon dioxide through the stomata was not well known.

Question 7

(a) (i) The question explained that the drying agent removed water, but many candidates thought that the drying agent caused rusting.

(ii) (iii) Methods of rust prevention were not well known and consequently few candidates were able to explain how the chosen method prevented rust formation.

(b) (i) **L** and **M** were often correctly identified as the oxides that would have no effect on the pH of pure water. Some candidates were able to explain their answer.

(ii) This was not well known. Very few candidates were able to link the red colour of oxide **M** with the property of transition metals to form coloured compounds.

(iii) This was not well known. Many candidates suggested calcium oxide and then went on to give the correct explanation for phosphorus oxide.

(c) (i) The equation needed to be exactly correct to gain the mark. Many candidates made one error and therefore scored no marks. Candidates need to ensure that they follow instructions. The question asked for a word equation. A number of candidates completed a balanced symbol equation and frequently it was an incorrect one.

(ii) Exothermic reactions were well known.

(iii) Few candidates were able to name the salt as magnesium sulphate.

Question 8

(a) Few candidates were able to insert the correct words into the sentences.

(b) (i) Few candidates knew that chemical energy was contained in coal.

(ii) Some candidates knew that sound and thermal energy were the forms of energy transferred to the surroundings.

(iii) A number of candidates were able to explain why the energy transfer was not 100% efficient.

(c) This part proved quite difficult for the candidates.

(d) (i) Few candidates were able to link the emission of radiation from radioactive materials to the health of the workers. There were very few references to the radiation being ionising.

(ii) Many candidates correctly explained that the radiation could not penetrate thick concrete.

(e) Many candidates were able to identify carbon dioxide as one of the products of combustion that leads to global warming.

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(f) (i) (ii) This was quite well answered. Many candidates gained a mark in either part, but few gained the mark in both parts.

(g) This was well answered.

Question 9

(a) Many candidates were able to interpret the graph well and gain full marks. Some candidates confused group 1 and group 2. Some candidates failed to include any comment about group 1 or group 2.

(b) (i) (ii) The functions in the diet of proteins and carbohydrates were well known.

(c) Few candidates were able to name a suitable mineral ion and state its function.

(d) Poor bone growth was not well known as a consequence of lack of vitamin D.

(e) Excluding other variables or making it a fair test were not well known.

(f) Many candidates were able to suggest what might have happened if the diets were swapped back again after 36 days, but many failed to give a reason.

(g) The characteristics of living organisms were well known.

Question 10

(a) (i) Fractional distillation was not well known.

(ii) A few candidates were able explain that the petroleum had to be heated.

(iii) (iv) Hydrocarbon or alkane was often given as the type of compound illustrated and many candidates correctly gave the formula as $C_8 H_{18}$. Candidates need to be able to show the correct formula for alkanes. Some candidates gave the formula as C^8H^{18} or 8C18H, which were not accepted.

(b) (i) (ii) Sulphur dioxide was not a common answer and consequently few candidates were able to gain any credit in **(ii)**.

Question 11

(a) The definition of respiration was not well known.

(b) Many candidates omitted this part. Water was quite well known as a product, but glucose and oxygen were less well known as the reactants. The equation required was a word equation, but some candidates attempted a balanced symbol equation, having not read the question carefully.

(c) (i) Due to the wording of the question, the candidates either needed to draw two arrows in the correct places and label them correctly or else draw two arrows showing the directions in which the air was moving in and out of the apparatus. Many candidates managed to do this.

(ii) Many candidates failed to show that they understood how the experiment was working. They were unable to state the purpose of the limewater in either flask.

(iii) Some candidates showed some understanding of the outcome of the experiment.

Question 12

(a) (i) (ii) (iii) Many candidates gained at least one mark here. Candidates were able to interpret the graph and identify appropriate places where the car was not moving, accelerating and had the most kinetic energy.

(b) (i) Neither radio waves nor light waves were placed in the correct positions in the electromagnetic spectrum by many candidates. The position of radio waves was better known than the position of light waves.

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(ii) The uses of microwaves for satellite TV and mobile phone communication were not well known. Many candidates suggested another use for microwaves in a microwave oven, such as heating water.

(iii) This was not known to many candidates.

(iv) Many candidates gained at least one mark here. Some candidates lost marks by giving multiple letters for each answer.

(c) Very few candidates could suggest using a magnet to tell the difference between steel and aluminium.

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Paper 0654/31
Extended Theory

Key message

Candidates should take notice of key words such a *state, define, explain* and *deduce* in deciding what response a question requires. They should build their answers around information supplied in the stem or in diagrams. Candidates should avoid explanations of the reverse of what is asked in the question and risk confusing their arguments.

Similarly candidates should take notice of whether chemical compounds should be *named* or their formulae given.

Calculations were generally done well with working shown. Those who are challenged by the algebra involved should be aware that word equations are acceptable, but they should not be mixed with symbols. Candidates are reminded that answers should be quoted to a suitable number of significant figures and rounded up or down as appropriate.

General comments

Candidates showed good use of English in expressing their ideas in continuous prose. They should try to use scientific terminology where possible rather than describing phenomena using less precise language. Learning the definitions specified in the syllabus earns marks directly as well as being an aid to language used in explanations.

Comments on specific questions

Question 1

(a) Many candidates calculated the energy output of the wind generator by multiplying power by time. Correct answers were reached when kilowatts were converted to watts and hours to seconds.

(b)(i) An example of damage to the skin caused by UV exposure, such as cancer or DNA mutation, was usually provided

(ii) Most gave a correct use for a part of the electromagnetic spectrum.

(c) Correct substitution into the kinetic energy formula was usually carried out successfully.

(d) The best explanations for charging of the nylon used the term *friction* and referred to the transfer of electrons.

(e) A few candidates explained the advantage of white fur in terms of poor emission of thermal energy. The majority demonstrated misconceptions including reflection of heat back to the bear.

(f) Most knew that the rocket is seen before it is heard because light travels faster than sound.

Question 2

(a) (i) The term *exothermic* was usually given for a reaction that causes a temperature increase.

(ii) The best suggestions for why the temperature increases and decreases recognised that thermal energy is only given out while the reaction is occurring, and that the temperature falls once the

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reactants are used up. Other responses stated that the temperature decreases while the rate of reaction is falling.

(iii) While some candidates were distracted by the *powdered* state of the copper, many realised that there would be no temperature change because there would be no reaction between copper and zinc sulphate, as copper is less reactive than zinc.

(b) Many candidates provided a correctly balanced equation for the oxidation of iron. Some lost marks when they tried to ease the balancing by using Fe_2, monatomic oxygen or ozone.

(c) (i) There were some good explanations of why hand warmer G releases thermal energy for longer. They recognized that larger grains have a smaller surface area, causing a lower rate of reaction resulting in the reactants lasting longer. Common errors included small grains having smaller surface area.

(ii) Most realised that the chemical potential energy of the contents decreases. Some candidates treated it as a closed system and applied the principle of conservation of energy, rather than realising that the hand warmer transfers thermal energy to the environment.

Question 3

(a) Candidates who were successful in this question were familiar with the experiment to compare inspired and expired air, or were able to interpret the diagram. A common error was to state that inspired air is all oxygen and that expired air is all carbon dioxide.

(b) Most knew that the limewater becomes more clouded or becomes milky more quickly and some candidates could explain this in terms of increased rate of respiration producing carbon dioxide at a greater rate.

Question 4

(a) (i) The three elements were usually identified and the choice explained by the fact that they consist of only one type of atom. Credit was also given for the statement that they appear in the Periodic Table. A definition of an element involving the word *element* was not accepted.

(ii) Candidates needed to state that salt water could not be given a formula because it is a mixture. Many responses attempted to explain in terms of varying composition but gave imprecise descriptions of the substances that sea water might contain, without answering the question.

(iii) There were many good descriptions of testing the purity of a sample of aspirin by measuring its melting point and comparing it with that of the pure compound. Some correctly noted that an impure sample would melt over a range of temperature. There were also good descriptions of chromatography, although comparison with pure aspirin was not always included.

(b) (i) Most diagrams of the electronic structure of an argon atom were correct.

(ii) Explanations of why both atoms are argon usually correctly identified equal proton numbers and different neutron numbers. A minority thought that gravity has an effect on atomic structure.

Question 5

(a) Ray diagrams showing reflection from the plane mirror were usually well drawn. There was some difficulty evident in labelling the angle of incidence.

(b) (i) The series and parallel circuits were generally well drawn.

(ii) Those candidates who knew a version of the formula for calculating the equivalent resistance of lamps in parallel generally achieved the correct answer. Those who realised that the total of two equal resistances in parallel is half that of one resistance also gained credit.

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Question 6

(a) (i) Many candidates realised that plants maintain their green colour if they have enough magnesium to make chlorophyll. Responses that implied that magnesium itself provides the colour, that magnesium makes chloroplasts or that chlorophyll is a cellular structure rather than a chemical compound, were not given credit.

(ii) Most candidates gained at least one mark for explaining that if a plant cannot absorb enough magnesium it grows slowly because chlorophyll is needed for photosynthesis. They realised that if there is less photosynthesis less sugar is provided and hence less energy for growth. Marks were sometimes lost when the link with magnesium was through chloroplasts rather than chlorophyll.

(b) (i) Comparison of the growth of plants with and without fertiliser was generally done well. Full marks required a comparison of the rate of growth or a description of the variation in rate. Phrases such as *increasing gradient* or *increasing rate of growth* were more appropriate than words like *exponential, steady* or *gradual*. Credit was also given for processing data, such as calculating a difference or ratio of heights, rather than simply reading off numbers from the graph.

(ii) A few candidates provided a scientific reason why one field gives a higher yield, by identifying nitrate, rather than nitrogen, as responsible for protein production.

(c) It was evident that many candidates were well prepared to answer this common question on the effect of fertiliser pollution on waterways. They showed understanding of the chain of causes and effects involved in eutrophication. To gain full credit they needed to state three of the processes.

Common misconceptions included algae absorbing too much oxygen, fish starving and animals suffering from lack of light.

Question 7

(a) (i) Candidates were asked to *deduce* which chart showed the composition of biogas. The word *deduce* should have suggested to candidates that a process of elimination was required. Credit was given if it was stated that a product of decomposition of organic material was methane or carbon dioxide.

(ii) Candidates were asked to *name* the compounds formed when natural gas burns, candidates should therefore have written the name rather than the formula.

(b) (i) There were many good definitions of a catalyst. Candidates should be aware that some catalysts do take part in the reaction while remaining unchanged.

(ii) The question indicated that information from the diagram should have been used to suggest how the gases are formed inside the car's engine. Candidates needed to state that the nitrogen and oxygen both come from the air drawn into the engine, and react due to high temperature. Carbon monoxide formation by incomplete combustion was mentioned by some. Marks were not awarded for imprecise statements suggesting that the carbon in the hydrocarbon fuel reacts with oxygen.

Question 8

(a) Good answers explained that seeds store a named source of chemical energy. They recognised that this is required for development of the seed into a plant capable of photosynthesis. Some answers implied growth of the seed itself.

(b) (c) Candidates scored well on this question on seed dispersal when they included sufficient detail. They should be aware of the difference between the terms *excrete* and *egest*.

Question 9

(a) (i) Good descriptions of the conduction process included faster vibration of particles and the passing of this increased vibration between particles of the metal. Many responses implied that the particles did not vibrate at room temperature. Statements about transfer of energy, although correct, did not add much to the information given in the question.

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(ii) Those who knew the definition of efficiency usually calculated the correct percentage.

(b) Most candidates identified at least one difference between boiling and evaporation. A common misconception was that boiling is the process of increasing temperature up to boiling point.

(c) Correct responses described the difference between compression and rarefaction as regions of high and low pressure, or particles being close together or far apart. Others suggested that compression is where waves are bunched.

(d) The correct diagram of particles in a liquid was usually chosen. It was often explained that the particles are closely packed. Instead of random arrangement, statements about the motion of particles were made, which did not use evidence from the diagrams.

(e) Candidates should be aware that where a space is provided, there is usually a mark available for a formula. Most calculations did involve a force divided by an area but attempts to change cm^2 to m^2 were rarely successful.

Question 10

(a) (b) A label line from Y ending at the junction between, iris and pupil, was not given a mark.

(c) Candidates need to be aware of the precise terms used to describe changes in a muscle (contract), and a ligament (less taut). The lens shape was described as becoming thicker or fatter, but terms such as *wider* were imprecise.

(d) There were many suggestions that muscles weaken in old age without referring to ciliary muscles, and the effect they have on lens shape. A very few mentioned loss of lens elasticity.

Question 11

(a) (i) The correct explanation of where the electrolysis of copper chloride was occurring needed to make reference to the number of gases produced, rather than the deposit of copper, which was not labelled on the diagram.

(ii) Those who knew oxygen is produced had to use terminology such as *the positive electrode* or *the anode* to gain full marks.

(iii) Several candidates identified hydrogen even if they had not succeeded in part **(ii)**.

(b) (i) Successful candidates either attempted to calculate the mass of copper deposited and then convert it to moles, or to convert the masses of the electrodes to moles and then subtract. The most common errors occurred in the mole conversion process.

(ii) Most recognised that the anode mass decreases, but explained this in terms of the deposition on the cathode, rather than ionisation of atoms at the anode.

Question 12

(a) (b) Most candidates gave an example of a fossil fuel and could define *non-renewable*. *Cannot be re-used* was not accepted as a meaningful definition.

(c) An alternative energy source was usually suggested as a way to reduce fossil fuel use. Electric cars were not acceptable as an alternative to the use of fossil fuel. Recycling had to be qualified as the recycling of a product of a fossil fuel.

Question 13

(a) (i) The formula $t = x/v$ was often applied correctly to the motion of the sound wave. The most common error was to fail to double the depth.

(ii) Those who knew the formula $\lambda = v/f$ obtained the right answer if they did not make an error in placing the decimal point.

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(iii)(iv) Many recalled the range of audible frequencies as 20 Hz to 20 000 Hz. Most knew that ultrasound could not be heard due to their frequency being above the audible range.

(b) (i) Some candidates had difficulty interpreting the diagram of this electricity generating device. Many realised that the oscillating float caused the magnet to move in the coil. The most able described the effect in terms of the cutting of magnetic flux or changing magnetic field inducing an e.m.f.

(ii) Many realised that a stronger magnet or more turns on the coil would increase the e.m.f.

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Paper 0654/32

Extended Theory

Key Messages

A general improvement was noted, with many more candidates seen to show working clearly, using the correct units, and giving formulae using the correct abbreviations as listed in the syllabus. Candidates should be reminded to give answers to the appropriate number of significant figures.

When drawing graphs, candidates should be reminded to take care to draw clearly, plotting points and drawing curves with precision.

When answering extended questions, candidates should be reminded to use the correct scientific terminology when describing or explaining phenomena. There were some instances where candidates were unable to gain credit due to using incorrect terminology.

General Comments

The majority of candidates showed a wide range of knowledge and understanding across the syllabus. Almost all candidates attempted to answer all the questions, and the majority communicated their responses clearly.

There were some instances of candidates appearing to write answers to a previous question, rather than the one being asked. Some did not do as asked, for example suggesting explanations when descriptions were required. There were also a number of candidates who crossed out correct answers and either did not replace them or replaced them with incorrect answers. Candidates should be reminded to read each question carefully and follow all the instructions given.

Comments on Specific Questions

Question 1

(a) (i) Most candidates had a reasonable knowledge of the difference between mass and weight. Fewer candidates were able to express their ideas clearly enough for them to be able to gain full credit. Many responses included the idea that mass remains unchanged, whereas weight changes with differences in gravitational field strength. These responses gained credit. To gain credit for explaining the meaning of the term *weight*, candidates needed to refer to the gravitational force acting on an object, rather than just the gravity. Many candidates also referred to mass as being how heavy an object is rather than a measure of the amount of matter. Some candidates confused the mass for the weight. A few chose to state the formula for weight, which did not gain credit unless qualified with further explanation.

(ii) Most candidates were able to correctly calculate the gravitational field strength as 9.78. A minority of candidates rounded the figure to 9.8, which also achieved credit. A few did not calculate the gravitational field strength and simply stated the figure 10, which was not credited.

(iii) This question was generally well answered, with many candidates gaining full credit for the formula and calculation. A common error was to calculate the work incorrectly by a factor of ten to give the figure of 60. These candidates still gained some credit if the correct formula was stated.

(iv) Candidates were still able to gain full credit for this question part if the gravitational field strength was incorrectly calculated in part **(ii).** Most candidates gained credit for the formula. However, it was unfortunate that some candidates who correctly calculated the gravitational field strength in

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part **(ii)** chose to use the value 10 for the calculation. These responses did not gain credit as candidates were asked to use their answer to part **(ii)**.

(b) The vast majority of candidates were able to gain partial credit for this question. Fewer gained full credit. The most common error was to fail to recognise that the aircraft had four engines, giving the incorrect calculation of 0.71. They were able to gain credit for stating the correct formula and the units. A few candidates used the incorrect units of N/kg.

Question 2

(a) (i) This question was often misunderstood. Many candidates simply listed the elements of magnesium, sulfur and oxygen rather than recognising the need to state the reactants needed to produce magnesium sulfate experimentally. Candidates who were able to recognise this most commonly stated magnesium and sulfuric acid or magnesium oxide and sulfuric acid.

(ii) The vast majority of candidates that answered part **(i)** correctly were also able to gain credit here. A very small minority of candidates were not able to gain credit here by not stating all the resulting products. For example if magnesium carbonate was given in part **(i)** then carbon dioxide and water would need to be given for part **(ii)**.

(b) The more able candidates were able to gain full credit here. However it was clear that many candidates still had difficulty completing bonding diagrams. The bonding diagram for hydrogen sulfide was generally completed well, with many candidates able to draw the correct covalently bonded compound. A few candidates included charges to their covalently bonded diagrams. This is not appropriate and should be discouraged. Some candidates did not use the formula given and completed diagrams for a compound of SH or NaS. Candidates found completing the bonding diagram for sodium sulfide far more difficult, with many simply drawing another covalently bonded compound. These did not gain credit. Many candidates attempted to show the electron transfer for the ionically bonded compound sodium sulfide. Candidates should be encouraged to complete the diagrams to show where the electrons end up rather than their transfer.

(c) (i) Most candidates gave the correct numbers of 4 and 3. A small number gave the incorrect numbers of 4 and 2.

(ii) The majority of candidates correctly understood that (g) referred to substances being in a gaseous state. Many of these recognised that the reaction had to occur at a high temperature for water to be in a gaseous state. A common misconception was that as particles are further apart in a gas, more energy is required for them to react. A small number of candidates did not state that (g) stood for gaseous and did not use the word gas in their answer.

Question 3

(a) Nearly all candidates completed Fig. 3.1, with most gaining at least partial credit. It is clear that among some candidates there is a misconception between breathing and respiration. Some candidates also used the word decomposition rather than the correct word combustion.

(b) Candidates that did attempt this question usually drew a correct arrow between plants and animals. Some candidates connected plants and animals but showed the wrong direction for the carbon transfer. A significant number chose not to answer this question. Candidates should be encouraged to read all questions and follow instructions carefully.

(c) Only the most able candidates were able to gain credit here. Most simply referred to light being necessary for photosynthesis. The most able candidates were able to recognise that carbon is recycled, whereas energy is not circulated or is lost from the system.

(d) (i) Most candidates were able to identify that more photosynthesis occurred during the spring/summer. The more able candidates referred to decay in the autumn. Many candidates gave the loss of leaves during the autumn resulting in less photosynthesis as an explanation. This was also credited. Candidates had to provide an explanation for differences in carbon dioxide concentration in the atmosphere for both spring/summer and autumn to gain full credit. Some candidates did not refer to photosynthesis in their responses preventing them from achieving full credit.

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(ii) This question was generally answered well with most candidates stating that carbon dioxide is used in photosynthesis and that deforestation would result in less photosynthesis and less carbon dioxide removed from the atmosphere. Some candidates did not take their explanations far enough, only stating that the carbon dioxide is used in photosynthesis. These responses only gained partial credit.

(iii) Many candidates were able to recognise that the combustion of fossil fuels increases carbon dioxide and that combustion of fossil fuels produces sulfur dioxide/acid rain. Only the most able candidates were able to explain that combustion of wood is balanced by recent photosynthesis.

Question 4

(a) Candidates generally scored well. A few candidates only stated one element per box, which prevented them from gaining full credit. Candidates had good knowledge of this topic with full credit not gained due to missing out elements, rather than stating incorrect ones.

(b) (i) Most candidates gained full credit. A small number gave the incorrect relative atomic mass of 30. Some candidates did not use the correct units and so only gained partial credit.

(ii) The most able candidates understood that the elements would have the same number of atoms. A significant number of candidates simply stated that the elements would have the same number of moles. Some candidates also stated Avogadro's constant, without explaining the relevance.

Question 5

(a) (i) The vast majority of candidates gained credit. A very small number did not gain credit by stating 150–160 cm rather than 156–160 cm.

(ii) The vast majority of candidates were able to correctly calculate the number of pupils as 30.

(b) Many candidates gave the type of variation as continuous. The incorrect answers of 'genetic' or 'height' were seen infrequently and very few stated 'discontinuous'.

(c) (i) Most candidates clearly understood that variation would have been caused by environmental factors. The most common correct answer given being differences in diet. A small number also gave the correct suggestion of mutation. Other responses were seen and credited if the suggestions were reasonable. Some candidates suggested the environment without any further qualification. These responses were not creditworthy.

(ii) Many candidates were able to recognise that the twins would have the same genotype or the same genes. It was unfortunate that some candidates described the genotype as being similar rather than the same. These responses did not gain credit. Some candidates stated that the twins came from the same fertilised egg. This was a statement from the previous question and so did not gain credit unless further qualified.

(d) Responses tended to be quite vague. There were many responses that referred to blood groups not changing. This implied that blood group inheritance is entirely genetic but was not clear enough to gain credit. Most candidates were able to recognise the blood groups showed discontinuous variation. Fewer were able to express this well enough to gain credit.

Question 6

(a) (i) This question was answered very well, with many candidates gaining credit for referring to friction and the transfer of electrons. Descriptions of friction were also accepted.

(ii) Many candidates used the correct formula. A noticeable number of candidates had trouble with the conversion of milliseconds to seconds, often giving the incorrect figure of 0.08 W rather than 800 W.

(iii) Candidates were still able to gain full credit here if they had calculated the answer to part **(ii)** incorrectly. Many candidates were able to state and use the correct formula.

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(b) Many candidates used a correct formula to give the answer 1.5 Ω. Some candidates calculated the resistance as if the lamps were in series rather than parallel. Some candidates that used the formula of $1/R_T = 1/R_1 + 1/R_2$ did not invert their answer.

(c) (i) Many candidates were able to correctly state that the sound got quieter or that the volume decreased. References to the pitch or vague responses such as the sound decreasing or becoming softer were not credited.

(ii) Candidates could gain all the available marks through a fully-labelled diagram. Very few candidates chose this option and concentrated on a written response. There was much difficulty in expressing what they knew and often diagrams did not score because they were not labelled. Most knew perpendicular for transverse and parallel for longitudinal but did not use 'direction of oscillation' or an equivalent, and confused this with direction of energy transfer. Many scored the mark for longitudinal being a series of compressions and rarefactions or requiring a medium.

(d) Few but the most able were able to express their responses clearly enough to gain full credit. Many described an electric motor and some candidates referred to the current creating a magnetic field. Candidates mainly gained credit for referring to the rotating coil cutting the magnetic field and the use of slip rings. Candidates should be reminded to use the correct terminology. Candidates needed to use the correct term *induced* when referring to the emf.

Question 7

A variety of letters were seen in candidate's responses. Few candidates gained full credit for this question. In some cases there seemed to be a random selection of letters with no common misconceptions apparent.

Question 8

(a) Most candidates were able to identify that the earth's crust contained a larger percentage of oxygen and explained how they came to this conclusion. Many calculated the percentage of oxygen in the Earth's crust as 46.6% and compared it to 21% in the earth's atmosphere. Some candidates only gained partial credit by stating the incorrect percentage of oxygen in the earth's atmosphere. Candidates should be reminded to be precise when quoting numerical data. Responses such as 'oxygen in the Earth's atmosphere is around 20%' or 'a fifth' did not gain credit.

(b) This question was generally very well answered. Most candidates gained credit for recognising that R was a solid with a giant structure. Some candidates explained further by including that S was a gas.

(c) (i) Most candidates gave the correct word equation and gained full credit. A few candidates provided a symbol equation, which was credited if fully correct. However, candidates should be reminded to read questions carefully and follow the instructions as the question asked for a word rather than a symbol equation. A noticeable number of candidates tried to include aluminium in their equation.

(ii) There were many excellent responses to this question. Many candidates were able to gain full credit for this question by referring to aluminium ions gaining three electrons. Some candidates included the additional detail that the ions were converted into atoms. A few candidates gave the correct ionic equation in addition to their explanation.

Question 9

(a) (i) Most candidates expressed a good understanding of the difference between a compression and a rarefaction. Most candidates described the particles as being closer together in a compression or further apart in a rarefaction. A few candidates referred to the waves being closer together or further apart, which was not creditworthy.

(ii) Most candidates gained credit for stating that the particles would be closer together in a liquid. Fewer were able to express why this would result in an increase in the speed of sound. Some candidates referred to particles passing on the vibrations more easily rather than more quickly.

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(b) Many candidates scored highly on this question. The most common correct answers seen were that boiling only occurs at the boiling point and that evaporation only occurs at the surface. Some candidates simply stated that the water boils at 100 °C, which did not gain credit.

(c) (i)(ii) Part **(i)** and **(ii)** were not answered as well as they could have been. Many candidates referred to the movement of the particles rather than the particle arrangement. Most candidates recognised that the particles in B were spaced so that some of the particles were touching and that particles were widely spaced in C. Far fewer candidates commented on the arrangement of these particles as random. Many candidates made reference to the particle movement, which was not asked for. There also were a few candidates describing the liquid as 'not in a fixed shape' or 'taking the shape of the container'. These are not particle descriptions.

Question 10

(a) There were many good answers seen. Most candidates recognised the process as osmosis. A small number of candidates gave the wrong process. Incorrect processes stated included absorption and transpiration. Many candidates were also able to state that water travels across a semi-permeable membrane. Fewer candidates were able to describe water as travelling from an area of high water potential to low water potential. Candidates should be reminded to use the correct terminology. Description of water travelling from high to low water potential is preferred to high water concentration to low water concentration, although the latter was credited.

(b) Answers for this question were often a vague reference to absorption of minerals. Candidates should be reminded that the correct term is mineral ions. Candidates who stated the absorption of a named mineral ion were credited. Some candidates referred to supporting the plant, which was incorrect.

(c) The vast majority of candidates correctly stated that the shape of the root hair cell gave an increased surface area.

(d) The vast majority of candidates were able to state that water was lost from the leaves/stomata. Some candidates gave additional detail and included the evaporation of water from the mesophyll cells.

(e) Many correct suggestions were seen with many candidates gaining credit for a combination of photosynthesis, turgor and growth. Fewer candidates suggested that water was required for transport. Some candidates described the use of water to keep the plant hydrated. These responses did not gain credit.

(f) The majority of candidates were able to explain that root hair cells are underground or are not in the presence of light. A number of candidates simply stated that root hair cells do not photosynthesise, without giving an explanation.

Question 11

(a) (i) This question was answered particularly well, with the vast majority of candidates being able to identify the compound as an alkene and making reference to the presence of a double bond.

(ii) Most candidates were able to describe the decolourisation of a solution of bromine. A minority of candidates described the opening of the double bond and the formation of bromoethene. The question asked for what would be observed, so these responses were not credited.

(b) Many candidates scored highly on this question, if they recognised the process as cracking. It was clear that many candidates could describe cracking in detail. A few candidates suggested the incorrect processes of fractional distillation, polymerisation and the Haber process.

(c) (i) Many candidates were able to show how they would calculate the relative molecular mass of ethene. A significant number appeared not to understand the question and chose to leave this question unanswered.

(ii) Few candidates were able to gain credit for parts **(ii)** and **(iii)**. Candidates that chose to draw a diagram of the polymerisation of ethene, generally scored highly. Many candidates did not seem to

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recognise that polymerisation had occurred. Those candidates that did recognise that polymerisation occurred generally scored well in both parts **(ii)** and **(iii)**.

(iii) Few candidates attempted this question, particularly if they had difficulty with part **(ii)**. Candidates that previously recognised the process of polymerisation were generally able to gain credit for explaining that many chains would be formed of varying lengths. A small number of candidates included different isotopes of carbon by way of explanation, which was not relevant here.

Question 12

(a) Most candidates recognised that the death rate was higher in country B and stable, whereas death rate in country A was decreasing. A few candidates tried to analyse the data for each year, which was unnecessary. Some candidates tried to provide an explanation for the differences, which was not asked for and did not gain any credit.

(b) Most candidates were able to identify the link between age and coronary heart disease. Some candidates tried to qualify this by suggesting that people had more time to smoke and eat unhealthily. Cases where lifestyle factors were given as the reason for an increase in the death rate rather than age, were not accepted.

(c) Most candidates gained partial credit, with the majority stating that eating too much fat would increase the risk of coronary heart disease. Fewer candidates achieved the second marking point. Very few candidates identified too much salt as a contributory factor. Some candidates suggested too much food or alcohol. These suggestions needed to be linked to obesity to be creditworthy. There were a number of candidates that appeared not to have read the question fully. Candidates suggesting answers such as smoking, exercise and stress where dietary related factors were asked for.

(d) This question was generally answered well. A variety of correct answers were seen including differences in stress, exercise, smoking rates and healthcare. A few candidates misread the question and included differences in diet and age, which they were specifically asked to avoid and so were not credited.

(e) The majority of candidates were able to suggest differences in population size as an explanation. Vague responses such as ‘to make it fair’ were not credited.

Question 13

(a) (i) Most candidates were able to place X-rays and gamma rays correctly in the electromagnetic spectrum. It was clear that most candidates had a good knowledge of the electromagnetic spectrum as very few candidates reversed the two rays.

(ii) Only some candidates chose to answer this question. Most of these gave the correct speed of 3×10^5 or 300 000. Some candidates did not realise that this question required them to give the speed in km/s rather than m/s.

(b) (i) A variety of responses were seen, however the majority of candidates identified the correct statements. A minority of candidates chose to only tick one or all three boxes, which did not gain any credit.

(ii) Candidates who were able to calculate the count rate at one, two and three half-lives scored highly on this question. Where candidates did not gain full credit was mainly due to the quality of the curve drawn. Candidates should be reminded to take care to complete graphical work with accuracy.

(c) Most candidates stated the correct order of 41523. A few candidates gave the alternative order of 51234, which was also credited. The most common incorrect order seen was 41532. These responses gained partial credit.

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Paper 0654/33
Extended Theory

Key message

Candidates should take notice of key words such a *state, define, explain* and *deduce* in deciding what response a question requires. They should build their answers around information supplied in the stem or in diagrams. Candidates should avoid explanations of the reverse of what is asked in the question and risk confusing their arguments.

Similarly candidates should take notice of whether chemical compounds should be *named* or their formulae given.

Calculations were generally done well with working shown. Those who are challenged by the algebra involved should be aware that word equations are acceptable, but words should not be mixed with symbols. Candidates are reminded that answers should be quoted to a suitable number of significant figures and rounded up or down as appropriate.

General comments

Candidates showed good use of English in expressing their ideas in continuous prose. They should try to use scientific terminology where possible rather than describing phenomena using less precise language. Learning the definitions specified in the syllabus earns marks directly as well as being an aid to language used in explanations.

Comments on specific questions

Question 1

(a) Successful candidates were able to relate reactivity and valence electrons with position in the Periodic Table.

(b) Candidates were asked to *deduce* which diagram showed an alloy. The word *deduce* should have suggested to candidates that a process of elimination was required. Credit was given for a definition of an alloy.

(c) (i) Many candidates knew that lowering temperature would reduce the rate of reaction. Those that went on to explain this in terms of particles noted their reduced speed or energy but often wrote about fewer collisions rather than a lower rate of collision. Some candidates attempted an explanation of what would have happened had the temperature been increased and confused their arguments.

(ii) A few candidates realised that 24 dm^3 should be converted to cm^3. Some could then calculate the number of moles in 8.4 cm^3 of hydrogen.

Question 2

(a) (i) Some candidates found the total voltage across the lamp while others may have confused the terms *cell* and *battery* and gave the voltage across the lamp as 1.5 V.

(ii) Those that knew the formula for charge were often successful in the calculation, but did not always give the correct unit.

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(iii) Most responses repeated the question in some form, rather than introducing new information about negatively charged electrons flowing from negative to positive and conventional current flowing from positive to negative.

(b) Those candidates who knew a version of the formula for calculating the equivalent resistance of lamps in parallel generally achieved the correct answer. Some gave the reciprocal of the correct answer. Those who realised that the total of two equal resistances in parallel is half that of one resistance also gained credit. Many candidates simply added the resistance.

(c) (i) Some candidates could identify both the angle of incidence and the angle of reflection, without confusion with refraction.

(ii) It was usually stated that angle C doubled. Some candidates gave a less precise answer by stating that the angle increased.

Question 3

(a) Most candidates suggested sexual contact, shared needles or exchange of blood as ways in which HIV infection might occur. Many misconceptions were evident concerning the body fluids which can carry the virus and the role of general hygiene in preventing infection.

(b) (i)(ii) The change in concentration of HIV particles was correctly described by many, while others misread the graph stating that concentration increases in the first year, decreases and then increases in the second.

(c) (i)(ii) The best responses explained the changes in white blood cell concentration in terms of response to infection and destruction by the virus, while others introduced the effect of medication and made vague statements about fighting between the virus and blood cells.

(d) Many candidates were aware that a person is more likely to suffer from other diseases, while some answers made vague reference to becoming sick more often. There were few references to suppression of the immune system or the role of antibody production.

(e) There were many sound suggestions for ways in which governments can prevent the spread of HIV. Other suggestions were either impractical or inhumane.

Question 4

(a) (i)(ii) Those who knew that electrons are transferred when a balloon becomes charged realised that the two balloons repel because they have the same charge. There were some attempts at a reverse argument.

(b) (i) Candidates should be made aware that the correct explanation for an echo should involve the *reflection* of sound waves rather than *bouncing*.

(ii) Correct responses described the difference between compression and rarefaction as regions of high and low pressure, or particles being close together or far apart. Others suggested that compression is where waves are bunched.

(iii) Explanations for the higher speed of sound in water than in air often included the smaller distance between particles, while not considering the time between collisions.

(c) Several candidates applied the formula a = F/m to the motion of the balloon but did not usually substitute the resultant force.

Question 5

(a) (i)(ii) Many candidates knew that the bonding in sodium chloride is ionic, and could sometimes draw alternate sodium and chloride ions with the correct charges in alternating positions on the diagram.

(b) (i) Some candidates suggested that the sodium chloride should be molten rather than dissolved in water. The term *diluted* was not appropriate.

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(ii) The products of the electrolysis of sodium chloride solution were known by some.

(iii) A few candidates were able to access this question involving the discharge of chloride ions.

(c) Many candidates knew the formula of chlorine and wrote a balanced equation. Others did not use the information provided, giving an equation which, though easier to balance, was inaccurate.

Question 6

(a) (i) Some of those who made an attempt at this question drew the route for the water vapour passing through one of the pores.

(ii) Some knew that the pore is a stoma.

(b) (i) Those that realised that water loss from a leaf is dependent on the rate of evaporation usually stated that the rate of water loss is greater with larger air spaces.

(ii) Some correctly explained the effect of more pores in terms of more escape routes.

(c) Many candidates could use this information to suggest smaller or fewer pores as an adaptation for desert conditions.

Question 7

(a) (i) The common name for the iron oxide was usually given as rust.

(ii) Those that did realise that both water and oxygen are required for rusting chose test-tube J rather than stating that just water was required for the rusting process.

(b) (i) Most candidates selecting a neutral oxide recognised the significance of pH.

(ii) Many candidates based their choice of oxide on its physical state, rather than it being an acidic oxide and thus the oxide of a non-metal. Several responses made statements about the acidity of the element itself.

(c) To begin to explain the energy transfer involved in the reaction candidates needed first to recognise that it is exothermic.

(d) Very few candidates were familiar with the Contact Process. The most common response was the word equation for the oxidation of sulfur.

(e) There were some correct suggestions that sulfuric acid could be used to make copper sulfate from copper oxide. Most involved the use of elemental sulfur.

Question 8

(a) Those who knew the definition of efficiency usually calculated the correct percentage.

(b) (i)(ii) The nature of nuclear fission and fusion were not well known.

(c) (i) The need to increase voltage for long distance power transmission was often explained in terms of the amount of power to be transmitted. This added little to the information in the question. A few candidates recognised that the current is reduced which reduces energy loss.

(ii) The transformer formula was not often quoted which led to errors in manipulation of the data.

(d) The gas produced from burning fossil fuels leading to acid rain was usually given as carbon dioxide rather than sulfur dioxide.

(e) Some candidates recognised that acid rain kills plants and animals in lakes by acidifying soil or water. Less common were responses that included leaf damage, leaching mineral ions out of soil, toxic compounds into lakes, or denaturing enzymes. More often answers would include general statements about acid burning plants or poisoning animals.

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(f) The best descriptions of how gases produced from burning fossil fuels cause global warming included carbon dioxide formation. They explained that carbon dioxide is a greenhouse gas, trapping solar radiation, radiating it back to Earth. Many responses involved damage to the ozone layer. Candidates should be aware that the effect on the ozone layer and the role of ozone depletion in global warming are both negligible, so are not included in the Coordinated Science syllabus, and are not acceptable answers to this question.

Question 9

(a) Most candidates recognised that the growth of both groups of mice increased and one was faster than the other, but they did not always structure their answer into similarity and difference, as prompted by the question.

(b) (c)(d) Many candidates knew the functions of protein and carbohydrate, could name a necessary mineral ion, and could describe its function. The most successful could name a particular nutrient present in milk.

(e) Many candidates mentioned the genetic similarity of mice from the same litter or that genetic make-up should not be a variable in the experiment.

(f) (i) The best explanations of why the diets of the two groups were swapped included that it shows that the difference is due only to the diet. Other answers simply described the experiment.

(ii) Most suggestions for the change in mass of the mice after the diet change were correct, but the reason in terms of lack of vitamins or comparison with the earlier part of the experiment was often missing.

(g) Candidates gained full marks if they could recall the syllabus definition for nutrition.

Question 10

(a) (i) Choice of the correct representation of an atom and a compound needed to be supported by general definitions applied to the examples in the diagram.

(ii) Successful solutions to the hydrocarbon identification problem usually relied on recognition of the butane molecule.

(iii) To access this question, candidates needed first to realise that carbon dioxide is a product of combustion and then explain its representation in the diagram.

(b) (i) Many candidates knew that the bonding in propane is covalent.

(ii) Many candidates counted 10 pairs of shared electrons in the molecule. Fewer could explain that each bond represents a shared pair.

Question 11

(a) Most who knew the equation for aerobic respiration could balance it.

(b) (i)(ii) Many candidates could state the differences between aerobic and anaerobic respiration.

(c) Most of those candidates who knew why anaerobic respiration is important in the brewing of beer obtained one of the marks available.

Question 12

(a) (i)(ii) Some candidates could suggest similarities and differences between different electromagnetic waves.

(iii) Those who knew the formula $\lambda = v/f$ obtained the right answer if they did not make an error in scientific notation.

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(iv) Some candidates could identify amplitude and wavelength in the diagram.

(b) (i) Candidates were given credit for using the area under the speed-time graph to calculate distance travelled. Successful candidates converted times to seconds, could find the areas under the rectangle and triangle, and add the results.

(ii) Many candidates chose the point where the horizontal line fell as a region of acceleration. They were given the benefit of the doubt.

(iii) Successful solutions to the acceleration calculation applied the formula $a=\Delta v/\Delta t$ or explained that the gradient of the graph had been used.

(iv) Those who knew the kinetic energy formula usually obtained the correct result.

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Paper 0654/04

Coursework

General Comments

The majority of Centres that entered candidates for this component have been doing so for several years now, and have gradually built up highly suitable sets of tasks, together with well-constructed mark schemes that enable appropriate and reliable assessment. There were examples of excellent work from many candidates, demonstrating high levels of achievement in even the more difficult skill areas such as evaluation and planning.

Not all Centres provided evidence for their assessment of C1. These tasks do not provide written evidence from the candidates, and so the assessors need to provide such evidence that can be seen by the external moderators. Most Centres provide tick lists that show how each individual candidate has met the criteria used during the assessment task.

A few Centres made the error of mixing skills within one mark scheme, for example attempting to write a single mark scheme that covered both C2 and C3. This is not appropriate, as it is essential that each skill is assessed separately. It is, of course, possible to assess more than one skill on one task, but there need to be separate mark schemes for each one.

The majority of Centres used a range of tasks covering topics from the biology, chemistry and physics areas of the syllabus. Although there is no specific requirement to do this, it was disappointing to see some Centres failing to use any assessment tasks covering one of these areas: for example, using tasks that were all based on physics and chemistry, with no biology.

Another issue with some Centres was the wide variation in the style of tasks, mark schemes and assessment between the different subject areas. Where the biology, chemistry and physics components of the course are taught and assessed by different teachers, it is very important for them to work together to ensure that the ways in which learners are assessed is comparable across all tasks. Similarly, if there is more than one teaching group, teachers should work closely together to ensure comparability of assessment.

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Paper 0654/51

Practical Test

Key message

Drawings should be as accurate as possible and clear enough to show essential features.

General comments

Candidates were able to complete the three exercises in the two hours allocated. The standard of graph plotting was high. An area for improvement for some candidates is the measurement and calculation of gradients.

Comments on specific questions

Question 1

It was important that candidates understood the criteria for biological drawings. Key areas for gaining credit were the quality of the lines drawn and the use of clear and precise labels.

Table 1.1 in **(b) (i)** was generally completed well and although answers of 'no change' were accepted it would have been more correct to have stated 'blue' for the biuret test and 'brown' for the iodine test where these tests were negative.

In **(b) (ii)** it was important to be able to correctly interpret both positive and negative results for food tests to identify the food group present. It was also necessary to be precise i.e. Benedict's solution tests for reducing sugar rather than just sugar.

The function of the stained areas in **(c) (ii)** was well understood. It was important here to communicate the idea that the water is transported or moved through the plant.

To answer part **(d)** well candidates needed to understand the difference in the distribution of xylem tissue in the root and the stem.

To gain full credit on part **(e)** candidates needed to focus on identifying the variable they were going to change and those that were to be kept constant in their plan. Candidates should also have suggested how observations were going to be made and subsequently used.

Question 2

Cloudy is still used to describe, incorrectly, a white precipitate. Milky is an accepted alternative for a white precipitate because it gives a colour whereas cloudy only implies the turbidity or haziness of a precipitate. So, if used, cloudy would also need a colour e.g. cloudy white.

Many candidates carried out the limewater test in **(a) (i)** and successfully measured the pH in **(a) (ii)** but far less were able to identify or classify **A**.

More marks were scored in part **(b)** which was essentially a qualitative analysis of copper(II).

Re-precipitation of zinc hydroxide from an alkaline solution (sodium zincate) using acid in part **(c) (ii)** requires great care and patience. It is also a difficult concept for some candidates.

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Part **(c) (iii)** was written with the aim of helping candidates to understand the chemistry involved but proved to still be a challenge. Despite this many candidates correctly identified the zinc cation.

Question 3

Method 1 in parts **(a)** and **(b)** produced high scores and caused few difficulties and most completed the tables for Method 2 in part **(c)** well. Some candidates may need further instruction on how to record times from electronic stopclocks. In most cases the period of the pendulum was calculated as instructed although some candidates had clearly attempted to time one swing of the pendulum**.** It is important that candidates pay attention to the number of significant figures or decimal places required for data or calculations. In this case T^2 had to be given to two significant figures.

For graphs, candidates should be encouraged to choose scales on which one little square is a more manageable figure, such as 0.10, 0.20, 0.50, as this can avoid unnecessary errors in plotting.

Candidates should always mark clearly on the graph the points or the triangle used to calculate the gradient and this should be based on at least half of the best fit straight line to improve accuracy. Plotted points should not be used unless the best fit straight line passes through them. Most candidates were able to calculate the gradient once they had chosen the points or triangle.

In part **(d) (iii)** the candidates had to calculate the spring constant, *k* and give their answer to a reasonable number of significant figures to gain credit.

Part **(e)** proved to be challenging. In the past candidates have often given parallax errors as a source of error but this question required them to state how such errors can be minimised.

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Paper 0654/52
Practical Test

Key message

Where responses to questions require candidates to compare the results of two or more experiments to explain something, they must include at least one reference to the relevant results.

General comments

Candidates were able to complete the three exercises in the two hours allocated. The standard of graph plotting was high. An area for improvement for some candidates is the measurement and calculation of gradients.

Comments on specific questions

Question 1

This question highlighted the importance of the Supervisor's Report as a means of communication. The use of concentrations of hydrogen peroxide other than those specified in the Confidential Instructions led to some candidates getting unexpected rates of reaction. Where this error was reported results could be considered so that all candidates were treated fairly. When using hydrogen peroxide it is always advisable to purchase a fresh supply and store it out of direct sunlight due to the problem of decomposition.

Most candidates had no difficulty in recording the correct titles and units in the Table 1.1 column headers in part **(a) (i)**, although a few wrote 'celery' instead of 'thickness' which was not accepted.

Full sets of results were usually seen in Table 1.1. Some were not to the nearest second as requested which emphasises the need for candidates to check the number of significant figures or decimal places required for data or calculations carefully.

Most candidates obtained the correct trend in their results although some recorded shorter, rather than longer times in experiment 2. The majority of candidates were able to calculate averages.

When plotting graphs candidates should be encouraged to choose scales on which one little square is a more manageable figure such as 0.10, 0.20, 0.50, and so on. This will reduce the chance of plotting errors. Even if points do not seem to support the drawing of a straight line through the origin, it is important to draw such a line when the instructions require it to gain the mark.

Part **(d)** involved taking a reading from the graph and required candidates to draw lines on the graph to show how they had arrived at the figure for time taken. Unfortunately very few candidates actually drew the lines on the graph.

Most candidates appeared to understand the effect of lowering the temperature and boiling the potato in part **(e)** but to gain full credit they needed to express their answers in terms of the number of bubbles.

Part **(f)** proved to be challenging for some candidates, particularly in part **(ii),** where many failed to compare the results from the two experiments.

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Question 2

Most candidates opted to draw a diagram supported by a small amount of writing for **(a) (i)** and it was generally answered well. There were the usual connectivity problems with apparatus which would have led to loss of gas and most candidates used limewater.

Cloudy is still used to describe, incorrectly, a white precipitate. Milky is an accepted alternative for a white precipitate because it gives a colour whereas cloudy only implies the turbidity or haziness of a precipitate. So, if used, cloudy would also need a colour e.g. cloudy white. Otherwise Table 2.1 in part **(a) (ii)** was completed successfully.

Part **(b)** was a less familiar exercise in which candidates had to choose which solid to test. This in itself did not cause many problems. Candidates that gained full credit showed they had carried out the tests carefully and describe their observations precisely. If candidates did not eliminate the correct solid in **(a)** they were not penalised for testing solid **B** in **(b)**.

Question 3

This question was constructed around a lens of focal length f = 15 cm which is why Cambridge should be contacted well before the examination if specific items listed in the Confidential Instructions cannot be sourced.

This optical experiment was carried out well by most candidates and the data obtained produced meaningful graphs. Consequently part **(a)** and **(b)** attracted high marks. As in **Question 1**, unsuitable scales were sometimes chosen which increased the chance of plotting errors.

Candidates should always mark clearly on the graph the points or the triangle used to calculate the gradient and this should be based on at least half of the best fit straight line to improve accuracy. Plotted points should not be used unless the best fit straight line passes through them. Most were able to calculate the gradient once they had chosen the points or triangle.

In part **(c) (iii)** the candidates had to calculate the focal length of the lens and give their answer to a reasonable number of significant figures to gain credit.

The precautions in **(d)** presented a challenge despite there being several possibilities. The use of a darkened room was the most popular response.

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Paper 0654/61
Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques. Candidates should have performed identification tests on the range of substances detailed in the specification.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of an excellent standard. but candidates need to take care when rounding calculated values. The standard of graph drawing was high. Knowledge of identification tests for ions needs improvement. Circuit diagrams need to be executed with care so that there are no gaps in the circuits drawn.

Comments on Specific Questions

Question 1

This experiment investigates plant transport systems in celery.

(a) (i) Most candidates drew the outline correctly. The more able candidates identified two stained areas.

(ii) More able candidates recognised xylem and water transport. Others incorrectly gave phloem and nutrient transport.

(b) The conclusion for Benedict's solution was well known but only the more able appreciated that the other two nutrients were not present.

(c) Candidates found planning this experiment challenging. The need to a minimum number of temperatures was appreciated by a significant number of candidates; measuring the distance moved by a coloured liquid in a set time was given by only the most able candidates. The control of other named conditions was well done.

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Question 2

The spring constant of a spring is investigated in this question.

(a) Most candidates correctly recorded the time to the nearest second.

(i) Many candidates correctly calculated T and T^2 and gave the answer to two decimal places..

(ii) Many candidates plotted the points correctly with some drawing a line of best fit. The question asks the candidates to draw the best fit straight line through the origin; a few candidates did not draw the line through the origin.

(iii) The more able candidates were able to calculate the gradient of the line; candidates needed to take care as the scales on the two axes are different. The question asks that the candidates show on the graph how they calculated the gradient; the lines or coordinates used for the calculation need to be shown on the graph and more than half of the graph line should be used.

(iv) The calculation was performed accurately by many candidates. The question requested that the answer be given to two significant figures; candidates need to take care to follow such instructions.

Question 3

In this experiment a mixture of three metal oxides is investigated.

(a) (i) Most candidates gave an alkaline colour and most went on to give a pH greater than 7.

(ii) The most able candidates named the filtrate as limewater. A minority named A as calcium oxide.

(**b**) **(i)** More able candidates identified a pale blue precipitate in at least one of the tests and the most able described the dissolving and solution colour in excess.

(ii) Candidates needed to state the formula (CuO) rather than the name of the compound.

(c) A very small number of candidates appreciated that the zinc oxide was insoluble in water and so the first step here was to dissolve the ions by reacting the oxide with an acid such as hydrochloric acid. The tests for zinc ions was recalled by more able candidates.

Question 4

Blood and pulse rates are examined in this question.

(a) (i) The most able candidates could name all 4 components correctly. A significant number confused red and white blood cells. Platelets and plasma were less well known.

(ii) Many candidates measured the line correctly.

(iii) More able candidates divided by one thousand to correctly calculate the actual diameter; a significant number multiplied by a thousand.

(b) (i) The majority of candidates calculated accurately the average heart rate in beats per minute.

(ii) A correct reason for pulse rate increasing such as the requirement for more oxygen was given by the majority of candidates.

(iii) Most able candidates appreciated that an average could be calculated or that anomalies could be spotted or that similar results could be confirmed.

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Question 5

This question examined the structure of electrical circuits.

Through the question there were many examples of large gaps left in the circuit diagrams drawn by candidates in answer to the different parts. Candidates should be encouraged to draw circuit diagrams carefully, to exclude accidental gaps.

(a) Many candidates were able to draw a circuit which could be used but many did not go on to outline how the results would show which bulbs were working and which were not. A significant number of candidates put the bulbs into a parallel circuit, so that they could test them all at once. A small number put all of the bulbs incorrectly into one series circuit

(b) Many candidates connected the ammeter in series but only the more able candidates connected the voltmeter in parallel across the bulb.

(c) Candidates found the construction of the table very challenging. Many candidates had columns or rows for current and potential difference but some also included extra columns such as voltage and resistance. Many candidates had the unit A but had Ohms or Joules instead of V for potential difference. Few candidates drew 5 columns / rows for the results of the 5 lamps.

(d) The equation R = V/I was quite well known but significant number of candidates gave the inversion.

Question 6

This experiment investigates the reaction between magnesium and hydrochloric acid.

(a) Many candidates know that the gas is hydrogen and the test for hydrogen was well known.

(b) More able candidates appreciated that the reaction vessel needed to be a conical flask containing a bung and a delivery tube where the delivery tube was above the level of the liquid. As the rate at which the gas evolves is being measured, the collection vessel must be have a scale to enable the measurement of volume of gas collected e.g. a measuring cylinder or a syringe. There were many collection vessels which also contained no graduations and were also sealed. More able candidates drew either the gas syringe or collection over water with a measuring cylinder.

(c) (i) Interpreting the graph in terms of the rate of reaction proved to be very challenging. More able candidates appreciated that the reaction was slowing down and then it stopped.

(ii) More able candidates appreciated that one or both of the reagents had been used up.

(d) Many candidates drew the line to the left of the original showing the increased rate of reaction for the higher temperature but only the more able stopped the graph at the same level as the original.

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Paper 0654/62
Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques. Candidates should have performed identification tests on the range of substances detailed in the specification.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments/use of rulers was of an excellent standard but candidates need to take care when rounding calculated values and when entering data into tables. Knowledge of identification tests for ions needs improvement.

Comments on Specific Questions

Question 1

This is an investigation into enzyme activity.

(a) Averages were usually calculated correctly.

(b) The majority of candidates labelled the axes with the correct variable but many did not include the correct unit on both axes. Many candidates plotted the points correctly and drew a line of best fit but some missed the wording in the question asking for the line to go through the origin.

(c) Most candidates could correctly use their graph to estimate the average time but some candidates did not draw the lines on the graph and so could not score both marks for this part.

(d) More able candidates appreciated a slower reaction for a lower temperature and no reaction after boiling the enzyme. However, there was a common misconception that cooling would denature the enzyme and that the higher temperature of boiling would speed the enzyme activity.

(e) The test for oxygen was well known by the majority of candidates.

Question 2

In this experiment four solids are identified by a series of reactions and tests.

(a) (i) Most candidates identified the reagent as hydrochloric acid and the gas as carbon dioxide.

(ii) The test for carbon dioxide was well known.

(b) More able candidates correctly named compound A as sodium chloride.

(c) The white precipitate produced for the sulfate test was known by more able candidates. The reactions of ammonia solution with zinc ions and copper ions was not generally well known. Most of the more able candidates appreciated that the ammonia need to be added until in excess giving both of the required observations correctly.

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Question 3

This experiment involves measuring the focal length of a converging lens.

(a) and **(b)** The majority of candidates measured the distances correctly.

(c) The calculation was generally performed well but many candidates did not give all of the data to two decimal places and so 1.00 was seen rarely. Many candidates rounded their calculator values incorrectly.

(d) (i) Many candidates plotted the points correctly and drew a line of best fit

(ii) More able candidates were able to calculate the gradient of the line. The lines or coordinates used for calculation need to be shown on the graph; more than half of the line should be used.

(iii) Focal length calculation was executed correctly by most candidates.

(e) Few candidates gave a precaution which would ensure accuracy.

Question 4

This is an investigation into the effect of various solutions on the heart rate of Daphnia.

(a) (i) The use of repition to increase reliability was well known.

(ii) Use of the data to identify the anomalous result in Experiment 1 was generally well answered.

(iii) More able candidates appreciated that the anomalous result should either be discarded or repeated,

(b) Many candidates appreciated that pond water was used as a control.

(c) (i) Most candidates correctly used the data and appreciated the increase in heart rate.

(ii) Most able candidates correctly compared the heart rate in decaffeinated coffee with that in pond water.

(d) Few candidates included the label “beats per minute” on the vertical axis. Most correctly drew four labelled bars.

(e) (i) The majority of candidates measured the line correctly.

(ii) More able candidates divided by 40 to calculate the actual size of the Daphnia.

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Question 5

This experiment looks at some features of Group V elements

(a) (i) The test for ammonia was generally well known.

(b) Many candidates correctly named an indicator and the effect that acid would have on that indicator.

(c) Properties of non-metals were well known.

(d) (i) Many candidates correctly placed a sample of bismuth into a circuit with a power supply but did not include either a lamp or ammeter so they were unable to tell whether the sample conducted or not.

(ii) Candidates found planning this experiment to be very challenging. A significant number thought that higher electrical conductivity equated to higher reactivity. Some candidates reacted the bismuth with cold water only, some reacted with acid only, the most able candidates who chose this method correctly added water first and if the reaction was not vigorous then went on to add acid and looked at rate of hydrogen production as a measure of reactivity. Some candidates looked at displacement reactions but few candidates had the metal salts in solution and many added bismuth to other metals rather than to the salt solutions. A few candidates correctly described putting bismuth and another metal into a cell but only the most able could use the size of the voltage produced to indicate the difference in reactivity between the two metals.

Question 6

This is an investigation into factors affecting the period of a pendulum.

(a) The idea of timing a number of swings and dividing by the number was not well known.

(b) and **(d)** The balance was read correctly by the majority of candidates

(c) Many candidates appreciated that the mass did not affect the period but only more able candidates gave creditworthy explanations, including no trend/pattern and the results being very close together.

(e) Most candidates measured the length correctly.

(f) Many candidates described the trend correctly but only the more able candidates commented on the anomalous result.

(g) Whilst many candidates appreciated the need to repeat only the more able also included the need to average these repeated results. A small number of candidates specified repetition of the anomalous result.

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Paper 0654/63

Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques. Candidates should have performed identification tests on the range of substances detailed in the specification.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of an excellent standard but candidates need to take care when rounding calculated values. The standard of graph drawing was high. Knowledge of identification tests for ions was generally poor.

Comments on Specific Questions

Question 1

This question is about an investigation into yeast cells.

(a) Many candidates knew that boiling denatures enzymes or kills yeast cells.

(b) More able candidates entered the correct colours into the table and the most able headed the first column with time and mins

(c) (i) Very few candidates appreciated that the addition of water was to maintain a constant volume or concentration.

(ii) Many candidates knew that the change in A was faster but only some realised that it was the sugar which brought this about.

(d) Very few candidates understood that oxygen from the air would re-enter the solution and so the tube would change back to blue.

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Question 2

This question involves tests for identifying three ions..

(a) The test for Fe^{2+} ions was not well known. Candidates needed to know that an aqueous solution is made of the solid; a few added sodium hydroxide or ammonia solution. Very few candidates knew that a green precipitate would form.

(b) Very few candidates added sodium hydroxide in order that ammonia gas to be given off so that it can be tested with damp red litmus paper. A small number of candidates added the litmus paper to the solid.

(c) Candidates needed to explain that an aqeuos solution is made of the solid and then hydrochloric acid added. A small number of candidates went on to add barium chloride solution and only a few of these knew that a white precipitate was formed.

Question 3

This is an investigation into the resistance of lamps in various circuits.

(a) Most candidates used the correct symbol for a voltmeter but only the most able correctly connected it across X and Y.

(b) (i) The majority of candidates read both meters correctly.

(ii) The units were not well known. Many candidates rewrote the quantity i.e. voltage, current and resistance.

(iii) Many candidates calculated the correct values but then some did not give the value to two decimal places or rounded the calculator value incorrectly.

(c) The higher achieving candidates used the two values in their answer but few were able to give a justification.

(d) More able candidates recognised that the resistances of the lamps may have been different.

Question 4

This is an investigation into the effect of temperature on enzyme activity.

(a) (i) and **(ii)** Most candidates read the temperature and time correctly.

(iii) Most candidates calculated the rate correctly.

(b) (i) Most candidates plotted the points correctly and a few drew a smooth curve.

(ii) The majority of candidates could correctly read the value from the graph.

(iii) The most able appreciated that there would need to be more experiments performed either side of their optimum temperature.

(d) Few candidates appreciated that the experiment needed repeating with water instead of acid and that this experiment remaining cloudy would prove that acid is needed.

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Question 5

This question involves the electrolysis of brine.

(a) (i) The higher achieving candidates realised that this would be a lamp or an ammeter.

(ii) The more able candidates drew the correct symbol for a cell or a battery. Many candidates drew circuits with short circuited batteries or no connections.

(iii) Some candidates knew that the electrodes should be unreactive and gave graphite or platinum as a suitable material.

(b) (i) Few candidates knew that a red-brown precipitate would form.

(ii) Few candidates knew the test for chlorine.

(iii) The test for hydrogen was quite well known.

Question 6

This was an investigation into the thermal conduction of five metal rods.

(a) (i) Many candidates read both stop-clocks correctly.

(ii) Many candidates labelled the axes and drew the points correctly.

(iii) On the most able candidates used the data to explain how they knew that there was no correlation between the percentage of magnesium and the time.

(b) More able candidates were able to choose either one or two changes that the candidate could make and these were usually to use same-sized rods of each material, and the same amount of wax on each rod.

(c) Very few candidates could explain how a change affected the reliability or accuracy of the experiment.

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