CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1**, **4**, **23**, **28** and **30**. **Questions 3**, **6**, **8**, **10**, **15**, **17**, **19**, **33**, **35** and **36** proved the most difficult for candidates.

Comments on specific questions

Question 5

This question investigates the necessity of light and carbon dioxide for photosynthesis. All options were frequently selected suggesting that candidates were unsure of the correct answer. This could either be due to a lack of knowledge of photosynthesis, or unfamiliarity with the iodine test.

Question 6

There were a significant number of incorrect answers on this question about the functions of different parts of the digestive system. Most successfully identified the gall bladder's function of bile storage, but many thought that the pancreas absorbs water.

Question 7

Candidates were divided on whether evaporation during transpiration occurs from the surface of the mesophyll cells or from the air spaces through the stomata.

Question 11

Candidates realised that using a homozygous dominant parent to produce homozygous recessive offspring would not work but were uncertain as to whether one parent could be heterozygous.

Question 13

A significant proportion of candidates labelled the line for photosynthesis as respiration. Taken with **Question 5** this suggests a lack of understanding of photosynthesis and the relationship between photosynthesis and respiration.

Question 15

Candidates chose the incorrect option **B** more often than the correct option **C**. They are expected to be able to identify physical and chemical changes and understand the differences between them.

Question 16

There was evidence that many candidates had guessed at the answer. Candidates are expected to be able to interpret and balance symbol equations.

Question 17

There was evidence that many candidates had guessed at the answer. During the electrolysis of the ionic compound, dilute sulfuric acid, oxygen is formed at the anode and hydrogen is formed at the cathode.

Question 19

Strong candidates deduced that an increased particle size of the solid decreases the rate of a reaction but does not change the amount of product formed.

Question 20

There was evidence that many candidates were unfamiliar with flame tests. Candidates should be able to describe and use flame tests to identify lithium, sodium, potassium and copper(II) cations.

Question 23

Candidates understood how to deduce the order of reactivity for metals from a set of experimental results and correctly selected option **B**.

Question 24

Candidates chose the incorrect option **C** more often than the correct option **D**. Candidates are expected to describe the use of carbon in the extraction of some metals from their ores and know that this process is reduction.

Question 26

Candidates chose the incorrect option **A** more often than the correct option **D**. Limestone, calcium carbonate, is used to treat acidic soils.

Question 27

Many candidates chose the incorrect option, **B**. Ethanol may be formed by fermentation of sugar and by reaction between ethene and steam**.**

Question 29

Many candidates could not identify option **D** as the correct answer, this being the only one with no resultant force acting.

Question 33

This question on melting and boiling was poorly understood. The majority of candidates believed that melting involves an increase in temperature and boiling a decrease, leading them to select the incorrect option **C**. Many thought the opposite. Very few knew that there is no temperature change involved in either process.

Question 34

It was widely known that an inverted image is produced, but a significant number believed the image to be enlarged.

Question 35

The first three options were all popular choices suggesting that candidates were unfamiliar with sound. **C** was the correct option.

Question 36

The topic here was electrostatic charging. Although most candidates were aware that electron transfer is involved, a large proportion thought that electrons moved from the cloth to the rod rather than the other way round. A significant number of candidates believed that protons move onto the rod.

Question 37

The most common mistake was to think that lamps in a lighting circuit are connected in series.

Question 38

This question on fuses involved using Ohm's law and was found demanding by most candidates. Many calculated the current by dividing the resistance by the voltage, leading them to choose the incorrect option **C**.

Question 40

Many candidates selected the incorrect option, **B**. This was due to candidates choosing half of the time range shown on the graph (i.e., half of 40 s) rather than the time for the activity to decrease by half.

CO-ORDINATED SCIENCES

Paper 0654/12
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1** and **18**. **Questions 6**, **13**, **20**, **24**, **30**, **33**, and **39** proved the most difficult for candidates.

Comments on specific questions

Question 5

This question investigates the necessity of light, chlorophyll and carbon dioxide for photosynthesis. All options were frequently selected suggesting that candidates were unsure of the correct answer. This could either be due to a lack of knowledge of photosynthesis, or unfamiliarity with the iodine test.

Question 6

There were a significant proportion of incorrect answers on this question about the functions of different parts of the digestive system. Most successfully identified the gall bladder's function of bile storage, but many thought that the pancreas absorbs water.

Question 7

Most candidates understood that increasing temperature increases the rate of transpiration, however, they were uncertain about the effect of humidity.

Question 8

This question investigated the effect of exercise on rate and depth of breathing. Almost all candidates successfully identified that rate would increase but were uncertain on whether depth increased or decreased.

Question 10

When asked to choose a correct statement about asexual reproduction a significant proportion believed that it involved fusion of gametes from one parent, option **A**. More correctly identified that it would produce genetically identical offspring and selected option **D**.

Question 13

A significant proportion of candidates labelled the line for photosynthesis as respiration. Taken with **Question 5** this suggests a lack of understanding of photosynthesis and the relationship between photosynthesis and respiration.

Question 14

Candidates chose the incorrect option **A** more often than the correct option **C**. They are expected to be able to name and suggest appropriate apparatus for the measurement of volume, including burettes, pipettes and measuring cylinders.

Question 17

There was evidence that many candidates had guessed at the answer. During the electrolysis of the ionic compound, dilute sulfuric acid, oxygen is formed at the anode and hydrogen is formed at the cathode.

Question 20

Candidates selected the incorrect option **B** more often than the correct option **D**. Heating an ammonium salt with a base, either sodium hydroxide or potassium hydroxide, produces ammonia gas which turns red litmus blue.

Question 21

More able candidates chose the incorrect option **D** rather than the correct option **A**. Noble gases are used to provide an inert atmosphere.

Question 23

Candidates chose the incorrect option **B** more often than the correct option **C**. Transition elements have high melting points and that as metals they conduct electricity.

Question 24

Candidates chose the incorrect option **C** more often than the correct option **D**. Candidates are expected to describe the use of carbon in the extraction of some metals from their ores and know that this process is reduction.

Question 28

A significant proportion of candidates thought that the area under a speed−time graph represents total time taken and therefore selected the incorrect option **D**. The area under a speed−time graph represents distance travelled, option **C**.

Question 29

This question was on resultant force and the incorrect option **A** was very popular. Although this involved the two objects with forces of the same magnitude acting, the resultants were not in the same direction. Candidates should be reminded to read the question carefully before answering.

Question 30

A significant proportion of candidates selected option **B**, perhaps confusing work done with power and therefore thinking that time taken is involved in the calculation.

Question 31

This question highlighted a misconception that power stations fuelled by nuclear fission do not use a turbine and generator.

Question 33

This question on melting and boiling was poorly understood. The majority of candidates believed that melting involves an increase in temperature and boiling a decrease, leading them to select the incorrect option **C**. Many thought the opposite. Very few knew that there is no temperature change involved in either process.

Question 34

Although most candidates knew that the object is further from the lens than the focal length, a significant proportion selected option **A**, which would result in a diminished image.

Question 35

All options were popular choices suggesting that candidates were unfamiliar with the electromagnetic spectrum.

Question 36

The topic here was electrostatic charging. Although most candidates were aware that the charges on the hair and the balloon would be different, many of them confused the sign of these charges and selected the incorrect option **B**.

Question 39

This question on fuses involved adding the currents for the two components, then choosing an appropriate fuse. Many candidates appeared either to average the two currents or to subtract one current from the other, arriving at 4 A, option **B**.

CO-ORDINATED SCIENCES

Paper 0654/13
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Questions 1**, **2**, **9**, **12**, **18** and **30**. **Questions 3**, **6**, **8**, **10**, **16**, **17**, **26**, **28, 29, 33**, and **39** proved the most difficult for candidates.

Comments on specific questions

Question 5

This question investigates the necessity of light, chlorophyll and carbon dioxide for photosynthesis. All options were frequently selected suggesting that candidates were unsure of the correct answer. This could either be due to a lack of knowledge of photosynthesis, or unfamiliarity with the iodine test.

Question 6

There were a significant proportion of incorrect answers on this question about the functions of different parts of the digestive system. Most successfully identified the gall bladder's function of bile storage, but many thought that the pancreas absorbs water.

Question 8

This question investigated the effect of exercise on rate and depth of breathing. Almost all candidates successfully identified that rate would increase but were uncertain on whether depth increased or decreased.

Question 10

When asked to choose a correct statement about asexual reproduction a significant proportion believed that it involved fusion of gametes from one parent, option **A**. More correctly identified that it would produce genetically identical offspring and selected option **D**.

Question 11

Most candidates identified that the selection was by humans, but a significant proportion incorrectly believed that chicken reproduction is asexual.

Question 13

A significant proportion of candidates labelled the line for photosynthesis as respiration. Taken with **Question 5** this suggests a lack of understanding of photosynthesis and the relationship between photosynthesis and respiration.

Question 14

Candidates chose the incorrect option **A** more often than the correct option **C**. They are expected to be able to name and suggest appropriate apparatus for the measurement of volume, including burettes, pipettes and measuring cylinders.

Question 16

Candidates chose the incorrect options **A** and **B** more often than the correct option **D**. Candidates are required to interpret and balance symbol equations.

Question 17

There was evidence that many candidates had guessed at the answer. During the electrolysis of the ionic compound, dilute sulfuric acid, oxygen is formed at the anode and hydrogen is formed at the cathode.

Question 18

Candidates understood very well that exothermic reactions give out heat energy.

Question 19

Candidates chose the incorrect option **A** more often than the correct option **C**. They are expected to be able to interpret data, both numerical and in graphs form, to make deductions about rates of reaction. The change in mass of flask and contents in Experiment 2 occurs slower than Experiment 1 so Experiment 2 has the lower rate of reaction and this could be explained by using an acid that is more dilute.

Question 26

Candidates chose the incorrect option **A** more often than the correct option **D**. Limestone, calcium carbonate, is used to treat acidic soils.

Question 28

A significant proportion of candidates thought that the area under a speed−time graph represents total time taken and therefore selected the incorrect option **D**. The area under a speed−time graph represents distance travelled, option **C**.

Question 29

This question was on resultant force and the incorrect option **A** was very popular. Although this involved the two objects with forces of the same magnitude acting, the resultants were not in the same direction. Candidates should be reminded to read the question carefully before answering.

Question 30

A significant proportion of candidates selected option **B**, perhaps confusing work done with power and therefore thinking that time taken is involved in the calculation.

Question 31

This question highlighted a misconception that power stations fuelled by nuclear fission do not use a turbine and generator.

Question 33

This question on melting and boiling was poorly understood. The majority of candidates believed that melting involves an increase in temperature and boiling a decrease, leading them to select the incorrect option **C**. Many thought the opposite. Very few knew that there is no temperature change involved in either process.

Question 34

Although most candidates knew that the object is further from the lens than the focal length, a significant proportion selected option **A**, which would result in a diminished image.

Question 35

All options were popular choices suggesting that candidates were unfamiliar with the electromagnetic spectrum.

Question 36

The topic here was electrostatic charging. Although most candidates were aware that the charges on the hair and the balloon would be different, many of them confused the sign of these charges and selected the incorrect option **B**.

Question 39

This question on fuses involved adding the currents for the two components, then choosing an appropriate fuse. Many candidates appeared either to average the two currents or to subtract one current from the other, arriving at 4 A, option **B**.

Question 40

The topic here was particles in the nucleus of an atom. Few candidates correctly selected option **B**, with many confusing neutrons with protons and therefore selecting option **A**.

CO-ORDINATED SCIENCES

Paper 0654/21
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1**, **2**, **4**, **5**, **8**, **21**, **28** and **30**. **Questions 7**, **14**, **27**, **32** and **36** proved the most difficult for candidates.

Comments on specific questions

Question 7

Candidates were divided on whether evaporation during transpiration occurs from the surface of the mesophyll cells or from the air spaces through the stomata.

Question 14

There was evidence that some candidates confused this question with the separation of a dissolved solid from a solution. Others appear not to have realised that evaporation alone, whilst it separates a liquid from a solution, does not result in obtaining the pure liquid.

Question 26

The majority of candidates selected the correct option **A**. Candidates should be able to describe the properties of molecules within a fraction obtained from petroleum, and consequently deduce that alkanes containing more carbon atoms in their chain are less volatile and so evaporate more slowly at the same temperature.

Question 27

Although the correct answer, option **D**, was chosen most often, there is evidence to suggest that some of the more able candidates chose the incorrect option **A**. They are expected to be able to deduce the structure of the polymer product from a given alkene and *vice versa*.

Question 29

This question was generally well answered, but a small proportion of candidates calculated acceleration by dividing mass by resultant force, arriving at the incorrect option **B**.

Question 30

The most common error here was to overlook the fact that kinetic energy depends on the square of the speed, therefore incorrectly arriving at option **C**.

Question 32

This question on melting and boiling was poorly understood. The majority of candidates believed that melting involves an increase in temperature and boiling a decrease, leading them to select the incorrect option **C**. Many thought the opposite. Very few knew that there is no temperature change involved in either process.

Question 36

The topic here was factors affecting the resistance of a wire. Option **B** was a more popular choice than the correct option **D**. Candidates making this mistake probably believed that halving the cross-sectional area would have the opposite effect to increasing the length, giving an overall effect of doubling the original resistance.

Question 38

In this question on the use of transformers in electricity distribution a significant proportion of candidates thought that both the current and the efficiency increase, not appreciating that increasing the voltage involves a corresponding decrease in current for a fixed quantity of power.

CO-ORDINATED SCIENCES

Paper 0654/22
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 1–5**, **8**, **15**, **21** and **22**. **Questions 7**, **14**, and **32** proved the most difficult for candidates.

Comments on specific questions

Question 7

There was evidence that candidates were uncertain about the answer to this question, with the three incorrect options being frequently selected. The question asked about pressures in the left ventricle and the aorta as blood starts to leave the heart. It is not necessary for candidates to know the pressures, rather to realise that if blood is to leave the heart, the pressure must be higher in the ventricle than the aorta.

Question 13

This question on eutrophication was well answered, although a significant proportion of candidates believed that the change in oxygen concentration was caused by the algae using it for respiration, rather than it being used by the decomposer bacteria.

Question 14

More able candidates chose the incorrect option **D** rather than the correct option **C**. Candidates are required to name and suggest appropriate apparatus for the measurement of volume, including burettes, pipettes and measuring cylinders.

Question 22

Candidates understood how the position of a metal in the reactivity series affects the method that can be used to extract the metal from its ore. They also knew that more reactive metals displace less reactive metals from their compounds and they were able to apply this to the extraction of the less reactive metals.

Question 28

A large majority of candidates were aware that it is the extension of the spring that must be considered, rather than the length. However, many selected option **C**, the reciprocal of the correct expression.

Question 30

The most common error here was to overlook the fact that kinetic energy depends on the square of the speed, therefore arriving at option **C**.

Question 31

Many candidates clearly understood the topic of efficiency and correctly selected option **C**.

Question 32

This question on melting and boiling was poorly understood. The majority of candidates believed that melting involves an increase in temperature and boiling a decrease, leading them to select the incorrect option **C**. Many thought the opposite. Very few knew that there is no temperature change involved in either process.

Question 33

A significant number of candidates selected options **B** or **D** rather than the correct option **C**. This suggests that they were only aware of thermal conduction involving vibrations and did not know about conduction by free movement of electrons.

Question 34

The incorrect option **B** was chosen by some candidates as they failed to find the angle of refraction as 28°.

Question 36

The topic here was electrostatic charging. Although most candidates were aware that the charges on the hair and the balloon would be different, many of them confused the sign of these charges and selected the incorrect option **B**.

Question 38

In this question on the use of transformers in electricity distribution a significant proportion of candidates thought that both the current and the efficiency increase, not appreciating that increasing the voltage involves a corresponding decrease in current for a fixed quantity of power.

CO-ORDINATED SCIENCES

Paper 0654/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on **Questions 2**, **7**, **13**, **15**, **21**, **22** and **28**. **Questions 10**, **14**, **29**, **32**, **34** and **38** proved the most difficult for candidates.

Comments on specific questions

Question 10

This question proved demanding for the majority of candidates. The question was concerned with the life cycle of a hydrozoan, with a diagram showing the various stages. A majority of candidates did not study the diagram closely enough to realise that there are both asexual and sexual stages in the life cycle, most of them only noticing the sexual stage.

Question 14

Candidates selected the incorrect options **A** and **D** more often than the correct option **B**. More able candidates chose the incorrect **C** more often than the correct answer. They are expected to be able to describe the preparation, separation and purification of salts using techniques for the reactions specified in the syllabus.

Question 15

Candidates knew very well how to identify chemical and physical changes.

Question 16

More able candidates selected the incorrect option **D** rather than the correct option **A**. Candidates are expected to be able to determine the formula of an ionic compound from the charges on the ions present, after first deducing the charges on ions from information given.

Question 17

More able candidates selected the incorrect option **B** rather than the correct option **C**. They are required to know the products of electrolysis of aqueous copper(II) sulfate using carbon electrodes, and to describe the observations at the electrodes.

Question 18

Candidates selected the incorrect options **A** and **D** more often than the correct option **B**. Candidates should be familiar with describing reduction and oxidation in terms of electron transfer and gain and loss of oxygen.

Question 22

More able candidates selected the incorrect option **A** rather than the correct option **B**. Candidates are expected to know the order of reactivity of the named metals, and to be able to describe the reaction, if any, between a metal and oxides of other metals.

Question 25

Candidates chose the incorrect option **A** more often than the correct option **D**. Limestone, calcium carbonate, is used to treat acidic soils.

Question 28

Few candidates had any difficulty in identifying the correct speed−time graph.

Question 29

In this question about a parachutist the majority of candidates believed that there was either a downward or an upward resultant force acting. Few appreciated that falling at constant speed implies zero resultant force.

Question 30

The most common error here was to overlook the fact that kinetic energy depends on the square of the speed, therefore arriving at option **C**.

Question 31

Although it was widely known that the energy release process in the Sun is nuclear, a slightly greater proportion of candidates thought that fission is involved, rather than fusion.

Question 32

This question on melting and boiling was poorly understood. The majority of candidates believed that both melting and boiling involve an increase in temperature, probably confusing temperature with thermal energy. Few knew that there is no temperature change involved in either process.

Question 34

Options **A** and **B** were popular choices. These candidates knew that the lens was converging, but also thought that one of statements 2 or 3 must be incorrect. Candidates should be aware that it is possible for all three statements to be correct.

Question 36

The topic here was electric charge. A significant proportion of candidates selected the incorrect options **B** and **C**. These candidates either divided the resistance by the voltage then multiplied by the time to arrive at option **B**, or multiplied the voltage and resistance then divided by the time to produce option **C**.

Question 38

In this question on the use of transformers in electricity distribution many candidates thought that both the current and the efficiency increase, not appreciating that increasing the voltage involves a corresponding decrease in current for a fixed quantity of power.

Question 40

A large majority of candidates were aware that radiation Y was gamma, but many confused alpha and beta, therefore selecting option **D**.

CO-ORDINATED SCIENCES

Paper 0654/31
Theory (Core)

Key message

Some candidates missed available marks due to their responses not answering the question completely. In these cases, candidates should be reminded to read the stimulus material and each question carefully and complete all the instructions contained within the question.

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.

General comments

A good standard of scientific knowledge was displayed by many candidates. Some candidates should be congratulated for their clear and accurate responses. Calculations were often done well with working shown.

Comments on specific questions

Question 1

(a) Almost every candidate gained full marks on this question.

(b) (i) Many candidates correctly labelled a ventricle. Almost every other part of the heart was selected by other candidates.

(ii) Many candidates correctly suggested that the function of part **Y** (valve) is to ensure a one-way flow of blood.

(iii) The septum was not well known. The aorta or vena cava were popular incorrect answers.

(iv) Muscle was well known as the type of tissue that the heart wall is made from.

(v) Pumping blood was well known as the function of the heart.

(c) Pulmonary artery or pulmonary vein were sometimes identified as one of the main blood vessels to or from the lungs. Renal artery or renal vein were rarely identified for the kidney. Many candidates just stated an unqualified artery or vein.

Question 2

(a) Coal was often correctly suggested as a fossil fuel. Natural gas was less frequently suggested. An unqualified gas was not accepted. Some candidates suggested oil or crude oil but petroleum had already been mentioned in the question.

(b) All three answers were well known although few candidates gained full marks. Bitumen, instead of naphtha, was a common error for the third gap.

(c) (i) Most candidates correctly stated that there are two elements in one molecule of octane. Twenty-six was sometimes suggested.

(ii) Most candidates correctly stated that there are 26 atoms in one molecule of octane. Eight and eighteen were sometimes suggested

(iii) Exothermic was correctly suggested by many candidates, with endothermic also being popular.

(iv) The limewater test for carbon dioxide was well known. A few candidates described the test for hydrogen gas.

Question 3

(a) (i) Some candidates knew that line **XY** is the normal. A common incorrect answer was line of reflection.

(ii) Many different angles were suggested as the angle of incidence. Some candidates labelled the incident ray.

(iii) 40° was correctly stated by many candidates. Popular incorrect answers included 50°, 80° and 140°.

(b) (i) More candidates incorrectly divided resistance by current than correctly multiplied resistance by current.

(ii) The correct answer of 4 Ω was far less popular than 8 Ω or 16 Ω. Very few candidates were able to explain their answer.

(iii) The lamp and switch were usually correctly identified. Battery was often suggested for the cell and an unqualified resistor for the variable resistor.

(c) Most candidates used an incorrect formula and divided the force by the distance. Some candidates omitted to convert the distance from centimetres to metres.

Question 4

(a) (i) Heterozygous for the description of the genotype and **rr** for the genotype were often correctly suggested.

(ii) This question was well answered.

(iii) A ratio of 3:1 was correctly suggested by many candidates.

(b) Ovule and pollen were popular and correct answers.

(c) Egg or ovum were often suggested. Ovary was sometimes suggested incorrectly.

(d) This question was not well answered. Some candidates were able to correctly deduce that a chromosome was being defined in the first row. Very few candidates knew the definition of a gene. A few candidates knew that an allele was a version of a gene.

Question 5

(a) Most candidates were able to state at least one physical property of metals.

(b) (i) 950 kg was frequently given as the mass of the aluminium in the alloy.

(ii) Some correct properties of aluminium alloys were correctly stated.

(c) (i) Bauxite was not well known as the ore of aluminium. Iron or iron ore were often incorrectly suggested.

(ii) Few candidates were able to define electrolysis.

(iii) Iron and copper were popular correct answers to this question.

(d) (i) Many candidates confused conserved with preserved and omitted to mention anything about aluminium ore being a finite resource.

(ii) Recycling was rarely mentioned.

Question 6

(a) (i) Infrared was often misplaced one place to the left or right.

(ii) X-rays and γ-radiation were frequently linked correctly to diagnosing broken bones and treating cancer respectively.

(b) (i) The correct order was α then β then γ. The reverse order was popular, but most other combinations were also suggested.

(ii) Mutation and cancer were both commonly suggested correct answers.

(c) (i) Many candidates found the definition of an isotope difficult.

(ii) Few candidates were able to complete this half-life calculation. Sixteen days was two half-lives and so the initial mass of iodine-131 was 0.2 g. Many candidates suggested 0.1 g.

(d) Some candidates were able to state the average range of audible frequencies but few were able to correctly compare this range with the range of the hospital patient.

(e) Few candidates knew that the form of energy stored in petroleum was chemical potential energy. Kinetic energy was a common correct answer for the second space.

Question 7

(a) This question was well answered. Some drew four lines and could not be awarded full marks.

(b) Some candidates completed the left-hand side of the equation correctly and some completed the right-hand side of the equation correctly. Fewer completed the whole equation correctly.

(c) Cell membrane and cytoplasm were the most popular correct responses. However, many candidates only identified one of these and so scored no marks.

(d) Zygote was quite well known. Fetus was a common incorrect response.

(e) Nucleus was well known.

Question 8

(a) (i) Most candidates correctly identified chlorine as the gas.

(ii) Many candidates correctly identified carbon monoxide. Some suggested methane.

(iii) Some candidates correctly identified nitrogen. Many others suggested oxygen.

(iv) Methane was well known as a greenhouse gas.

(v) Helium was well known as a noble gas. Nitrogen was sometimes incorrectly suggested.

(b) (i) Many candidates identified the gas collected as carbon dioxide. Hydrogen was a common incorrect suggestion.

(ii) Some candidates answered in terms of acidity rather than pH change. Few candidates explained that carbon dioxide is acidic or that it is a non-metal oxide.

(iii) Most candidates were able to state at least one way of increasing the rate of the reaction. A common error was to suggest an unqualified ‘temperature’ rather than increase the temperature (of the acid).

Question 9

(a) (i) Few were able to explain that forces **K** and **M** needed to be equal and opposite because there would be no resultant force and consequently the surfboard would move at constant speed.

(ii) Gravitational (force) or weight were often correctly suggested.

(iii) The two quantities needed to calculate the work done by the wind were not well known. The weight of the wind surfer was often suggested.

(b) (i) Many candidates doubled the amplitude when labelling the wave.

(ii) Some candidates were able to give a general definition of frequency but few were able to explain the significance of the 0.1 Hz. A suitable explanation would be that one wave passes a fixed point every ten seconds

(c) (i) The idea that the remaining water molecules would be less energetic was well known.

(ii) The idea that the temperature of the sea water would decrease was well known.

(d) Many candidates correctly calculated the density of sea water as 1024 kg / m^3. Some candidates were confused by the volume of the sea water being quoted as 5.0 m^3. They then used 125 (i.e. 5 × 5 × 5) as the volume.

Question 10

(a) (i) Almost all candidates correctly determined the total decrease in mass as 57 g.

(ii) The decrease in mass will be less than in the first investigation was the correct prediction identified by many candidates. All the other predictions were suggested by a few candidates.

(b) Evaporation was well known as the process by which water is lost from the surfaces of the mesophyll cells during transpiration. Respiration and osmosis were suggested by a few candidates.

(c) Stomata was the correct response. Xylem and leaf were common incorrect responses.

(d) Many candidates gained one mark but few gained more than one mark. A correct reference to xylem was the most popular marking point. There were very few references to root cortex cells.

(e) (i) Few candidates gave a suitable response. The popular response was growth.

(ii) Light and carbon dioxide were frequently given as requirements of photosynthesis.

Question 11

(a) (i) Most candidates did not know what electronic structure meant. Popular incorrect answers were 19, 39 and one outer shell electron.

(ii) There were many answers referring to one outer shell electron. But few candidates linked the number of outer shell electrons with group number.

(iii) The correct numbers were 19 electrons and 20 neutrons. These were the most common numbers suggested, although few candidates gained both marks.

(iv) Very few candidates gained both marks.

(b) Few candidates gained both marks. A common error was to state that a compound contains two or more elements but to omit chemically combined from the definition. Another common error was to refer to a compound as a mixture of elements.

(c) This was well answered by many candidates.

Question 12

(a) Many candidates were able to suggest that the area of the normal wheels was less, but few candidates stated that the pressure would therefore be greater.

(b) Most candidates identified diagram **Z** as the gas but fewer suggested that the diagram showed the molecules separated from each other.

(c) (i) Kinetic energy was usually identified as the form of energy gained as the tractor accelerates.

(ii) Gravitational potential energy was usually identified as the form of energy gained as the tractor moves up the hill.

(d) Most candidates correctly determined the constant speed as 0.5 m / s.

CO-ORDINATED SCIENCES

Paper 0654/32
Theory (Core)

Key message

Some candidates missed available marks due to their responses not answering the question completely. In these cases, candidates should be reminded to read the stimulus material and each question carefully and complete all the instructions contained within the question.

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.

General comments

A good standard of scientific knowledge was displayed by many candidates. Some candidates should be congratulated for their clear and accurate responses. Calculations were often done well with working shown.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified the motor neurone.

(ii) Few candidates correctly referred to electrical signals or impulses.

(iii) Sensory and relay neurones were quite well known.

(iv) Many candidates gained at least one mark with rapid being the best-known description.

(b) (i) Most of the candidates who were able to work out the average reaction time were able to give their answer to two significant figures.

(ii) There were few correct responses. The brain was the most popular response but some candidates suggested it as the effector and not the coordinator.

Question 2

(a) (i) Most candidates correctly identified two metals from the list.

(ii) Some candidates correctly identified nitrogen. Many others suggested oxygen.

(iii) Helium was well known as a noble gas. Nitrogen was sometimes incorrectly suggested.

(iv) Copper was well known as a transition element. Sodium was a common incorrect response.

(b) (i) The chemical formula of the gas made, H_2, was not well known. Many candidates attempted to write a balanced symbol equation.

(ii) Some candidates were able to determine that the salt made is magnesium chloride. Sodium chloride was often suggested.

(iii) Filtration was well known as the method of separation.

(iv) Most candidates were able to state at least one way of decreasing the rate of the reaction. A common error was to suggest an unqualified 'temperature' rather than decrease the temperature (of the acid).

(c) (i) Few candidates were able to state that an alloy is a mixture of metals.

(ii) The correct answer, 1840 kg, was frequently calculated.

Question 3

(a) (i) The most common correct response was viewing broken bones.

(ii) X-rays were usually placed in the correct position in electromagnetic spectrum.

(iii) Mutation and cancer were both commonly suggested correct answers.

(b) (i) Most candidates gained at least one mark, showing a good understanding of wave properties.

(ii) The range of audible frequencies for a healthy human ear was not well known.

(iii) Some candidates were able to state that the measurements needed were the time taken and the distance. Some candidates were able to describe the calculation, usually by quoting the formula, speed = distance ÷ time.

Question 4

(a) Most candidates showed good data handling skills and correctly identified all the enzymes. A common error was to suggest that the enzyme that works best in neutral conditions was enzyme D.

(b) Temperature was correctly suggested by many candidates as a factor that affects enzyme activity.

(c) This question was poorly answered. Some candidates correctly suggested biological, but chemical and reaction were frequently suggested.

(d) Few candidates gained more than one mark on this question. The elements present in proteins and fats were not well known.

(e) (i) Glucose was well known as the smaller molecule that starch is made from.

(ii) Glycogen was correctly identified by some candidates. Amino acid was frequently suggested.

Question 5

(a) Some candidates did not describe the reaction between calcium and water. A good description needed to include ideas about a gas being released or fizzing being observed.

(b) (i) Many candidates were able to write the correct word equation. A number of candidates attempted to write a correct symbol equation. Few were able to do this correctly.

(ii) Methane was correctly suggested as a greenhouse gas.

(iii) Some candidates knew that the number of different elements in $CuSO_4$ is three. Some candidates knew that the total number of atoms in $CuSO_4$ is six. Few knew both.

(c) (i) A reference to a loss of oxygen was required to correctly answer this question.

(ii) The meaning of exothermic was well known.

(iii) Many correct metals were suggested by the candidates. Magnesium was a common incorrect answer.

Question 6

(a) The expected answer was that electricity will not be generated at night or when there was little sunlight. Some candidates gave vague responses about poor weather conditions.

(b) (i) Almost every candidate gave the correct response, **C**.

(ii) This calculation was well done by many candidates. A common error was to multiply 40 000 by 10.

(iii) Many candidates gave the correct answer of 2000 N. However, few were able to explain that forces **B** and **D** needed to be equal because there would be no resultant force and consequently the tractor would move at constant speed.

(c) Few candidates knew that the form of energy stored in the diesel fuel was chemical potential energy. Kinetic energy was a common incorrect answer.

(d) (i) Most candidates were able to use the graph to determine the maximum speed of the tractor as 2 m / s.

(ii) Almost all candidates were able to indicate a time when the tractor moves at constant speed. Candidates are advised to place the **X** in the middle of a changing speed section, rather than at one end or the other.

(iii) Few candidates were able to work out the area under the graph as 5 m. Instead, they used distance = speed × time.

Question 7

(a) (i) Most candidates correctly labelled a rib. A common error was to label the lung.

(ii) Many candidates correctly labelled the diaphragm. A common error was to label the trachea.

(b) The commonest response was inspired air is the air we breathe in and contains oxygen and expired air is the air we breathe out and contains carbon dioxide. This was insufficient. Strong responses stated that inspired air contains more oxygen, less carbon dioxide and less water vapour than expired air.

(c) Some candidates correctly named the pulmonary artery or pulmonary vein. Many candidates just stated an unqualified artery or vein.

(d) (i) Red blood cells were well known as the part of the blood that transports oxygen.

(ii) Plasma was well known as the part of the blood that transports hormones.

(e) Some candidates were able to identify adrenaline as the hormone secreted in a ‘fight or flight’ situation.

Question 8

(a) (i) Some candidates correctly identified chlorine as a gas and iodine as a solid. A common incorrect response was to state that both chlorine and iodine are liquids.

(ii) Common incorrect responses were Br and Br^{2+}.

(iii) Many candidates knew that the halogens are in Group 7 or VII.

(iv) The number of electrons in an iodine atom was correctly determined as 53 by most candidates.

(b) Some candidates were able to state that chlorine and hydrogen would bond covalently. Fewer were able to explain that this type of bonding occurs between two non-metals.

(c) (i) This was well answered by many candidates. A few candidates identified the anode as the cathode and *vice versa*.

(ii) The two products of the electrolysis were rarely identified as lead and bromine. A common incorrect answer was hydrogen. Candidates should avoid referring to bromine as bromide.

Question 9

(a) Most candidates correctly identified the solid, liquid and gas from the descriptions given.

(b) (i) This question was poorly answered. Few candidates mentioned conduction or convection.

(ii) Some candidates correctly suggested that plastic is an insulator

(c) Many candidates gained two marks for a correct calculation. Fewer candidates correctly stated the unit of resistance as the ohm, Ω.

(d) Many candidates were able to deduce that the wire would move downwards or in the opposite direction.

Question 10

(a) (i) All three parts were identified by some candidates, although few candidates scored full marks

(ii) The lower epidermis was not well known. Cell, cell membrane and cell wall were all popular incorrect responses.

(b) (i) This was well answered. Many candidates showed good data handling skill to use the information to determine that oxygen is not required for photosynthesis.

(ii) Most candidates knew what was happening but some did not refer to photosynthesis in their answers. Vague references to the reaction slowing down were insufficient.

(c) (i) Magnesium was not well known as the main mineral ion required for making chlorophyll.

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Question 11

(a) (i), (ii), (iii) and (iv) Some candidates correctly identified some of the molecules. There were no common incorrect responses.

(b) Water was well known as a product of complete combustion. Hydrogen was the most popular but incorrect response.

(c) Many candidates suggested that a compound contained two elements. Fewer suggested that the elements were chemically bonded or combined.

(d) C_3H_8 was the correct and most popular response.

(e) Some candidates correctly drew one bonding pair of electrons. A few candidates correctly drew four bonding pairs of electrons. Some candidates offered no response to this question or just drew the bonds between the atoms.

Question 12

(a) A few candidates correctly suggested electrons as the charged particles removed from the car. A more common insufficient response was negatively charged particles.

(b) Many candidates drew a series circuit rather than a parallel circuit. Some candidates omitted to include a switch.

(c) Most candidates used an incorrect formula and divided the force by the distance. Some candidates omitted to convert the distance from centimetres to metres.

(d) (i) Some candidates knew that line **XY** is the normal. A common incorrect answer was line of reflection.

(ii) Many different angles were suggested as the angle of incidence. Some candidates labelled the incident ray.

(iii) Most candidates gained at least one mark. Laterally inverted was the better-known description.

CO-ORDINATED SCIENCES

Paper 0654/33
Theory (Core)

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(iii) Most candidates gained at least one mark. Laterally inverted was the better-known description.

CO-ORDINATED SCIENCES

Paper 0654/41
Theory (Extended)

Key messages

Candidates are reminded to check whether questions relating to graphs are asking for a description, an explanation, or both, of the data. This was particularly important in **Questions 9(b)** and **10(c)(ii)**.

An important skill that candidates should practise is the conversion of units and rearrangement of formulae. When completing calculations, candidates should remember to state the formula used, show the working, express the value to an appropriate number of significant figures and include units.

It is particularly important for candidates to read questions carefully and use their knowledge to give a response to the context of the question. Some candidates gave scientifically accurate answers but they did not answer the question asked.

General comments

In general, candidates showed a good level of understanding of the syllabus content and were able to apply their knowledge to unfamiliar contexts. Most candidates were able to articulate their ideas well and give clear and concise responses. Candidates who were awarded high marks could explain the meaning of scientific terms using the wording in the syllabus.

Some areas of the syllabus were better known than others. Candidates should be reminded to revise all the material detailed in the syllabus. A useful tool is to use the syllabus as a revision guide and go through the syllabus ensuring that each learning objective has been covered.

Comments on specific questions

Question 1

(a) (i) Almost all candidates were able to correctly identify the sperm cell, however, fewer knew the name of the root hair cell. Common incorrect responses included animal cell and either root cell or hair cell.

(ii) Only some candidates correctly identified cell **A** as a ciliated cell, and a relatively small proportion were able to explain the adaptations in terms of moving cilia. Many candidates incorrectly identified the cilia as villi and gave a response in terms of improved absorption.

(iii) Many candidates were able to state a large surface area as an adaptation of a red blood cell. The term biconcave was not always seen, however, credit was still given where surface area was discussed. Other adaptations, such as no nucleus or the presence of haemoglobin, were also credited.

(b) The main components of blood were well known with a range of correct responses seen. A small number of candidates included red blood cells in their response.

(c) (i) This question asked candidates to explain the structure of artery walls. While most candidates could identify that this was because of the high blood pressure in arteries, few included details of the thick walls preventing bursting.

(ii) Most candidates were able to explain why veins have valves.

(iii) The majority of candidates were able to give either improved, easier or faster diffusion as a correct response. Some candidates correctly answered in terms of a shorter diffusion length, while responses in terms of gas exchange were less common.

Question 2

(a) The correct response of alkenes was commonly seen.

(b) While many candidates knew that the process by which ethene is made is called cracking, many incorrectly stated fractional distillation.

(c) (i) Candidates were required to include details of both the long chain shape of a polymer molecule and its nature in terms of either monomers or small molecules. Many candidates correctly referenced long chain molecules in their response, however, credit was not given for a statement relating to a long chain hydrocarbon.

(ii) Almost all candidates correctly drew the structures of chloroethene and poly(tetrafluoroethene).

(d) A relatively large number of candidates stated the correct formula for hydrogen. Some candidates included a full symbol equation in their response, for which full credit was given.

(e) Not all candidates could correctly describe what is meant by a saturated hydrocarbon. Many incorrect responses mentioned the water content of the molecule, showing little understanding of technical terminology.

(f) While some candidates could correctly draw this structure, many did not realise that the compound formed by the reaction would not contain a double bond.

Question 3

(a) (i) The majority of candidates were able to correctly calculate weight.

(ii) Most candidates could correctly apply the formula for work done to this context. A number of candidates did not recognise that the unit for work done is the Joule, with incorrect units including Newtons and Newtons per metre.

(b) (i) The vast majority of candidates could calculate the potential difference across the motor. Candidates are reminded that they must include full details of their workings for ‘show that’ questions.

(ii) Most candidates could correctly apply the formula to calculate resistance. Some candidates failed to recognise that they needed to use the potential difference across the motor, rather than the e.m.f. of the circuit.

Question 4

(a) (i) Almost all candidates used the key correctly to give an answer of 4.

(ii) While the majority of candidates gained marking points 1 and 4, many candidates did not realise that genotypes need to have both alleles included. Responses of t and T were commonly seen in the second and third sentences.

(iii) Some candidates correctly stated the probability as being 0%, however, many incorrect responses identified the probability as 100%.

(b) The majority of candidates were able to identify that mitosis produces nuclei with paired chromosomes, while fewer also indicated that the cells produced have diploid nuclei and that mitosis occurs after exact duplication of chromosomes. A small number of candidates selected the statements which related to meiosis.

(c) Some candidates were able to state that a human diploid cell contains 46 chromosomes, with commonly seen incorrect responses including 23 and 48.

(d) Most candidates were unable to state that a change in a gene or chromosome is a mutation, no other response was credited.

Question 5

(a) (i) This question required candidates to describe the numerical change in the pH value of an acid as alkali is added. Many candidates failed to gain a mark by describing that the acid was neutralised or became less acidic, rather than giving a quantitative description of the pH increasing.

(ii) Most candidates correctly stated the type of substance being produced as a salt. A small number tried to answer this question with the name of a specific compound.

(iii) Candidates were challenged by the question, with a very small number being able to correctly determine the formula of the salt produced and balance the equation. Many candidates did not appreciate that the sulfate ion will remain intact after the reaction, with compounds such as potassium sulfide and potassium oxide being included as products.

(iv) Not all candidates were able to state the formula of the ion present in acids, with incorrect responses often stating the formula of small molecules rather than an ion.

(b) Most candidates were able to correctly calculate the relative formula mass of ammonium sulfate.

(c) (i) This question required candidates to state the sources of hydrogen and give two conditions required for the Haber process. Most candidates were able to state all three conditions required, however, far fewer included accurate descriptions of the sources of the gases, with common incorrect responses stating that both gases are obtained from air.

(ii) Not all candidates were able to correctly complete this calculation. Where the correct answer was calculated, candidate's work was well structured and clear. Common mistakes included calculating the number of moles present in 51 kg of ammonium nitrate. A significant proportion of candidates did not know how to attempt this type of calculation.

Question 6

(a) (i) Most candidates were able to state that the source of energy for the tides is the Moon, with some candidates including additional information relating to the gravitational attraction of the Moon.

(ii) Many candidates failed to state the formula for kinetic energy. Amongst those candidates who could recall the formula for kinetic energy, some incorrectly rearranged the formula to determine the speed of the water flow.

(b) (i) A significant number of candidates failed to attempt this question. Of those that did attempt it, most correctly identified that the magnetic fields go from north to south.

(ii) This question required candidates to identify the slip rings and describe their use in a simple a.c. generator. Most candidates confused Fig. 6.2 with a motor and incorrectly stated that the labelled part was the split ring commutator and then described the production of an alternating current.

(iii) Most candidates recognised that the output from an a.c. generator will be sinusoidal in nature, however, some graphs were drawn very inaccurately showing a varying time period or amplitude. A small number of candidates sketched a graph with an increasing then constant output voltage.

(c) This question required candidates to recall the speed of light, and then use this value to calculate the frequency of the wave. While many candidates correctly stated the speed of light, many used the speed of water calculated in **6(a)(ii)**. These candidates were awarded error carried forward marks for this question. The formula for wave speed was generally well known and candidates were able to rearrange it to determine the frequency.

Question 7

(a) Stigma was commonly seen as a correct response to this question. However, a significant number of candidates were unable to identify this part of a flower. An incorrect response of anther was commonly seen.

(b) Most candidates correctly described the features of the pollen and flowers from an insect-pollinated flower, with common responses including spiky and sticky pollen alongside colourful petals. A minority of candidates answered in terms of the features of wind-pollinated flowers, which was not always made explicitly clear in the response.

(c) Most candidates could state the ovule or ovary as the location for fertilisation.

(d) A significant number of candidates were able to describe how asexual reproduction leads to a lack of genetic variation in a species, with some only giving vague responses relating to offspring being similar to their parents. A smaller number of candidates then went on to include details of either a difficulty in adapting to environment change or to the ease of disease spread.

(e) Many incorrect responses, including light, nutrients and unqualified descriptions of temperature were seen. Germination requires oxygen, water and a suitable temperature.

Question 8

(a) Most candidates were able to state the proton number for argon, and many could also give the electronic structure for magnesium.

(b) (i) The vast majority of candidates knew that isotopes have varying numbers of neutrons, while some answered in terms of nucleons, fewer included detail on the identical numbers of protons.

(ii) Some candidates related the chemical properties to the number of electrons in the outer shell of chlorine, however, many incorrectly linked the number of protons to the chemical properties, or gave vague, unqualified answers in terms of the number of electrons.

(c) Most candidates were able to explain that argon's low reactivity is caused by the full outer shell of electrons.

(d) Only the most able candidates were able to give a satisfactory description of metallic bonding. While some candidates mentioned a sea of electrons in their response, very few also included detail of the lattice of positive ions. The option to include a diagram to help with the description was not well utilised, with few candidates labelling what they did draw. A significant number of candidates answered in terms of ionic bonds forming between a metal and a non-metal.

(e) Some candidates gave the correct formula for magnesium chloride.

(f) Candidates found this equation less challenging than **5(a)(iii)**, however, there were still a significant number of candidates who could not determine the formula of the salt being formed. Incorrect responses included fluorine and chlorine bonding together and incorrect ratios used in sodium fluoride. Candidates who correctly determined the formula of the product often then went on to correctly balance the equation.

Question 9

(a) Candidates were able to describe the motion of the smoke particles as being caused by collisions with other particles, however, many failed to include that these particles are light, fast moving air particles. Some candidates simply gave a description of the random movement of particles in a gas rather than describing Brownian motion.

(b) This question proved challenging for candidates. There was a requirement for candidates to use the shape of the graph to describe and explain how the resistance of the filament lamp changes as potential difference increases. Very few recognised that the resistance is equal to the reciprocal of the gradient. Many candidates simply described the relationship between current and potential difference without any mention of resistance, while others were able to state that the resistance increases, but without any explanation of why this happens. Only a small number of candidates related the change in resistance to the increasing temperature of the filament.

(c) (i) Many candidates were able to correctly draw two accurate rays on the diagram. Fewer drew the inverted image required to gain full marks. Some candidates incorrectly drew an undeviating ray through the principal focus closest to the object while there was a significant proportion of candidates who appeared not to know how to draw any meaningful rays.

(ii) The refractive index was calculated correctly by many candidates. Incorrect responses of 22 and 1.79 were commonly seen where the formula was not known.

Question 10

(a) Most candidates were able to identify the two involuntary actions.

(b) Most candidates stated the ability to respond to a stimulus as being sensitivity.

(c) (i) Most candidates could correctly use Fig. 10.1 to calculate the time taken for the blood glucose concentration to return to normal.

(ii) This question required candidates to explain the shape of the graph shown in Fig. 10.1. A significant proportion of candidates gave descriptions of the shape of the graph, often quoting specific data, but without any sort of explanation which did not earn any credit. Of the candidates that explained the graph, most included the release of insulin as part of their answer. Very few included anything about the pancreas detecting the increase in blood glucose concentration.

(iii) Only a small proportion of candidates could identify this type of response as negative feedback.

(d) The correct answers of adrenaline and glucagon were commonly seen, however, most candidates only included one of these answers. Commonly seen incorrect responses included insulin and glycogen as well as testosterone. At times, ambiguous spelling of glucagon made it difficult to distinguish from glycogen.

Question 11

(a) Almost all candidates were able to state that experiments 2 and 3 show that volume of acid does not affect the rate of reaction.

(b) This question required candidates to state how increasing temperature and concentration affect the rate of a reaction, and then give an explanation for each factor. The majority of candidates gained marks for stating that in both cases, the rate of reaction increases. Some candidates explained that increasing temperature increases the (kinetic) energy of the particles, while others simply stated that the particles move faster, both of these responses were credited. Very few candidates could give an explanation of why increasing concentration increases the rate of reaction, with many responses relating entirely to the rate of collisions rather than using ideas about particles as given in the stem of the question. Where candidates knew that a higher concentration of acid contains more particles, many failed to gain a mark, as they did not qualify their response with the idea of per unit volume.

(c) While some candidates were able to convert the concentration of hydrochloric acid from mol / dm^3 to g / dm^3, many failed to correctly calculate the relative formula mass, using only chlorine.

(d) This question proved challenging for candidates. Many incorrect responses stating that breaking bonds releases energy were seen. Some candidates were awarded two marks for explaining that bond making is exothermic while bond breaking is endothermic. Very few could then compare the energy taken in by the reaction to the energy given out to give a full explanation as to why the reaction is exothermic overall. Responses involving a comparison of the number of bonds broken and made were common.

Question 12

(a) (i) Most candidates correctly calculated the resultant force, however, a small number gave a final answer of 7.9 which was not given any credit.

(ii) Most candidates were able to describe how the rocket would move upwards, but few linked the upwards resultant force to an upwards acceleration.

(iii) Many candidates knew that the gravitational field strength decreases as the rocket moves away from Earth. Some responses simply stated that gravity decreases in space, which in this case was given credit. Very few candidates answered this question in terms of the decreasing mass of the rocket.

(b) A large proportion of candidates gained full marks for this challenging calculation. Most candidates were able to apply the formula for speed to calculate the total distance travelled, credit for this was given even where the unit conversion for time was missing or incorrect. Some candidates incorrectly used the formula for the area rather than the circumference of a circle to determine the radius of the orbit, and this was commonly followed by a subtraction of 2 000 km to obtain the final answer.

(c) (i) Some candidates correctly identified the ionising radiation types as alpha and beta but very few could explain that this was caused by the charge of the particles. Most incorrect responses tried to use the penetrating ability of the ionising radiations to explain their deflection.

(ii) Some candidates were able to use correct nuclide notion to determine the proton and mass numbers for the decay of iodine-131. A significant number of candidates were unable to state the notation for a beta particle, leading to incorrect responses.

CO-ORDINATED SCIENCES

Paper 0654/42
Theory (Extended)

Key messages

Candidates are reminded to check whether questions relating to graphs are asking for a description, an explanation, or both, of the data. This was particularly important in **Questions 7(a)(ii)** and **10(b)**.

An important skill that candidates should practise is the conversion of units and rearrangement of formulae. When completing calculations, candidates should remember to state the formula used, show the working, express the value to an appropriate number of significant figures and include units. **Questions 3(a)(ii)**, **3(d)(i)**, **6(c)(iii)** and **12(a)(ii)** are examples where these skills were particularly beneficial.

It is particularly important for candidates to read questions carefully and use their knowledge to give a response to the context of the question. Some candidates gave scientifically accurate answers but they did not answer the question asked.

General comments

A high standard of scientific knowledge and understanding was displayed by many of the candidates. Many candidates should be congratulated for their articulate and accurate responses.

Some areas of the syllabus were better known than others. Candidates should be reminded to revise all the material detailed in the syllabus. A useful tool is to use the syllabus as a revision guide and go through the syllabus ensuring that each learning objective has been covered.

Comments on specific questions

Question 1

(a) (i) Nearly all candidates correctly calculated the difference between the resting pulse rate and the pulse rate during exercise.

(ii) Some candidates were uncertain about which part of the heart was contracting. The part contracting should have helped candidates to identify that it was the muscular wall. Some candidates interpreted this question differently and named the part of the heart as the ventricle, which was also acceptable. Candidates that recognised the process as respiration, were generally able to state the correct reactants. However, there were a number of candidates that gave inappropriate reactants such as nutrients or protein, even though they had given respiration as the process.

(b) (i) This question was generally well answered provided candidates had read the question carefully. This question specified changes to the diet. Many candidates gave other recommendations to reduce the risk of developing coronary heart disease such as exercise and stopping smoking. Although these were correct, they were irrelevant to the question being asked.

(ii) The sex chromosomes were generally well known. The most common misconception was to write the number of chromosomes in a gamete or to name the gamete rather than state the chromosomes as XY.

(c) There were some very good answers seen, with a number of candidates identifying that the cells produced as a result of meiosis would be genetically dissimilar and be haploid. Very occasionally

candidates confused mitosis and meiosis. Sometimes candidates repeated themselves and gave different permutations of the same answer. For example, stating that the cells would have half the number of chromosomes, have unpaired chromosomes and are haploid, are all the same marking point. Candidates should try to make as many different points as the mark allocation.

Question 2

(a) Most candidates were able to state the correct percentage for nitrogen and oxygen in clean air. Very occasionally the two values were muddled. Some candidates gave values very close to the required answer, however, these values could not be credited. Candidates should use the values as stated in the syllabus.

(b) (i) Equations were generally completed accurately and correctly balanced. Some candidates did not appreciate that nitrogen is a diatomic molecule. It was rare that candidates completed the correct equation, but not do the balancing.

(ii) Candidates generally gained the first marking point by describing an increase in kinetic energy of the particles due to increased temperatures. Fewer were able to describe the increased frequency of collisions. It was common to see candidates describing 'more collisions' but they need to be more precise in their responses and instead give some reference to increasing rate of collision or increased number of collisions per unit time.

(iii) This question was answered less successfully. Some candidates struggled to express that there would be more particles in a given volume. Some candidates got confused and referred to increasing kinetic energy or strength of collision, which was irrelevant in this instance. Again, it was common to see candidates referring to 'more collisions' rather than describing the frequency of collisions.

(c) (i) Some candidates were uncertain about which bonds would be broken. A wide variety of answers were seen including bonds on the product side of the equation. It was common to omit the carbon-oxygen triple bond.

(ii) Only the most able were able to access all of the available marking points. It was evident that many of the candidates held the misconception that bond breaking releases energy and is exothermic. Some candidates did not seem to appreciate that during chemical reactions bonds are both broken and made, not one or the other. The best responses explained the difference in the energy taken in during bond breaking and released during bond making.

Question 3

(a) (i) Candidates were generally able to show the gravitations potential energy correctly. On rare occasions candidates used equations of their own devising, which mathematically gave the correct value but did not use a correct formula and so were not credited.

(ii) There were occasionally inaccuracies seen when applying the kinetic energy equation. Common inaccuracies including not dividing the value by two and not squaring the velocity. Candidates should be encouraged to show the formula they are using and all the working in calculation questions.

(b) (i) Most candidates gave the required response of friction. Common incorrect answers included kinetic, thermal and gravitational energy as well as resistance.

(ii) Most candidates gave the required response of conduction. Common incorrect answers included convection, radiation, thermal energy and exothermic and endothermic energy.

(iii) Candidates generally referred to the transfer of energy by vibration of particles. The most able candidates were able to clearly express conduction as these vibrations being passed from particle to particle. Fewer candidates were able to add to this by describing the involvement of delocalised electrons in conduction.

(c) Most candidates were able to calculate the density, however, very few candidates stated the formula. The volume being expressed in standard form proved problematic to some candidates,

who had difficulty using this value in their calculations. The ability to transfer values to standard form and back again is a beneficial skill for candidates to practise.

(d) (i) Most candidates were able to identify the limit of proportionality on the graph. Occasionally this question was omitted. Candidates should be reminded to read questions carefully and complete all the questions required of them. There were occasional inaccuracies seen with the limit of proportionality sometime identified on the line past 0.5 mm.

(ii) A significant number of candidates used the wrong formula of extension multiplied by the force to give a value of 50 N / m. Another very common issue was in the conversion of mm to m. The conversion of values between two sets of units is an important skill for candidates to practise.

Question 4

(a) (i) Fossilisation was not a well-known process in the carbon cycle. The most common incorrect answer seen being combustion and decomposition. Several candidates tried to give a description of the process rather than stating the name of the process.

(ii) The process of feeding was usually added to the carbon cycle diagram accurately. Occasionally this question was omitted or the arrow was pointing in the opposite direction.

(iii) Candidates that were able to identify the process of photosynthesis, generally answered this question successfully. It was rare that candidates stated the respiration equation. It was evident that there was some confusion amongst some candidates who tried to give the equation for combustion.

(iv) Combustion was correctly stated by many as the name of the process. However, it was also common that the name of the process was omitted or described vaguely as emissions. This question asked for the effect on the atmosphere. A number of candidates went too far in the journey and went on to describe global climate change, when this answer required reference to the increasing concentration of carbon dioxide in the atmosphere.

(b) (i) Many candidates gave the correct responses of kwashiorkor or marasmus. There were occasional struggles with the spelling of kwashiorkor, however, if the response was recognisable or phonetically spelt, these were accepted.

(ii) Most candidates gave the correct molecules as amino acids. It was evident that some candidates did not read the question carefully and gave the elements of proteins instead of the name of the smaller molecules that proteins are made from.

Question 5

(a) Some candidates found this question difficult. The relative mass of the particles proved more problematic than the charge. Many were uncertain about the relative mass of the electron.

(b) (i) Most candidates described the loss of one electron. There were very rare instances where candidates described the loss of multiple electrons or the gaining or sharing of electrons.

(ii) Only the most able candidates were able to successfully construct the required ionic half equation. A number of candidates had the gain of electrons resulting in positive ions ‘$Na + e^- \rightarrow Na^+$’.

(c) This question was very well answered. The vast majority of candidates were able to identify the atomic number of bromine. There were occasional difficulties with the electronic structure of fluorine, with some suggesting eight electrons or one electron in the outer shell.

(d) (i) Despite being given the formula of the reactants, some candidates had difficulty displaying the balanced symbol equation. Common errors included expressing the product as $NaCl_2$ and not balancing the equation.

(ii) Many candidates tried to show the ions as a covalently bonded molecule with shared electrons. Some candidates tried to show the process of the transfer of electrons, rather than the resultant ions. A number of candidates showed the number of outer electrons of the atoms of sodium and chlorine rather than the ions.

Question 6

(a) The majority of candidates knew the difference between mass and weight and were able to express this clearly and state the correct units for each.

(b) This question was particularly well answered with most candidates able to calculate the distance. Few candidates stated the formula that they used.

(c) (i) This question proved challenging for some of the candidates. Inaccuracies included the incorrect number of lamps, the inclusion of extraneous circuit components and drawing of a series circuit instead of a parallel circuit. Switches were generally added in the correct place in the circuit.

(ii) Candidates that read the stem of the question carefully and realised the importance of four lamps, generally answered this question successfully. The most common incorrect answer was 16 A.

(iii) Most candidates were able to calculate the power output and state the formula they used. The principle of error carried forward was applied as the candidates were expected to use their answer from part **(ii)** so a number of candidates were credited for their value of 3840 W.

Question 7

(a) (i) It was evident that some candidates thought transpiration was an enzyme-controlled process and drew a bell-shaped curve. However, most candidates were able to label the axis correctly and drew a line indicating a positive correlation.

(ii) This question was very challenging, however, there were some excellent detailed and accurate responses seen. Some candidates tried unsuccessfully to explain an increase in the rate of transpiration. The best responses related an increase in water vapour in the atmosphere to a decrease in the water potential gradient resulting in a decrease in evaporation. There was some confusion between temperature and humidity shown by some candidates, with some identifying that an increase in humidity would increase the temperature and so increase the rate of transpiration.

(b) (i) Again many candidates found this question challenging. Candidates should be reminded to use the correct terminology as specified by the syllabus. The best responses explained the movement of water up the xylem in terms of a transpiration pull creating a reduction in water potential at the top of the xylem. Many candidates tried unsuccessfully to explain this in terms of osmosis.

(ii) Many candidates gave the correct term of cohesion. Occasionally adhesion was seen, which was not credited. Some candidates stated hydrogen bonding, which was also acceptable.

(c) A significant number of candidates gave stomata as one of the responses. Candidates should be reminded to read the question stem carefully. This question required the names of two cells and the stomata is not a cell. Many candidates were able to identify guard cells with fewer identifying the spongy mesophyll cells. A number of candidates gave palisade mesophyll cells, which are primarily adapted for photosynthesis.

(d) The process of translocation was reasonably well known with nearly all candidates gaining at least partial credit. Candidates generally identified that translocation occurred in the phloem. Fewer recognised the involvement of movement of amino acids. The most common incorrect answer was that translocation involved the movement of glucose. This is inaccurate as carbohydrates are translocated as sucrose, not glucose.

Question 8

(a) There were a number of vague responses relating to the improvement of growth. This was acceptable but the best responses that gained full credit referred to some additional detail such as the use of nitrates for protein synthesis or the use of mineral to prevent the discolouration of leaves.

(b) The calculation was generally well done. One of the biggest difficulties candidates faced was the calculation of the formula mass for both K_2CO_3 and K_2SO_4.

(c) The correct colour flame was generally given as lilac. A wide variety of incorrect colours were occasionally seen including green and orange.

(d) (i) The majority of candidates had a good understanding of the purpose of a catalyst and were able to express this successfully.

(ii) Some candidates struggled to express their responses adequately. A number of candidates simply rephrased the question.

(e) (i) The majority of candidates were able to interpret the graph successfully in order to state that the percentage of ammonia made decreased. On rare occasions it appeared that some candidates made the assumption that an increase in the temperature would increase the percentage of ammonia made without referring to the graph.

(ii) The majority of candidates were able to give a correct temperature and pressure from the graph. Occasional inaccuracies in graph reading were seen.

Question 9

(a) (i) Not all candidates could state the name Brownian motion. Random motion was often given.

(ii) Candidates generally recognised that movement of the pollen grains was caused by collision with other particles. A number of candidates were under the misconception that the pollen grains collided with other pollen grains or air particles. Some candidates incorrectly thought the pollen grains were motile. Only the most able candidates were able to describe the movement of pollen grains being caused by collision with water particles.

(b) (i) Candidates found it difficult to draw accurate ray diagrams. Common errors included ray lines not going through the focal point or not being refracted by the lens. The candidates were most successful in drawing the upper line that went through the lens before going through the focal point. They found it more difficult to draw the lower line that travelled through the focal point before entering the lens. Occasionally the image of the arrow was incorrectly drawn as smaller or omitted altogether. There were some inaccuracies due to the equipment candidates used. Candidates should be reminded to use a sharp pencil and a ruler when drawing ray diagrams.

(ii) The difference between a real image and a virtual image was well-known with many candidates stating that a real image could be projected on a screen.

(c) (i) A significant proportion of candidates omitted the units for the speed of light. Whenever a numerical value is stated, it is important that units for that value are also stated.

(ii) Most candidates knew some of the differences between gamma and radio waves. The statements that were most frequently confused were that radio waves have a higher frequency than visible light and that gamma rays have a longer wavelength than visible light.

Question 10

(a) Most candidates were able to identify two risk factors from the graph. It was reasonably common to see some candidates not reading the question carefully and giving two other risk factors unrelated to the information in the figure.

(b) Candidates should be reminded to pay close attention to the command words in order to answer the question fully. This question required both a description and an explanation. Most candidates were able to describe that there would be an increase in the percentage of COPD in the country, fewer were able to explain that this is because smoking tobacco causes COPD.

(c) The components of tobacco smoke were more commonly identified than the effect of carbon monoxide. Nicotine being the most commonly identified component. There were many vague effects of carbon monoxide described such as breathing difficulties, these could not be credited. The best responses referred to carbon monoxide binding to haemoglobin preventing red blood cells from carrying oxygen.

(d) Candidates found this question challenging and there were many vague responses relating to damage to the respiratory system. The syllabus clearly states that an increase in concentration of carbon dioxide in the blood leads to an increased breathing rate.

(e) Ciliated cells were frequently seen. Cilia was also frequently seen, which was also acceptable. The most common incorrect answers seen were alveoli, villi and goblet cells.

Question 11

(a) The structure of butane was correctly drawn by the majority of candidates. Very occasionally candidates attempted to include a double bond or omitted the bonds between the carbon atoms.

(b) The conditions required for cracking were very well known by candidates. If specific temperatures or pressure were given these were accepted as long as they were correct. Some candidates needed to be more specific in their answers. References to heat were not credited.

(c) Some candidates struggled to express themselves clearly. The best responses identified that the bond could be broken anywhere in the chain. Recognition that alkanes and alkenes were made was also creditworthy.

(d) The general formula for alkanes was generally given. Occasionally candidates gave the general formula for alkenes.

(e) The first step of the calculation proved difficult for some with the formular mass of carbon dioxide often given as 28 rather than 44. Some candidates muddled the formula for calculating the volume, often dividing by the wrong value of 24. This was a three-step calculation and candidates should be reminded to write down all their stages of working as credit is still available for some parts of the working even if their final answer is an incorrect value.

Question 12

(a) (i) The majority of candidates were able to identify the core.

(ii) A number of candidates had difficulty in rearranging the formula with some candidates giving the value of 72250 V. Rearrangement of formulae is a skill that is beneficial for candidates to practise, as this skill is required in many of the calculation questions, particularly in the chemistry and physics components of the paper.

(b) This question was poorly answered. A wide variety of inaccurate and careless drawings were seen. It was evident that the magnetic field pattern around a solenoid was poorly understood. Those candidates that could draw the correct shape of the field often drew arrows pointing in contradictory directions.

(c) (i) A common issue was giving the incorrect nuclide notation for an alpha particle, often stating the mass number as 6. The proton numbers of both particles were generally correct.

(ii) The alpha particle was often described as being charged or having a positive charge. Very occasionally candidates suggested that alpha carried a negative charge. An incorrect idea seen was that it was because α-particles have high ionising power or low penetrating power making it unable to get through the magnetic field. Only the most able candidates could extend their responses further by explaining that charged particles experience a force when moving through the magnetic field.

CO-ORDINATED SCIENCES

Paper 0654/43
Theory (Extended)

Key messages

Questions on the Co-ordinated Sciences paper can require the application of a concept specified in one branch of science to a context from another branch. For example, in **Question 4(b)(i)** an explanation of the factors affecting the rate of a chemical reaction had to be applied to the rate of photosynthesis.

An important skill that candidates should practise is the conversion of units and rearrangement of formulae. When completing calculations, candidates should remember to state the formula used, show the working, express the value to an appropriate number of significant figures and include units.

Questions may be subtly different to those appearing on past papers in the same context. Candidates should take care not to automatically provide a practised response without checking all the requirements of the question.

General comments

In general, candidates showed a good level of understanding of the syllabus content and were able to apply their knowledge to unfamiliar contexts. Most candidates were able to articulate their ideas well and give clear and concise responses. Candidates who were awarded high marks could explain the meaning of scientific terms using the wording in the syllabus.

Comments on specific questions

Question 1

(a) Most candidates could identify some parts of the female reproductive system.

(b) Almost all knew the name of the male gamete and correctly stated sperm.

(c) The comparisons of size and number of male and female gametes were usually correct. There was often confusion between the terms, motility and mobility.

(d) The coating of the egg cell was usually correctly described as a jelly. Acceptable alternatives to the energy storing feature of egg cells would have been fat or carbohydrate, but food was too vague.

Question 2

(a) (i) Boiling point was often correctly given as the reason why substances in petroleum can be separated.

(ii) Candidates that did not show that the top part of the fractionating column is coolest usually placed an **X** at the bottom.

(b) A correct use was usually suggested for the fractions. Candidates needed to show that gasoline and diesel oil are used as fuels rather than just stating that they are used in vehicles.

(c) The structure of propane was nearly always drawn well.

(d) Many candidates succeeded in balancing the equation for the combustion of butane.

(e) Many candidates correctly described the difference between a chemical and physical change as being the formation of a new substance.

Question 3

(a) (i) Most methods of determining the volume of graphite involved displacement. Those requiring weighing needed to state that the mass and density were required for use in the formula V = m / d. Candidates did not gain credit for measuring linear dimensions.

(ii) The density calculation was usually carried out well.

(b) (i) The most successful candidates described how lubricants increase the efficiency of a machine in terms of forces and energy transfers as indicated by the question. It was often correctly stated that lubricants reduce the force due to friction causing less energy to be transferred as heat. The role of wasted energy in reducing efficiency was less well known.

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

(iii) The value of the power output was usually correct.

Question 4

(a) Most candidates could use the table to find the temperature at which the rate of photosynthesis was highest.

(b) (i) Some explanations recognised correctly that increasing temperature increases the energy of molecules which increases the frequency of collision. They referred to the question by stating that this causes an increase in the rate of photosynthesis, rather than just an increase in the rate of reaction. The best responses explained in terms of the increased number of molecules reaching the activation energy. Vague references to more collisions did not gain credit.

(ii) Most candidates could use the table to find the temperature at which photosynthesis stopped due to denaturing of enzymes.

(c) (i) There were a few complete descriptions of carbohydrate transport which used the term translocation and stated that sucrose moves through the phloem.

(ii) Some responses named starch as the larger molecule made from glucose for storage. Some smaller molecules were suggested.

(d) Many candidates knew that light energy is transferred to chemical energy in photosynthesis.

Question 5

(a) One of the cations in the list was usually identified as being attracted to the cathode.

(b) A few candidates referred to the mobility of ions in an aqueous solution allowing it to conduct electricity. Many made incorrect reference to moving electrons or the electrical properties of metals.

(c) (i) The positive electrode was almost always named as the anode.

(ii) Many candidates could write the ionic half-equation for a process taking place during the purification of copper. The term electrolyte was seldom used to describe the role of aqueous copper(II) sulfate solution. It was common for candidates to refer to the movement of copper to the cathode rather than to the deposit of copper onto a pure copper cathode.

(d) Those who knew that the discharge of aluminium ions is reduction explained that it involves the gain of electrons.

Question 6

(a) The majority of candidates correctly stated that velocity has direction.

(b) Most interpretations of the speed-time graph described initial acceleration followed by constant speed. A few noted that the acceleration was originally constant and then decreased. There was some confusion between the speed-time graph and a distance-time graph.

(c) Those who knew the formula for kinetic energy could usually use it to obtain the correct answer.

(d) (i) A difference between evaporation and boiling could usually be suggested. A few candidates were under the misapprehension that boiling is the process of reaching boiling point.

(ii) At least one way to increase the rate of evaporation could usually be suggested.

Question 7

(a) (i) The great majority of candidates identified the initial pulse rate from the graph.

(ii) Most stated the change in pulse rate to support their description of the effect of adrenaline. Successful candidates referred to the increase and avoided simply describing the shape of the graph, for example, as a spike.

(b) (i) Most correctly stated an effect on the eye by describing widening or dilation of the pupil. Some attempted to describe the mechanism for dilation.

(ii) Many knew that the optic nerve carries impulses to the brain.

(c) (i), (ii) and (iii) There were some complete descriptions of the process by which a hormone decreases blood glucose concentration, identifying insulin as being produced by the pancreas, causing glucose to be converted to glycogen and its subsequent storage in the liver. There was often confusion between these organs.

(d) Most candidates described at least one way in which the nervous and hormonal control systems differ. There was some confusion between their speed and their longevity of action. Some answers consisted of one difference described in two ways.

Question 8

(a) Candidates often described the more random arrangement of ions in molten magnesium compared to solid magnesium. Descriptions of changes in movement sometimes included movement around each other without mentioning that ions vibrate about fixed positions in a solid.

(b) The diagram of the arrangement of particles in a gas was usually drawn well.

(c) (i) The volume of gas collected was almost always read correctly from the graph.

(ii) Successful candidates explained the higher initial rate of reaction by referring to the highest acid concentration or greatest magnesium surface area. Some used vague terms such as more acid.

(iii) The increased initial rate of reaction at higher temperature was often correctly shown by a steeper line on the graph. A minority of candidates showed that the yield is unchanged by drawing a line which levelled off at the same volume as before.

(d) Some explanations referred correctly to the larger number of particles per unit volume, which increases the rate of collisions. Some answers simply referred to more particles or more collisions and were insufficient for credit. Other candidates appeared to have the misconception that concentration affects the success of collisions.

(e) The formula for magnesium chloride was often correct. Candidates should be aware that this formula need not be written as part of an equation.

Question 9

(a) (i) Candidates often used the graph to state that the resistance increases as light intensity decreases. Some associated the increase in the number of slides with an increase in light intensity. Only the most successful could describe how the increase is smaller at lower light intensity.

(ii) Most calculations of charge through the LDR involved the correct resistance, read from the graph. Many stated the correct formulae for current and charge. Common errors included failure to convert the resistance to ohms and incorrect manipulation of the formulae.

(b) (i) There were some correct definitions of frequency, while others omitted any reference to unit time.

(ii) There were a few accurate calculations of the wavelength. Common errors included the use of an incorrect value for the speed of light and incorrect rearrangement of the formula.

(iii) A form of electromagnetic radiation with a frequency higher than visible light was usually stated.

Question 10

(a) (i) Many candidates could state the missing blood group.

(ii) Most identified the most common blood group.

(iii) There were a few good descriptions of the evidence showing that blood group is an example of discontinuous variation, there being a limited number of phenotypes with no intermediates. Many made irrelevant observations of trends in the data.

(iv) The cause of blood group variation was sometimes stated as genetic, while mutation was often incorrectly suggested.

(b) Almost all candidates recognised some features of natural selection and selective breeding. Knowledge that selective breeding occurs over many generations was the least well-known feature.

(c) Most statements of the disadvantages of sexual reproduction correctly included the longer time taken and the requirement to find a mate. There was some confusion between the normal genetic variation occurring in sexual reproduction and mutation occurring in both sexual and asexual reproduction.

Question 11

(a) Many completed the equation for the combustion of sulfur. Some introduced elements other than sulfur and oxygen.

(b) (i) A few candidates knew the name of the catalyst used in the Contact process.

(b) (ii) Please note that due to an issue with question 11(b)(ii), full marks have been awarded to all candidates for this question to make sure that no candidates were disadvantaged.

(c) The energy level diagram was often labelled correctly.

(d) Many candidates knew how to find the volume of sulfur trioxide from the number of moles. Those who calculated the number of moles from a formula tended to have more success than those working from first principles.

Question 12

(a) There were some good calculations of the mass of the crate by those who were able to rearrange a learned formula.

(b) Explanations of the increased stability of the truck often involved the lowering of the centre of mass. Unsuccessful responses suggested that the centre of mass moved to the ground.

(c) (i) A few candidates could use the relative directions of force, magnetic field and current in a conductor to show the direction of forces on the coil in the motor.

(ii) Very few candidates realised that point **Y** on the coil does not experience a force because the current is parallel to the magnetic field.

(d) (i) There were some correct suggestions that a β-particle is deflected by a magnetic field because it is charged. Full marks required the recognition that a force is responsible for the deflection. Many candidates confused the magnetic field with an electric field.

(ii) Some candidates stated that the deflection of an α-particle is opposite in direction to that of a β-particle because of the difference in charge. Others stated the charge on the α-particle without comparing it with that on the β-particle.

CO-ORDINATED SCIENCES

Paper 0654/51
Practical Test

Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques. The reading of the instruments was generally good. The standard of graph drawing was generally high although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line.

Candidates found interpreting and evaluating experiments and recording precise observations very challenging.

Comments on specific questions

Question 1

(a) The majority of candidates drew a large clear detailed diagram of the leaf. Some outlines were sketchy with multiple feathery lines and gaps, very few were too small and almost all showed the required detail.

(b) (i) Most candidates gave an appropriate length to the nearest mm. A small number gave their value in cm or measured the width of the leaf.

(ii) Most candidates drew a line and measured it correctly. The most common error was not to draw the line and so the measurement could not gain credit. A small number measured the width.

(iii) Most candidates calculated their value correctly. A small number inverted the division. Rounding was a problem for a significant number of candidates.

(c) (i) Many candidates knew the testing reagents. Many gave sugar rather than reducing sugar or reversed the other two reagents.

(ii) Many candidates did this practical carefully and recorded their results accurately. Some contaminated the samples and had mixed results.

(iii) Most candidates interpreted their results correctly to name the nutrients present in leaf **B**.

Question 2

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A diagram and a results table were not required, stronger candidates included both to illustrate their answer, and these often contained several of the marking points.

A significant number did not name the apparatus they were using, scale is insufficient for balance.

Many candidates thought the water would drip off the leaves into a container. Some put the plants into plastic bags to collect the condensation without appreciating that the wind on the outside of the bag was not the same as the wind on the leaves. Many used fans with different settings without using a plant with no wind, the task needed a comparison between wind and no wind.

Measuring the amount of something is too vague, the quantity being measured needs to be specified, in this experiment it was mass and/or volume.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient - the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn then the quantities on each axis need to be specified.

Question 3

(a) (i) Many candidates heated carefully and recorded all three masses to the same number of decimal places.

(ii) The best diagrams were large, drawn with a ruler and pencil and the apparatus labelled. Some omitted the gauze, the Bunsen burner or the crystals being heated.

(b) (i) Almost all candidates subtracted the values correctly. Some used the mass of the empty basin instead of the basin and powder after heating.

(ii) Almost all candidates divided the values correctly.

(iii) Almost all candidates subtracted the values correctly. Some candidates used the mass of the basin and hydrated crystals rather than the dry powder.

(iv) Most candidates divided the values correctly.

(v) Most candidates divided their values correctly. Many quoted their answer to several significant figures rather than just one which would denote the whole number of water molecules in the formula.

(c) Most candidates correctly described the addition of water. Crystallisation was also seen.

(d) Many candidates suggested repeating the values but few either averaged these repeats or used them to identify and exclude any anomalies. Using values to more significant figures or decimal places was a common incorrect response.

(e) Candidates found this challenging. Misreading the balance, rounding values and less water in the copper sulfate were all common responses.

Question 4

(a) Most candidates recorded the results to tests 1, 2 and 3 correctly. Test 4 often had a white precipitate and the test 5 flame colour was often red or lilac.

(b) Stronger candidates interpreted their results correctly and gave two appropriate ions. Some only gave the cation and chlorine was quite common.

Question 5

(a) (i) Many candidates recorded an appropriate measurement. Common incorrect responses included a value in mm or a value to the nearest cm.

(ii) Candidates found the diagram quite challenging. Many had the beaker sitting on top of the blocks rather than between them.

(iii) Most candidates recorded a suitable height for the beaker.

(b) Most candidates calculated the volume correctly from their values and many had measured carefully and so had a value within the expected range. It was common for the value to be too large.

(c) Almost all candidates recorded a volume and many had poured the water carefully so had a volume within the range expected. It was common for the value to be too large.

(d) Almost all candidates subtracted the values correctly. A small number reversed the numbers.

(e) (i) Stronger candidates appreciated the irregular nature of the beaker, usually the pouring spout, or discussed the blocks not being parallel. Misreading the measuring cylinder was a common response.

(ii) Many candidates appreciated that some of the water spilled or remained in the beaker. Not accurate and parallax were very common responses.

Question 6

(a) Most candidates recorded a value for current.

(b) Most candidates recorded all values for current and many gave values which were less than 1.00 A and increased down the table. Many either quoted the values to only one decimal place or gave some to one and some to two decimal places.

(c) Almost all candidates calculated the resistances correctly. A small number inverted the division.

(d) (i) The standard of graph drawing was generally good. Some candidates reversed the axes and a significant proportion omitted the labels and/or the units on the axes. Whilst many scales were linear some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid.

(ii) Many candidates drew a smooth curve close to all of the points. Some drew dot-to-dot lines, used a ruler between points, drew multiple lines or drew a straight line between the first and last points.

(e) Many candidates appreciated the increase in resistance, fewer described the non-linear nature of the curve. Proportional should be reserved for straight lines which pass through the origin.

CO-ORDINATED SCIENCES

Paper 0654/52
Practical Test

Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques. The reading of the instruments was generally good. The standard of graph drawing was generally high although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line.

Candidates found interpreting and evaluating experiments and recording precise observations very challenging.

Comments on specific questions

Question 1

(a) (i) All candidates recorded a correct colour for the solution in the bag and almost all for the beaker, although some gave white.

(ii) Almost all candidates had a full set of results where the liquid in the beaker turned blue-black. A small number also had the liquid in the bag turning blue-black.

(b) Many candidates correctly interpreted the results to conclude that starch molecules are large and iodine molecules are small. Stronger candidates included the movement of the iodine molecules out of the tubing or described the reaction of iodine and starch. Some candidates repeated the question stem and discussed large and small molecules with no reference to starch or iodine. A small number discussed the starch molecules breaking down to smaller molecules so that they could enter the bag.

(c) Candidates found this challenging with most discussing accuracy rather than precision. A small volume being measured was also common.

(d) Many candidates applied the question to the experiment and discussed the removal of iodine from the outside of the bag. Non-creditworthy responses included to stop contamination and remove impurities, these were too generic to gain credit.

(e) Stronger candidates discussed the results, stating a longer time to turn blue-black or more brown/negative results. Many candidates knew that the reaction would be slower but omitted to apply this to the experiment. A longer time for the results is insufficient as bag **A** does not change.

(f) Benedict's reagent and the observation were well known. Some candidates gave the colour as blue or used biuret or iodine.

Question 2

(a) Many candidates drew a large clear detailed diagram of the cells. Some outlines were sketchy with multiple feathery lines and gaps. Very few were too small and almost all showed the required detail. A small number were larger than the box so not all of the cells fitted.

(b) (i) Many candidates drew a line and measured it correctly, 760 and 7.6 were quite common incorrect lengths. The most common error was to omit the line so the measurement could not gain credit.

(ii) Most candidates calculated the magnification correctly. A small number inverted the division or incorrectly rounded their answer.

(c) Many candidates appreciated the variation in thickness of the leaf so that it would need to be measured at several places and the average calculated. Incorrect responses included measure at another point, measure the thickest and thinnest part and average, parallax error, rounding error and needing a more accurate ruler.

Question 3

(a) (i) Many candidates recorded a full set of volumes of gas increasing down the table and either the increase in volume slowing or plateauing as time progressed. Some candidates placed the bung back slowly and so lost some of the gas.

(ii) Burette was quite well known. If a pipette is to be used then it needs to be a volumetric pipette. Beaker was a popular incorrect response.

(iii) Using a gas syringe to collect and measure the volume of a gas was well known. A small number described counting bubbles or using a burette.

(iv) Stronger candidates appreciated that there would be solid left in the flask. Incorrect responses often stated when all the hydrochloric acid has been used up and when a solution is formed.

(**v)** Stronger candidates appreciated that gas is lost as the apparatus is connected or that the reaction was still happening after 300 seconds. Incorrect responses included not enough acid added and not enough calcium carbonate added.

(b) (i) The standard of graph drawing was generally good. Some candidates reversed the axes and a significant number omitted the label and/or the units on the axes. Some did not start the axes at 0,0 despite there being a plottable point there. Whilst most scales were linear, some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid.

(ii) Many candidates drew a line of best fit suitable for their plotted points. Some drew a straight line connecting the first and last points and a few drew two lines, a curve and a straight line.

(iii) Most candidates found this challenging and either described the shape of the graph, the volume of gas collected or the rate, with no reference to the graph.

Question 4

(a) Many candidates performed the tests carefully and gave detailed observations. All candidates recorded white precipitates for the first parts of tests 1 and 2, non-creditworthy responses included cloudy and milky. Stronger candidates added sufficient excess for the precipitates to redissolve. Test 3 was usually correct. White precipitate, cloudy or milky was common for test 4

(b) Many candidates used their results from the table and the qualitative analysis notes on the final page of the question paper to give the ions commensurate with their results. Some did not use the qualitative analysis notes and chose ions which were not shown by their results.

Question 5

(a) The symbol for the voltmeter was well known and most connected it in parallel. A small number connected the meter in series.

(b) Most candidates recorded values for voltage and current. A small number had the voltage higher than 3 V and the current greater than 1 A.

(c) Most candidates recorded values for voltage and current. Some had the current higher than that in **(b)**.

(d) Most candidates recorded values for voltage and current. A significant number had very different values for the voltage.

(e) Most candidates calculated the resistances correctly and stronger candidates had these in the correct order of magnitude.

(f) Candidates found this question challenging. Many multiplied resistance **2** $\times$ 1.5 and then stated that their answer was, or was not, within 10% and so gained partial credit. Stronger candidates did the necessary 10% calculation and used this figure to show that the values either were, or were not, within 10%.

(g) Candidates found this question challenging with many putting the bulb into a different circuit to check it. Stronger candidates appreciated that the question asked for an observation and so looked for a reading on the ammeter or looked at the filament in the bulb to see if was broken.

Question 6

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A significant number did not name the apparatus they were using, particularly the measuring cylinder.

Stronger candidates used five different areas of water surface and repeated each one. Some compared only two different areas. Many discussed measuring the temperature decrease rather than the temperature at the start and the end and then calculating the temperature decrease. Some appreciated that either the time or the temperature decrease needed to be the same so that the results could be compared. Incorrect methods included recording the time for the water to evaporate or the volume of the water to decrease.

Stronger candidates drew a clear table with headings and units. Many omitted to draw a table, the bullet points in the question are there to guide candidates to know what is required by the question.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient - the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn then the quantities on each axis need to be specified.

CO-ORDINATED SCIENCES

Paper 0654/53
Practical Test

Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques. The reading of the instruments was generally good. The standard of graph drawing was generally high although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line.

Candidates found interpreting and evaluating experiments and recording precise observations very challenging.

Comments on specific questions

Question 1

(a) Almost all candidates obtained a full set of results with increasing volume down the table. A very small number had decreasing volumes.

(b) Many candidates appreciated the loss of gas at the start and suggested either quicker bung replacement or asking someone else to start the stop-watch. Some suggested changing the apparatus to a syringe with no explanation which was not creditworthy.

(c) (i) The standard of graph drawing was generally very good. Some candidates reversed the axes and a number omitted the label and/or the units on the axes. Many gave the unit for time as seconds but used the values in minutes. Whilst most scales were linear some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid or did not start the axes from 0,0 although there was a point to plot there.

(ii) Some candidates drew the smooth curve appropriate for their points. Some drew dot-to-dot lines, used a ruler between points, drew multiple lines or ignored some of the points and drew a straight line between the first and last points. Some drew a curve and a straight line.

(iii) Candidates found this quite challenging. The variables cited in the question are the ones whose relationship should be described and both should be comparative. Many simply described the graph. Proportional should be reserved for a straight line which passes through the origin.

(iv) Stronger candidates appreciated that all of the hydrogen peroxide must have been used up. The most common response was the reaction had stopped, this is insufficient for an explanation.

Question 2

(a) (i) Many candidates did the tests carefully and obtained four correct colours. Purple was quite common for iodine and potato and also for celery and biuret.

(ii) Most candidates interpreted their results correctly to give the nutrients present and absent. A small number added other nutrients not present, including reducing sugars and lipids.

(b) (i) Most candidates gave ethanol and many also stated water. Some gave ethanol and fats.

(ii) White emulsion was well known. Some gave white solution or white precipitate, both of which are incorrect. Cloudy and milky are insufficient.

Question 3

(a) (i) Many candidates recorded a colour for all solutions and most had the colours different.

(ii) Many candidates recorded a pH for every solution and most had the pH's different.

(iii) Almost all candidates assigned acid, alkali or neutral accurately to the pH and colour, some omitted some of the strong / weak descriptions.

(b) (i) Almost all candidates recorded a time / no reaction for all of the solutions, with hydrochloric acid the fastest

(ii) Most candidates had hydrochloric acid as the most reactive, fewer put the unreactive ones on the same level as each other.

(c) Candidates found this challenging. The relationship needed the variables in the question to be used in the description and also for them to be comparative. Few appreciated that solutions of pH 7 and above do not react.

(d) The test for carbon dioxide was quite well known. Cloudy solution and cloudy emulsion were popular incorrect responses.

Question 4

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A diagram and a results table were not required, stronger candidates included both to illustrate their answer, and these often contained several of the marking points.

A significant number did not name the apparatus they were using, scale is insufficient for balance.

Many candidates heated the solution to dryness and weighed the solid remaining. Common incorrect responses dissolved solids in water and then evaporated the water or compared the amount of solid that would dissolve into water at different temperatures. Few repeated the heating for each solution. A significant number reacted the solutions with acid then collected and compared the volume of gas given off.

Measuring the amount of something is too vague, the quantity being measured needs to be specified, in this experiment it was mass and volume of solution used or volume of gas collected.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient – the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn then the quantities on each axis need to be specified.

Question 5

(a) Most candidates measured the length of the pendulum correctly. Some gave their answer to the nearest cm rather than 0.1 cm, 40.0 cm was expected.

(b) (i) Almost all candidates recorded an appropriate time. A small number were very small.

(ii) Almost all candidates calculated their value of T correctly. A very small number differed by a factor of 10.

(iii) Most candidates calculated T^2 correctly, $2 \times T$ was the common incorrect response.

(c) (i) Most candidates calculated l correctly, often as an error carried forward from $2T$ in **(b)(iii)**. A significant number gave their answer to more than three significant figures.

(ii) Candidates found this challenging. Stronger candidates did the necessary 10% calculation and used this figure to show that the values either were, or were not, within 10%.

(d) Most candidates had values for t and T recorded.

(e) The majority of candidates thought the values were proportional because as one increases the other increases and so did not gain credit. Stronger candidates appreciated that as l doubled T does not double and therefore the values are not proportional.

(f) (i) Reading the rule perpendicularly or at eye-level were the most common correct responses. Many described reading carefully or accurately, both of which are too vague to be credited.

(ii) Stronger candidates appreciated that the time being measured is longer, few explained that the errors in timing are less significant or have a lower percentage error when the total time in longer. Easier to measure was a popular incorrect response.

Question 6

(a) Almost all candidates recorded the temperature correctly. A small number recorded to the nearest degree rather than the nearest 0.5°C.

(b) (i) Many candidates recorded a value for θ_H at 10 mm.

(ii) Many candidates recorded a value for θ_H at 20 mm and most were below the value in **(b)(i)**.

(iii) Many candidates recorded a full set of values.

(c) Most candidates described the relationship between air temperature and the distance from the lamp, a small number did not use comparative terms. Proportional needs to be reserved for those relationship where there is a constant ratio between the values.

(d) Candidates found this difficult and many continued the trend and predicted negative values rather than their initial room temperature.

(e) (i) All candidates recorded a temperature and almost all had a higher value than θ_H at 100 mm. A small number had an identical value.

(ii) Almost all candidates subtracted correctly, a very small number subtracted the wrong values.

(f) Stronger candidates appreciated that the thermometer needs to cool down as the distance increases. The most common response was to allow the thermometer to heat up. Heat to the maximum temperature and cooling to room temperature were also common incorrect responses.

CO-ORDINATED SCIENCES

Paper 0654/61
Alternative to Practical

Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

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

Comments on specific questions

Question 1

(a) The majority of candidates drew a large clear detailed diagram of the leaf. Some outlines were sketchy with multiple feathery lines and gaps, very few were too small and almost all showed the required detail.

(b) (i) Most candidates measured the length correctly, the most common error was to give the value in cm rather than mm. A small number measured the width. 450, 45 and 40.5 were all common responses.

(ii) Most candidates drew a line and measured it correctly. The most common error was not to draw the line and so the measurement could not gain credit. A small number measured the width.

(iii) Most candidates calculated their value correctly. A small number inverted the division. Rounding was a problem for a significant number of candidates.

(c) (i) Most candidates knew the testing reagents. A small number reversed the answers, gave reducing sugar or amino acids for protein or carbohydrate for starch.

(ii) Colours of the testing reagents were well known. Yellow, orange, purple and colourless were common responses for biuret; brown, blue, green, white and yellow were common for iodine.

(iii) Candidates found this challenging. Stronger candidates appreciated that the green colour masks the colour of the test. Affecting the results was a common response that was too vague to gain credit. A significant number thought the leaf would carry on photosynthesising if the colour was not removed.

(iv) Candidates found the detail needed challenging. Many simply repeated the question stem or stated that no flames should be used without an explanation.

(v) The observation was quite well known. White was insufficient and a significant number gave precipitate or solution rather than emulsion. The best answer for this question is white emulsion, cloudy and milky are insufficient.

Question 2

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A diagram and a results table were not required, stronger candidates included both to illustrate their answer, and these often contained several of the marking points.

A significant number did not name the apparatus they were using, scale is insufficient for balance.

Many candidates thought the water would drip off the leaves into a container. Some put the plants into plastic bags to collect the condensation without appreciating that the wind on the outside of the bag was not the same as the wind on the leaves. Many used fans with different settings without using a plant with no wind, the task needed a comparison between wind and no wind.

Measuring the amount of something is too vague, the quantity being measured needs to be specified, in this experiment it was mass and/or volume.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient - the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn, then the quantities on each axis need to be specified.

Question 3

(a) (i) Candidates found the diagram challenging. The best diagrams were large, drawn with a ruler and pencil and the apparatus labelled. The gauze was often missing or placed under the Bunsen burner. A beaker was often drawn instead of a basin. Some drew the Bunsen burner with an upwards arrow and labelled it, this is sufficient.

(ii) The majority of candidates interpreted the information in the question to elicit the colour seen. Stops bubbling, no water seen and powder formed were common non-creditworthy responses.

(b) Almost all candidates quoted the values to two decimal places. A small number truncated the values rather than rounding or used the three decimal place values from the readings.

(c) (i) Almost all candidates subtracted the values correctly.

(ii) Almost all candidates divided the values correctly. The most common error was 0.1 which has insufficient significant figures.

(iii) Almost all candidates subtracted the values correctly. Some candidates used the mass of the basin and hydrated crystals rather than the dry powder.

(iv) Most candidates divided the values correctly, many quote the value as 0.2 which has insufficient significant figures.

(v) Most candidates divided their values correctly, many quoted their answer to several significant figures rather than just one which would denote the whole number of water molecules in the formula.

(d) Many candidates suggested repeating the values but few either averaged these repeats or used them to identify and exclude any anomalies. Using values to more significant figures or decimal places was a common error.

(e) Candidates found this very challenging. Misreading the apparatus, rounding values, more copper sulfate used, less water in the copper sulfate and the copper sulfate expands and increases in mass were all common responses.

(f) Adding water was well known. Freezing and crystallisation were common incorrect responses.

Question 4

(a) Candidates needed to use the evidence in the table to elicit the test in each case which would allow one of the three unknowns to be identified by giving a different result to the test compared to the other two. Many candidates gained full credit. Some answers cited the reagents without giving the results for the test which allowed the identification. A significant number used tests which were not in the table and so not creditworthy, including bromine, litmus and universal indicator.

(b) Many candidates described the correct test. Omitting precipitate in the observation was very common.

Question 5

(a) Many candidates measured and recorded the diameter correctly.

(b) (i) Candidates found this challenging. The most common response was to make it accurate which is a repeat of the question stem. Stopping the beaker moving was also common.

(ii) Candidates found this quite challenging and many drew the arrow inside the beaker.

(c) Most candidates measured the height correctly. Some gave 72 or 7.0 cm.

(d) Most candidates calculated the volume correctly. Many candidates showed their working which allowed partial credit to be gained from an incorrect answer.

(e) The majority of candidates read the measuring cylinder correctly. Common incorrect responses included 116, 114.5, and 110.5 cm^3.

(f) Most candidates calculated the volume correctly.

(g) (i) Candidates found this challenging. Rounding, inaccurate measuring, parallax, thickness of the glass and moving water were common incorrect responses.

(ii) Stronger candidates gained credit. Parallax, inaccurate measuring cylinder and glass thickness were common incorrect responses.

Question 6

(a) Most candidates recorded the correct ammeter reading. A small number gave 0.12 A.

(b) Most candidates calculated the resistance correctly. The data in the table is to one decimal place and so the answer to the calculation needs to be given to one decimal place, 2.72 was a common incorrect response.

(c) (i) The standard of graph drawing was generally good. Some candidates reversed the axes and a significant proportion omitted the labels and/or the units on the axes. Whilst many scales were linear some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid.

(ii) Many candidates drew a smooth curve close to all of the points. Some drew dot-to-dot lines, used a ruler between points or drew multiple lines.

(iii) Many candidates read the value from the graph correctly. Stronger candidates calculated I from their value from the graph.

(d) Many candidates appreciated the increase in resistance, fewer described the non-linear nature of the curve. Proportional should be reserved for straight lines which pass through the origin.

(e) Many candidates recognised the component as a resistor with the more successful recognising it as a variable resistor. Fuse and thermistor were common incorrect responses.

CO-ORDINATED SCIENCES

Paper 0654/62
Alternative to Practical

Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques. The reading of the instruments was generally good. The standard of graph drawing was generally high although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line.

Candidates found interpreting and evaluating experiments and recording precise observations very challenging.

Comments on specific questions

Question 1

(a) The unit was well known. A small number of m and s were seen.

(b) Many candidates correctly interpreted the results to conclude that starch molecules are large and iodine molecules are small. Stronger candidates included the movement of the iodine molecules out of the tubing or described the reaction of iodine and starch. Some candidates repeated the question stem and discussed large and small molecules with no reference to starch or iodine. A small number discussed the starch molecules breaking down to smaller molecules so that they could enter the bag.

(c) Candidates found this challenging with most discussing accuracy rather than precision. A small volume being measured was also common.

(d) Many candidates applied the question to the experiment and discussed the removal of iodine from the outside of the bag. Non-creditworthy responses included to stop contamination and remove impurities, these were too generic to gain credit.

(e) Stronger candidates discussed the results, stating a longer time to turn blue-black or more brown/negative results. Many candidates knew that the reaction would be slower but omitted to apply this to the experiment. A longer time for the results is insufficient as bag **A** does not change.

(f) (i) The test for reducing sugar was well known. Some omitted to heat or gave blue for the observation.

(ii) The test for protein was well known. Benedict's, fat test and red-brown were also quite common.

Question 2

(a) Many candidates drew a large clear detailed diagram of the cells. Some outlines were sketchy with multiple feathery lines and gaps. Very few were too small and almost all showed the required detail. A small number were larger than the box so not all of the cells fitted.

(b) (i) Many candidates drew a line and measured it correctly, 760 and 7.6 were quite common incorrect lengths. The most common error was to omit the line and so the measurement could not gain credit.

(ii) Most candidates calculated the magnification correctly. A small number inverted the division or incorrectly rounded their answer.

(c) Many candidates appreciated the variation in thickness of the leaf so that it would need to be measured at several places and the average calculated. Incorrect responses included measure at another point, measure the thickest and thinnest part and average, parallax error, rounding error and needing a more accurate ruler.

Question 3

(a) (i) Using a gas syringe to collect and measure the volume of a gas was well known. The most common incorrect response was counting bubbles.

(ii) Burette was quite well known. If a pipette is to be used then it needs to be a volumetric pipette. Beaker was a popular incorrect response.

(iii) The majority of candidates gave a correct observation, usually the stopping of fizzing/bubbling. Incorrect response included when the colour change stops, when less gas is formed and when there is no gas in the measuring cylinder.

(b) Candidates found this difficult. Incorrect responses often stated when all the hydrochloric acid has been used up and when a solution is formed.

(c) Most candidates read the volumes from the measuring cylinders correctly. Incorrect responses included 32 and 27 for 60 seconds and 43 and 44 for 150 seconds.

(d) (i) The standard of graph drawing was generally very good. Some candidates reversed the axes and a significant number omitted the label and / or the unit on the axes. Some omitted to begin the axes at 0,0 despite there being a plottable point there. Whilst most scales were linear some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid.

(ii) The majority of candidates chose the anomalous point. A small number chose one of the last three points or circled more than one point.

(iii) Candidates found the line challenging. When a question asks for the line of best fit, the line may be a straight line or a curve depending on the placement of the points. Many drew the curve and then added a straight line, drew a straight line or drew the line incorporating the anomalous point.

(e)(i) Many candidates found this challenging and either described the shape of the graph or the volume of gas collected. Stronger candidates described the changing rate during the reaction and illustrated these by referencing the graph.

(ii) Many candidates drew a line above the existing line to denote the faster reaction and more successful candidates had the completion of the reaction at the same volume as the original curve. The final volume was often drawn higher than the original, which is incorrect.

Question 4

(a) Candidates were required to use the data in the question to ascertain the observation for tests on two chemicals. Many candidates stated ‘no reaction’, ‘n/a’ or left the table blank, none of which can gain credit as they are not observations. Some only gave the colour or the precipitate rather than both. Dark blue precipitate for copper sulfate was common, as was white precipitate in all four of the last four boxes in the table.

Question 5

(a) The symbol for the voltmeter was well known and many connected it in parallel. Quite a large number connected the meter in series.

(b) (i) Almost all candidates recorded both readings correctly. A small number of incorrect responses included 3.0, 3.1 and 3.2 V for the voltmeter and 1.05, 0.2 and 0.3 A for the ammeter.

(ii) Candidates found this question challenging. Many discussed stopping the current, resetting the meters or for safety.

(c) (i) Whilst the majority of candidates calculated the value correctly many recorded it as 4.75 Ω instead of following the pattern of the rest of the data in the table.

(ii) The unit of resistance was well known. Incorrect responses included J and W.

(d) Candidates found this question challenging. Many multiplied 12×1.5 and then stated that 18 was not within 10% and so gained partial credit. Stronger candidates went on to calculate 10% and so show that 18 was not within 10%.

(e) Candidates found this question challenging with many putting the bulb into a different circuit to check it. Stronger candidates appreciated that the question asked for an observation and so looked for a reading on the ammeter.

(f) (i) The majority of candidates drew three lamps in parallel and included a power supply and ammeter in the circuit. Some drew more than three lamps, had some lamps in series and some in parallel or omitted the power supply.

(ii) Variable resistor was not well known. Common responses included fuse, resistor and LDR.

Question 6

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A significant number did not name the apparatus they were using, particularly the measuring cylinder.

Stronger candidates used five different areas of water surface and repeated each one. Some compared only two different areas. Many discussed measuring the temperature decrease rather than the temperature at the start and the end and then calculating the temperature decrease. Some appreciated that either the time or the temperature decrease needed to be the same so that the results could be compared. Incorrect methods included recording the time for the water to evaporate or the volume of the water to decrease.

Stronger candidates drew a clear table with headings and units. Many omitted to draw a table, the bullet points in the question are there to guide candidates to know what is required by the question.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient - the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn then the quantities on each axis need to be specified.

CO-ORDINATED SCIENCES

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Key messages

It is advisable for candidates to read the questions carefully to ensure they have answered all aspects of the question, this will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.

General comments

Candidates generally demonstrated good understanding of basic practical knowledge and techniques. The reading of the instruments was generally good. The standard of graph drawing was generally high although candidates need to remember that axes need to be labelled with quantity and unit and a line of best fit needs to be a single line.

Candidates found interpreting and evaluating experiments and recording precise observations very challenging.

Comments on specific questions

Question 1

(a) If a pipette is used it needs to be a volumetric or a graduated pipette, a dropping pipette is unsuitable and pipette is insufficient. A measuring cylinder was not precise enough for this volume.

(b) Most candidates stated a suitable safety precaution but fewer explained what was being protected or what it was being protected from.

(c) Most candidates calculated the average volume correctly. The most common non-creditworthy response was 18. Some did not follow the pattern of data in the table.

(d) (i) The standard of graph drawing was generally very good. Some candidates reversed the axes and a number omitted the label and/or the units on the axes. Many gave the unit for time as seconds but used the values in minutes. Whilst most scales were linear some were awkward which often led to the incorrect plotting of points. A small number used a scale where the points did not cover at least half of the grid or did not start the axes from 0,0 although there was a point to plot there. The plot of 13.8 caused the most difficulty.

(ii) Some candidates drew a smooth curve close to all of the points. Some drew dot-to-dot lines, used a ruler between points, drew multiple lines or ignored some of the points and drew a straight line between the first and last points.

(iii) Candidates found this quite challenging. The variables cited in the question are the ones whose relationship should be described and both should be comparative. Many simply described the graph. Proportional should be reserved for a straight line which passes through the origin.

(iv) Stronger candidates appreciated that all of the hydrogen peroxide must have been used up. The most common response was the reaction had stopped, this is insufficient for an explanation.

(e) Control variables were well known, the most common being time. Many stated celery or hydrogen peroxide without including volume or concentration.

(f) Candidates found this challenging. Reliability and accuracy were the most common non-creditworthy responses.

(g) The test for oxygen was not well known. Flame tests, limewater test and the popping of a lighted splint were all common incorrect responses.

Question 2

(a) The reagent colours were quite well known. Some candidates mixed the positives for Benedict's and iodine or put no reaction rather than the colour for a negative result.

(b) Many candidates interpreted their results correctly. Common incorrect responses included omitting reducing from sugar, stating carbohydrate for reducing sugar and adding additional nutrients including fats, lipids and fibre.

Question 3

(a) (i) The majority of candidates recorded all seven colours correctly. A small number repeated colours.

(ii) Most candidates assigned acid, alkali and neutral correctly. The description proved more challenging with some candidates missing some of the strong / weak descriptors.

(iii) Stronger candidates appreciated that the colour in universal indicator would be yellow and that the colour of the orange juice would mask this colour. The most common non-creditworthy response was that the pH lay between two colours on the chart given.

(iv) Many candidates chose a weak alkali so that it neutralised the sting without burning the skin. Salt solution and vinegar where popular incorrect choices with the explanation being they would neutralise the sting.

(b) (i) Most candidates recorded both times correctly. 2, 25 and 2:25 for orange juice and 28 for vinegar were popular incorrect responses

(ii) Most candidates put the acids in the correct order, fewer put the solutions of salt, soap and sodium hydroxide together on the same level.

(c) Candidates found this challenging. The relationship needed the variables in the question to be used in the description and also for them to be comparative. Few appreciated that solutions of pH 7 and above do not react.

(d) The test for carbon dioxide was quite well known. Cloudy solution and cloudy emulsion were popular incorrect responses.

Question 4

Candidates were generally quite well prepared for this style of question and many addressed the bullet points and gave a logical description of the investigation. Control variables were well known.

A diagram and a results table were not required, stronger candidates included both to illustrate their answer, and these often contained several of the marking points.

A significant number did not name the apparatus they were using, scale is insufficient for balance.

Many candidates heated the solution to dryness and weighed the solid remaining. Common incorrect responses dissolved solids in water and then evaporated the water or compared the amount of solid that would dissolve into water at different temperatures. Few repeated the heating for each solution. A significant number reacted the solutions with acid then collected and compared the volume of gas given off.

Measuring the amount of something is too vague, the quantity being measured needs to be specified, in this experiment it was mass and volume of solution used or volume of gas collected.

Candidates find processing results and drawing conclusions challenging. Where repeats have been undertaken, averaging is insufficient – the reason for averaging needs to be explained. Citing a conclusion from previous knowledge or simply looking for a pattern in the results is insufficient. The use of the results to formulate a conclusion for the details of their investigation is required. If a graph is to be drawn, then the quantities on each axis need to be specified.

Question 5

(a) (i) Most candidates measured the length correctly, many gave the answer to the nearest cm rather than 0.1 cm, so 8 was the most common incorrect response.

(ii) The majority of candidates multiplied their answer to **(a)(i)** by 5, many gave 8 or multiplied by 2, 4, 10 or 20.

(b) (i) Most candidates calculated the average time correctly, some did not divide by three or gave their answer to more than three significant figures, 25.5 was also common.

(ii) Almost all candidates calculated T correctly.

(iii) Most candidates calculated T^2 correctly, $2 \times T$ was the most common incorrect response.

(c)(i) Most candidates calculated L correctly, often as an error carried forward from $2T$ in **(b)(iii)**.

(ii) Candidates found this challenging. Stronger candidates did the necessary 10% calculation and used this figure to show that the values either were, or were not, within 10%.

(d) The majority of candidates thought the values were proportional because as one increases the other increases and so did not gain credit. Stronger candidates appreciated that as L doubled T does not double and therefore the values are not proportional.

(e) Parallax was not well known. Most candidates gave generic answers including more accurate, more precise and easier to see closer which were not creditworthy.

Question 6

(a) The majority of candidates recorded the temperature correctly, 20.4°C was a common error.

(b) (i) Almost all candidates completed the column in the table correctly, although a significant number omitted the question.

(ii) The units were quite well known, C° was a common error.

(iii) Stronger candidates appreciated that the thermometer needs to cool down as the distance increases. The most common response was to allow the thermometer to heat up. Heat to the maximum temperature and cooling to room temperature were also common incorrect responses.

(c) (i) The majority of candidates gave a comparative relationship between the variables in the question. Some candidates described the relationship as proportional which was not shown by the data.

(ii) Many candidates calculated the average correctly. Many divided by 100.

(d) Candidates found this very challenging and a significant number omitted the question. There was no pattern to the responses, many were very high and many were very low including negative temperatures.

(e) Many candidates subtracted the values correctly. 0.035°C was the most common incorrect response and 0°C was quite common.

(f) Safety precautions were well known and many gave a detailed explanation, less successful candidates gave either a very brief explanation or described exploding lamps.