

CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses.

Question 16 proved challenging for the candidates.

In the physics section, candidates found **Questions 29, 38** and, particularly, **35** challenging.

Comments on specific questions

Question 1

Most candidates correctly chose **B** as the answer, with a substantial number choosing **C**. Candidates need to equate respiration with the release of energy from food.

Question 7

Candidates need to ensure that they are clear about what is meant by the terms vasoconstriction and vasodilation.

Question 8

Whilst many candidates correctly identified diploid zygotes being produced in sexual reproduction, a considerable number believed that the gametes were diploid.

Question 9

Candidates were equally divided on whether the stigma was part of the stamen or carpel, and a substantial number also placed the ovary in the stamen. Candidates need to ensure that they have a clear understanding of the parts of a flower,

Question 10

This question also produced a similar equal division of answers, with similar numbers of candidates believing that fertilisation occurred in the uterus and the oviduct. Many also suggested the ovary as the site of fertilisation.

Question 11

On the subject of artificial selection, similar numbers of candidates incorrectly decided that animals were better suited to their environment with artificial selection, rather than giving the correct response of having increased economic importance.

Question 12

In this question on the carbon cycle, although many candidates correctly selected the arrow representing respiration, those representing photosynthesis or consumption by animals were also commonly chosen.

Question 16

Candidates chose the incorrect **B** and **C** more often than the correct answer, **A**. They need to understand the change in the number of electrons that occurs when an atom becomes a positive ion.

Question 21

Some candidates chose the incorrect **C** rather than the correct answer **D**, recognising the test for zinc ions, but not the test for sulfate ions.

Question 22

More candidates chose the incorrect **C** than the correct answer **B**. They need to recall the trend in the reactivity of Group 7 elements, and to recognise that the elements in the Periodic Table are arranged in mass number order, rather than in atomic number order.

Question 26

Some candidates chose the incorrect **D** rather than the correct answer, **C**. Candidates need to ensure that they know that acidic soil, not alkaline soil, is neutralised by lime (calcium oxide) and by limestone (calcium carbonate).

Question 29

In this question on density, many candidates chose option **A**. They must ensure that they are clear about the relationships between density, mass and volume.

Question 31

A common misconception here was to confuse kinetic energy with rate of increase of speed rather than actual speed, leading to the choice of option **A**.

Question 35

The majority of candidates found this question on refraction and critical angle challenging, with few realising that the angle of refraction is exactly 90° ; options **A** and **B** were popular choices.

Question 38

This question on units proved challenging to a number of candidates, with the correct option **A** being the least popular choice for these candidates.

Question 40

The topic here was the nature of ionising radiation, and it was commonly misconception that γ -rays are negatively charged.

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Paper 0654/12
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses. Candidates performed very well on **Question 16** and **Question 21**.

Question 18 and **Question 22** proved challenging to the candidates.

In the physics section, candidates found **Questions 34, 35** and, particularly, **29** and **36** challenging.

Comments on specific questions

Question 3

Candidates need to make the connection that a gamete contains a nucleus, and must therefore be larger.

Question 4

This question required candidates to interpret a graph, and apply it to their knowledge of enzyme activity. Whilst a slight majority did interpret the data correctly, many chose either the temperature below the enzyme's optimum, or the one that caused denaturation. Interpretation of graphs appears to be a challenge to many candidates and one which may need more practice.

Question 6

This question gave a fairly equal spread on answers. Candidates must ensure that they know and recall the structure and functions of the two sides of the heart. Most of them knew that an artery carries blood away from the heart.

Question 10

Candidates should ensure that they know and understand the parts and functions of the flower. Most did not know the function of the stigma, a majority of them believed that it secreted nectar, while many believed it made the female gametes. .

Question 16

Candidates had no difficulty in determining the formula of butane from its molecular representation.

Question 18

Candidates found this question challenging. Many stronger candidates chose the incorrect **C** rather than the correct answer, **B**, thinking that iron ions, rather than chromium ions, move through the electrolyte.

Question 21

Candidates were able to recall the products of the reaction of magnesium with dilute hydrochloric acid.

Question 22

More candidates chose the incorrect **B** and **C**, rather than the correct answer, **D**. The incorrect **A** was chosen by some of the stronger candidates. They need to recall the general properties of metals, and that transition elements have high melting points, and consequently that they have high boiling points.

Question 26

Many stronger candidates chose the incorrect **D** rather than the correct answer, **C**. Candidates need to ensure that they know that acidic soil, not alkaline soil, is neutralised by lime, calcium oxide, and by limestone, calcium carbonate.

Question 27

Some stronger candidates chose the incorrect **D** rather than the correct answer, **B**. They need to be clear that the monomer, ethene, is an unsaturated hydrocarbon, whilst the polymer, poly(ethene), is a saturated hydrocarbon.

Question 29

A large proportion of candidates of all abilities chose option **A** in this question on density; they must ensure that they are clear about the relationship between density, mass and volume.

Question 34

Candidates must ensure that they are clear about what is meant by the frequency and by the period of the waves. Many candidates incorrectly chose option **B**.

Question 35

This question was about reflection by a plane mirror, and a large proportion of candidates believed the 40° angle shown on the diagram to be the angle of incidence, leading them to choose this value as the angle of refraction.

Question 36

The topic here was dispersion of light. Although it was widely known that red and violet were the colours at either end of the spectrum formed, relatively few knew that the violet light is refracted most.

Question 39

Many weaker candidates found this question on units challenging.

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Paper 0654/13
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses. Candidates performed very well on **Question 15**.

In the physics section, candidates found **Questions 29, 39** and, particularly, **40** challenging.

Comments on specific questions

Question 4

A majority of candidates correctly identified the xylem as the part of the vascular bundle transporting water; a substantial number confused its position with that of the phloem.

Question 6

In this question regarding the order in which air passes through structures during inspiration, a substantial number of candidates confused bronchi and bronchioles, although slightly more got it correct than incorrect.

Question 7

Candidates found this question on the nerve cells challenging. They must ensure that they recognise types of nerve cell, and know the order in which impulses pass through them.

Question 10

There was a fairly even spread of responses. Candidates must ensure that they clearly understand the terms homozygous and heterozygous. They should read the question carefully so that they are clear about what is being asked.

Question 11

The majority of candidates incorrectly believed that artificial selection gave both plants and animals a better chance of survival in the wild. They need to be clear about the terms artificial and natural. Most correctly believed that the term could apply to both plants and animals.

Question 14

More candidates chose the incorrect **B** and **C** than the correct answer, **D**. They need to recall that isotopes of an element have different numbers of neutrons and that the elements are arranged in order of their atomic numbers in the Periodic Table.

Question 15

Candidates clearly understood how to obtain pure copper chloride when it is mixed with copper. A few candidates incorrectly thought that filtration comes before the addition of water to the mixture.

Question 16

More candidates chose the incorrect **B** and **C** than the correct answer **A**. Some candidates identified the number of protons and neutrons in the given isotope of phosphorus, rather than identifying the composition of this isotope.

Question 21

A number of candidates chose the incorrect **C**, rather than the correct answer, **D**. They recognised that the oxide of hydrogen is neutral and that noble gases do not burn, but were unclear about the type of oxides formed by metals and non-metals.

Question 26

A number of candidates chose the incorrect **D** rather than the correct answer, **C**. Candidates need to ensure that they know that acidic soil, not alkaline soil, is neutralised by lime (calcium oxide) and by limestone (calcium carbonate).

Question 27

Some candidates chose the incorrect **D**, rather than the correct answer, **C**. Whilst they knew that poly(ethene) is made by addition polymerisation, they need to be clear that the monomer is unsaturated whilst the polymer is saturated.

Question 29

In this question on density, a large proportion of candidates chose option **A**. They must ensure that they are clear about the relationships between density, mass and volume.

Question 30

Some candidates chose option **D**, they need to understand that the larger resultant force to the right does not eliminate any effect of forces to the left.

Question 35

This question was about the image formed by a plane mirror, and a common misconception was to believe it to be real.

Question 36

The topic here was the converging lens. Although it was very widely known that the image formed is to the right of the lens in the diagram, relatively few appreciated that it lies beyond the principal focus.

Question 38

Most candidates gave one of the options **B**, **C** and **D** in this question on magnetism. Candidates need to ensure that they know which metals are magnetic and which are not; aluminium and copper are non-magnetic.

Question 39

This question about units proved to be challenging to a number of candidates.

Question 40

Candidates should ensure that they are familiar with Ohm's law and are able to manipulate the equation in order to calculate the current and choose the correct response.

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Paper 0654/21
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses.

Candidates performed very well on **Question 14**, **Question 15**, **Question 16**, and **Question 21**.

Question 26 proved challenging for the candidates.

In the physics section, candidates found **Questions 35**, **37** and, particularly, **33** and **34** most challenging.

Comments on specific questions

Questions 2, 4, 6

These questions were answered most successfully.

Question 5

Candidates need to ensure that they are clear about the terms translocation with transpiration. The majority believed that the xylem translocates water. A minority of candidates correctly chose the phloem and amino acids, and similar proportion incorrectly believed that the phloem translocates glycogen.

Question 7

While the majority of candidates correctly decided the ciliary muscle contracts when focussing on a near object, they were equally divided on whether the suspensory ligaments slacken or tighten, and the resulting shape of the lens.

Question 9

Whilst the majority of candidates answered this question correctly, a significant number believed the stigma was part of the stamen. Candidates must ensure that they know the parts of a flower.

Question 14

Candidates understood liquids in terms of their volume and shape very well.

Question 15

Candidates were clearly able to work out how to separate a mixture of copper chloride from copper.

Question 16

Candidates had no difficulty in recognising the electronic structure of an atom of potassium.

Question 19

Stronger candidates chose the incorrect **C** more than the correct answer, **B**. They need to distinguish between products of the electrolysis of a molten binary compound and those obtained from the specified electrolysis of concentrated aqueous sodium chloride.

Question 21

Candidates understood very well the factors that affect the rate of a chemical reaction.

Question 26

The incorrect **C** and **D** were chosen more than the correct answer, **B**. In the Contact process sulfur trioxide is dissolved in concentrated sulfuric acid rather than in water because the reaction with water is very exothermic and causes the thermal decomposition of the sulfur trioxide that is formed.

Question 29

In this question on density a large proportion of weaker candidates chose option **A**. Candidates must ensure that they are clear about the relationships between density, mass and volume.

Question 30

Although most calculated the resultant force correctly, weaker candidates often then multiplied this by the mass to calculate acceleration.

Question 31

The most common mistake here was to multiply the maximum speed by the total time to find the distance travelled.

Question 33

The topic for this question was change of state, and it proved a challenge for a very large proportion of candidates. Candidates should ensure that the term “latent heat of fusion” is clearly understood.

Question 34

This question on refraction was also challenging. The majority appreciated that the frequency of the wave remains constant. The effect on wavelength was not so commonly recalled.

Question 35

Many candidates need to be clear about critical angle. Options **A** and **B** were the more popular incorrect choices.

Question 37

Candidates need to distinguish between e.m.f. and p.d. Many candidates made the incorrect choice of option **D**.

CO-ORDINATED SCIENCES

Paper 0654/22
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses.

Candidates performed very well on **Question 14**, **Question 17**, **Question 21**, and **Question 22**.

Question 15 proved challenging for the candidates.

In the physics section, candidates found **Questions 28** and **36** challenging.

Comments on specific questions

Questions 2, 12

These questions were very well answered.

Question 8

This question proved challenging. Candidates were equally divided over whether the stigma secreted nectar, or aided the germination of pollen grains. It appears that they know a sweet solution is produced, but not its purpose.

Question 14

Candidates were clearly able to work out how to separate a mixture of copper chloride from copper.

Question 15

The incorrect **A** and **B** were chosen more than the correct answer, **C**. Most thought that all noble gases have eight electrons in their outer electron, whereas helium has only two. Many confused the uses of argon with those of helium.

Question 17

Candidates had no difficulty in determining the formula of butane from its molecular representation.

Question 21

Candidates understood very well the factors that affect the rate of a chemical reaction.

Question 22

Candidates were able to recognise the processes of oxidation and reduction which were represented by a word equation.

Question 26

The incorrect **C** and **D** were chosen more than the correct answer, **B**. In the Contact process sulfur trioxide is dissolved in concentrated sulfuric acid rather than in water because the reaction with water is very exothermic and causes the thermal decomposition of the sulfur trioxide that is formed.

Question 28

This question concerned speed-time graphs; the incorrect option **A** was most popular choice. Candidates need to be aware that that acceleration can be positive, giving a graph with an upward slope, or can be negative, in which case the graph has a downward slope.

Question 29

In this question on density a large proportion of weaker candidates chose option **A**. Candidates must ensure that they are clear about the relationships between density, mass and volume.

Question 30

A large majority of candidates were aware that the series arrangement produced an extension of $2x$, many thought that the springs in series caused an extension of x , the same as a single spring.

Question 31

The most common mistake here was to multiply the maximum speed by the total time to find the distance travelled.

Question 34

Candidates found this question on refraction challenging. The majority appreciated that the frequency of the wave remains constant; the effect on wavelength was not so commonly recalled.

Question 37

This question was about reflection by a plane mirror, and many candidates believed the 40° angle shown on the diagram to be the angle of incidence, leading them to choose this value as the angle of refraction.

Question 39

Weaker candidates generally knew the correct equation relating change and current, but were less certain about the direction of electron flow.

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Paper 0654/23
Multiple Choice

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

General comments

The majority of candidates successfully selected the correct responses.

Candidates performed very well on **Question 15** and **Question 21**.

In the physics section, candidates found **Question 40** challenging and, particularly, **Questions 28, 35** and **39**.

Comments on specific questions

Question 2

This question very well answered.

Question 3

Candidates need to ensure that they are aware of the factors which denature enzymes. They were equally divided as to whether denaturing of an enzyme is caused by too high or too low a temperature, or whether it is only caused by too high a temperature.

Question 6

Candidates must ensure that they can identify the structures of a leafy stem and know their functions. Many candidates correctly identified the xylem as the area transporting water, many wrongly identified the phloem. This could be due either to not knowing which area transports water, or to not identifying the separate areas on a diagram correctly.

Question 8

There was an equal division of answers correctly identifying glucagon or incorrectly identifying glycogen in this question. Candidates should ensure that they do not confuse the two very similar words.

Question 11

Candidates were equally divided here over the correct answer and one of the incorrect answers. Candidates need to ensure that they are clear about the terms homozygous and heterozygous.

Question 15

Candidates were clearly able to work out how to separate a mixture of copper chloride from copper.

Question 19

Stronger candidates chose the incorrect **B** more than the correct answer, **A**. The question concerned the electrolysis of concentrated aqueous sodium chloride. Candidates understood how to determine the products of the electrolysis of a molten binary compound; in their answer they needed to name the specified products of the electrolysis of a concentrated aqueous solution of sodium chloride.

Question 20

The incorrect **C** was chosen more than the correct answer, **D**. Candidates understood how to identify exothermic reactions from measured temperature changes; they must also ensure that they understand these reactions in terms of the energy transfers that take place.

Question 21

Candidates understood very well the factors that affect the rate of a chemical reaction.

Question 25

Stronger candidates chose the incorrect **A** more than the correct answer, **B**. They recognised the need for the presence of water for rusting; they did not appreciate the effect of boiling water on dissolved oxygen and its role in the rusting process.

Question 26

The incorrect **C** and **D** were chosen more than the correct answer, **B**. In the Contact process sulfur trioxide is dissolved in concentrated sulfuric acid rather than in water because the reaction with water is very exothermic and causes the thermal decomposition of the sulfur trioxide that is formed.

Question 28

Most candidates were aware that the area under a speed-time graph represents distance travelled. Candidates need to distinguish speed and velocity, many of them did not appreciate that constant speed does not necessarily imply constant velocity.

Question 29

In this question on density a large proportion of candidates chose option **A**. They must ensure that they are clear about the relationships between density, mass and volume.

Question 30

Candidates should be reminded that in almost every case all information in a question is relevant, in this instance the initial value of 4.0 cm. They must take into account the length of the unloaded spring when determining the extension; many incorrectly chose option **D**.

Question 31

The most common mistake made by weaker candidates was to multiply the maximum speed by the total time to find the distance travelled.

Question 35

Candidates found this question on refraction challenging. The majority appreciated that the frequency of the wave remains constant; the effect on wavelength was not so commonly recalled.

Question 36

Total internal reflection was found to be challenging by many. A popular belief was that the angle of incidence is equal to the angle of refraction.

Question 37

The topic here was the converging lens. Although it was very widely known that the image formed is to the right of the lens in the diagram, relatively few appreciated that it lies beyond the principal focus.

Question 39

Candidates need to ensure that they know and understand the behaviour of thermistors and light-dependent resistors.

Question 40

Candidates should make sure that they can work out the direction of the force on a wire carrying an electric current in a magnetic field. This question proved challenging.

CO-ORDINATED SCIENCES

Paper 0654/31
Theory (Core)

Key messages

Candidates have a good understanding of what the questions were asking.

A good standard of scientific knowledge was displayed by most candidates. Some candidates should be congratulated for their clear and accurate responses.

Calculations were frequently done well with working shown.

General comments

Most candidates attempted all the questions. Many candidates answered most of the questions well. There was a good range of marks on every question. Candidates generally scored on all questions. In addition to scientific knowledge, the ability of the candidates to understand the question and express themselves clearly was important.

Candidates should read each question carefully and complete all the instructions contained within the question to be able to access the maximum credit available.

Learning the definitions specified in the syllabus gains credit directly as well as being an aid to language used in explanations.

Any formula quoted should be in a standard form and use recognisable symbols. A number of candidates used the chemical formula of a substance rather than the words for a substance in their answers, for example CaCO_3 rather than calcium carbonate.

Comments on specific questions

Question 1

- (a) (i) The septum was not well known.
- (ii) Many candidates labelled one of the ventricles. Common incorrect responses identified the pulmonary artery.
- (b) The most common response was the aorta rather than the pulmonary artery.
- (c) The heart pumping or contracting was well known; few candidates referred to the aorta in their answer.
- (d) Many candidates showed a good understanding of the functions of the different components of blood.

Question 2

- (a) (i) Most candidates correctly stated two physical properties of metals. Shiny was the most popular response. A common incorrect response was magnetic.

- (ii) Many candidates gained most of the available credit. Molecule was often incorrectly suggested for the last word.
- (b) (i) Candidates needed to ensure that the label line went to the electrode and not the connecting wire or terminal sign.
 - (ii) Oxygen was the most popular response and the correct one. Aluminium was sometimes suggested.
- (c) (i) Candidates need to ensure that they understand the meaning of the term “reduced” in this context.
 - (ii) Few candidates identified ammonia as the compound of nitrogen. Most candidates correctly suggested the colour change of damp red litmus.

Question 3

- (a) (i) The correct answer of 10.25 s was common.
 - (ii) Many candidates calculated the speed as 10.438 m/s. This answer should be rounded to 10.44 or 10.4, but not 10.43.
 - (iii) Chemical energy was not well known as the first answer. A number of candidates suggested nutrient or nutrition or food energy.
- (b) Most candidates knew that the athlete was transferring more energy; few explained that this energy was being transferred at a greater rate.
- (c) The basic ideas of evaporation and cooling were not well known. Some candidates gave answers to this question which showed that they had confused the process with sweating.

Question 4

- (a) Neurone was well known, but not sensory.
- (b) A few candidates referred to the central nervous system. A few candidates described the sequence from sensory neuron to relay neurone to motor neurone. Few candidates referred to the effector (muscle) response.
- (c) Coughing, sneezing and sweating were frequently suggested as responses that were reflex actions.
- (d) The effects of the release of adrenaline on the body were quite well known with many different correct answers given. Few candidates referred to the increase in blood glucose concentration.

Question 5

- (a) (i) Salt was the most popular response and the correct one. Hydrogen and carbon dioxide were sometimes suggested.
 - (ii) The chemical reaction was frequently recognised as a neutralisation reaction.
- (b) (i) All three pH values were required for credit to be awarded. Some candidates chose to use numbers other than 1, 7 and 13.
 - (ii) The correct response potassium chloride was often given. Oxygen and hydrogen were common incorrect responses.
 - (iii) Most candidates suggested that the temperature needed to be measured. They also needed to state that an increase in temperature would be observed.
- (c) (i) Oxygen and nitrogen were usually given. To gain the credit both gases needed to be given.

- (ii) Candidates must ensure that they understand how to describe compounds and mixtures, correct descriptions were rarely given.
- (iii) This was well answered.
- (iv) This was well answered.

Question 6

- (a) (i) **C** was commonly recognised as the weight of the police car.
- (ii) Many candidates found the question challenging. Force **B** had to be greater than force **D** because the car was accelerating. Candidates also needed to mention that the two forces were acting in opposite directions.
- (iii) The only accepted answer was changing the shape of an object. Many candidates gave answers about changing the speed or direction of the motion of an object.
- (iv) The newton was well known.
- (b) (i) This question was well answered.
- (ii) Some candidates described how the loudness changed.
- (c) Candidates found this part of the question challenging. A few candidates referred to the image being virtual or upright. Very few candidates described the image as laterally inverted. Candidates must read and follow the instructions in the question, some described the image as magnified or diminished which could not be awarded credit.
- (d) The only simple way of deciding whether the bodywork was made from steel or aluminium was to use a magnet. This was suggested by some candidates. Some of these candidates incorrectly stated that aluminium was magnetic and steel was not.
- (e) This was well answered. However, some candidates placed the energies the wrong way round.

Question 7

- (a) Most candidates gained at least some credit but few were awarded full credit. They need to be clear about the definitions of the terms.
- (b) (i) Many candidates correctly suggested **EE** and **Ee**; many others incorrectly included **ee** in their answer.
- (ii) Recessive was well known but not homozygous. Heterozygous and less dominant were frequently suggested.
- (c) Most candidates suggested that unattached was dominant; the response was not sufficiently specific. Few candidates stated either of the marking points.

Question 8

- (a) Calcium carbonate was correctly suggested by some candidates. Carbon, oxygen, carbonate and calcium were popular incorrect responses.
- (b) (i) The correct answer of 45 cm^3 was frequently given.
- (ii) The idea of adding more limestone was frequently suggested. Some candidates suggested adding more carbon dioxide.
- (iii) Most candidates were able to answer this. A few stated that a quantity needed to be changed rather than increased. This was not precise enough to be awarded credit.

- (c) (i) Lime or calcium oxide as the white solid was not well known. Carbon dioxide as the gas was well known.
- (ii) The idea of neutralising acidic soil was fairly well known. A number of candidates suggested that it was added as a fertiliser.

Question 9

- (a) (i) Diffusion was often suggested rather than conduction.
- (ii) The arrows drawn needed to show that air descended from the ceiling and that the air returned to its starting point to complete the convection cycle.
- (iii) Diffusion was often suggested rather than convection.
- (b) (i) Candidates needed to express the idea that sound needed a medium.
- (ii) This was well answered. Many candidates correctly suggested light.
- (c) (i) Candidates needed to ensure that they knew the meaning of the term isotope.
- (ii) Candidates described the ionising effect and penetrating effect of alpha particles but did not explain what an alpha particle was. A response of a positively charged helium nucleus would have gained full credit.

Question 10

- (a) (i) A pH value of 7 was usually given.
- (ii) A pH value of 6 or below or 12 was usually given.
- (b) (i) The place where protease was secreted was well known.
- (ii) Candidates need to know that amino acids are the products made by the action of protease. Protein was often suggested.
- (c) (i) The function of enzymes as a catalyst was well known. Few candidates described the effect of enzymes on large insoluble food molecules.
- (ii) Some candidates suggested mechanical digestion or chewing. Few went further and explained that the food was broken into smaller pieces or that chewing increased the surface area of the food.

Question 11

- (a) (i) There were 44 neutrons in a bromine atom. Many candidates suggested 35, which was the atomic number or number of protons or electrons.
- (ii) There were 17 electrons in a chlorine atom. Some candidates suggested 18 or 35.
- (iii) Group 7 (VII) was well known.
- (b) (i) Orange / yellow was fairly well known as the colour change observed when chlorine reacts with sodium bromide solution. Green and white were common incorrect responses.
- (ii) Few candidates referred to bromine being displaced. Few candidates referred to the relative reactivities of chlorine and bromine.
- (c) (i) Many candidates were able to answer this. A response which stated "carbon and hydrogen" was not sufficiently precise; this statement needed to include the word molecule or substance or compound. A response stating "a compound containing carbon and hydrogen" would have been acceptable for partial credit.

- (ii) Common and incorrect responses described the hydrocarbon as unreactive. There needed to be a link to the aqueous bromine test for distinguishing between alkanes and alkenes.
- (d) The correct response to this question was simple – many ethene molecules joining together. Many candidates referred to double bonds being created in the reaction.

Question 12

- (a) (i) Candidates needed to suggest that opposite charges attracted or that positive charges attract negative charges. Many answers were too vague to gain credit.
 - (ii) Many candidates repeated their response to (i) and described the positive charges attracting the negative charges. Few candidates suggested that the reason why the positive charges stayed away from each other was that like charges repelled each other.
- (b) (i) The idea that the particles would move faster when warm was well known. A few candidates attempted to answer (ii) here.
 - (ii) Candidates needed to state that the air molecules were colliding with the walls of the tyre.
- (c) (i) Radiation was well known as the method of energy transfer. Thermal energy and ultraviolet were incorrect responses frequently seen.
 - (ii) Candidates needed to fill in where infra-red went in the electromagnetic spectrum. If candidates filled in the whole electromagnetic spectrum it made it impossible to determine which wave the candidates were suggesting as their answer.
- (d) (i) This was quite well answered; candidates should ensure that they know the correct circuit symbol for a cell.
 - (ii) Candidates needed to realise that the resistance they were calculating was the combined resistance of the two resistors. This meant that they needed to divide their answer of 7.5 by 2 giving the correct answer of 3.75 Ω .

Question 13

- (a) (i) Candidates needed to know that phototropism was the response observed. Photosynthesis was frequently incorrectly suggested.
 - (ii) Many candidates mentioned photosynthesis; this needed to be linked with idea that the plant was getting more light and therefore could photosynthesise more.
- (b) This was well answered by some candidates who mentioned the role of the root hairs and the diffusion of water.
- (c) Magnesium was not frequently suggested. Other substances, which were not ions, such as chloroplasts and glucose, were frequently mentioned.

CO-ORDINATED SCIENCES

Paper 0654/32
Theory (Core)

Key messages

Candidates seemed to have a good understanding of what the questions were asking.

A good standard of scientific knowledge was displayed by most candidates. Some candidates should be congratulated for their clear and accurate responses.

Calculations were frequently done well with working shown.

General comments

Most candidates attempted all the questions. Many candidates answered most of the questions well. There was a good range of marks on every question. Candidates generally scored on all questions. In addition to scientific knowledge, the ability of the candidates to understand the question and express themselves clearly was important.

Candidates should read each question carefully and complete all the instructions contained within the question to be able to access the maximum credit available.

Learning the definitions specified in the syllabus gains credit directly as well as being an aid to language used in explanations.

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

Comments on specific questions

Question 1

- (a) (i) The trachea was well known as **A**. Some candidates confused a bronchus with a bronchiole for **B**.
- (ii) Most candidates were able to label the heart correctly.
- (b) A correct response to this question needed to compare the composition of inspired and expired air. Statements such as inspired air contains oxygen and expired air contains carbon dioxide were insufficiently precise.
- (c) Many candidates suggested that breathing became faster but few suggested that breathing became deeper.
- (d) This was well answered by most candidates.

Question 2

- (a) (i) This was well answered. Popular correct responses were an increase in temperature and effervescence.
- (ii) Magnesium chloride was well known. A common incorrect response was magnesium hydroxide.
- (b) (i) The word equation was completed correctly by some candidates. A common error was to identify magnesium or oxygen as a product.

- (ii) Many candidates incorrectly suggested that magnesium was reduced during the reaction.
- (c) (i) Many candidates calculated the mass of aluminium as 6 g.
 - (ii) Correct responses included the ideas that the alloy was stronger or more resistant to corrosion. Candidates must read the question carefully, a number referred to density in their answer.
- (d) (i) Some candidates explained that a period in the Periodic Table was a horizontal row of elements. Many candidates described the groups in the Periodic Table.
 - (ii) Candidates need to be able to describe properties specific to transition metals.

Question 3

- (a) Very few candidates described what happened to the nucleus of a uranium-235 atom during nuclear fission.
- (b) Many candidates used their knowledge to suggest a suitable way of safely storing waste radioactive isotopes. Candidates must read the question carefully; some described how radioactive isotopes could be handled safely.
- (c) (i) Many candidates thought that the resistance would increase rather than decrease.
 - (ii) Many candidates correctly suggested that length of the cable could be changed to change the resistance.
- (d) (i) Most candidates drew a suitable diagram to show the arrangement of particles in a gas. To be awarded credit, the liquid diagram needed to show an irregular arrangement of particles with most of them touching each other.
 - (ii) Temperature needed to be mentioned in a correct response to this question.

Question 4

- (a) (i) **D** was commonly identified as the cuticle.
 - (ii) **G** was commonly identified as the palisade mesophyll layer.
 - (iii) The position of the vascular bundle was correctly identified by many candidates. There was no popular incorrect position.
- (b) (i) Many candidates identified one of products. Few candidates identified both products as oxygen and glucose.
 - (ii) Light was well known as the form of energy required for photosynthesis. Chemical energy was incorrectly suggested by some candidates.
 - (iii) Many candidates were able to describe the presence of chloroplasts as one way in which palisade mesophyll cells were adapted for photosynthesis.
- (c) Candidates found this challenging. Very few candidates placed stomata in the first gap and few candidates placed cell membrane or cytoplasm in the second gap.

Question 5

- (a) (i) The atomic number of atom **B** was correctly identified as ten by many candidates. Twenty two was incorrectly suggested by some.
 - (ii) The mass number of atom **D** was frequently identified as forty.
 - (iii) Atoms **B** and **C** were sometimes identified as the two atoms that were the same element. Some candidates were able to explain why.

- (iv) Atom **E** contained the greatest number of electrons. Many candidates explained why they had chosen atom **E**.
- (b) (i) Many candidates described a catalyst as a substance that increased the rate of a reaction. Few candidates suggested that it remained chemically unchanged after the reaction. Many candidates made the connection between enzymes and catalysts.
 - (ii) This part was well answered. Many candidates suggested either that ammonia was not an element or that ammonia was a compound.
 - (iii) Many candidates described the bonding as covalent. Fewer were able to explain why.
- (c) The commonest and the correct answer was eight. Four, six and seven were common wrong answers.

Question 6

- (a) (i) **R** was usually identified as the weight of the tractor.
 - (ii) Many candidates suggested that forces **Q** and **S** were equal and opposite so that the tractor was stable and did not fall over. The correct answer was that the tractor was travelling at constant speed.
 - (iii) The calculation involved two unit conversions, from kilometres to metres and from minutes to seconds. A number of candidates completed the calculation correctly. A common error, when converting kilometres to metres, was to suggest that 1.1 km was 110 m.
- (b) Candidates needed to explain that the surface area of the tractor tyres in contact with the ground was much greater than area of the car tyres in contact with ground. This would cause the tractor to exert less force on the ground than the car and therefore the car sinks into the ground. Some candidates confused the air pressures within the tyres of the tractor and car and pressure the tractor and car exerted on the ground through the areas of the tyres that were in contact with the ground.
- (c) This part of the question was found challenging. Most candidates drew the refracted ray either as a reflected ray or as an undeviated ray entering the water. A few candidates correctly labelled the angle of incidence. A few more correctly labelled the angle of reflection.
- (d) Candidates need to be familiar with how molecules behave during evaporation. Some candidates gained partial credit but few gained full credit. The basic ideas of evaporation were not well known.

Question 7

- (a) (i) Almost all candidates determined the year as 2004.
 - (ii) The correct answer was 45.7%. A number of candidates calculated a value of 54.3%. Many calculated the difference as 5903 and stated that the percentage decrease was 59.03%
- (b) Most candidates gained some credit and some gained full credit for referring to loss of habitat/shelter and a loss of source of food.
- (c) Natural selection was the only acceptable response. Incorrect responses were artificial selection and reproduction.

Question 8

- (a) (i) Some candidates were awarded full credit for this question for correctly identifying the two ideas of untreated water containing harmful microorganisms that cause disease and chlorine killing these microorganisms.

- (ii) Some candidates described a correct colour change, for example solution turns brown. Some candidates explained the chlorine was more reactive than iodine. Few candidates suggested that iodine was displaced. A number of candidates referred to the reactivity of sodium relative to chlorine.
 - (iii) This was well known. Many candidates explained that there was no reaction because argon was a noble gas or unreactive.
- (b) (i) Many candidates suggested that a chloride ion was negative. Very few of these candidates explained why. Candidates needed to suggest that chlorine was a non-metal or that non-metals gain electrons when they become ions.
- (ii) A number of candidates remembered the test using sodium hydroxide solution. The formation of a blue precipitate was quite well known.

Question 9

- (a) (i) Kilowatt was well known.
- (ii) 1.16 kW was the only value accepted.
- (iii) Any value between 10 and 12 km/h was accepted.
- (b) Many candidates explained that the pitch would be lower if the frequency of the sound decreased.
- (c) (i) Many candidates stated one other renewable energy resource. Water was deemed to be too vague as a response. A better response would have water/ocean waves or hydroelectric power or tidal power. A number of candidates suggested wind which was given in the question so could not be awarded credit.
- (ii) The correct response was upwards or up. Many candidates suggested downwards or in circles. Others suggested North, East, South or West.
- (iii) Radiation was known by many candidates as the process responsible for the thermal energy transfer from the Sun to the Earth.
- (iv) Candidates need to ensure that they are familiar with the properties of the different parts of the electromagnetic spectrum. Infra-red was not known as the part of the electromagnetic spectrum responsible for most of the thermal energy transfer from the Sun to the Earth. Ultraviolet was a more popular response.

Question 10

- (a) Most candidates gained some credit, usually for identifying **C** as the vagina. The third row in the table was the greatest challenge to candidates. They needed to identify the place where implantation occurred as **E**, and needed to state clearly that this was the uterus lining or wall rather than just the uterus.
- (b) (i) Nuclei was the only accepted response.
- (ii) Candidates needed to describe how the number of cells increased and that the zygote moved into the uterus for implantation. Many candidates described how a zygote was formed, this was not awarded credit.
- (c) This was well answered by many candidates. Some candidates found it difficult to explain that genetically different offspring were produced with sexual reproduction.

Question 11

- (a) (i) Petroleum and crude oil were the only two acceptable responses to this question. Oil was deemed too vague.

- (ii) Fractional distillation was the process used to separate gasoline from raw material J. Filtration and cracking were two popular incorrect responses.
- (iii) Many candidates gained partial credit. All three correct responses were given frequently.
- (b)(i) Many candidates were unable to gain any credit because they were linked. Nitrogen should have been 78% and oxygen 21%. The values needed to add up to 99% to give a total of 100%.
- (ii) Some candidates knew that the carbon dioxide increase was due to combustion of the fuel; they then tried to find a different explanation for the increase in water vapour.
- (iii) Many candidates gained full credit for suggesting two harmful air pollutants.

Question 12

- (a) Many candidates only gained partial credit because all four forms of energy were required to gain full credit.
- (b)(i) Many candidates correctly suggested using a 13 A fuse. A common incorrect response was a 5 A fuse. Candidates needed to be able to explain why they had chosen a 13 A fuse.
- (ii) Candidates need to understand the purpose of a fuse. Some candidates suggested that the fuse kept the washing machine working.
- (c) Many candidates showed good data handling skills and correctly calculated the value of the resistance. Many also knew that the unit of resistance was the ohm.
- (d)(i) Candidates found the question challenging, few candidates were able to describe any differences between the magnetic properties of iron and steel. Candidates need to be able to distinguish between the magnetic properties of iron and steel, to be able to discuss hard and soft magnetic materials and permanent and temporary magnetism.
- (ii) The correct response was 2197 cm^3 . Some candidates calculated the volume of the block as 78 cm^3 .
- (iii) Candidates need to be able to rearrange the formula to make mass the subject of the formula. Few candidates calculated the mass as 17136.6 g.

Question 13

- (a) Most candidates gave a satisfactory description of the changes to blood glucose concentration for the first and second time interval. The third time interval description was more complicated because candidates needed to describe a slight increase for five minutes and then a levelling off and remaining unchanged for the rest of the period of time.
- (b) Some candidates gained maximum credit for the equation and a few more gained partial credit for correctly stating the left hand side of the reaction equation.
- (c) Adrenaline was the most popular and the correct answer.
- (d) Many candidates found this question challenging. A few candidates gained some credit usually for suggesting that the hormone travelled to liver to be destroyed.

CO-ORDINATED SCIENCES

Paper 0654/33
Theory (Core)

Key messages

Candidates seemed to have a good understanding of what the questions were asking.

A good standard of scientific knowledge was displayed by some candidates. Some candidates should be congratulated for their clear and accurate responses.

Calculations were frequently done well with working shown.

General comments

Most candidates attempted all the questions. Some candidates answered most of the questions well. There was a good range of marks on every question. Candidates generally scored on all questions. In addition to scientific knowledge the ability of the candidates to understand the question and express themselves clearly was important.

Candidates should be reminded to read each question carefully and complete all the instructions contained within the question in order to be able to access the maximum marks available.

Learning the definitions specified in the syllabus earns marks directly as well as being an aid to language used in explanations.

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

Comments on specific questions

Question 1

- (a) (i) Candidates found this part challenging. Few gained full credit. Many candidates wrote down the descriptions from the diagram.
- (ii) Few candidates used the information in the diagram to answer this part. Some candidates gained full credit.
- (b) Most candidates scored most of the available credit, usually for renal vein and hepatic artery.

Question 2

- (a) (i) Most candidates correctly stated one physical property of metals. Shiny was the popular response.
- (ii) Transition metal was a popular response.
- (iii) Candidates' responses needed to refer to the particular properties of transition metals.
- (b) (i) The word equation was completed correctly by some candidates. A common error was to identify water as the other product.

- (ii) Many candidates identified carbon as the substance oxidised. Some candidates correctly explained why carbon was oxidised.
- (iii) Many candidates gained full credit for a good description of the test for carbon dioxide.

Question 3

- (a) (i) Nearly all the candidates correctly identified a point when the water skier was not moving.
- (ii) Nearly all the candidates correctly identified a point when the water skier was travelling at maximum speed.
- (iii) Nearly all the candidates correctly determined that the water skier was travelling at maximum speed for 20 seconds.
- (b) Most candidates correctly stated that force **A** was greater than force **F**.
- (c) (i) Candidates found the part challenging. Few candidates indicated the wavelength accurately.
- (ii) Some candidates described the term amplitude. The best responses used the idea of the still water level indicated on the diagram.
- (d) Most candidates gained at least partial credit, usually for identifying chemical energy in the fuel.
- (e) Candidates need to be familiar with how molecules behave during evaporation. The basic ideas of evaporation were not well known. Some candidates gained partial credit but few gained full credit.

Question 4

- (a) (i) The difference in internal body temperature was correctly determined by most candidates.
- (ii) The idea that the internal body temperature decreased back to the original temperature was well known. A few candidates gave responses which were too vague, suggesting that the internal body temperature cooled down.
- (b) Most candidates gained at least partial credit. The most popular ideas were sweating and the skin becoming red.
- (c) Respiration releasing thermal energy was not well known. Few candidates gained any credit.
- (d) This question was well answered.

Question 5

- (a) (i) Few candidates suggested that the colour change was from green to blue. A number suggested red to blue.
- (ii) Many candidates did not give pH values.
- (iii) Candidates needed to refer to a lighted splint and the subsequent squeaky pop explosion in order to be awarded the credit available.
- (iv) To gain the full credit available for this part there needed to be a reference to using a thermometer or measuring the temperature change and a reference to the temperature increasing.
- (b) (i) Some candidates correctly stated that it was ionic bonding. Some incorrectly stated covalent or chemical bonding.
- (ii) Electrolysis was quite well known as the process.
- (iii) Candidates needed to ensure that the label line went to the electrode and not the connecting wire or terminal sign.

- (iv) Chlorine was quite well known as the non-metallic element produced in the process. Hydrogen was a common error.

Question 6

- (a) (i) Many candidates measured the focal length from the diagram rather than stating the focal length from the information given in the question.
- (ii) The focal point was quite well known.
- (b) (i) Many candidates were able to identify X-rays and infra-red. A number identified gamma as **A** suggesting that they did not recognise the gamma symbol shown on the diagram.
- (ii) Most candidates appreciated that the answer was going to be at one end of the electromagnetic spectrum or the other. The majority of these candidates correctly suggested the gamma ray end of the spectrum.
- (c) (i) Many candidates showed good data handling skills to rearrange the formula into $\text{time} = \text{distance} / \text{speed}$ and then complete the calculation.
- (ii) Candidates should be familiar with the concept that sound needs a medium.
- (d) (i) Most candidates were able to suggest another renewable energy source on Earth.
- (ii) Oil was accepted as a non-renewable energy source but petroleum would have been a better response.

Question 7

- (a) Most candidates gained most of the available credit with many gaining maximum credit.
- (b) (i) Most candidates were able to state that pollen could be transferred by the wind.
- (ii) Most candidates gained some credit with many gaining maximum credit.

Question 8

- (a) (i) Some candidates knew the term alloy as a mixture of metals.
- (ii) More candidates were able to answer this question correctly than (i).
- (b) Most candidates gained some credit with many gaining maximum credit.
- (c) (i) Many candidates found this calculation challenging. The majority incorrectly divided 50 by 25 and a few multiplied 50 by 25.
- (ii) Candidates needed to explain whether the quantity they were changing was increasing or decreasing. For example, changing the temperature was insufficient. Increasing the temperature was correct.
- (d) Many candidates gained some credit. There were at least four suitable compounds to choose from.

Question 9

- (a) (i) Candidates found the question challenging. Use in mercury thermometers was a possible answer as was a bimetallic strip.
- (ii) Candidates found the question challenging. Correct answers included leaving gaps in roads / bridges / rail tracks to accommodate expansion.
- (b) Most candidates were able to carry out the calculation correctly. Fewer were able to quote the correct units.

- (c) Most candidates gained partial credit with many gaining maximum credit.
- (d) Few candidates explained that isotopes had different neutron numbers.
- (e) (i) A number of candidates correctly identified wire **K** but few explained why. The explanation needed to include both shortest length and largest diameter.
(ii) Some candidates showed good data handling skills to rearrange the formula into $R = V / I$ and then complete the calculation. Many did not rearrange to formula correctly.

Question 10

- (a) (i) There were many correct answers.
(ii) There were many correct answers. 43 °C seemed to be a common incorrect answer.
- (b) The idea that 37 °C was the optimum temperature because it was close to body temperature was well known.
- (c) Most candidates gained full credit. The link between fat, lipase and glycerol and fatty acids seemed the least known.
- (d) Most candidates gained some credit. Enzymes acting as catalysts was well known.

Question 11

- (a) (i) Cracking was a common incorrect answer. Candidates found this part of the question challenging.
(ii) Many other elements were mentioned but there were few examples of carbon and hydrogen.
(iii) Some candidates were able to give a suitable product and a use for the product.
- (b) (i) Most candidates knew that a catalyst increased the rate of a reaction. Few candidates knew that a catalyst remained unaltered at the end of the reaction.
(ii) Candidates needed to know a test for alkenes, bromine was not well known as the testing reagent.
- (c) (i) Some candidates knew this. Some candidates realised that there was a carbon-carbon double bond in the structure. Some candidates drew the structure for methane.
(ii) Very few candidates knew that it was water that reacted with ethene to produce ethanol.
(iii) Candidates need to understand the idea of polymerisation.

Question 12

- (a) Candidates need to know about the idea of electron transfer in static electricity.
- (b) Many candidates gained most of the available credit.
- (c) Conduction was well known.
- (d) Most candidates attempted this and a range of credit was awarded.

Question 13

- (a) (i) Twenty three chromosomes was a common error.
(ii) Male was commonly mentioned, but few candidates linked that with the presence of X and Y chromosomes.

- (iii) Few candidates explained that the X chromosome was inherited from the mother and the Y chromosome from the father.
- (b) Many candidates placed the two obvious alternatives in the wrong places.
- (c) Although the idea of a sperm cell and egg cell joining together was well known, the idea that it was the nuclei of these two cells combining together was not well known.

CO-ORDINATED SCIENCES

Paper 0654/41
Theory (Extended)

Key messages

Candidates who did well in this paper

- noted the guidance provided by the question to help them with their answer
- added to the information provided by the question
- avoided ambiguity by writing answers that made sense without reference to the question
- showed their working in calculations, including formulae
- took care using standard notation
- used significant figures appropriately.

General comments

There was evidence that the majority of candidates had been well prepared to the level this paper requires and across the range of topics covered by the syllabus. Most wrote responses which were organised and legible. Some should have ensured that numbers were not written ambiguously. The most successful were familiar with the terminology and standard wording of definitions and explanations of phenomena as they appear in the syllabus. Full marks were obtained where the number of marks and the space allocated were used as guides to the length and detail required in answers. Candidates appeared to use the time available intelligently in order to answer all parts of the paper.

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

Comments on specific questions

Question 1

- (a) (i) Most candidates could identify the parts of the villus by their functions.
- (ii) Most could explain that the large surface area of the villus aids absorption.
- (b) The basic units that make up fats were often stated correctly. Sometimes just fatty acids or glycerol were named. Glucose was a common incorrect suggestion.
- (c) The mechanism of breakdown of fats by bile was often described well in terms of increasing the surface area for action by the enzyme. The best answers used the term *emulsify*. Others confused the physical breakdown of globules with the chemical breakdown of molecules. Some suggested incorrectly that bile contains an enzyme.
- (d) The vast majority of candidates suggested that coronary heart disease can be caused by too much fat in the diet.
- (e) Most suggested correctly that exercise reduces the risk of obesity.

Question 2

- (a) (i) The formula of aluminium oxide was usually deduced as Al_2O_3 . Other common suggestions included AlO_2 and $2Al_3O_2$.
- (ii) The best explanations for why aluminium oxide has a high melting point were based on the large amount of thermal energy needed to overcome the high attractive force between oppositely charged ions. In spite of being reminded that aluminium oxide is ionic, some candidates discussed intermolecular forces. Others attempted to relate the properties of aluminium oxide to those of elemental aluminium.
- (iii) A few candidates recalled that cryolite is mixed with aluminium oxide to lower the melting point.
- (iv) There were some good descriptions of the migration of the aluminium ion to the cathode of the electrolytic cell, and its discharge through the gain of three electrons. A half-equation sometimes clarified the answer. Some responses suggested that electrons were removed directly from oxide ions, while others confused the anode and cathode.
- (b) The bonding in carbon dioxide was usually shown correctly. Incorrect diagrams often suggested the candidate had not checked that outer shells contained eight electrons.

Question 3

- (a) (i) There were many good answers to the two-stage calculation of the force required to accelerate the tractor. They showed the formula used to calculate the acceleration and substituted this into the force formula. An error in rounding the acceleration to two significant figures sometimes resulted in an inaccurate force. Some attempted to use the force formula without stating a value for the acceleration.
- (ii) Those who knew the kinetic energy formula often calculated the increase correctly. Some received credit for the calculation of one kinetic energy and others for subtracting the initial energy from the final energy.
- (b) This calculation of energy input was usually answered well. Some candidates who made an error in the calculation gained credit from a correct formula for efficiency. In this problem efficiency is defined as a percentage in terms of *useful* energy output and energy input rather than just input and output:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

- (c) (i) Most candidates used a ruler to draw a diagram of rays coming to a point focus in the grass.
- (ii) Many candidates knew that only a real image can be projected onto a screen. Some showed understanding by describing how a virtual image is caused by light rays appearing to originate but not actually coming from that image. Others simply described the properties or position of virtual images formed by a lens, which was not sufficient.

Question 4

- (a) (i) Many candidates correctly interpreted the term *trend* as the pattern of change in the number of deaths over time rather than the relationship between the number of deaths and the number of cigarettes smoked.
- (ii) There were many good suggestions of why smoking has decreased, including descriptions of actions taken by governments. Descriptions of the improved awareness of harmful effects did not always highlight knowledge of the link between smoking and lung disease.
- (b) The best suggestions of why there is a lag between number of cigarettes smoked and deaths specifically recognised the time taken for cancer to develop.
- (c) The effects of the components of tobacco smoke were well known.

- (d) Successful candidates knew that the role of cilia is to remove mucus from the gas exchange system, and that mucus traps bacteria. They identified damage to cilia and realised that bacteria trapped in mucus would reproduce and cause infection.

Question 5

- (a) Many candidates knew the general equation for the reaction between acid and alkali.
- (b) (i) Most knew the formulae of the reactants and products and could write a balanced equation for the reaction. Attempts at writing state symbols were less successful. Common errors included the representation of solid potassium chloride and aqueous water.
- (ii) There were few who realised the involvement of hydrogen ions and hydroxide ions in the reaction. Common errors included the participation of oxide ions and ions of elements not present in the reaction.
- (c) (i) There were some excellent calculations of the volume of hydrogen, showing understanding of the stoichiometry of the reaction, and the meaning of *molar gas volume*.
- (ii) There were a number of candidates who correctly identified *Avogadro's Number*. There were a range of phonetic spellings of the name. The number itself was not required.

Question 6

- (a) Most candidates knew the two components of the generator. The inclusion of a battery was a common error.
- (b) (i) Many explanations of the need for transmission at high voltage identified the decrease in energy loss due to reduced current. Some candidates attempted to explain in terms of the need to supply the town with sufficient energy or voltage.
- (ii) Those who knew the transformer formula usually calculated the output voltage correctly.
- (c) (i) Most candidates knew the relationship between amplitude and loudness. The use of the term *noise* was not helpful.
- (d) (i) The best responses described compression in terms of the effect on air pressure or density. Some confusion with the modulation of frequency was evident.
- (ii) Many candidates described wavelength as the distance between successive compressions. Others read the question as requiring information about the factors affecting wavelength.

Question 7

- (a) (i) and (ii) The main constituent of limestone was usually correctly identified as calcium carbonate and the gas formed with acid as carbon dioxide.
- (b) (i) Most candidates realised that half the limestone reacted in the time taken for half the carbon dioxide to be produced. A common error was to read the time from the graph as 1.24 rather than 1.4 minutes.
- (ii) The best explanations of why the rate of reaction decreases involved recognition that concentration of acid or the surface area of limestone decreased, causing a decrease in the rate of collision of particles. Candidates were not given credit for stating the effect of decreased number of acid particles or decreased number of collisions. Those who discussed the effect of the reduced number of reacting particles in limestone did not always make it clear that it is the surface particles that react.

- (c) (i) The best responses described the exothermic reaction as the combustion of carbon or the reaction between carbon and oxygen, and the endothermic reaction as the decomposition of calcium carbonate or limestone.
- (ii) Many candidates knew that thermal energy is changed to chemical energy in an endothermic reaction.
- (iii) The best explanations of why the waste gases contain nitrogen simply recognised that nitrogen is contained in air and passes through the kiln without reacting.

Question 8

- (a) (i) Most candidates calculated the percentage correctly from the data.
 - (ii) Some stated the type of variation as *discontinuous* or used an equivalent term. *Continuous variation* was often suggested.
 - (iii) The most successful suggestions for the cause of the variation involved variation in genes. Candidates who attempted more complex explanations were less likely to be given credit.
- (b) *Mutation* was usually correctly suggested as the cause of the orange colour.
- (c) Most candidates described correctly how the farmer should breed from the brown rabbits only. Many discussed selecting those with useful genotypes. These attempts to go beyond the scope of the question rarely gained credit. The best responses specified the need to select from the offspring and to continue the breeding programme over many generations.

Question 9

- (a) (i) The watt was usually given as the correct unit.
 - (ii) Those who knew the relationship between electrical power and current usually obtained the correct answer.
- (b) Candidates who gave the best descriptions of how thermal energy passes through a metal noted that a particle explanation was required. They took care to avoid repeating the question by stating that thermal energy is conducted. They recognised that particles vibrate more and that this vibration or kinetic energy is passed between particles. A common misconception was that more energetic particles pass through a metal by convection.
- (c) Those who knew the formula for specific heat capacity or could rearrange the formula for thermal energy supplied usually obtained a satisfactory quantitative answer. Full marks were only obtained when the candidate chose a unit for specific heat capacity consistent with the data or manipulated the units of mass and energy to match the unit of specific heat capacity employed.
- (d) Most candidates stated that water molecules receive more energy on a warm day. Fewer recognised that evaporation increases because more molecules have enough energy to leave the water surface. Candidates did not often imply that molecules have a range of energies.

Question 10

- (a) The vast majority of candidates could define the term *ecosystem*.
- (b) The most successful explanations of why brown trout can be described as feeding at the third or fourth trophic level simply described two of the food chains in which they are involved. Where the trophic levels were not specified, benefit of doubt was given that answers referred to the third and fourth level respectively. The intentions of those candidates who made unambiguous statements were less likely to be misunderstood.
- (c) Most explanations for the limited number of trophic levels usually identified the loss of energy from the food chain between each level and the insufficient amount of energy remaining to sustain further levels. Some candidates discussed relative numbers of predators and prey with less success.

Question 11

- (a) (i) The correct number of neutrons was usually found from the symbol of bromine.
- (ii) The electronic structure of a chlorine atom was usually correct.
- (b) The initial colour of bromine solution was usually described as a shade between brown and yellow. The final appearance was often given as colourless, with clear, transparent and white not being acceptable.
- (c) (i) Full marks were given for a representation of a poly(ethene) molecule showing four carbon atoms in a single bonded linear chain, two hydrogen atoms single bonded to each carbon atom and an indication that the chain continues. A number of candidates drew the structure of butane and gained the first of these marks.
- (ii) Many candidates knew that poly(ethene) is formed by addition polymerisation.
- (iii) Some candidates described the breakdown of protein by hydrolysis under acidic or alkaline conditions, while others recalled the action of the enzyme protease. Both answers were acceptable.

Question 12

- (a) Successful candidates explained the difference in temperature of the saddles in terms of the difference in the absorption of radiation, rather than making a statement such as *black absorbs radiation*. Comparison of the absorption of light was not acceptable.
- (b) (i) Those who knew the formula for resistances in parallel usually calculated the combined resistance correctly. Those who made an error in the calculation often gained some credit for stating the correct formula. A common mistake was to quote the formula as: $R = 1/R_1 + 1/R_2$.
- (ii) An Ohm's Law formula correctly rearranged usually gave a correct answer to the calculation of current.
- (c) (i) Visible light and infra-red were usually placed in their correct positions in the electromagnetic spectrum. Their order was sometimes reversed.
- (ii) Many candidates knew the formula relating frequency to speed and wavelength. Most errors occurred in handling powers of 10.
- (iii) Most knew that α -particles are the most ionising.

Question 13

- (a) Most candidates could identify the liver and pancreas.
- (b) The best descriptions of the reduction of glucose concentration recognised that it is the pancreas that releases insulin causing the liver to convert glucose to glycogen. Common errors involved confusing the roles of pancreas and liver.
- (c) Many candidates used the term *negative feedback* or *homeostasis* to describe the control of glucose concentration. Other terms used were too close to the wording of the question.
- (d) The names of the correct elements in glucose or their symbols were usually provided. Those who wrote the formula of glucose were not successful as they did not demonstrate knowledge of the term *element*.

CO-ORDINATED SCIENCES

Paper 0654/42
Theory (Extended)

Key messages

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 candidates need to ensure that their handwriting is clearly legible.
- Calculations were generally done well with working shown. Candidates are expected to give correct units with their answers and round their answers up or down to an appropriate number of significant figures.
- Skills that would be beneficial for candidates to practise are the conversion of units, for example from cm^3 to dm^3 , and the rearranging of formulae as this proved problematic for some.
- Data analysis type questions require candidates to add to the information in the stimulus material, often by manipulating data, rather than just re quoting figures.

General comments

Questions where candidates are required to annotate diagrams are often omitted. In these cases, candidates should be reminded to read the stimulus material and each question carefully and complete all the instructions contained within the question to be able to access the maximum marks available.

Candidates generally showed good use of English, expressing their ideas in continuous prose. Correct scientific terminology as stated in the syllabus should always be used. Learning the definitions specified in the syllabus earns marks directly as well as being an aid to language used in explanations.

Comments on specific questions

Question 1

- (a) (i) Most candidates correctly stated the letters corresponding to the parts of the body responsible for bile production, fat digestion and lipase production. A common error was to state the letter **K** (gall bladder) rather than the letter **L** (liver) for bile production.
- (ii) Candidates need to be able to distinguish between physical and chemical breakdown of fats. Some candidates incorrectly referred to bile causing a chemical breakdown of fat molecules into glycerol and fatty acids rather than a physical breakdown. The best responses used the term *emulsification* and referred to increased surface area of fats.
- (b) This was generally well answered with many references to absorption taking place across the villi walls in the small intestine. There were fewer references to the role of lacteals. Some candidates stated incorrect areas of absorption including the liver and large intestine.
- (c) Many candidates had the correct idea but did not express it fully. The best responses included explanations of extremes of pH causing enzymes to denature. Some candidates incorrectly stated that an acidic environment has a high pH value.

Question 2

- (a) (i) Many correct responses were seen. The most common being evidence of a gas being released or bubbling and a temperature increase. Some candidates referred to a temperature change or decrease. References to new products being made or vague references to colour changes were not awarded credit.
- (ii) The majority of candidates gave the correct answer of magnesium chloride. Common incorrect answers included magnesium oxide and magnesium hydroxide.
- (iii) Correct references to loss of electrons were commonly seen. Some candidates incorrectly stated that electrons were gained.
- (b) Many correct balanced equations were seen. Some candidates included Mg_2 producing balanced but incorrect equations.
- (c) (i) Most candidates gave the correct answer of 183 g.
- (ii) There were many incorrect answers with some candidates dividing 200 by the relative atomic mass of magnesium, giving an answer of 8.33.
- (iii) Most candidates referred to alloys being harder or stronger. There were some vague references to improvement of properties, which were not awarded credit.

Question 3

- (a) (i) Candidates scored well here, particularly those who calculated the times of the athletes. There were some who used a valid alternative to calculate how far the athletes could run in 20.5 s and comparing this to 200 m. Some of those who worked out the average speed needed to qualify, were unclear as to whether the time should be higher or lower and gave R rather than P, Q and S as the answer.
- (ii) Many correct answers were seen. A minority of candidates tried to use an incorrect formula.
- (b) The majority here put the **X** on the front surface of the mirror. Most of the candidates who had the right idea were reasonably accurate with their positioning of the **X**.
- (c) (i) There were some excellent responses seen, with accurate descriptions of the changes to molecules during the evaporation process. Very few candidates confused evaporation with boiling.
- (ii) Most candidates scored well on this part of the question. A few referred to temperature or surface area without qualifying with higher or lower.

Question 4

- (a) Some very good comparisons of the differences between breast milk and formula milk were seen. A few candidates simply restated the data given in the question without calculating differences.
- (b) (i) Many excellent answers were seen. There were also a number that only referred to transfer through the umbilical cord. There was often added detail about the transfer of nutrients by diffusion.
- (ii) The most common error was to include faeces as well as the two correct answers. Some answers included materials that would be going to the fetus.

Question 5

- (a) (i) Many candidates stated the correct letters of **C** and **D**. Incorrect letters of **E** and **A** were also commonly seen.
- (ii) The vast majority of candidates stated the correct letter of **B**.

- (iii) Many candidates stated the correct letters of **C** and **E**. A few also incorrectly included the letter **A** in addition to the letters **C** and **E**.
- (b) (i) Few gained full credit. There were several correct references to fractional distillation with fewer referring to the liquefaction of air. Some candidates tried to describe combustion in air and removal of carbon. Few did this successfully. It was a common idea that nitrogen could be filtered out from air.
 - (ii) The vast majority of candidates knew the conditions required. Very occasionally inaccurate figures were stated, for example 2 atm or 200 °C.
- (c) (i) Some candidates stated the formula correctly. Those who did generally referred to transfer of electrons to form an ammonium ion as if it was a metal ion. Candidates should be reminded that an explanation in terms of "swapping and dropping" of charges is not appropriate and should refer to balancing of charges.
 - (ii) The majority of candidates gave the correct colour change of litmus paper. Some candidates did not make it clear that it was the gas being tested with litmus paper. Fewer knew how to obtain ammonia from ammonium sulfate by adding sodium hydroxide and warming.

Question 6

- (a) Many candidates suggested that because a black surface was a good absorber, the radiator would absorb more heat than the water. A number realised the shape of the foils would increase surface area for greater radiation of thermal energy.
- (b) Most candidates stated the correct formula. Some found rearranging the formula difficult, confusing energy and specific heat capacity.
- (c) (i) Almost all candidates matched the magnet and the battery with the correct letters. The letter Y was often incorrectly matched with the rotor, the coil or the axle.
 - (ii) Most candidates gave the correct answer of faster rotation.
- (d) Very few candidates were able to recall the meaning of the term *electric field*.
- (e) The most successful responses described the use of a small current circuit to switch on a high current circuit. There were many vague references to aspects of safety. There were also several responses referring to large and small circuits or large and small voltages. These were not awarded credit.
- (f) (i) The most common error seen was to add the two resistances. Some candidates failed to invert their answer.
 - (ii) The use of the same formula as part (i) was required here. Some candidates added the two answers.

Question 7

- (a) Candidates need to know the parts of the eye and their functions; with the exception of the retina, these were not well known. A common misconception was that only the lens refracts light. Some candidates did not give the function of the parts and simply referred to the iris giving the eye colour and the lens changing focus with no reference to light.
- (b) This was generally well answered. Candidates should be reminded that ligaments do not contract, only muscles contract. Ligaments should be described as tightening and loosening rather than contracting and relaxing.
- (c) Most candidates were able to suggest the shorter distance to the brain than to the spinal cord.

Question 8

- (a) (i) A variety of answers were seen including a gas being released and temperature change. Fewer candidates referred to a correct colour change. Some candidates referred to a colour change without specifying the colour. Candidates were more successful in explaining that chlorine is more reactive than iodine. A few candidates did not know the order of reactivity, stating that iodine is more reactive than chlorine. Another common error was to use the term **iodide** rather than **iodine**.
- (ii) The majority of candidates were successful in describing argon as having a full outer shell of electrons.
- (b) This was generally well done, with candidates completing all the circles with the correct symbols and charges. Occasionally some candidates quoted Cl^{2-} or muddled the order of the ions.
- (c) Hydrogen for **Y** was the most commonly seen, followed by sodium chloride for **X**. Fewer candidates were successful in naming a correct corresponding compound for **Z**.

Question 9

- (a) (i) Most candidates gave the correct figure. Some candidates missed or added a zero.
- (ii) Most candidates could correctly calculate the work done using the formula $W = F \times D$.
- (iii) Most candidates realised this was the same as the answer they had given in part (ii). Some candidates used the formula $W = mgh$, which was also acceptable.
- (iv) Candidates needed to multiply the surface area of one elephant foot by four to reflect that elephants have four feet on the ground. Some incorrectly used mass instead of force in their calculations.
- (b) (i) This was particularly well answered. It was clear that many candidates knew the range of frequencies heard by humans.
- (ii) This question part was answered less well. Many gave one correct answer for a compression and a corresponding one for rarefaction, rather than two different answers. Many referred to waves being closer or further apart rather than particles, and there was much reference to pitch, speed amplitude and wavelength.
- (iii) Some candidates referred to distance between peaks or waves rather than compressions. Candidates should be reminded to read the question carefully and answer as the question instructs.

Question 10

- (a) (i) Candidates generally gave the correct answer of snails.
- (ii) Candidates generally gave the correct answer of frogs.
- (b) (i) Sulfur dioxide was commonly seen. The most common incorrect answers were methane and carbon dioxide.
- (ii) Candidates need to be clear about acid rain, global warming and the ozone layer. There were some good answers referring to the emission of longer wavelength radiation from the Earth. Most candidates could state that an increase in carbon dioxide in the atmosphere leads to global warming.

Question 11

- (a) Most candidates gave the correct response of petroleum or crude oil. The most common incorrect answer was fossil fuels.
- (b) (i) The majority of candidates drew the correct structure of butane. Very few structures of butene were seen. Very occasionally other alkanes were drawn such as propane and pentane.
- (ii) Most candidates recognised the difference as single bonds and double bonds. Fewer referred to number of hydrogen atoms. Some candidates referred to carbon and hydrogen molecules rather than atoms. The most common similarity given was the presence of four carbon atoms.
- (c) (i) It was a common belief that amounts of water and carbon dioxide would change in opposite directions or be less in the exhaust gases. Many who put that amounts would both increase, often gave no reason or gave no indication this was due to combustion.
- (ii) Several candidates incorrectly suggested that oxygen was produced in a reaction in the engine. Some candidates did realise that not all the oxygen is used in combustion. Vague references to incomplete combustion were not awarded credit.
- (d) (i) Many candidates stated that nitrogen and oxygen would react at the high temperatures present in the engine. A common error was to suggest that it was a reaction between carbon dioxide and nitrogen. There were also several vague references to nitrogen and oxygen mixing, which were not awarded credit.
- (ii) The answer of catalyst was commonly seen.
- (iii) Few correct answers were seen here. A surprising number of candidates stated another unreactive gas such as neon or argon. Some candidates described why nitrogen was unreactive rather than why it was reduced.

Question 12

- (a) Many correct answers were seen, with the majority of candidates gaining at least partial credit.
- (b) Those that completed this question generally scored highly, showing correct reflection of the top ray. A common error was to draw lines for the top two rays only and omitting to continue the path of the bottom ray.
- (c) Few candidates gave the correct meaning of the term *thermal capacity*. There were many unclear answers referring to the amount of heat an object could hold. It was evident that some candidates were unclear about the terms *specific heat capacity* and *thermal capacity*.

Question 13

- (a) Correct names for parts **P** and **Q** were commonly seen, **P** sometimes being mistaken for the cuticle and **Q** being mistaken for a palisade cell.
- (b) (i) Sucrose was the most common correct answer. Very few candidates stated amino acids, which was a correct alternative. Incorrect answers of glucose and water were frequently seen.
- (ii) The majority of candidates were able to name the tissues shown in the photograph.
- (c) The majority of candidates were able to correctly match the parts of a plant cell with their function.

CO-ORDINATED SCIENCES

Paper 0654/43
Theory (Extended)

Key messages

Candidates who answered questions well

- noted the guidance provided by the question to help them with their answer
- chose words carefully when describing their observations
- did not confuse quantities such as mass and weight, energy and matter, temperature and heat
- drew diagrams with enough precision to be scientifically correct
- showed their working in calculations, including formulae
- used consistent units throughout a calculation

General comments

There was evidence that the majority of candidates were prepared across the range of topics covered by the syllabus for this paper. Most wrote responses which were organised and legible. The use of English and mathematical skills were generally sufficient to demonstrate scientific understanding. Full answers were written where the number of marks and the space allocated were used as guides to the length and detail required. Candidates appeared to use the time available to answer all parts of the paper.

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

Comments on specific questions

Question 1

- (a) (i) Many candidates described the lumen of the artery as smaller than the lumen of the vein. Some noted that the former has a circular shape. There was some confusion between the terms *lumen* and *wall* of a blood vessel.
- (ii) Most explained that higher blood pressure necessitates the thickness of the artery wall. Use of the term *pressure* on its own did not gain credit.
- (iii) The valve was usually correctly identified as the structure in veins, and its function correctly described as preventing backflow.
- (b) The vast majority selected the person most at risk from coronary heart disease with a correct explanation, stated two other risk factors and suggested two ways in which another person could reduce their risk.

Question 2

- (a) (i) *Transition metals* was usually named as the collection of metals that contains copper. Some candidates named some of the other transition metals rather than naming the collection.
- (ii) Typical properties of transition metals were often correctly suggested as not being typical of Groups I and II. The lower reactivity of copper was also acceptable. Some candidates incorrectly suggested some general metallic properties.

- (b)(i) Chlorine or its symbol, Cl_2 , was sometimes identified as an element as it contains only one type of atom. Attempts to define an element as containing only one element were common.
- (ii) Candidates who knew that the charges on the copper and chloride ions are in balance deduced the formula of the copper ion with the correct charge, Cu^+ . The formula of one of the copper chlorides was often written.
- (c)(i) The meanings of the state symbols were well known.
- (ii) Very few candidates could recall a visual observation made during the reaction, such as a brown coating of copper or a reduction in the blue colour of the solution. Many understood the word *observation* to have its general meaning as a reflection on something that has been noticed, rather than in its use in a scientific context.
- (iii) Many candidates knew that a displacement reaction occurs because zinc is more reactive than copper.
- (iv) The particles which are oxidised and reduced were sometimes identified with the direction of movement of electrons described correctly.

Question 3

- (a)(i) The weight of the vehicle and astronaut was usually calculated correctly.
- (ii) Those who knew the formula for acceleration or could rearrange the formula for applied force usually obtained a satisfactory quantitative answer. Weight was sometimes confused with mass. The unit of acceleration was not well known.
- (b)(i) Most candidates applied the formula for the speed of a wave appropriately to verify the speed of radio waves, rather than working backwards from the answer. Omission of $\times 10^6$ was a common error.
- (ii) The formula for time taken was often applied correctly when the unit of distance was adjusted.
- (iii) Radio waves were usually located in the right place in the electromagnetic spectrum.
- (iv) Most candidates realised that sound requires a medium for propagation. A minority explained in terms of the time taken for information to be transmitted over a large distance

Question 4

- (a)(i) Some candidates explained the need for chlorophyll in terms of the absorption of light energy in order to form a carbohydrate during photosynthesis. Other responses did not explain in terms of energy as suggested in the question or included a vague description of the source of energy from the Sun. Several suggested that light energy is converted to glucose rather than to chemical energy.
- (ii) The equation for photosynthesis was well known.
- (b) There were some good answers relating mineral ion to function and the effect of deficiency.

Question 5

- (a)(i) The effect of lithium hydroxide solution on the colour of the indicator was sometimes described correctly.
- (ii) There were many correct balanced equations for the reaction. The most common errors were to write the formula of the product as Li_2O or LiO .

- (b) (i) Some candidates knew that an electrolyte must permit mobility of ions. Others were less specific in their discussion of conductivity or suggested that electrons are conducted.
- (ii) Those who knew the polarity of electrodes usually stated that positively charged ions are attracted to the negatively charged cathode.
- (iii) The best descriptions of the formation of atoms followed the advice in the question stating that lithium ions each gain one electron at the cathode to form an atom. Many candidates understood this question as asking how lithium ions are formed or where lithium atoms appear.

Question 6

- (a) A very few candidates compared the motion of the cars as having speeds with the same magnitude but velocities with different direction.
- (b) (i) Those who knew the formula for work done usually obtained the right answer.
- (ii) Fewer candidates knew the formula for power.
- (c) Most candidates stated that an increase in water temperature results in molecules receiving more energy. Fewer recognised that evaporation increases because more molecules have enough energy to leave the water surface or to overcome attractive forces. Candidates did not often imply that molecules have a range of energies.

Question 7

- (a) The placenta was usually labelled correctly.
- (b) The parts of the diagram showing a growing baby were usually correctly matched to their function.
- (c) Two common features of the placenta and alveoli were often identified. *Thin membrane* or *wall* were sometimes confused with *cell membrane* or *cell wall*.
- (d) There were many tables completed correctly to show the direction of movement of substances at the placenta.

Question 8

- (a) (i) The term *alloy* was well known.
- (ii) A physical property differing in brass and copper was usually identified. Most avoided comparing a chemical property.
- (iii) There were some good explanations of the role of zinc in galvanising. They included the sacrificial oxidation of zinc instead of iron due to the greater reactivity of zinc. Some candidates restricted the role of zinc to providing a layer protecting the steel from exposure to oxygen and water.
- (b) Many candidates could calculate the number of moles of zinc and acid in the reactant mixture. The best responses showed understanding of the stoichiometry of the reaction to explain their deduction that there was insufficient acid.
- (c) Those who knew the test for sulfate usually stated its positive result.

Question 9

- (a) (i) Candidates who knew the nature of the beta particle often applied the rules of conservation of mass and charge to complete the equation for the decay process.
- (ii) The meaning of the term *isotope* was well known.
- (iii) Many candidates deduced that three half-lives were involved. Others attempted to use a formula which seldom led to the correct answer.

- (b) A mark was sometimes obtained by a response that recognised that latent heat of vaporisation supplies the energy for a change of state or to overcome the force between atoms. Very few suggested that temperature was constant as the kinetic energy of atoms did not increase. There was misuse of the term *heat* when *temperature* was intended and confusion between the terms *latent heat* and *boiling point*.
- (c) (i) There were many correctly completed sentences describing the changes to the block of aluminium.
- (ii) Those who knew the formula for specific heat capacity or could rearrange the formula for thermal energy usually obtained the correct answer.

Question 10

- (a) Most candidates used the information to state the correct number of chromosomes after mitosis and meiosis.
- (b) (i) While most responses suggested that the candidate had knowledge of the process of meiosis, they did not always apply it to explain its necessity for sexual reproduction.
- (ii) An advantage and a disadvantage of sexual reproduction were often given. There was some misunderstanding concerning the merit of this method with respect to inheritance of disease.

Question 11

- (a) Many candidates could link at least three of the raw materials with a useful product. The production of ammonia proved to be the most challenging process. Some candidates lost marks by choosing more than one product in a row.
- (b) (i) *High temperature* or *high pressure* was very often correctly suggested as a reaction condition required for cracking. Candidates should be aware that writing *temperature* or *pressure* is not sufficient to describe an environment.
- (ii) Many candidates knew the positive result of the bromine test for alkenes. Some did not describe the final appearance as a colourless solution, using descriptors such as clear, transparent or white. For full marks the link with unsaturation was required.
- (iii) The bonding in ethene was usually shown correctly. Incorrect diagrams often suggested the candidate had not checked that outer shells contained eight electrons.
- (iv) Many responses included two compounds that could be produced by an addition reaction.

Question 12

- (a) (i) Those who knew the formula for resistances in parallel usually calculated the combined resistance correctly. Those who made an error in the calculation often gained some credit for stating the correct formula. A common mistake was to quote the formula as: $R = 1/R_1 + 1/R_2$.
- (ii) There were a few well-presented answers to this two stage calculation. Some marks were obtained by writing the formulae for current and for power. The most common error was to confuse current and power.
- (b) Most candidates used a ruler to draw a ray from the cyclist to the driver, reflected from the mirror, without gaps. Where the angles of incidence and reflection were drawn between rays and the normal to the mirror, there was often the incorrect suggestion that the ray travels from the driver to the cyclist rather than from the cyclist to the driver.
- (c) (i) The abbreviation for electromotive force was not recognised by many.
- (ii) Most candidates knew a way in which the e.m.f. can be increased.

- (d)(i) Many attempted to draw a line between two compressions to indicate a wavelength. A few were drawn accurately between the same points in consecutive compressions.
- (ii) Many candidates correctly suggested that the distance between compressions increases when frequency decreases. Others read the question as requiring information about the factors affecting wavelength.

Question 13

- (a) (i) The name of the hormone was well known.
- (ii) Many explanations of phototropism stated that auxin accumulates on the shady side. The implication was often that it moves there from the light side rather than being destroyed on the light side. The best responses went on to use terminology precisely to state that the auxin on the shady side causes elongation of cells rather than growth of cells, and faster growth of the shoot rather than growth or elongation of the shoot.
- (b) Those who realised that auxin is produced in the tip of the shoot predicted that there would be no change in growth once the tip is removed.
- (c) The vast majority of candidates could define sensitivity and chose *growth* as the other characteristic of living organisms.

CO-ORDINATED SCIENCES

Paper 0654/51
Practical Test

Key messages

Best-fit lines do not necessarily pass through every point and should have an approximately equal distribution of points to either side of the line.

General comments

The vast majority of candidates finished the whole paper. The standard of writing was high.

Comments on specific questions

Question 1

The units in **(a)(i)** were generally well done. A common error was the use of ml^3 . All candidates recorded a full set of results and most recorded them to the nearest cm^3 as instructed.

Labelling of the axes and plotting of points on the graph was carried out accurately. Many curves were forced through the points and there were a few inappropriate straight lines. The reading from the graph was usually well done. Most candidates appreciated that the shape of the graph represented slowing of the reaction. Some incorrectly described this as happening after an initial increase.

Nearly all candidates gave an appropriate safety precaution but not all provided a suitable reason for their stated precaution.

In **(e)**, it was rare to see the majority of the available credit awarded. Most candidates stated what should be kept constant and appreciated that the temperature had to be varied. They also needed to specify how many temperature readings would be needed and to suggest values of temperature. Most candidates who mentioned graphs suggested similar graphs to those in **(b)**. Few realised that a separate graph would be needed for each temperature. A small minority suggested the alternative of plotting volume in a fixed time against temperature.

Question 2

This experiment required great care in description of solutions and precipitates. Candidates need to know that a solid formed when two solutions are added together should be described as a precipitate. It was easier to describe the colours of the precipitates if the test-tubes were placed side by side. Many correct colours were recorded. The effect of excess ammonia solution was seen by most candidates. The term "clear solution" should be avoided because all solutions should be clear. It is better to describe a solution by its colour or lack of colour.

Many candidates obtained the correct observations. Often they did not identify **H** as the chloride. The reference to "Notes for Use in Qualitative Analysis" on the back page of the question paper provided additional information for candidates which they could have used. Part **(a)(iii)** was answered well and error carried forward was applied here.

For **(a)(iv)** candidates did not appreciate why dilute nitric acid is often used in the tests for chloride and sulfate. The use of the acid confirms the presence or absence of a carbonate.

The reactions in **(b)** worked better than expected with many candidates gaining full credit in **(i)** and identifying iodine in **(ii)**. Many candidates recognised this reaction as redox or displacement.

Identification of the halides was often correct.

Question 3

The vast majority of responses recorded l_0 to the nearest millimetre. Distance l_0 needed to be carefully drawn on the diagram. Candidates are getting better at explaining how to view scales perpendicularly. A small number of candidates suggested laying the spring alongside the ruler.

Most candidates gained full credit in **(b)**.

Generally graphs were plotted well using sensible scales. Candidates should avoid awkward scales which usually lead to poor plotting and almost always lead to errors when reading intercepts or calculating gradients. Best-fit straight lines did not need to pass through the origin. Intercepts were usually read with accuracy. Candidates who forced their line through the origin often realised that zero made no sense and usually made up a figure; they would have been better to redraw their line.

Part **(c)(iv)** was not well answered; candidates need to have appreciation of what was an acceptable difference within the limits of experimental accuracy between values.

Gradients continue to be calculated well. The triangle chosen must be large enough; it should be taken from at least half of the line. Candidates needed to show on the graph how they were calculating their gradient.

Most candidates appreciated that line **D** should start from the same intercept on the l axis and have a larger gradient. A few candidates either showed a smaller gradient or the same gradient.

CO-ORDINATED SCIENCES

Paper 0654/52
Practical Test

Key Messages

Drawings should not be sketched and should use most of the box provided.

General Comments

The vast majority of candidates finished the paper. The standard of writing was high.

Comments on Specific Questions

Question 1

Drawings need to be large enough; at least half of the box provided should be used for drawings. Details of the centre of the banana were generally well done even when the outer line could have been better drawn, with a continuous line. Most candidates were awarded full credit for the measurements. A small number of candidates gave the measurements in centimetres. Magnification was usually correct. Sometimes the answer was given as a percentage or as a ratio. Percentage was allowed.

In **(b)**, a positive starch test was easily obtained and identified by the candidates. The Benedict's test in **(c)(i)** also gave an observable colour and most candidates recognised this as the test for reducing sugars including glucose. Some candidates wrongly concluded the presence of sugars or carbohydrates. Many candidates recognised the need to wear goggles or adopt another suitable safety precaution; they also needed to give a reason for the precaution. The protein test in **(d)** gave a negative result and the lack of protein in the food was the most common conclusion. Positive tests for protein were only credited if this was reported by the Supervisor. Many candidates appreciated that the ethanol needed to come into contact with the banana but few stated that this should happen before the addition of water. The observation for a positive fat test was well known. A significant number of responses wrongly included a precipitate.

Question 2

The copper(I) oxide turned black in **(a)** for nearly all candidates. The reaction in **(b)(i)** worked well; to be awarded credit candidates must be clear as to which is the filtrate and which the residue. Occasionally the blue precipitate in **(b)(ii)** was incorrectly described as green or as a milkiness. Candidates should know that a solid formed from the addition of two liquids should be described as a precipitate.

The displacement reaction in **(b)(iii)** worked very well and the effervescence and the test-tube getting hotter were usually detected and recorded. The description of what happened to the solution and to the solid needed to be clearer and more detailed; many candidates simply gave a colour change for the overall mixture.

The reaction with potassium iodide solution in **(b)(iv)** also worked well and candidates who filtered the mixture gained full credit. Otherwise the colour of iodine was recorded for the solution and the solid.

Copper was the most common conclusion in **(c)(i)**. Iron represented the one incorrect metal that was seen. Most candidates were able to support their conclusion with "blue" evidence. Relatively few provided second piece of evidence which supported their answer.

The reagents for **(c)(ii)** were well known and appeared on the Notes for Qualitative Analysis on the back page of the question paper. Some candidates suggested the use of both silver nitrate and barium nitrate for

which they were awarded some credit. The additional credit was awarded if the candidates explained how both acids reacted with each of the two reagents.

Question 3

Most candidates recorded d_2 to the nearest millimetre in **(a)(i)** and gained some credit. Often they were very inconsistent with this down the table for which there was no penalty. Consequently full credit in **(a)(iii)** was usually awarded.

Descriptions for **(a)(ii)** were often vague. For such questions there is need to describe exactly what should be measured and carried out.

Calculation of a and b was well done with very few errors. Graph plotting was good. Errors seen were the omission of units, transposition of axes, mis-plotting due to the choice of awkward scales, not incorporating the origin (0,0) and occasionally plotting of d_1 or d_2 . Many drew very good best-fit straight lines. An approximately equal distribution of points to either side of the line was expected. Some candidates forced their lines through the origin.

Gradients continue to be calculated well. The triangle chosen should be large enough; it should be taken from at least half of the line. Candidates should show on the graph how they were calculating their gradient.

Intercepts were read accurately although those who forced their lines through the origin chose not to give zero as an answer. In **3(d)** calculations were good. Candidates should use the appropriate number of significant figures in their answers.

Most candidates obtained partial credit in **(e)** for choosing the difficulty in balancing the rule or the lack of uniformity of the loads. Few candidates gained full credit.

CO-ORDINATED SCIENCES

Paper 0654/53
Practical Test

Key messages

Drawings should not be sketched and should use most of the box provided.

General comments

The vast majority of candidates finished the paper. The standard of writing was high.

Comments on specific Questions

Question 1

Drawings need to be large enough; at least half of the box provided should be used for drawings. Details of the centre of the banana were generally well done even when the outer line could have been better drawn, with a continuous line. Most candidates were awarded full credit for the measurements. A small number of candidates gave the measurements in centimetres. Magnification was usually correct. Sometimes the answer was given as a percentage or as a ratio. Percentage was allowed.

In **(b)**, a positive starch test was easily obtained and identified by the candidates. The Benedict's test in **(c)(i)** also gave an observable colour and most candidates recognised this as the test for reducing sugars including glucose. Some candidates wrongly concluded the presence of sugars or carbohydrates. Many candidates recognised the need to wear goggles or adopt another suitable safety precaution; they also needed to give a reason for the precaution. The protein test in **(d)** gave a negative result and the lack of protein in the food was the most common conclusion. Positive tests for protein were only credited if this was reported by the Supervisor. Many candidates appreciated that the ethanol needed to come into contact with the banana but few stated that this should happen before the addition of water. The observation for a positive fat test was well known. A significant number of responses wrongly included a precipitate.

Question 2

The copper(I) oxide turned black in **(a)** for nearly all candidates. The reaction in **(b)(i)** worked well; to be awarded credit candidates must be clear as to which is the filtrate and which the residue. Occasionally the blue precipitate in **(b)(ii)** was incorrectly described as green or as a milkiness. Candidates should know that a solid formed from the addition of two liquids should be described as a precipitate.

The displacement reaction in **(b)(iii)** worked very well and the effervescence and the test-tube getting hotter were usually detected and recorded. The description of what happened to the solution and to the solid needed to be clearer and more detailed; many candidates simply gave a colour change for the overall mixture.

The reaction with potassium iodide solution in **(b)(iv)** also worked well and candidates who filtered the mixture gained full credit. Otherwise the colour of iodine was recorded for the solution and the solid.

Copper was the most common conclusion in **(c)(i)**. Iron represented the one incorrect metal that was seen. Most candidates were able to support their conclusion with "blue" evidence. Relatively few provided second piece of evidence which supported their answer.

The reagents for **(c)(ii)** were well known and appeared on the Notes for Qualitative Analysis on the back page of the question paper. Some candidates suggested the use of both silver nitrate and barium nitrate for

which they were awarded some credit. The additional credit was awarded if the candidates explained how both acids reacted with each of the two reagents.

Question 3

Most candidates recorded d_2 to the nearest millimetre in **(a)(i)** and gained some credit. Often they were very inconsistent with this down the table for which there was no penalty. Consequently full credit in **(a)(iii)** was usually awarded.

Descriptions for **(a)(ii)** were often vague. For such questions there is need to describe exactly what should be measured and carried out.

Calculation of a and b was well done with very few errors. Graph plotting was good. Errors seen were the omission of units, transposition of axes, mis-plotting due to the choice of awkward scales, not incorporating the origin (0,0) and occasionally plotting of d_1 or d_2 . Many drew very good best-fit straight lines. An approximately equal distribution of points to either side of the line was expected. Some candidates forced their lines through the origin.

Gradients continue to be calculated well. The triangle chosen should be large enough; it should be taken from at least half of the line. Candidates should show on the graph how they were calculating their gradient.

Intercepts were read accurately although those who forced their lines through the origin chose not to give zero as an answer. In **3(d)** calculations were good. Candidates should use the appropriate number of significant figures in their answers.

Most candidates obtained partial credit in **(e)** for choosing the difficulty in balancing the rule or the lack of uniformity of the loads. Few candidates gained full credit.

CO-ORDINATED SCIENCES

Paper 0654/61
Alternative to Practical

Key messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental technique, to have carried out experiments similar to the ones shown in the paper and be able to draw apparatus. Candidates should have used standard laboratory apparatus and be able to read values from a variety of measuring instruments and record the values to the requested accuracy. Candidates should have performed identification tests on the range of substances detailed in the specification.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was good. The standard of graph drawing was generally high although candidates need to remember that axes need to be linear and covering at least half of the grid. Candidates must read the questions carefully so that they answer what is being asked by the question. Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results. Candidates need to ensure that they have good knowledge of identification tests for ions and that they have practised drawing diagrams of apparatus.

Comments on specific questions

Question 1 – Enzyme catalysed reactions

- (a) (i) Almost all candidates gained credit for plotting the points. They needed to include the units on the axes labels to be awarded further credit.
- (ii) Many candidates gained credit. A clear single line was required; some lines were feathery, very thick or had multiple lines. A small number of candidates connected the points using a ruler.
- (b) (i) Whilst most candidates could read the value from their graph correctly to gain credit they also needed to draw the lines on the graph to show how they had arrived at their answer.
- (ii) Few candidates gained credit as they described the change in volume of mixture rather than the rate of reaction.
- (c) Whilst most candidates could name a safety precaution fewer explained why it should be taken.
- (d) Many candidates repeated the experiment as described in (a) and so did not gain credit. Control variables scored the most highly. Few cited the number or range of temperatures to be used. Very few appreciated that the graph to be drawn would be different to that in (a).

Question 2 – Identification of Solutions

- (a) (i) Many candidates gained credit. Incorrect responses included H as it is a colourless solution and J because it forms a cream precipitate.
- (ii) Candidates found this challenging. Many discussed different reactions without reference to the observations in the table.

- (iii) Few candidates gained credit. Few appreciated that the identity of the solutions was already known and so carbonate did not need to be eliminated or thought that the silver nitrate was already acidic.
- (b) (i) Candidates found it challenging to use the observations in the table to explain their usually correct choice of solutions.
- (ii) Safety precautions were well known. Common responses which were not awarded credit included lab coats, tying hair back and standing up.
- (iii) Candidates found this challenging. Some repeated the original test and many omitted this question. Stronger candidates gained credit.
- (c) (i) Many candidates gained credit, and the most common response was measuring cylinder. Common responses which were not awarded credit included beaker and measuring tube.
- (ii) Few candidates gained credit. Many thought it was a control, or that it was omitted in order to find the volume needed without the indicator or to increase accuracy.
- (iii) Candidates found this challenging.

Question 3 – Length of a Spring

- (a) (i) The vast majority of candidates measured the spring correctly. A few candidates gave 2.8.
- (ii) Stronger candidates gained credit. Common non-creditworthy responses included keeping the spring vertical or still or not measuring the loops on the ends.
- (b) The majority of candidates gained at least partial credit with many gaining full credit.
- (c) (i) Whilst the graph was generally well executed, many did not start the axes at 0,0 and some had non-linear scale or scales which did not cover at least half of the grid.
- (ii) The line was drawn well by many candidates. Some thought that the line should go through the origin.
- (iii) Many candidates read the intercept correctly. Those that did not start the axes at 0,0 as requested usually did not have an intercept to read. Some candidates attempted an intercept value from a non-linear scale or estimated a value from a line extending out of the grid.
- (d) Candidates found this challenging. Stronger candidates were able to assess their values whilst discussing an experimental accuracy value of around 10 per cent.
- (e) Candidates found this challenging. The most common line started to the left of the original but had a less steep gradient and so crossed the original or went vertically upwards usually to the right of the original.

Question 4 – Cells

- (a) (i) Most candidates gained partial credit with many gaining full credit. Some had feathery outlines and some drew more than one cell. Some drew a plant cell with a cell wall, or had a rectangular or circular cell.
- (ii) The majority of candidates correctly labelled the nucleus. Some drew label lines which did not touch the nucleus.
- (b) (i) Whilst many candidates measured the cell correctly some recorded the measurement in cm.
- (ii) Candidates needed to draw the line on their cell in order to gain credit for the measurement.
- (iii) Many calculated the magnification correctly. A significant number inverted the calculation of subtracted the values. Many candidates rounded their calculator value incorrectly.

- (c) The fat test was quite well known. Some candidates omitted the water, or described the observation as a milky solution or a white precipitate. Biuret was seen a few times.

Question 5 – Salt preparation

- (a) Almost all candidates gained partial credit with some gaining full credit. ABED and ABDE were the most common incorrect responses as many found positioning the filtering step difficult.
- (b) Many candidates gained credit. The most common incorrect responses included: when the reaction stops and when it stops changing colour.
- (c) Candidates found the diagram very challenging. There were many filter papers with no funnel, or filter paper drawn with holes. The substances also needed to be labelled.
- (d) (i) Stronger candidates gained credit. Many thought it was to make more copper sulfate or to complete the reaction.
- (ii) Candidates found this very challenging. Many thought it was to help with filtration.
- (e) Candidates should ensure that they know the test for copper(II) ions. Dark blue precipitate and blue solution were common incorrect responses. Few included observations for both a small amount and an excess of the reagent.

Question 6 – Energy efficiency

- (a) The circuit diagram was often completed correctly. A significant number drew lines through the meters or drew the voltmeter in series.
- (b) (i) Current was usually read correctly, voltage was often 2.4. Few candidates gave time to 2 significant figures, most copied the reading and a small number gave 742.
- (ii) Most candidates multiplied the values correctly.
- (iii) Stronger candidates calculated the kinetic energy correctly but many forgot to include m in their calculation or did not square t .
- (iv) Stronger candidates calculated the efficiency correctly but many omitted to multiply by 100 or inverted the division.
- (c) Many candidates stated that energy was 'lost', but did not explain how.
- (d) Candidates found this challenging. Many described more circuits or repetition, but did not then average the results. Some used invented apparatus, used more accurate stop clocks or used more people to measure.

CO-ORDINATED SCIENCES

Paper 0654/62
Alternative to Practical

Key messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques and to have carried out experiments similar to the ones shown in the paper. Candidates should have used standard laboratory apparatus and be able to read values from a variety of measuring instruments and record the values to the requested accuracy. Candidates should have performed identification tests on the range of substances detailed in the specification.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques. The reading of instruments was of an excellent standard, calculations were well executed and food tests were quite well known. The standard of graph drawing was generally high, although candidates need to remember to include quantities with units on the axes and to draw smooth curves or straight lines with a single line. Candidates need to ensure that they have good knowledge of identification tests for ions. They must read the questions carefully so that they answer what is being asked by the question. Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results.

Comments on specific questions

Question 1 – Drawing skills and food tests

- (a) (i) Most candidates gained partial credit and many gained full credit. A few candidates drew feathery outlines, did not enlarge the drawing or missed the detail in the centre.
- (ii) Many candidates measured the diameter of the banana in the figure correctly although some gave their answer in centimetres. Candidates needed to draw the diameter on their drawing to gain credit for the measurement.
- (iii) The majority of candidates calculated the magnification correctly. Some inverted the division or subtracted the values. Rounding was sometimes incorrect.
- (b) Whilst many candidates appreciated that this was a test for protein some did not realise that the test was negative.
- (c) (i) Most candidates appreciated that this was a sugar test but many did not recall that the test is for reducing sugars. Many knew the correct observation. Heating was often omitted.
- (ii) Whilst many could state a safety precaution far fewer could explain why it was needed. Common non-creditworthy responses included lab coat, tying hair back and standing up.

Question 2 – Identification of ions

- (a) (i) The test for copper(II) ions was quite well known. Dark blue precipitate and blue solution were common incorrect responses.
- (ii) The tests for chloride ions and sulfate ions were not well known. Indicators, sodium hydroxide and ammonia solution were common incorrect responses. Some candidates put a dash, which is not acceptable for “no reaction”.
- (b) The diagram was well known but the labels were often missing or reversed.
- (c) (i) Many candidates gained credit. Non-creditworthy responses included: endothermic, diffusion, neutralisation, reduction, oxidation.
- (ii) Few candidates identified the powder correctly. Common incorrect responses included: magnesium, magnesium oxide, magnesium chloride, copper oxide, copper sulfate, cobalt chloride.
- (d) Many candidates gained credit. Answers such as it is heated are too vague to be creditworthy.

Question 3 – Mass of a metre rule

- (a) (i) Many candidates gained credit but a significant number gave the measurement of one edge or the other, i.e. 88.3 or 87.3.
- (ii) Candidates found this very challenging. Many repeated the stem and some omitted the question. Common responses included: at eye level, measure it and using a ruler.
- (b) Most candidates calculated the two distances correctly.
- (c) (i) Whilst the graph was generally well executed, many did not start the axes at 0,0. Some had non-linear scales or scales which did not cover at least half of the grid. Units were often omitted from the labels on the axes. Some reversed the axes.
- (ii) The line was drawn well by many candidates. Some thought that the line should go through the origin.
- (iii) Many candidates read the intercept correctly. Those that did not start the axes at 0,0 as requested usually did not have an intercept to read. Some candidates attempted an intercept value from a non-linear scale or estimated a value from a line extending out of the grid.
- (d) Most candidates multiplied the values correctly.
- (e) Few candidates gained credit. Non-creditworthy responses included: the ruler was not balanced, parallax error on the readings, rounding of values and pivot not being in the centre.

Question 4 – Photosynthesis

- (a) Many candidates placed the plant in the dark but some did not include a time. A significant number thought the plant should be boiled in alcohol to destarch it.
- (b) Most candidates gained partial credit usually for the correct observation and often for ethanol. Fewer candidates boiled the leaf in water. Very few candidates used a hot water bath.
- (c) Candidates found this challenging. Many said to remove the starch. Some discussed fair testing, testing for chlorophyll, to see if starch is needed for photosynthesis and control experiments.
- (d) Many candidates gained partial credit for the positive result, stronger candidates gained full credit. The most common error was to label the areas white and green.

Question 5 – Rate of Reaction

- (a) Most candidates gained credit. A small number gave the reading on the balance.
- (b) (i) Many candidates subtracted the values correctly. Some added all of the values in the column.
- (ii) Candidates found this challenging. Some thought the values included the mass of the flask, that not all of the calcium carbonate had reacted, carbon dioxide was lost from the flask or that the values had been rounded to 2 decimal places.
- (c) Few candidates gained credit. Many thought that the cotton wool kept the carbon dioxide gas in the flask or that it did not allow oxygen into the flask.
- (d) (i) Many candidates plotted the points correctly.
- (ii) Many candidates gained credit. Some of the curves were feathery and some had multiple lines.
- (e) (i) Stronger candidates gained partial credit for the line but fewer appreciated that twice the amount of acid would result in twice the mass of carbon dioxide being lost.
- (ii) Many candidates gained partial credit for the line being steeper and stronger candidates gained full credit.

Question 6 – Speed

- (a) (i) Most candidates recorded the times correctly. A small number copied the times into the table.
- (ii) Most candidates calculated the average correctly.
- (iii) Candidates found this challenging and gave reasons why some of the times may be inaccurate rather than all of them.
- (iv) Many candidates gained credit. Non-creditworthy answers included: to get an average or to reduce errors.
- (v) Many candidates described the relationship correctly. The most common error was to describe the relationship between height and time.
- (b) (i) Many candidates did not appreciate that their answer should account for the time being too large and so many gave reasons such as pressing the button too early or too late without specifying at the start or at the end.
- (ii) Very few candidates gained credit. Most included the anomalous result in their calculation rather than ignoring it.
- (c) Most candidates gained partial credit with many gaining full credit. A significant number controlled the mass of the ball.

CO-ORDINATED SCIENCES

Paper 0654/63
Alternative to Practical

Key messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques, to have carried out experiments similar to the ones shown in the paper and be able to draw apparatus. Candidates should have used standard laboratory apparatus and be able to read values from a variety of measuring instruments and record the values to the requested accuracy. When planning an experiment, candidates need to consider the steps involved.

General comments

Candidates from some centres demonstrated good understanding of practical knowledge. The reading of instruments was of an excellent standard but candidates need to consider the number of significant figures required by the readings. Diagrams of apparatus are improving, but care should be taken with drawing connections between the pieces. Undertaking practical prior to the examination helps the candidates to state observations and to interpret and evaluate experimental methods, techniques and results.

Comments on individual questions

Question 1 – Photosynthesis

- (a) (i) The majority of candidates recorded the temperature for T_1 correctly but most candidates gave 26 as their answer for T_2 .
- (ii) Many candidates gave a correct statement but a significant number stated that the number of bubbles would increase without reference to whether this was for an increase or a decrease in temperature. Stronger candidates explained their statement, but many repeated their statement using different wording or included the temperature reference as their explanation.
- (iii) Stronger candidates gained credit. Many candidates discussed the lamp. Other common non-creditworthy responses included: type of pondweed, volume of water and temperature.
- (b) Most candidates appreciated that the number of bubbles would be less but many gave decreasing temperature as their reason.
- (c) (i) The test was quite well known. The most common incorrect responses included relighting a lighted splint, lighting a burnt splint or a lighted splint burning with a larger flame.
- (ii) Some candidates found this challenging. Many repeated the stem of the question; speed, effectiveness and efficiency were common responses.
- (iii) Many candidates appreciated that the collection vessel needed to be graduated but did not include water in the beaker. There were also many test-tubes, downwards delivery into a measuring cylinder and apparatus which was not airtight.

Question 2 – Rate of reaction

- (a) (i) Candidates found this challenging. Many did not use a conical flask or collected the gas in a test-tube or by downwards delivery into a measuring cylinder. Candidates should ensure that the connections which they draw between pieces of apparatus are possible. Some used the apparatus used in question 1. Few candidates labelled the delivery tube.
- (ii) The majority of candidates gained credit. Some candidates discussed the formation of a white precipitate.
- (b) (i) Most candidates gained full credit.
- (ii) Many candidates gained credit. Some drew very thick or feathery lines or joined the points using a ruler.
- (iii) Whilst most candidates gave a value commensurate with their line, many did not draw the lines on their graph to show how they obtained their given value.
- (c) Many candidates drew a line with a steeper gradient but fewer appreciated that the line should plateau at the same value as the line in (a)(ii). Some candidates drew a less steep line usually plateauing at a smaller volume.

Question 3 – Series and parallel circuits

- (a) (i) Many candidates read the scales correctly. Common incorrect responses included 0.19 and 1.8.
- (ii) Most candidates multiplied their values in (a)(i) correctly.
- (iii) Candidates found this very challenging. Incorrect responses included restoring or resetting readings, making sure the earlier reading did not add on to the reading, for accuracy and for safety.
- (b) (i) Whilst most candidates multiplied the values correctly, fewer recorded their answers to two significant figures.
- (ii) Many candidates added the values correctly although many multiplied the values.
- (c) Few candidates gave an observation as their answer. Many discussed a difference in power or current.
- (d) Candidates found this very challenging. Some quoted $V = IR$ but did not use the figures and many used $R = IV$. Of those who discussed current, few also considered potential difference.

Question 4 – Breathing

- (a) Candidates found this very challenging. Few considered maximum volume in their answer. Many described the difference in water levels without reference to the practical details.
- (b) (i) Most candidates chose the correct sample and discussed the levels of oxygen or carbon dioxide but few explained the reason for this difference. A common non-creditworthy response was “oxygen is breathed in and carbon dioxide is breathed out”.
- (ii) The test was quite well known. Weaker candidates used burning splints, litmus or plants.
- (c) This was well known. It was common for candidates to either halve or give the same value for the volume of air in each breath.
- (d) Most candidates gained at least partial credit usually for measuring pulse rate before and after exercise. Few discussed measuring a pulse for a stated time. Stronger candidates discussed either a large sample size or repetition but few included averaging.

Question 5 – Electrolysis

- (a) Most candidates gained at least partial credit. Some thought the inert electrodes were the + and – signs and the aqueous copper chloride the copper coating on the cathode.
- (b) (i) Some candidates recalled this test but sometimes did not include bleaching. Many thought electrolysis, and all common gas tests were seen. Some gave the test for chloride ions.
- (ii) Stronger candidates gave one of the two observations with fewer giving both. The most common non-creditworthy response was blue solution. White precipitate was quite common.
- (c) (i) This was well answered.
- (ii) Many candidates calculated the mass correctly.
- (iii) Many candidates gained credit for the relationship but fewer included the use of data in their answer.

Question 6 – Specific heat capacity

- (a) Many candidates used the correct symbol for a voltmeter, although many had a line running through it, but connected it in series. Some drew it in the power supply.
- (b) (i) Stronger candidates gained credit. Some discussed the temperature being higher near the coil but did not discuss equalising the temperature through the water.
- (ii) Stronger candidates gained credit. Many thought the power was still switched on.
- (c) Many candidates multiplied the values correctly. A common response was 1800.
- (d) Rearranging the equation proved to be challenging. All permutations of the numbers were seen.
- (e) (i) Candidates found this very challenging. Not enough information in the experiment, values too high or low or misreading meters were all common responses.
- (ii) Few candidates gained credit. Removing the heater and stirring were common responses.
- (f) Candidates found this very challenging. Answers explaining that the heater was not hot enough, and that 72 °C is below 100 °C were seen quite often.