CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses. It was noticeable that the two questions involving plant diagrams were less well answered. Candidates found interpreting a graph challenging.

Chemistry:
Candidates performed very well on **Question 18** and **Question 22**.
Question 19 and **Question 27** proved very challenging for the candidates.

Physics:
In this paper candidates did not find any physics questions particularly easy or difficult.

Comments on specific questions

Question 5

This question on leaf structure had the majority of candidates incorrectly identifying the cuticle as the epidermis, and a significant number confusing palisade and spongy mesophyll.

Question 6

Although the small intestine was correctly identified as the major site of absorption by about one third of candidates, almost equal numbers selected the large intestine, and only slightly less the stomach. Candidates need to be able to distinguish the different areas and to learn the function of each.

Question 8

A significant proportion of candidates believed that glucose was produced, and water used during aerobic respiration. Candidates must be able to distinguish between respiration and photosynthesis.

Question 9

While many candidates correctly identified the sensory neurone as the structure carrying nerve impulses to the CNS, an almost equal proportion chose the motor neurone or the spinal cord. Choosing the spinal cord suggests that they consider only the brain to be in the CNS

Question 10

In this question on pollination candidates must ensure that they know the site of pollination and do not confuse it with where the pollen is produced. many also confused pollination with fertilisation.

Question 11

Candidates had great difficulty interpreting a normal distribution curve as the one most likely to be correct for student heights. Candidates need to be familiar with this form of data presentation and must read the axes carefully.

Question 12

Almost all candidates correctly identified that energy is obtained from food.

Question 17

Many stronger candidates chose the incorrect **D** rather than the correct answer, **C**. They understood that a temperature increase can be measured in an exothermic reaction. However, they did not appreciate that the temperature in the mixture was measured until the acid had just neutralised the alkali, and that the mixture would only start to cool down after neutralisation when there would be no further addition of acid.

Question 18

Candidates understood well the role of a catalyst in increasing the rate of a chemical reaction.

Question 19

Some of the stronger candidates chose the incorrect **A** rather than the correct answer, **D**. In the incorrect **A**, all four of the oxides were in the wrong columns. Candidates are required to know that metals form basic oxides and that non-metals form acidic oxides.

Question 22

Candidates were able to distinguish between the properties of aluminium that make it suitable for making food containers, and other properties of aluminium.

Question 25

More candidates, particularly some of the stronger candidates, chose the incorrect **A** than the correct answer, **B**. They needed to know that calcium carbonate neutralises acidic industrial waste, they confused its role in lowering of soil acidity with lowering soil pH.

Question 26

More candidates chose the incorrect **D** than the correct answer, **C**. The main constituent of natural gas is methane whereas air's main constituent is nitrogen.

Question 27

More candidates chose the incorrect **B** than the correct answer, **A**. Some of the stronger candidates chose the incorrect **D**. Candidates are expected to understand that poly(ethene) is made by the process of addition polymerisation, and that even though the polymer molecule is made from alkene monomer molecules, the polymer itself does not contain any double bonds.

Question 28

This question on speed−time graphs was generally well answered, although several weaker candidates opted for **C**, possibly caused by confusion with a distance−time graph.

Question 29

The most common misconception here was to believe that the pressure exerted was unaffected by the choice of block face (**D**).

Question 30

Here a considerable proportion of candidates of all abilities thought that the average speed of remaining molecules increases during evaporation.

Question 35

The topic of this question was electromagnets. All three incorrect options were popular. Candidates need to ensure that they understand why particular materials are used as the core.

Question 36

This question on electric current was found to be challenging. A significant number opted for **D**, having assumed that the p.d. across each resistor was 120 V, as would have been the case had they been connected in parallel.

Question 37

Many candidates found this question challenging, nearly one in two could not identify the mystery component.

Question 38

This was another question on electricity that also proved challenging for many.

Question 39

Almost a quarter of candidates believed that decreasing the current would produce a negative reading on the balance.

Question 40

Isotopes were not widely understood, with many candidates confusing protons with electrons and neutrons.

CO-ORDINATED SCIENCES

Paper 0654/12
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses.

Chemistry:
No Questions were particularly easy for the candidates.

Question 14 and **Question 16** proved most challenging for the candidates.

Physics:
In this paper candidates found physics **Questions 28**, **29**, **35**, **40** and, particularly, **36** very challenging.

Comments on specific questions

Question 4

This question had almost equal numbers of candidates choosing between the correct, and one of the incorrect responses. Candidates need to look carefully to see that the optimum temperature is closer to 40 °C than 30 °C when selecting the correct response, and not be distracted by the shape of the curves.

Question 9

While many candidates correctly identified the sensory neurone as the structure carrying nerve impulses to the CNS, an almost equal proportion chose the motor neurone or the spinal cord. Choosing the spinal cord suggests that they consider only the brain to be in the CNS.

Question 10

Candidates need to ensure that they know the site of pollination and do not confuse it with the site of production of pollen. They must also be able to distinguish between pollination and fertilisation

Question 11

This question was found to be very challenging. Very few candidates realised that sperm cells contain only an X or Y chromosome, not two, and were equally divided as to whether X or Y gives rise to a male.

Question 14

More candidates, particularly some of the stronger candidates, chose the incorrect **A** than the correct answer, **D**. They understood that as a result of both melting and boiling particles have random arrangements. They also needed to realise that only before melting, and not boiling, do particles have a regular arrangement.

Question 16

Many candidates chose the incorrect **A** rather than the correct answer, **D**. Stronger candidates often chose the incorrect **B**. They needed to understand that fluoride, the ion formed from a fluorine atom, has a full outer shell of electrons, although the stronger candidates did know that fluoride ions have a negative charge.

Question 17

Some of the stronger candidates chose the incorrect **C** and incorrect **D** rather than the correct answer, **A**. They are required to know the electrode products for the electrolysis of concentrated aqueous sodium chloride using inert electrodes. They appeared to confuse these with the products formed during the electrolysis of molten sodium chloride, which is not required Core knowledge.

Question 24

More candidates chose the incorrect **D** than the correct answer, **C**. They must read the question carefully; it asks which process does not cause the change in the composition of the air as illustrated by the data in the table. It is possible that candidates gave the incorrect response **D** because they knew that respiration reduces the amount of oxygen in air and increases the amount of carbon dioxide,

Question 27

More candidates chose the incorrect **A** than the correct answer, **B**. They knew that addition polymer molecules are large. They needed to recall that the carbon to carbon double bonds are absent from the polymers but are present in the monomer molecules from which addition polymers are made.

Question 28

Candidates need to be familiar with the concepts of, and units for, mass and weight.

Question 29

The most common misconception here was to believe that the object with the greatest volume (**D**) also had the greatest density.

Question 33

Many candidates did not recall the nature of the image formed by a plane mirror.

Question 35

Slightly fewer than one in three were aware of the nature of the core of an electromagnet.

Question 36

Candidates must ensure that they understand how fuses operate. The majority of candidates believed that multiple fuses were needed, opting for **A** or **B**, and a large proportion of the remaining candidates thought that a fuse in the neutral wire was correctly placed.

Question 38

Here more than one in four candidates thought that connecting a second wire in series with the first would increase the current.

Question 39

Nuclide notation was not widely understood, with many candidates unclear about the significance of proton and nucleon numbers.

Question 40

Candidates need to ensure that they understand the concept and how to carry out the calculation in this question on half-lives.

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Paper 0654/13
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses.

Chemistry:
No questions were particularly easy for the candidates.

Question 14 and **Question 20** proved most challenging for the candidates.

Physics:
In the physics section **Question 31** was very well answered, but candidates found **Questions 28**, **29**, **39** and, particularly, **36** and **40** very challenging.

Comments on specific questions

Question 4

This question had almost equal numbers of candidates choosing between the correct, and one of the incorrect responses. Candidates need to look carefully at the graphs to see that optimum temperature is closer to 40 °C than 30 °C when selecting the correct response.

Question 9

While many candidates correctly identified the sensory neurone as the structure carrying nerve impulses to the CNS, an almost equal proportion chose the motor neurone or the spinal cord. Choosing the spinal cord suggests that they consider only the brain to be in the CNS.

Question 10

Candidates must ensure that they are clear about the site of pollination and differentiate it from where the production of pollen occurs. They must also ensure that they do not confuse pollination with fertilisation.

Question 11

This question was found to be very challenging. Candidates needed to realise that sperm cells contain only an X or Y chromosome, not two, and to know whether X or Y gives rise to a male.

Question 12

Almost all candidates correctly identified herbivores as plant eaters.

Question 14

More candidates, particularly some of the stronger candidates, chose the incorrect **A** than the correct answer, **D**. They understood that as a result of both melting and boiling particles have random arrangement, they also needed to realise that only before melting, and not boiling, do particles have a regular arrangement.

Question 16

Stronger candidates often chose the incorrect **B** rather than the correct answer, **D**. They knew that fluoride ions have a negative charge. They also needed to understand that these ions have full outer electron shells.

Question 17

Stronger candidates often chose the incorrect **D** rather than the correct answer, **A**. They are required to know the electrode products for the electrolysis of concentrated aqueous sodium chloride using inert electrodes. They appeared to confuse these with the products formed during the electrolysis of molten sodium chloride, which is not required Core knowledge.

Question 20

Many candidates chose the incorrect **B** and incorrect **C** rather than the correct answer, **D**. Some of the stronger candidates chose the incorrect **A**, in which all four of the oxides were in the wrong columns. Candidates are required to know that metals form basic oxides and that non-metals form acidic oxides.

Question 21

Candidates chose the incorrect **D** more often than the correct answer, **B**. They are required to know how to use separation techniques to produce pure samples from mixtures, and specifically how crystals can be formed from an aqueous solute through crystallisation.

Question 24

More candidates chose the incorrect **D** than the correct answer, **C**. It is possible that they knew that respiration reduces the amount of oxygen in air and increases the amount of carbon dioxide, but forgot that the question asks which process does not cause the change in the composition of the air as illustrated by the data in the table.

Question 28

Few candidates were familiar with the concepts of, and units for, mass and weight.

Question 29

A very common misconception here was to believe that the object with the greatest volume (**D**) also had the greatest density.

Question 31

The great majority of candidates were secure in their knowledge of non-renewable energy sources.

Question 33

It seems likely that those who mistakenly chose option **A** knew that the image is laterally inverted, but failed to read the word "**not**" in the question. Candidates should be reminded to read questions carefully.

Question 35

Many candidates need to be aware of the nature of the core of an electromagnet.

Question 36

Candidates must ensure that they understand how fuses work. The majority of candidates believed that multiple fuses were needed, opting for **A** or **B**, and a large proportion of the remaining candidates thought that a fuse in the neutral wire was correctly placed.

Question 37

The majority of candidates could not identify the mystery component.

Question 38

Here more than one in three candidates thought that connecting a second wire in series with the first would increase the current.

Question 39

Nuclide notation was not widely understood, with many candidates unclear about the significance of proton and nucleon numbers.

Question 40

Candidates need to ensure that they understand the concept of half-lives and the calculations involved. Option **A**, equivalent to two half-lives, was particularly popular incorrect response.

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Paper 0654/21
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses.

Chemistry:
Candidates performed very well on **Question 17** and **Question 23**.

No question proved to be particularly difficult for the candidates.

Physics:
In this paper candidates performed particularly well on **Question 35** but found **Question 37** quite challenging.

Comments on specific questions

Question 9

While most candidates correctly chose pupils constricting and lens becoming thinner when viewing a distant object in bright light, many believed that the lens became fatter. Almost all correctly deduced that the pupil constricted. This suggests that they were concentrating on the light rather than the distance of the object.

Question 10

Candidates need to be clear about what is meant by pollination and what by fertilisation.

Question 12

Almost all candidates correctly identified that energy is obtained from food.

Question 17

Candidates knew well that copper sulfate solution is the electrolyte used in electroplating a nickel object with copper.

Question 22

A significant number of candidates chose the incorrect **B** rather than the correct answer, **C**. They had deduced the reverse reactivity order for the four metals.

Question 23

Candidates were easily able to distinguish between the properties of aluminium that make it suitable for making food containers, and other properties of aluminium.

Question 25

Candidates chose the incorrect **C** more often than the correct answer, **B**. They are required to know the reactions involved in the Contact process, including the essential condition of the use of a vanadium oxide catalyst in the oxidation of sulfur dioxide to sulfur trioxide.

Question 26

Candidates chose the incorrect **A** more often than the correct answer, **D**. They are required to know that the cracking of long chain alkanes produces alkenes, and can also produce alkanes and hydrogen.

Question 28

In this question on Hooke's law the most common mistake was to treat the given loaded length of 10.0 cm as the extension, leading to the choice of option **B**. Candidates must read the question carefully.

Questions 30, **32** and **33**.

These questions on the units of work and power, thermal radiation and wave terms were very well answered, causing little difficulty for a large majority of candidates.

Question 34

A common error here was to choose option **B**, this being the only one showing the formation of a real, rather than a virtual, image.

Question 35

This was the best answered of the physics questions, with echoes proving to be very well understood

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Question 37

The topic of this question was electrical energy, and more than one in three candidates opted for **B**, presumably calculating the power (3.0 × 3.0) but failing to multiply by the time. They needed to multiply by the time, in seconds.

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Paper 0654/22
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses.

Chemistry:
Candidates performed very well on **Question 17**, **Question 21**, **Question 22**, **Question 23** and **Question 25**.

No question proved to be particularly difficult for the candidates.

Physics:
In this paper candidates performed particularly well on question **35** but found questions **30** and **38** challenging.

Comments on specific questions

Question 2

Although many candidates answered this question correctly, some candidates need to be clearer about what is meant by the terms flaccid and plasmolysis.

Question 5

Almost all candidates got this question on chlorophyll right.

Question 9

While most candidates correctly chose pupils constricting and lens becoming thinner when viewing a distant object in bright light, many believed that the lens became fatter. Almost all correctly deduced that the pupil constricted. This suggests that they were concentrating on the light rather than the distance of the object.

Question 10

Candidates should ensure that they are clear what is meant by pollination and what by fertilisation.

Question 17

Candidates were able to calculate the mass of sulfuric acid using the volume and concentration specified.

Question 21

Candidates understood well the use of crystallisation to produce crystals of sodium chloride from an aqueous sodium chloride solution.

Question 22

Candidates knew very well the relationship between the number of outer shell electrons in atoms of elements and the group number of these elements.

Question 23

Candidates knew well that metals are malleable, rather than brittle, and that they are good thermal conductors.

Question 25

Candidates very easily named the four organic compounds from the diagrams of their molecular structures.

Question 28

In this question on Hooke's law the most common mistake was to treat the given loaded length of 10.0 cm as the extension, leading to the choice of option **B**. Candidates must read the question carefully.

Question 30

Many candidates were uncertain about the ultimate source of the energy resources listed.

Questions 32 and **35**

These questions on wave terms and echoes were very well answered, causing little difficulty for a large majority of candidates.

Question 34

A common error here was to choose option **C**, these candidates failing to convert the time to seconds.

Question 37

The misconception in this question on thermistors was to believe that their resistance increases when heated, leading to the choice of the incorrect option **A**.

Question 38

Candidates must ensure that they understand how fuses work. The majority of candidates believed that multiple fuses were needed, opting for **A** or **B**, and a large proportion of the remaining candidates thought that a fuse in the neutral wire was correctly placed.

CO-ORDINATED SCIENCES

Paper 0654/23
Multiple Choice

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

General comments

Biology:
The majority of candidates successfully selected the correct responses.

Chemistry:
Candidates performed very well on **Question 20**, **Question 22** and **Question 25**.

No question proved to be particularly difficult for the candidates.

Physics:
In the physics section candidates performed particularly well on **Questions 32** and **34** but found **Question 31** challenging.

Comments on specific questions

Question 2

This question, showing a plant cell undergoing osmosis, proved very challenging, with almost equal numbers of candidates choosing each answer.

Question 8

Many candidates correctly answered this question on carbon dioxide concentrations, however, a substantial number believed that less carbon dioxide was found during the night and more during the day. Candidates should consider the diagram carefully, and they also need to understand that photosynthesis only occurs during daylight.

Question 9

While most candidates correctly chose pupils constricting and lens becoming thinner when viewing a distant object in bright light, many believed that the lens became fatter. Almost all correctly deduced that the pupil constricted. This suggests that they were concentrating on the light rather than the distance of the object.

Question 10

Candidates should be clear about the process of pollination and not confuse it with fertilisation.

Question 18

A few of the stronger candidates chose the incorrect **B** rather than the correct answer, **D**. They are required to know that alkalis turn red litmus paper to blue, and that sodium hydroxide solution is an alkali.

Question 19

A significant number of candidates chose the incorrect **D** rather than the correct answer, **C**. They understood that a temperature increase can be measured in an exothermic reaction. However, they did not appreciate that the temperature in the mixture was measured until the acid had just neutralised the alkali, and that the mixture would only start to cool down after neutralisation when there would be no further addition of acid.

Question 20

Candidates understood well how increasing temperature causes an increase in the rate of a reaction.

Question 22

Candidates understood well how to recognise neutral and amphoteric oxides, as well as acidic and basic oxides, from their reaction, or lack of reaction, with acids and alkalis.

Question 23

Although most candidates chose the correct answer, **B**, a few chose the incorrect **A**. They are required to understand the specified separation and purification techniques, which includes how crystals can be formed from aqueous solutions.

Question 24

Some of the stronger candidates chose the incorrect **B** rather than the correct answer, **A**. They are required to predict the properties of elements below potassium in Group I and below iodine in Group VII using knowledge of the trends in physical and chemical properties of elements within these groups.

Question 25

Candidates knew which properties of metals make them suitable for use in aircraft parts.

Question 28

In this question on Hooke's law the most common mistake was to treat the given loaded length of 10.0 cm as the extension, leading to the choice of option **B**. Candidates must read the question carefully.

Question 29

Many candidates forgot to take into account the fact that the chair was resting on four legs rather than one and as a result they opted for **B**. Careful reading is advised.

Question 30

This question concerned kinetic energy. The approximately one in four who chose the incorrect option **B** possibly simply multiplied the mass by the speed and then looked for a match.

Questions 31

The topic here was power, and option **C** attracted well over half the candidates. They should have converted the time given to seconds.

Questions 32, **33** and **34**.

These questions on kinetic theory, wave terms and echoes were very well answered, causing little difficulty for a large majority of candidates.

CO-ORDINATED SCIENCES

Paper 0654/31
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 gained credit on all questions. Few gained no credit on any question but very few gained full credit on any question. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

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

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

Comments on specific questions

Question 1

(a) Many candidates correctly filled in three or more correct answers. Common errors were to confuse the cell wall with the cell membrane and not to know the site of photosynthesis.

(b) (i) Carbon dioxide was quite well known as the other product of respiration. Glucose was often suggested.

(ii) Diffusion was well known as the process. Candidates must ensure that they are clear about the definitions of concentration and of water potential. Few candidates referred to the random movement of particles.

Question 2

(a) The use of chlorine to sterilise water was known by some candidates. Some candidates described the killing of bacteria in water and swimming pools. Candidates need to give more detail when referring to cleaning water or cleaning swimming pools. Use of chlorine as a bleach was not well known.

(b) (i) 2, 8, 8 was well known as the electronic structure of argon.

(ii) The full outer shell of electrons was often given as the reason for the lack of reactivity of argon.

(iii) Few candidates gained any credit. Candidates should have explained that the chloride ion has more electrons than protons and that electrons have a negative charge.

(c) (i) Some candidates correctly balanced the equation. Many others attempted to change the formula of hydrogen chloride.

(ii) Very few candidates gave the response that a covalent bond contained two electrons. The common incorrect answer was eighteen.

Question 3

(a) (i) Most candidates gained some credit but few gained full credit. The commonest errors were giving the wrong symbol for a resistor and drawing the switch across the a.c. power supply.

(ii) Calculating the combined resistance of two resistors was completed correctly by many candidates.

(iii) 0.2 A was a common incorrect calculation on this question.

(iv) The correct response was that the ammeter was connected in series. However, many candidates described using wires to connect the ammeter to the circuit. Many candidates also suggested a parallel connection.

(v) The symbol for the ammeter was well known.

(b) (i) This part was not well answered. Some candidates drew the **X** too close to the mirror. Others drew the **X** at the point on the mirror where reflection occurs.

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(ii) Same size and inverted were well known as the two descriptions of the image.

(iii) Some candidates were able to do this correctly. Many others drew a ray reflected into the eye of the boy. Candidates also needed to ensure that they had the correct angles of incidence and reflection. Candidates should not draw dotted lines and should check that the arrows on the rays are going the correct way.

Question 4

(a) (i) Most candidates were able to give 31 days as the number of days of the menstrual cycle shown.

(ii) Candidates found this question challenging. Few candidates placed ticks in the correct boxes to show the days when menstruation occurred.

(iii) Candidates found this question challenging. Fewer candidates were able to place a cross in one box between day 12 and day 16 to indicate when ovulation occurred.

(b) Candidates need to ensure that they know what changes occur to the uterus lining after menstruation and that they can describe these changes. Many candidates suggested that the lining would break down again.

(c) Some candidates gained full credit and most candidates gained at least some credit. Zygote was the best known answer.

(d) Many candidates gained full credit for correctly identifying two parts of the female reproductive system through which sperm cells pass before fertilisation occurs in the oviduct. A common error was to suggest the oviduct or fallopian tube.

Question 5

(a) (i) Coal was commonly given as a fossil fuel. Oil was not accepted. The answer needed to be crude oil or petroleum. Similarly, gas was not sufficient; it needed to be natural gas.

(ii) Few candidates suggested that fossil fuels contain sulfur or sulfur compounds. Many candidates thought that sulfur reacted with carbon dioxide to produce sulfur dioxide.

(iii) Sulfur dioxide being acidic was well known.

(iv) The formation of acid rain and the consequences of acid rain in the environment were quite well known.

(b) (i) Candidates need to ensure that they know that NH_3 is the formula of ammonia. Am was a common suggestion.

(ii) Many candidates referred to the use of ammonium sulfate as a fertiliser. Some candidates described the use as neutralisation of acidic soil.

Question 6

(a) (i) The common error was to use 10 seconds as the time and not 35 seconds.

(ii) Most candidates correctly determined the length of time that the elevator travelled at constant speed as 20 seconds. Some candidates wrongly attempted a calculation.

(b) (i) Many candidates were able to correctly place both visible light and microwaves. Many others knew one of them.

(ii) Many candidates gained full credit.

(c) Many candidates explained that the steel strip would be attracted to the magnet.

Question 7

(a) Many candidates were able to suggest that the rate of transpiration was greater in the lower epidermis than in the upper epidermis. Very few candidates suggested that the rate of transpiration increases and then levels out with increasing temperature.

(b) Some candidates related the difference in transpiration rates to stomata. Very few stated that the lower epidermis has more stomata.

(c) Many candidates were able to label correctly the axes on the graph but some used the same axes as **Fig. 7.1**. Many candidates incorrectly drew a straight line similar in shape to that used in **Fig. 7.1**.

(d) Many candidates were able to start with the root hair cells and then the root cortex cells. Many reversed the order of xylem and mesophyll cells.

Question 8

(a) Some candidates were able to suggest a physical test that would demonstrate that a solid had a metallic property. Many incorrectly described magnetism.

(b) (i) Alloy was well known but compound was often suggested.

(ii) This was quite well answered. Many candidates were able to clearly identify **X** as a pure metal and **Z** as a mixture of metals. Fewer candidates linked the pure metal with a unique melting point.

(c) (i) Many candidates identified carbon dioxide as the gas given off and limewater as solution **S**.

(ii) Few candidates identified the reaction as a redox, oxidation or reduction reaction. Displacement reaction was also accepted.

(iii) Some candidates were able to explain that calcium is more reactive than carbon.

(d) (i) Candidates need to ensure that they know that bauxite is the ore from which aluminium is extracted. The most common response was iron ore.

(ii) Candidates found this part challenging. A few candidates described saving bauxite or the idea that bauxite was non-renewable.

Question 9

(a) Some candidates correctly identified negative charge followed by positive charge. Many candidates reversed the charges. The idea that opposite charges attract was well known.

(b) (i) This was well done by many candidates who gained full credit. Some candidates divided 330 by 10 instead of multiplying 330 by 10. A common mistake was to state that the unit was m / s.

(ii) Sound travelling slower than light was well known but some candidates suggested that sound travelled faster than light.

(c) (i) The correct answer was 5500 N which was calculated by adding 500 N to 5000 N. Many candidates subtracted 500 N from 5000 N and gave their answer as 4500 N.

(ii) Candidates found this part challenging. Many candidates incorrectly subtracted 1000 N from their answer to **(i)** or subtracted 500 N from 5000 N.

Question 10

(a) (i) Carbohydrate was well known.

(ii) Vitamins and minerals were well known. A few candidates attempted to get full credit by writing vitamin A and vitamin B.

(b) Many candidates knew that it was the emulsion test and the positive result. Fewer could describe the test.

Question 11

(a) All answers were fairly well known. Few candidates gained full credit.

(b) (i) The change in mass was usually correct.

(ii) The change in mass per minute was often correct. Some candidates divided 15 by 3 instead of dividing 3 by 15.

(iii) Candidates need to be familiar with the idea that materials escaped from the burner. Very few candidates identified carbon dioxide and water vapour as the two products of combustion escaping.

(c) (i) Water or steam was well known but ethene was less well recalled. Alcohol, yeast and glucose were all commonly suggested.

(ii) Fermentation was quite well known. There were no popular wrong answers.

Question 12

(a) (i) All labelled parts of the crane were suggested. Many who suggested the generator did not explain that the generator had the greatest weight.

(ii) Some candidates were able to use the product of force multiplied by perpendicular distance from the pivot to calculate the moment of the weight of the blade.

(iii) Candidates found this part of the question challenging; very few referred to turning effect in their response.

(b) (i) Some candidates knew that the kinetic energy of the wind was the first answer. Many candidates referred to wind energy. More candidates knew that electrical energy was the second answer.

(ii) Some candidates gained full credit here. Vague answers about windy weather were given as a disadvantage; they could not be awarded credit. A clearer answer would have been to suggest

that no electricity would be produced when there was no wind. Some candidates contradicted themselves stating that an advantage was no pollution and then a disadvantage was visual or noise pollution.

(c) (i) The frequency increasing was well known.

(ii) Candidates need to ensure that they know the range of audible frequencies for a human ear. Many candidates did not give a range.

Question 13

(a) This was well answered. Many candidates gained full credit. The definition of inheritance was the most well known.

(b) Many candidates gained at least some credit but very few gained full credit. Many candidates seemed to assume that there was only one tick per column.

(c) Most candidates gained at least some credit here, usually for the phenotypic ratio. Many candidates swapped the male and female gametes.

CO-ORDINATED SCIENCES

Paper 0654/32
Theory (Core)

Key messages

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

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

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

Comments on specific questions

Question 1

(a) Many candidates correctly filled in three or more correct answers. Common errors were to confuse the cell wall with the cell membrane and not to know the function of the cytoplasm.

(b) Some candidates were able to explain that photosynthesis produces glucose although many gave producing food as their response. Many candidates were able to explain that animal cells were unable to photosynthesise due to lack of chloroplasts (or chlorophyll).

(c) (i) Carbon dioxide was quite well known as the other product of respiration. Glucose was often suggested.

(ii) The process was well known as osmosis. Many candidates also suggested that the movement was across the cell (partially permeable) membrane. Very few candidates referred to the random movement of the molecules.

Question 2

(a) (i) Atomic number or proton number was well known as the quantity represented by the numbers in **Fig. 2.1**. Number of electrons was also allowed as long as there was an indication that it was the number of electrons in an atom.

(ii) Some candidates referred to other elements in **Fig. 2.1** rather than the elements whose symbols were shown. Some candidates identified the elements by name rather than by their symbol. Few candidates identified the halogen as Br.

(b) Many candidates correctly showed the electronic configuration of the phosphorus atom as 2.8.5.

(c) (i) O_2 was commonly known as the formula of an oxygen molecule.

(ii) Very few candidates described the difference between a mixture of two elements and a compound of two elements. A few candidates attempted to describe the difference in ease of separation but this was not accepted as information from **Fig. 2.3** and **Fig. 2.4** had not been used in their response.

Question 3

(a) Most candidates showed a good understanding of the energy transformations involved. A number of candidates suggested thermal energy for the second or third transformation, but this was not a response corresponding to a useful energy transfer for which the question asked.

(b) Many candidates showed good data handling skills and correctly calculated the average speed of the cyclist

(c) (i), (ii) and **(iii)** Most candidates were able to gain at least some credit and many gained most of that available. A few candidates did not show the position of their **X**, **Y** or **Z** clearly and therefore were not awarded the credit.

(d) (i) Many candidates correctly drew the circuit diagram. Candidates needed to ensure that they used thecorrect circuit symbols and drew a series circuit.

(ii) The formula for determining the resistance of the lamp was well known. Most candidates were able to complete this calculation.

Question 4

(a) (i) Most candidates correctly determined the number of teeth as 32.

(ii) Most candidates correctly completed the percentage calculation.

(iii) Many candidates were able to describe either that the sheep ate only grass or plants or that molars were used to chew or grind food. Few candidates described both.

(b) Mechanical digestion was not well known. Indigestion and chemical digestion were frequently mentioned.

(c) Care of teeth was well known to most candidates. There was credit awarded for an idea linked to oral hygiene (e.g. brush or floss teeth) and further credit for an idea linked to diet (e.g. consume less sugary food or drink).

Question 5

(a) (i) Calcium chloride was not well known but there were no popular wrong answers.

(ii) Many candidates gained credit here for knowing one or two of the gases evolved, if any. Very few candidates knew all three answers.

(b) This was not well known. Many candidates answered by repeating the question and referring to calcium atoms losing electrons.

(c) (i) The meaning of the term endothermic was quite well known.

(ii) Thermal decomposition was not well known. There were no popular wrong answers.

(iii) Few candidates correctly constructed the word equation. Many used the three correct compounds but not in the correct places.

(iv) Some candidates used the information given in the question to make a sensible suggestion.

(d) Some candidates remembered that acidic waste products were treated with limestone to neutralise them.

Question 6

(a) (i) Most candidates correctly located radio waves in the electromagnetic spectrum.

(ii) Many candidates correctly showed one wavelength using a double headed arrow, but a number needed to be more careful with the drawing of their arrows.

(iii) Candidates found this part of the question challenging. Few understood that radio waves / signals travelled at a very fast speed. Many candidates suggested that sound waves travelled very fast.

(b) (i) Many candidates did not draw straight lines. Many drew light rays which did not remain parallel until they reached the lens. Few candidates focussed the rays onto the image sensor.

(ii) The term focal length was not well known.

(c) (i) The melting point of water was not well known. 100 °C was a far more common response as were many other temperatures between 0 °C and 100 °C.

(ii) Many candidates correctly labelled the diagrams water, ice and steam respectively. A few labelled the diagrams liquid, solid and gas respectively and therefore did not gain maximum credit.

Question 7

(a) Most candidates showed some understanding of the term transpiration. However, few candidates were awarded more than partial credit.

(b) Many candidates incorrectly stated that the rate of transpiration was directly proportional to humidity.

(c) Many candidates were able to label correctly the axes on the graph but some used the same axes as **Fig. 7.1**. Many candidates incorrectly drew a straight line similar in shape to that used in **Fig. 7.1** rather than a line showing a directly proportional relationship.

(d) Xylem was not well known as the vessel in plants that transports water from the roots to the leaves. The common incorrect answer was stem.

Question 8

(a) The process of electrolysis was quite well known. Many candidates reversed the anode and cathode.

(b) (i) Few candidates correctly identified both gas **P** and gas **Q** as oxygen and hydrogen respectively. Many other gases were incorrectly suggested.

(ii) The volume of gas **P** was usually determined as 10 cm^3.

(iii) Few candidates gave at quantitative comparison of the rates of production of the two gases. Most gave qualitative comparisons such as gas **Q** is greater than gas **P** rather than gas **Q** is produced at twice the rate of gas **P**.

(iv) The rate of production of gas **P** was often correctly determined as 0.5 cm^3 / minute. A number of candidates incorrectly determined the rate as 2.0 cm^3 / minute.

(c) (i) Aluminium was not well known as the metal extracted from bauxite. Iron was often suggested.

(ii) Few candidates suggested recycling aluminium as a way of reducing the need for bauxite.

Question 9

(a) Most candidates gained some credit but few were able to correctly identify all five energy resources. Geothermal was commonly incorrect.

(b) Some candidates gained full credit here. Many vague answers about windy weather were given. A clear answer would have been to suggest that no electricity would be produced when there was no wind.

(c) A number of candidates correctly suggested that the cables might snap but few explained that this would be a consequence of the cables contracting during cold weather.

(d) (i) Few candidates correctly suggested that the temperature would remain constant whilst the water was boiling. Many suggested that it would increase.

(ii) The mass of water lost was invariably calculated correctly.

(iii) Few candidates suggested that the water was converted into steam. Evaporation was frequently suggested. This was accepted as an answer.

Question 10

(a) Candidates must ensure that they know the difference between phenotypic variation and genetic variation. Phenotypic variation is differences in physical features or appearance that may be observed. Genetic variation is differences in the genotype.

(b) Few candidates suggested correctly why the ability to roll the tongue was an example of discontinuous variation.

(c) Many candidates gained partial credit for identifying at least one of the three correct examples of continuous variation, but few candidates correctly identified all three.

(d) Many candidates gave responses which were unnecessarily complicated. A common misunderstanding was that the alleles changed.

Question 11

(a) Filtration and evaporation were well known as the two methods of separation.

(b) (i) The purpose of the condenser was not well known. Many candidates suggested that it was to allow water in and out of the apparatus.

(ii) Some candidates were able to explain that ethanol and water could be separated by fractional distillation because they have different boiling points.

(c) (i) Few candidates were able to identify the raw material as petroleum. There were no common incorrect responses.

(ii) Few candidates were able to complete the diagram of the ethane molecule, although many either drew a carbon – carbon double bond or showed four single carbon – hydrogen bonds.

(d) (i) Cracking was well known.

(ii) Few candidates knew the colour change for the bromine solution, although a number of candidates were able to give the correct initial colour for the bromine solution.

Question 12

(a) (i) Weight was not well known as the vertical downwards force.

(ii) Most candidates divided 625 000 by 10 instead of multiplying by 10.

(iii) Some candidates understood that the forces needed to balance. Many divided the force by two.

(b) (i) The dangers of ionising radiation were well known.

(ii) Many candidates incorrectly suggested beta or gamma radiation rather than alpha radiation.

(iii) Sources of background radiation were quite well known.

(iv) Many candidates incorrectly calculated the number of atoms remaining as 1 000 000 or even 2 000 000.

Question 13

(a) (i) Urine and semen were the only two correct answers. Sperm was not accepted.

(ii) Very few candidates were able to correctly identify the prostate gland.

(b) (i) Fertilisation was not well known as the term used to describe the fusion of male and female gametes. Zygote was commonly suggested.

(ii) The testes were well known as the part of the male reproductive system where gametes are produced.

(iii) The ovum was well known as the female gamete.

(c) Most candidates gained full credit.

CO-ORDINATED SCIENCES

Paper 0654/33
Theory (Core)

Key messages

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

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

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(b) Some candidates were able to explain that photosynthesis produces glucose although many gave producing food as their response. Many candidates were able to explain that animal cells were unable to photosynthesise due to lack of chloroplasts (or chlorophyll).

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(ii) The testes were well known as the part of the male reproductive system where gametes are produced.

(iii) The ovum was well known as the female gamete.

(c) Most candidates gained full credit.

CO-ORDINATED SCIENCES

Paper 0654/41
Theory (Extended)

Key messages

In calculations candidates generally showed a high level of skill in simple arithmetic and algebraic manipulation. Where errors occurred, it was usually in one of the following areas:

- Using numbers expressed in standard notation and handling powers of 10.
- Expressing answers to a sensible number of significant figures, i.e.
  a final result should be rounded up or down to a number of significant figures equal to the least number used in the data, and intermediate answers should be rounded to one more significant figure.
- Converting units, i.e.
  the units of all data should be converted to the metre, kilogram, SI system before substitution into a formula.

General comments

It was evident that the most successful responses were produced by candidates who had gained information from the question about what topics should be covered, the structure of the answer expected and terms that should be used. They ensured that their response was not simply repeating the information given in the question. They used the number of marks and the space available as clues about the number of points to be made and the required length of the response. They differentiated between the requirements of questions requiring them to *state*, *describe* and *explain*. They showed evidence of having used the syllabus in their preparation to determine the correct scientific terminology to employ in definitions and explanations of phenomena.

Comments on specific questions

Question 1

(a) (i) Most candidates recognised that the rate of photosynthesis initially increased with increasing light intensity, after which the rate stayed constant. Some suggested incorrectly that photosynthesis stopped.

(ii) Many explained the plateau part of the graph in terms of the light intensity not affecting rate of photosynthesis and some stated that another factor was limiting the rate.

(b) (i) The air spaces and stoma were often both identified as allowing efficient gas exchange in the leaf.

(ii) Many candidates correctly labelled a palisade cell in the leaf.

(c) The products of photosynthesis were well known. The question asked for formulae rather than names. The formula of oxygen was sometimes given as $6O_2$, which did not gain credit.

Question 2

(a) (i) Many candidates were adept at working out the balanced equation for the reduction of zinc oxide.

(ii) The zinc ion was recognised as being reduced due to the gain of electrons by those who knew the relationship between reduction and electron movement. Some candidates misread the question and explained in terms of the movement of oxygen.

(iii) It was quite well known that carbon cannot be used to extract aluminium due to being less reactive.

(b) (i) Some knew that bauxite is aluminium ore. Aluminium oxide was not acceptable.

(ii) Correct responses explained the need to use a molten electrolyte in terms of the mobility of ions rather than the mobility of electrons.

(iii) Some candidates knew that cryolite is used to reduce the melting point of the electrolyte.

(iv) A number of correct half-equations were provided. The entity e^{3-} was sometimes suggested.

(c) (i) Most had a good understanding of the term *finite resource*, while others incorrectly related it to abundance.

(ii) There were some good suggestions for methods to conserve aluminium based on recycling and the use of alternative materials. Other candidates confused the term *conserved* with *preserved* and suggested methods of avoiding corrosion.

Question 3

(a) (i) The majority showed how the value of the current was obtained.
i.e. $I = V / R = 12/30 = 0.40$ A.
Candidates should be aware that substituting the value into a formula and demonstrating equality does not gain credit.
i.e. $V = IR$, $12 = 0.40 \times 30$.

(ii) Most candidates could use the formula $P = IV$ to calculate the power.

(iii) Many could apply the formula $Q = It$ to find the charge but a minority knew that the time had to be converted to seconds.

(b)(i)(ii)(iii) Labelling of the generator was done well. Some candidates did not appreciate that the magnetic field line should be drawn from the north to the south pole.

(iv) Some candidates could differentiate between d.c. and a.c. The best responses were clear in describing the periodic change in current direction, rather than suggesting vaguely that the current *can* change direction. Candidates should be aware that they should avoid using the term which they are defining in their answer. Hence responses such as *the direction of the current alternates* did not gain credit.

(c) Most candidates gained some credit. The best responses gave a logical explanation to the effect that increased pitch is due to higher frequency which decreases wavelength so compressions and rarefactions become closer.

Question 4

(a) The vast majority could use the pie chart to correctly calculate the total percentage of deforestation caused by agriculture.

(b) Most responses successfully described how combustion releases carbon dioxide into the atmosphere. Many realised that trees can no longer remove carbon dioxide while not always explaining that photosynthesis is the mechanism of absorption.

(c) The best descriptions of the effects of deforestation mentioned erosion and soil movement rather making vague reference to the stability of soils. Several mentioned flooding and waterlogging. Credit was given for desertification but a link between lack of trees and drying of soil was not accepted. Although loss of nutrients through leaching or removal of fertile soil was often mentioned there were some suggestions that trees provide a net supply of nutrients to soil.

(d) Most of those who gained full credit used the syllabus definition of *ecosystem*.

Question 5

(a) Most candidates could identify at least one of the stages in the ethanol production process.

(b) There was good understanding of the nature of a hydrocarbon.

(c) (i) There were a few good answers to the chemical calculation. Most difficulty was experienced in applying the equation to use the relative numbers of moles involved in step 2.

(ii) Candidates should be aware that as the type of stove causing the least environmental damage was a choice of one from two, all available credit was awarded for the explanation. Those acknowledging that carbon dioxide is a greenhouse gas which contributes to climate change gained full credit. Statements that the butane stove produces less carbon dioxide added nothing to the information in the question and did not gain credit.

Question 6

(a) (i) Visible light was usually placed in the correct region of the electromagnetic spectrum.

(ii) Some candidates knew the speed of light. An answer of 300 000 was often given, suggesting some difficulty with units.

(b) (i) There were many good suggestions for the speed of sound in water, with explanations placing the value between that of air and steel or describing its dependence on the physical properties of solids, liquids and gases.

(ii) Most candidates attempted to calculate the difference between the times taken for sound to travel through each medium. Difficulties were apparent in rearranging the formula $v = x / t$ and in converting km to m.

(iii) Those who could rearrange the formula $v = f\lambda$ could usually calculate the wavelength.

(iv) The best responses compared the direction of oscillation or vibration with the direction of longitudinal and transverse wave travel. Less successful descriptions used the term *wave direction* for the displacement and the propagation. There were some good attempts at drawing useful diagrams although these often lacked a label showing the direction of wave travel.

Question 7

(a) (i) Most candidates calculated the rate of diffusion correctly.

(ii) The relationship between temperature and the rate of diffusion was usually correct.

(iii) Most suggestions for variables that should be kept constant were valid.

(b) There were many good answers explaining that the dye particles move from the solution where concentration is highest, down the concentration gradient into the agar cube. The random motion of dye particles was not often cited as the mechanism.

(c) Most knew that carbon dioxide is the product of respiration diffusing out of cells.

Question 8

(a) (i) Some candidates realised that nitrogen and chlorine are diatomic so their relative molecular masses are twice their relative atomic masses.

(ii) Those who knew that diffusion rate increases with decreasing relative molecular mass identified nitrogen correctly.

(b) Most candidates could work out the structure of the two isotopes of chlorine.

(c) (i) Some candidates applied their knowledge of the trend in reactivity down Group VII to predict the observation of halogen displacement.

(ii) The correct word equation was provided by most candidates, including some who did not predict the correct observation.

(d) Many candidates who succeeded this far did not predict ”no reaction” when aqueous chlorine is added to aqueous sodium fluoride. There was some confusion between the use of the words *fluorine* and *fluoride*.

Question 9

(a) (i) There were several good speed–time graphs. Successful candidates drew a line from 0,0 to 1.0,1.6, extrapolated the graph and stopped at 1.3 s. The best graphs dropped to 1.3,0. Others incorrectly continued the line at 2.1 m / s.

(ii) The best responses clearly described the differences between the results for the hammer and for the feather obtained on Earth and those obtained on the Moon. They stated that **the hammer** took less time **on Earth** due to the greater acceleration due to gravity **on Earth**, and that **on Earth** the feather took more time **than the hammer** due to air resistance.

(b) Successful candidates realised that a white surface absorbs less thermal radiation than a black surface, reducing the chance of the astronaut overheating. Others suggested that white suits reflect all thermal radiation. Responses referring to the reflection of other radiations were not credited.

(c) Most candidates could suggest a harmful effect of ionising radiation.

(d) Correct symbol equations depended on candidates knowing that atomic and mass numbers are conserved, and correctly identifying the daughter element from the Periodic Table.

Question 10

(a) (i) Many candidates correctly identified the lumen and wall of the vein. Some labelled the surrounding tissue as the wall.

(ii) The existence of valves in veins was known by some.

(b) Many explained that the wall of the artery is thicker than the wall of the vein to prevent bursting under the higher pressure. Use of the word *burst* was less ambiguous than terms such as *contain.*

(c) Most candidates could state two lifestyle factors that increase the risk of developing coronary heart disease.

(d) (i) Adrenalin and insulin were usually named correctly.

(ii) A few responses stated that auxin causes plant cells to elongate. Most described the plant moving towards the light, suggesting that the question had been misread.

Question 11

(a) (i) Most methods of measuring the rate of carbon dioxide production included the use of a gas syringe to collect the gas. Some candidates may have had more success in describing other methods if they had drawn a detailed diagram. Few went on to explain that the rate would be calculated by dividing the volume by time.

(ii) Many candidates were aware that the rate of reaction was greater at higher temperature. They may have found the explanation more straightforward had they concentrated on the *initial* rate. Good responses went on to identify the cause as increased rate of collision of particles and that more collisions would be successful. A few candidates explained that more particles would have the activation energy or sufficient energy to react.

(b) There were a few good descriptions of the method for making lead chloride. They chose a soluble lead salt and a soluble chloride. They realised that aqueous solutions of each salt had to mixed rather than adding the two solids to water. They were clear in stating that the product is the residue in the filtration process.

(c) Strong bonding was often identified as the cause of the high melting point of lead chloride. The question required reference to the structure as an ionic lattice or a giant structure so reference to intermolecular forces prevented credit being awarded.

Question 12

(a) A few candidates could name two of the energy resources not having the Sun as their source, from nuclear, geothermal and tidal.

(b) The increase in pressure caused by increase in temperature was usually explained by the increased speed of particles and their increased rate of collision with the tyre walls. Collision between particles was not accepted.

(c) Most knew that raising the centre of mass would lead to instability. Those who tried to describe the effect of instability succeeded if they referred to the increased tendency to topple on the slope rather than stating that it would topple.

(d) (i) The ray diagram was drawn accurately by many candidates.

(ii) Some candidates knew that refractive index = $\frac{\text{speed of light in a vacuum}}{\text{speed of light in glass}}$

Many got into difficulties describing the ratio. Others described refraction.

(iii) There were some good comparisons of real and virtual images concerning projection on a screen or whether light rays pass through the image. Less successful attempts described the images formed by particular devices. Some showed confusion with the term *virtual* used in a computer science context.

(e) Most candidates knew that strong forces between atoms cause solids to have a fixed shape.

Question 13

(a) In explaining the importance of the shape of an enzyme, many candidates knew the significance of the active site. Some could describe the substrate fitting or binding to the active site. There were few references to the active site and the substrate having complementary shapes. Many explanations referred to nutrient or reactant rather than to substrate or molecule.

(b) The strongest responses included an explanation that followed logically from the results, typically that solution C contained an enzyme because enzymes are proteins and proteins turn Biuret reagent purple.

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.

- Calculations were generally done well with working shown. Candidates are expected to round their answers up or down to an appropriate number of significant figures. These skills were required in **Questions 6(a)(ii)** and **12(b).**
- It would be beneficial for candidates to practise expressing values in standard form as well as converting units as this proved problematic for some. Forgetting to convert the units was particularly evident in **Questions 3(a)(i)** and **6(a)(ii)**.
- Candidates should be encouraged to read the question carefully and to complete all the instructions contained within the question. Questions where candidates had to annotate diagrams such as **4(a)(ii)**, **5(b)(i)**, **7(a)** and **10(a)(i)** were often omitted.

General comments

The number of marks available for each question on the right-hand side and the number of answer lines provided is a good indicator of level of response required by the candidate. Candidates should be reminded to read the stimulus material in each question carefully and complete all the instructions contained within the question and not to write down scientifically correct but irrelevant information.

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 credit directly as well as being an aid to language used in explanations.

There were several instances were candidates rewrote the stem of the question instead of providing new information in their answers. It would be beneficial for some candidates to practise highlighting key information in the stem, particularly the command words, to identify what is expected from them in their responses.

Comments on specific questions

Question 1

(a) (i) Nearly all the candidates were able to identify the correct optimum temperature.

(ii) Many candidates could describe the enzyme as becoming denatured at high temperatures. Fewer explained denaturation in terms of changes to the shape of the active site of the enzyme preventing successful collision of the substrate and enzyme.

(b) The most common error that prevented candidates from achieving full credt was to draw the peak of the graph at neutral rather than in the acidic region. Most candidates labelled the axes correctly.

(c) This proved more challenging for candidates, with many confusing Biuret reagent with Benedict's solution. Those candidates that did identify the correct colours, generally also described enzymes as being proteins.

Question 2

(a) (i) The correct answer of nitrogen as the major component of air was the most commonly seen. Few candidates identified methane as the major component of natural gas. The most common incorrect answer being nitrogen or hydrogen.

(ii) Few candidates were awarded all the available credit. The correct answer of carbon dioxide was commonly seen. Fewer candidates gave water and common incorrect answers included nitrogen and hydrogen.

(b) Most candidates gave the correct process of cracking. Occasionally incorrect answers of polymerisation and the Haber process were seen.

(c) (i) Occasionally candidates tried to make two products rather than one correct product. However, this was rare and the majority of candidates gave the correct answer.

(ii) Some of the candidates found this part of the question challenging; with a number giving the incorrect answer of yeast. Other common incorrect answers seen were alcohol and oxygen.

(d) (i) Candidates found this question more challenging and there were a number that gave no response. Of those that did, few gained full credit. Most of the candidates that attempted this question could identify ethene as the monomer. Fewer described many ethene monomers combining to form a polymer.

(ii) Inclusion of a double bond was a common incorrect response. Occasionally candidates forgot to include brackets. Another common misconception was that there had to be a chain of three carbon atoms in the formula.

Question 3

(a) (i) How to calculate kinetic energy was generally well known and understood. The most frequent error seen was to not convert 46 g into 0.046 kg, resulting in an answer of 57500 J. A useful skill for candidates to practise is converting units from one form to another and using this in calculations.

(ii) Most candidates could distinguish between the terms speed and velocity, commonly referring to velocity having direction.

(b) (i) Most candidates could identify the correct range of masses. Some candidates gave the entire range from 0 g to 600 g. The explanation was less successful with many candidates describing why values past 400 g did not show Hooke's law rather than why the values between 0 g to 400 g did.

(ii) A number of candidates divided 10 by 1.6 rather than the other way around. Those that completed the first calculation were usually able to calculate the correct answer of 48 g.

(c) (i) The vast majority of candidates could state the correct energy transfer as radiation.

(ii) Candidates should ensure that they know the difference between fusion with fission; a large number of candidates confused them. Occasionally other incorrect answers such as radioactivity and combustion were seen.

Question 4

(a) (i) The part labelled **A** was commonly identified as the waxy cuticle. The incorrect answer of upper epidermis was frequently seen. **B** was commonly identified as the lower epidermis. The incorrect answers of stomata or guard cells were also often seen.

(ii) Most candidates were able to draw an arrow to show the pathway of carbon dioxide entering the leaf. Candidates should be encouraged to read all the material given to them and to use the mark allocation on the right-had side of the page to inform them of the marks available for each question part.

(b) This question was generally well answered with a range of suitable features given. Very occasionally candidates gave features of cells in the spongy mesophyll layer.

(c) Candidates found this very challenging with many trying to describe chlorophyll itself rather than the role it plays in the leaf. Some candidates could describe the synthesis of carbohydrates with most giving the named example of glucose. Fewer described chlorophyll transferring light energy to chemical energy.

(d) This question was very well answered. Very few candidates muddled photosynthesis and respiration and only a very small number gave the word equation.

Question 5

(a) (i) The majority of candidates were able to give the correct answer of filtration. A very few candidates gave the incorrect answer of fractional distillation.

(ii) Candidates needed to describe how filtration works rather than describing the method used by the candidate in the question.

(b) (i) Those that did answer this question generally gained credit with only a few drawing a line over or touching the green spot.

(ii) Most candidates were able to correctly identify xanthophyll and compare its position to its R_f value.

(iii) This proved very challenging for candidates. Few realised that they had to use the chromatogram to extract the compound. A number of inaccurate answers were seen including, fractional distillation of the compound or drying the chromatogram. A number of candidates suggested starting with a pure orange substance.

Question 6

(a) (i) Most candidates were able to correctly calculate the resistance. The most common error was to forget to invert the answer or to add the two resistances together.

(ii) Some candidates completed this with well-laid-out, clear answers. Common errors were to use 16.5 as the resistance rather than the figure of 33 and forgetting to convert the time into seconds. Candidates should be encouraged to write out their formulae and write answers out in a logical clear manner.

(b) (i) The majority of candidates could describe molecules colliding with the walls of the tyre. Fewer describe this as exerting a force with most referring to exerting a pressure, which was already given in the question.

(ii) This question was very well answered with the majority of candidates gaining credit.

(c) (i) Candidates need to ensure that they understand the process of thermal conduction and can explain it. Many candidates used the terms particles and electrons interchangeably. Often candidates stated that increased thermal energy would cause the particles to start to move rather than increase the speed of their vibration. Several candidates referred correctly to delocalised electrons but fewer were able to correctly describe their role in the transfer of thermal energy often confusing this with electrical conduction.

(ii) Many candidates could describe the stronger attractive forces in a solid. Some candidates were able to describe the particles in a gas as moving freely but fewer referred to particles in a solid being in a fixed arrangement. These ideas needed to be combined to gain full credit**.**

Question 7

(a) This question was well answered with most candidates identifying the septum. Occasionally the **X** was drawn too low on the muscular wall of the ventricle. Very occasionally the valves were mistaken for the septum.

(b) Candidates must read the question carefully and ensure that their answer is relevant. There were many excellent descriptions of the double circulatory system, however, this was unnecessary and

did not answer the question. Candidates needed to refer to the atria or ventricles, and to describe muscular contraction.

(c) Most candidates gained at least some of the available credit, usually for stating vena cava or pulmonary vein. Several candidates stated other blood vessels and whilst they may have been veins, they were not the veins of the heart and so were not creditworthy.

(d) (i) This question was generally well answered, with stopping smoking and reduction of consumption of fatty food frequently seen. Occasionally candidates suggested increasing consumption of fruit and vegetables, without also referring to the reduction of consumption of fatty food. More detail was required to gain credit.

(ii) Most candidates gave reference to genetic factors. A few candidates did not appear to know what non-lifestyle factors meant and gave other ways to improve a person's lifestyle.

Question 8

(a) (i) This question was well answered by most candidates, with many giving a correct balanced equation. Occasionally Fe_2 and Al_2 were seen rather than 2Fe and 2Al.

(ii) This proved challenging for most candidates. Candidates need to ensure that they understand what is meant by oxidation and reduction and by the terms oxidising and reducing agents. Those candidates that did identify aluminium as the reducing agent often stated that the oxidising agent was iron rather than iron oxide or Fe^{3+} ions.

(b) (i) Many candidates had the right idea but found it challenging to express it clearly. Some candidates correctly described the heat as supplying the necessary activation energy. A number of candidates inaccurately described the heat increasing the activation energy or referred to speeding up of the reactions.

(ii) This question was very well answered with many candidates gaining credit. Some candidates needed to be more detailed in their responses not only referring to a decrease in chemical energy but also mentioning the chemical energy in the products or reactants.

(c) (i) Some good diagrams and descriptions were seen. Many candidates chose not to include a diagram, which was acceptable if a clear description was given. A number of candidates tried to describe ionic or covalent bonding. Those who did correctly identify metallic bonding often referred to a sea of delocalised electrons. Fewer referred to positive iron ions, with a number of references to iron atoms.

(ii) Most candidates correctly described an alloy as a mixture of metals.

(iii) A wide range of answers were seen with many candidates referring to differences in melting and boiling points as well as malleability, ductility and hardness. Responses giving vague references to strength were not awarded credit.

Question 9

(a) (i) Most candidates were able to describe frequency, with a few candidates giving descriptions of pitch or amplitude instead.

(ii) This question was well answered and candidates clearly understood what the audible range is for humans. A few candidates gave the audible frequency range for humans rather than a frequency outside the upper limit.

(iii) Some good definitions of longitudinal waves were seen. Some candidates need to be clear about the difference between longitudinal and transverse waves.

(b) Most candidates drew accurate diagrams. Accuracy in drawing the angles of reflection is important if full credit is to be gained.

(c) Candidates must read the question carefully. Many candidates thought that there were 3×10^{14} atoms remaining rather than 1×10^{14}. However, there were also many candidates that gained full credit.

Question 10

(a) (i) The stronger candidates were able to draw correct arrows across the cell membrane.

(ii) A number of candidates incorrectly chose cell C. Those candidates that did choose cell D often only referred to a greater concentration inside than outside the cell rather than a greater concentration gradient.

(b) (i) Candidates need to be able to distinguish between the biological processes of egestion and excretion. The meanings of these terms are both stated in the syllabus and are not interchangeable. Candidates that gained credit generally referred to removal of waste products from the body. Fewer referred to toxic materials, waste products of metabolism or materials in excess.

(ii) Candidates should make sure that their answer is relevant and of the appropriate length. This question specifically asked for the pathway of carbon dioxide from the blood to outside the body. Candidates needed only to describe the pathway of carbon dioxide through the structures of the gas exchange system rather than explaining diffusion or the processes of inhalation and exhalation.

Question 11

(a) This question was correctly answered by many of the candidates.

(b) (i) Most of the candidates gave a temperature within a suitable range. However, there were occasional answers of 0 °C and 2000 °C seen.

(ii) An increase in yield was a commonly seen response. Frequent incorrect answers included reference to saving energy or safety.

(iii) Many candidates referred to less kinetic energy of the particles. Some candidates described this as decreasing the number of collisions rather than referring to collision frequency. The stronger candidates linked this with a decreased rate of reaction.

(c) Only some candidates gave the response oleum. Some candidates tried to deduce the name by referring to the formula, however these were rarely successful.

(d) Stronger candidates mostly gained full credit. Steps 1 and 2 were generally answered correctly, although incorrect answers of 15.6 were frequently seen. Step 3 proved more challenging with the value of 196 often given. Step 4 usually gained credit by a calculation of step 2 multiplied by step 3.

Question 12

(a) Most candidates could describe the caterpillar tracks as providing a larger surface area, with most of these linking the idea of this lowering the pressure. Occasionally candidates muddled the ideas of force and pressure.

(b) The correct calculation was frequently seen. The majority of candidates wrote out their calculations in a clear manner. There were occasional inaccuracies in the rounding of the final figure. Rounding of figures correctly and to the appropriate number of significant figures is a skill that would be useful for candidates to practise.

(c) Many candidates just repeated the information that was found in the stem of the question in various ways. A number of candidates identified that these were transverse waves.

(d) There were some excellent responses seen. Candidates should be reminded to use the correct terminology and refer to an electromotive force as being induced. To be awarded full credit

candidates needed also to make a point of specifying that a change in direction of the electromotive force occurred every half turn.

Question 13

(a) (i) There were some excellent responses with many candidates giving detailed and accurate explanations of the initial part of the process of eutrophication.

(ii) Many candidates found this part of the question challenging; they often missed the involvement of decomposers which limited the credit available to them. Some candidates tried to explain the death of the fish in terms of lack of food source. Some credit was given to candidates that suggested that a lack of oxygen in the lake was caused by a lack of photosynthesis.

(b) Many candidates knew the role of magnesium ions in a plant. Fewer candidates could link the synthesis of amino acids with the role of nitrate ions. A number of candidates referred to the element nitrogen rather than nitrate ions.

CO-ORDINATED SCIENCES

Paper 0654/43
Theory (Extended)

Key messages

In questions involving a calculation, once the correct mathematical relationship was established there was seldom a mistake in algebraic or simple arithmetic processes.

Candidates in this examination need to be able to use numbers expressed in standard notation and to handle powers of 10.

They need to express answers to a sensible number of significant figures, i.e. a final result should be rounded up or down to a number of significant figures equal to the least number used in the data, and intermediate answers should be rounded to one more significant figure.

They should convert units, i.e. the units of all data should be converted to the metre, kilogram, second system before substitution into a formula.

General comments

Candidates should take the time to read instructions in the stem and question part carefully. They often contain information about areas that should be covered, a suggestion for the structure of the answer and terms that should be used. They should check that their answer is not simply repeating the information given in the question. There were instances where candidates had answered a question they had met before which was different to that in this paper. The number of marks and the space available give clues about the number of points to be made and the required length of the response.

Comments on specific questions

Question 1

(a) (i) Almost all candidates read the correct optimum pH from the graph.

(ii) In explaining why the enzyme was inactive at pH 12, most candidates stated that the enzyme was denatured. Fewer explained this in terms of the change in shape of the active site. Some knew that the substrate no longer bonded to the active site. There were few references to the active site and the substrate no longer having complementary shapes.

(b) Candidates who succeeded in answering this question were able to apply their knowledge of the factors affecting the rate of chemical reactions to the context of enzyme activity and gave an explanation at the molecular level. Good responses identified the cause of increased activity as increased rate of collision of particles and that more collisions would be successful. Few candidates explained that more particles would have the activation energy or sufficient energy to react.

(c) (i) Some candidates gave a complete list of the constituent elements of proteins.

(ii) Those who knew that Biuret solution is used to test for proteins usually gave the correct colour change.

Question 2

(a) Many candidates recognised that process **A** was fractional distillation but most were challenged by naming the industrial processes.

(b) Some knew that boiling point enabled naphtha to be separated from the mixture.

(c) Some candidates recognised an endothermic reaction. While some knew that bond breaking takes energy in, very few made a comparison between the amount of energy taken in during bond breaking and the amount of energy given out in bond making.

(d) Several candidates knew that hydration of ethene requires high temperature and high pressure.

(e) (i) Ethene was often identified as the monomer. It was seldom made clear that a large number of monomer molecules are involved.

(ii) Good responses explained the difference in reactivity of ethene and poly(ethene) in terms of saturation. Many candidates thought that reactivity was dependent on length of the molecule.

Question 3

(a) (i) Many candidates stated that force **Q** was greater than force **S** during acceleration. Some found it challenging when they attempted to describe changes in the forces.

(ii) Almost all candidates knew that force **R** was the weight of the aircraft.

(iii) Most knew that weight is the effect of *gravitational* field on a mass, while some others wrote *magnetic*.

(b) The calculation of acceleration from the graph was done well with many choosing the correct units.

(c) Many candidates stated that an aircraft gains kinetic energy at take-off but fewer suggested gravitational potential energy.

(d) (i) Strong answers stated that a compression is a region of higher pressure or where particles are more closely packed rather than suggesting that waves are forced closer together.

(ii) Better responses described wavelength as the distance between successive compressions rather than the width of a compression.

Question 4

(a) (i) Most candidates counted the number of trophic levels correctly.

(ii) One of the producers was usually correctly allocated to the first trophic level.

(iii) Many candidates constructed a food chain to include a tertiary consumer. They gained credit if they followed the instruction in the stem of the question and drew a food chain originating from the food web in the figure.

(b) Most explanations recognised that the limpet population decreased due to increased predation by crabs. Some candidates assumed that this is caused by the decrease in population of mussels as stated in the question rather than specifying that it is due to loss of mussels as a source of food for the crabs.

(c) Respiration was often described as chemical reactions releasing energy. General terms such as *food* were sometimes used instead of nutrient or glucose.

Question 5

(a) (i) A few candidates explained the shape of the graph correctly by referring to the decreasing rate at which carbon dioxide is collected or the decreasing rate of reaction. They noted that the concentration of acid decreases as it reacts which leads to a decreased frequency of particle collision. Many responses suggested that due care had not been taken in reading the question. Some answered as if the acid is in excess. Others responded as if they had been presented with a graph of rate against temperature.

(ii) Some candidates drew the 30 °C graph correctly. Most graphs showed a greater initial rate although they did not always plateau at the same volume as 20 °C, or reach the maximum earlier.

(b) (i) Most candidates used the graph to find the correct volume of gas produced in 10 minutes.

(ii) Those who could use the molar volume to calculate the number of moles of carbon dioxide could not often use the equation to find the number of moles of acid used.

(c) Some candidates realised that one mole of each compound contains the same number of molecules to give a ratio of 1 : 1.

Question 6

(a) Those who knew the formula P = F/A usually calculated the correct digits for the value of pressure. Many found difficulty in converting cm^2 to m^2 so arrived at an incorrect power of 10.

(b) Several candidates knew the formula for refractive index: n = sin i/sin r. Some inverted the ratio in their calculation. Some evaluated i/r.

(c) (i) Most responses included the fraction 3.0/6 to show that the wavelength is 0.5 m.

(ii) Those who could rearrange the formula $v = f\lambda$ usually calculated the correct frequency.

(d) (i) One of the dangers of exposure to ionising radiation was usually suggested.

(ii) The differences between α and β-particles were well quite known.

(iii) Those candidates who worked back to write out a decay equation usually arrived at the correct symbol for the daughter nuclide. Most found this question challenging.

Question 7

(a) Most candidates concluded that the green part of the leaf tested positive for starch. Many stated that this was due to photosynthesis. Fewer explained that photosynthesis produces glucose and that this is turned into starch.

(b) A few named the magnesium ion as the mineral ion needed to make chlorophyll. There were many other suggestions, some of which were molecules.

(c) Several candidates described the transport of carbohydrate from a source to a sink through the phloem. Very few used the term *translocation* or stated that sucrose was the carbohydrate that is distributed.

(d) Most candidates knew that carbon dioxide is needed for photosynthesis. Some wrote $6CO_2$, and others wrote the name of the compound even though the formula was required by the question.

(e) The term *cohesion* was not well known.

Question 8

(a)(i) and **(ii)** The electronic structure of a sodium atom and its relationship with group number were well known.

(b) (i) Where the change in indicator colour was known, the initial colour was often omitted. A common misconception was that sodium hydroxide is acidic.

(ii) Those who knew that rubidium is more reactive than sodium could often describe the similarity and difference in the reactions. Sometimes this was explained by the trend in reactivity down the group.

(c) The arrangement of ions in sodium chloride was usually drawn well.

Question 9

(a) Good explanations of why a solid expands less than a gas contrasted the strength of bonding and whether the molecules are in fixed positions or free to move. Candidates often gained partial credit from the description of the structure of a solid and another from that of a gas.

(b) A few candidates were familiar with thermocouples. Many described a thermometer.

(c) (i) Many candidates calculated a correct value for the resistance of the hotplate from the Ohm's law formula.

(ii) Fewer candidates applied the formula E = V*I*t to find the energy supplied to the hotplate.

(iii) The best descriptions of the differences between water and steam used the question to structure their answer into a comparison of forces, distances and motion.

Question 10

(a) (i) Candidates gained most credit by comparing the distribution of oxygenated and deoxygenated blood, the number of atria or ventricles and the use of lungs or gills. Those who described the human circulatory system simply as double circulation were more likely to be awarded credit than those who attempted to describe the paths of blood through the system.

(ii) Several were familiar with the septum as a structure in the human heart.

(b) Some could apply their knowledge of gas exchange in lungs to suggest features allowing efficient gas exchange in the gills. Others described features of individual cells.

(c) Several descriptions of the role of arterioles in reducing body temperature included the term *vasodilation*. Other wording used to describe the widening of arterioles was sometimes ambiguous. The best descriptions described increased blood flow to the skin allowing loss of thermal energy, although the need to route more blood to internal organs was a common misconception. Capillaries in the skin surface were rarely mentioned.

Question 11

(a) The fact that carbon reacts with oxygen in the blast furnace was quite well known.

(b) (i) Fewer candidates identified carbon monoxide as the reducing agent.

(ii) The few successful responses were based on the guidance, given by the question, to refer to *atoms, ions* and *electron transfer*. Thus " *electrons* are *transferred* to iron *ions* to form iron *atoms*" gained full credit.

(c) The chemical basis of the removal of acidic impurities in the blast furnace was not well known.

(d) (i) Some candidates understood that aluminium cannot be extracted in a blast furnace due to its high reactivity.

(ii) A few candidates were aware of the oxide layer which prevents the corrosion of aluminium.

Question 12

(a) The formula for calculating efficiency was well known. An incorrect result was most likely to be due to difficulty in obtaining data from the diagram.

(b) Those who knew the formula Q = It usually calculated the correct charge.

(c) (i) Several candidates identified the split ring commutator. There was some confusion with the term *slip ring*.

(ii) The arrow showing the direction of the magnetic field was sometimes drawn correctly as a straight line between the poles.

(iii) There were some good explanations of the movement of the coil of the motor. Some candidates found describing the interaction between the fields challenging. Descriptions involving attraction and repulsion between the coil and magnets were not acceptable. Candidates need to be clear about the differences between the working of a motor and a generator.

Question 13

(a) Most candidates noticed that the time taken by the dye decreased as the temperature was increased.

(b) Most explanations stated that particles move from high to low concentration. Some identified the process as diffusion, although there was some confusion with osmosis. Fewer described the dye particles as moving randomly until their distribution is uniform.

CO-ORDINATED SCIENCES

Paper 0654/51
Practical Test

Key messages

To achieve well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves, as possible.

Drawings of apparatus should be done with a pencil and ruler and should be labelled. 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.

Centres are provided with a list of required apparatus well in advance of the examination date. Where centres wish to substitute apparatus, it is essential to contact Cambridge International to check that the change is appropriate and that candidates will not be disadvantaged. Any changes must be recorded in the Supervisor's report.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical biology, chemistry and physics techniques.

The majority of candidates entering this paper were well prepared and able to demonstrate some ability and understanding across the whole of the range of practical skills being tested. All parts of every practical test were attempted and there was no evidence of candidates running short of time. The majority of candidates were able to follow instructions correctly and record observations clearly.

The gathering and recording of data presented few problems for any candidates. There was evidence of some candidates not having the use of a calculator.

Comments on specific questions

Question 1

(a) (i) The heading and its corresponding unit was usually inserted correctly. The abbreviation "m" was not accepted for "minutes", although "min(s)" was. A minority of candidates did not read the question carefully enough, and inserted seconds as the unit of time.

(ii) Most candidates produced a full table of results with the temperatures of the water in the test-tubes showing the expected decreasing trend. Candidates should have recorded the temperatures to the nearest 0.5 °C. Many tables showed that the larger test-tube produced a greater fall in temperature of the water than the smaller one over the 5 minutes, when this should not have been the case.

(b) (i) Most graph axes were correctly labelled, but often a scale was chosen which was too small, so much of the graph paper was left unused. Candidates should choose a graph scale that will ensure that the plotted line or curve fills at least half of the grid.

(ii) The plots were generally accurate, although often untidy. Many candidates drew large "blobs" to display the plotted points and left it to the examiner to decide where the centre of the point was. Candidates should be encouraged to use thin crosses, with the intersection of the two cross lines at the point being plotted. Reasonable attempts were made at drawing a curve of best fit for both sets of points. Occasionally candidates did not follow the instruction given and left the curves unlabelled.

(c) (i) The drop in the temperature of the water in both test-tubes during the time of cooling was usually calculated correctly.

(ii) Candidates needed to compare both graphs and give a correct comparison between the rate of heat loss from the test-tubes. Candidates were expected to compare the gradients of the curves or to compare the temperature drops shown by each graph in the same time, and link this to the rate of heat loss of the test-tubes.

(iii) The stronger candidates were able to use their results from **part (ii)** and make the link that smaller animals needed more energy from their food for each gram of body mass than adults, because the rate of heat loss is greater for small animals.

Question 2

The question discriminated well, with the full range of marks being awarded to candidates.

The question involved planning an experiment to compare the amount of heat given out when three given acids reacted with an alkali. Many candidates found it challenging to name an alkali, particularly one suitable for using in this experiment.

Most candidates used a suitable vessel in which to carry out the reaction. Most found the requirement to state how they would reduce heat losses while the reaction occurred very challenging. Details of the apparatus and method of carrying out the experiment needed to be included.

The majority of candidates incorrectly added the alkali to the acid and then proceeded to take temperature readings at fixed intervals of time, while the temperature of the mixture was increasing. The stronger candidates understood that the initial temperature of the acid should be taken before adding the alkali, and then to wait and record the highest temperature reached by the mixture.

Most candidates were able to identify one control variable so that the comparison would be a fair one. The most popular correct chosen variable was the volume of the acid / alkali. Far less frequently did candidates realise that the same concentrations of acids / alkalis should be used and that the starting temperature for each experiment should be the same.

Credit was available for explaining how the readings taken could be used to make a comparison about the amount of heat given out in each reaction. This was seldom awarded, because candidates had carried out an incorrect procedure. What was required was that the temperature rise for each reaction be calculated. The greater the temperature rise, the greater the amount of heat given out during the reaction.

Question 3

(a) (i) The time for 20 oscillations was recorded by all candidates. Most candidates timed the oscillations accurately and recorded a value within the tolerance limits required.

(ii) The time T for one oscillation was calculated incorrectly by many candidates. Instead of dividing their answer in **(i)** by 20, many candidates divided their answer in **(i)** into 20.

(iii) The value for T^2 was usually correct. Answers were accepted to any number of significant figures.

(b) Credit was awarded for the accuracy of the measurements made here. Any calculated value of g of 10 ± 2 (m / s^2) gained credit. Additional credit was awarded for candidates expressing their answer to 3 significant figures, as asked for in the stem of the question. Many candidates did not follow this instruction and answers were quoted to a variety of significant figures.

(c) Most candidates gave a full set of values here. The majority of answers showed correctly that the value of the period T had increased.

(d) Most calculations were correct.

(e) A correct comparison between the two measured values of the acceleration due to gravity, *g*, was usually made, with candidates stating whether their values agreed, or not, with the actual value of 9.8 m / s^2. Far fewer candidates went on to state why they considered that there was / was not agreement between the values.

Answers such as "the values are very close / not too far apart / within 10% of each other" were accepted. The reverse argument applies if candidates stated that their values disagreed with the value 9.8 (m / s^2).

(f) (i) The frequency calculation was almost invariably done correctly.

(ii) Candidates found this final part challenging. Candidates needed to realise that if the oscillations take a longer time to complete, then any error in the timing or reaction time errors in starting and stopping the stop-clock would be less significant.

Question 4

(a) Candidates were awarded credit for drawing an enlarged, clear and continuous outline of the piece of fruit. Some further detail of the centre of the piece of fruit was also expected. To gain credit the diagrams needed to be carefully drawn and large enough. When candidates are asked to make an enlarged drawing, it is expected that their drawing will fill at least half the box provided for them to draw their diagram in.

(b) (i) The diameter of the piece of fruit provided was usually measured and recorded to the nearest millimetre. Occasionally candidates confused the unit mm with cm, and it was obvious that they had measured the diameter in centimetres, despite the unit mm being given on the answer line.

(ii) Usually, a measurement was provided for the diameter of the drawing. Despite the requirement stated in the question, that a line be drawn on their diagram to show this diameter, no line had been drawn by many candidates. In these cases, no credit could be awarded.

(iii) The calculation of the magnification was usually done correctly. Answers were accepted to any number of significant figures. A minority of candidates incorrectly divided the diameter of the actual fruit by the corresponding diameter on their drawing.

(c) The name of the reagent used to test for the presence of reducing sugar was well known, as was a colour that indicated a positive test for the presence of reducing sugar.

Question 5

(a) (i) Few candidates observed that effervescence occurred when aqueous sodium carbonate reacted with dilute nitric acid. Most did observe, however, the white precipitate formed when the aqueous sodium carbonate reacted with barium nitrate solution.

(ii) Most candidates observed that no reaction occurred when aqueous sodium sulfate reacted with dilute nitric acid and that a white precipitate was formed when the aqueous sodium sulfate reacted with barium nitrate solution.

(b) (i) About half the candidature used the results they had obtained correctly and were able to explain why barium nitrate solution, on its own, does not distinguish between the carbonate ion and the sulfate iron.

(ii) The stronger candidates knew that in qualitative analysis the problem in **part (i)** can be overcome by the addition of nitric acid to remove the carbonate first.

(c) This question discriminated well and produced the full range of marks for candidates' responses. The best way to identify the cation and the anion in substance **H** was to systematically add the given reagents to the solution **H**, noting the test carried out and any observations made in **Table 5.2**. Candidates needed to have made a plan, and when they added the reagents to make comments about what they observed each time.

Tables needed to be more clearly set out for the examiner to follow; this made it difficult to award credit for the various stages of the process.

The conclusions drawn by candidates for each test used, often did not match the expected results for the reagents added.

There was a number of well thought out methods used, where candidates correctly identified the anion and the cation in a minimum number of steps.

Question 6

(a) The unstretched length of the spring was almost always recorded. Occasionally it was obvious to the examiner that the candidate had used centimetres, despite the instruction to use millimetres and the unit mm also being given on the answer line.

(b) (i) The stretched length was almost always recorded and the extension of the spring calculated correctly.

(ii) The calculation of the spring constant *k* from the equation provided caused few problems. The most common error made in the question was the substitution into the equation of the mass of the object, 300 g, instead of its weight, 3 N.

(c) Most candidates were able to describe at least one valid way of avoiding errors in the measurement of the length of the spring. The most common correct response was to place the ruler close to the spring.

Other equally acceptable answers seen far less frequently were to view the ruler perpendicularly, to clamp the rule vertically or to use a set-square.

A very common incorrect answer given by candidates was to wait until the spring stops moving before taking a reading. This was not acceptable because good experimental practice dictates that the spring must be at rest before a measurement of its length is attempted.

(d) Sensible values of the stretched length of the spring and its extension when the stone was added were usually recorded.

(e) The equation supplied was usually used correctly by candidates to determine the mass of the stone. An error carried forward arising from an incorrect value of *k*, previously calculated was allowed.

(f) Sensible values of the stretched length of the spring and its extension when the stone was completely immersed in water were usually recorded.

(g) The calculation of the density of the stone by substitution into the given equation was very well done by the majority of candidates. Additional credit awarded here was given to those candidates who had carried out the experiment with care and had obtained a value for the density of the stone of 3.0 ± 1.0 (g/cm^3). It is pleasing to report that this credit was awarded to a majority of candidates.

CO-ORDINATED SCIENCES

Paper 0654/52
Practical Test

Key messages

To achieve well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves, as possible.

Drawings of apparatus should be done with a pencil and ruler and should be labelled. 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.

Centres are provided with a list of required apparatus well in advance of the examination date. Where centres wish to substitute apparatus, it is essential to contact Cambridge International to check that the change is appropriate and that candidates will not be disadvantaged. Any changes must be recorded in the Supervisor's report.

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical biology, chemistry and physics techniques.

The majority of candidates entering this paper were well prepared and able to demonstrate some ability and understanding across the whole of the range of practical skills being tested. All parts of every practical test were attempted and there was no evidence of candidates running short of time. The majority of candidates were able to follow instructions correctly and record observations clearly.

The gathering and recording of data presented few problems for any candidates. There was evidence of some candidates not having the use of a calculator.

Comments on specific questions

Question 1

(a) and (b) Food test colours were well known and many candidates gained full credit.

A very common error that candidates made, was stating that there was no reaction or colour change for the negative results instead of stating the colour observed in each test-tube.

(c) The nutrient content of each solution was usually deduced correctly.

Common errors included stating carbohydrate instead of reducing sugar and reversing the order of protein and starch.

(d) Most candidates knew that the next step in the procedure for testing the vegetable oil for fat was to pour the mixture into water.

Question 2

(a) (i) Most candidates had a volume of sodium hydroxide solution remaining for experiment 1 of 10 cm^3, or more, and gained credit for this.

The volume remaining was rarely recorded to the nearest 0.5 cm^3.

(ii) The table was nearly always completed with the volumes remaining from experiments 2 and 3.

(b) (i) Most candidates subtracted the values correctly.

(ii) Many candidates chose the values which were the closest. The most common reason given was the exclusion of an anomalous reading. Some candidates thought that all values should be used, irrespective of how close they were, because that gave the average of the results. Other incorrect reasons were that all values were chosen because the full range of values must be used or that it must include the lowest and the highest values.

(iii) Most candidates performed the average calculation correctly.

(iv) The calculation was usually carried out correctly. The stronger candidates, as requested, gave their answers to an appropriate number of significant figures.

(c) The stronger candidates gave a creditworthy explanation, suggesting using a pipette to get a more accurate measurement of the volume. Many candidates thought that Universal Indicator was more accurate than litmus or discussed giving a pH range.

Question 3

(a) (i) Most candidates quoted a sensible value for the reading on the voltmeter and recorded it to a suitable number of decimal places.

(ii) All values of the voltage were usually recorded, and the results of most candidates showed values which increased as the length of wire in the circuit increased.

(iii) The current in the circuit was usually measured and recorded. Not all values of current were expressed to 0.01 A, as required.

(b) In most cases, the graph was drawn well.

Some candidates did not start their axes from 0,0 as requested. This made it impossible for them to answer **3(c)** correctly. Occasionally non-linear scales were used.

The plotting of the points was usually accurate. The line of best fit was usually well placed. Some candidates ignored the points and forced their line through the origin or drew multiple or feathery lines or gave “point-to-point” lines.

(c) The graph line was extended correctly in most cases and the value of the intercept on the vertical axis was usually read accurately.

(d) Most candidates substituted into the given equation and calculated the resistance of the unknown resistor correctly. Far fewer candidates were awarded the additional credit which was an accuracy mark. If candidates had performed the experiment with care and accuracy, their value for the unknown resistance should have been 5 Ω. Credit for accuracy was awarded to candidates whose answers ranged from 4 Ω to 6 Ω.

(e) Candidates found this very challenging. Candidates who read the question carefully and gave a practical reason for the result not being accurate, met with more success. Acceptable answers were: it is difficult to measure the position of the sliding contact to the nearest millimetre, the cell might run down, there might be a zero error on the ammeter or the voltmeter.

Question 4

(a) Most candidates gained partial credit, and many gained full credit. Candidates needed to give clear outlines, to enlarge the drawing and to include the surface detail.

(b) (i) Many candidates gained credit; some gave their answer in centimetres, despite being asked for millimetres. Candidates needed to draw the diameter on their drawing to gain credit for the measurement.

(ii) Most candidates used the string correctly and recorded a sensible value for the circumference of the nut. Despite the instruction to measure the circumference of the nut to the nearest millimetre, some candidates gave their answer in centimetres.

(iii) Most candidates substituted correctly into the given equation and calculated the diameter of the nut correctly.

(iv) The majority of candidates calculated the magnification correctly. A small percentage of candidates inverted the division or subtracted the values.

Question 5

(a) (i) A time for the bubbles to reach the top of the test-tube when the acid concentration was 2.0 mol / dm^3 was almost always recorded.

(ii) and (iii) The remaining times for the other two acid concentrations were usually recorded. Occasionally the times were recorded in minutes despite the instruction to use seconds. The expected trend was an increasing time as the concentration of the acid decreased. The results of a minority of candidates displayed quite the opposite.

(iv) The volumes of hydrochloric acid and water to make up a solution of concentration 0.5 mol / dm^3 was usually deduced correctly.

(b) (i) The relationship was generally described well, although a significant number referred to time rather than rate.

(ii) Candidates found this challenging. Many discussed repeating, accuracy and reliability. Acceptable answers are: if one value is misread, then two values is not sufficient to deduce a trend, three values is too narrow a range, if a graph is plotted then more points are needed.

(iii) The stronger candidates gained partial credit, usually for repeats. A significant number changed the concentration of the hydrochloric acid, despite being told not to. Many changed the temperature or even changed the method completely.

(c) Many candidates correctly substituted a gas syringe for the test-tube and stronger candidates measured the volume collected in a set time or the time for a set volume to be collected. Some candidates counted bubbles not appreciating that they would be given off too quickly to count.

Question 6

(a) (i) Most candidates recorded a sensible temperature for the initial temperature of the hot water. Occasionally it was obvious from the result recorded that the candidate had recorded the temperature of the room instead.

(ii) **Table 6.1** was nearly always completed with the temperatures recorded at 30 s intervals and displaying a downward trend, as expected.

(b) Candidates found this quite challenging. Repeating, getting another student to measure the temperature as well, and not touching the thermometer were common non-creditworthy responses. Acceptable responses seen from candidates include reading the thermometer perpendicularly / at eye level, stirring the water before taking the temperature and not letting the thermometer touch the sides or the bottom of the beaker.

(c) (i) and (ii) Most candidates subtracted the two values correctly and performed the calculation correctly.

(d) All candidates repeated the experiment with the smaller volume of hot water. The majority of candidates' results correctly showed a larger temperature drop in 180 s for the smaller volume.

(e) Many candidates calculated the new average rate of fall of temperature correctly. To gain the credit they also needed to round their answers correctly.

(f) The relationship between volume and rate of cooling was described correctly by many candidates. Far fewer included the results data in their answers which they needed to do to gain the full credit.

Question 7

The question discriminated well, with the full range of marks being awarded to candidates.

Very few candidates omitted the question, and many of the stronger candidates gave detailed answers.

The reagent was well-known and stronger candidates appreciated the need to heat.

The use of a water bath as a safety precaution was not well known.

Most candidates could identify at least one control variable and a small number identified three.

A colour for a positive result was well known.

Fewer candidates gave the colour for a negative result, some identified blue as being the colour for the least concentrated reducing sugar solution.

The stronger candidates gave the colours for the range of concentration of reducing sugar, some gave only the colours for the extremes of concentration or for the most concentrated solution.

The whole range of marks were awarded, and some candidates gave detailed, well written and structured answers which gained full credit.

CO-ORDINATED SCIENCES

Paper 0654/53
Practical Test

Key messages

To achieve well in this examination, candidates need to have a thorough grounding in practical work during the course. Candidates should have as much personal experience of carrying out experiments themselves, as possible.

Drawings of apparatus should be done with a pencil and ruler and should be labelled. 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.

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General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical biology, chemistry and physics techniques.

The majority of candidates entering this paper were well prepared and able to demonstrate some ability and understanding across the whole of the range of practical skills being tested. All parts of every practical test were attempted and there was no evidence of candidates running short of time. The majority of candidates were able to follow instructions correctly and record observations clearly.

The gathering and recording of data presented few problems for any candidates. There was evidence of some candidates not having the use of a calculator.

Comments on specific questions

Question 1

(a) (i) The heading and its corresponding unit was usually inserted correctly. The abbreviation "m" was not accepted for "minutes", although "min(s)" was. A minority of candidates did not read the question carefully enough, and inserted seconds as the unit of time.

(ii) Most candidates produced a full table of results with the temperatures of the water in the test-tubes showing the expected decreasing trend. Candidates should have recorded the temperatures to the nearest 0.5 °C. Many tables showed that the larger test-tube produced a greater fall in temperature of the water than the smaller one over the 5 minutes, when this should not have been the case.

(b) (i) Most graph axes were correctly labelled, but often a scale was chosen which was too small, so much of the graph paper was left unused. Candidates should choose a graph scale that will ensure that the plotted line or curve fills at least half of the grid.

(ii) The plots were generally accurate, although often untidy. Many candidates drew large "blobs" to display the plotted points and left it to the examiner to decide where the centre of the point was. Candidates should be encouraged to use thin crosses, with the intersection of the two cross lines at the point being plotted. Reasonable attempts were made at drawing a curve of best fit for both sets of points. Occasionally candidates did not follow the instruction given and left the curves unlabelled.

(c) (i) The drop in the temperature of the water in both test-tubes during the time of cooling was usually calculated correctly.

(ii) Candidates needed to compare both graphs and give a correct comparison between the rate of heat loss from the test-tubes. Candidates were expected to compare the gradients of the curves or to compare the temperature drops shown by each graph in the same time, and link this to the rate of heat loss of the test-tubes.

(iii) The stronger candidates were able to use their results from **part (ii)** and make the link that smaller animals needed more energy from their food for each gram of body mass than adults, because the rate of heat loss is greater for small animals.

Question 2

The question discriminated well, with the full range of marks being awarded to candidates.

The question involved planning an experiment to compare the amount of heat given out when three given acids reacted with an alkali. Many candidates found it challenging to name an alkali, particularly one suitable for using in this experiment.

Most candidates used a suitable vessel in which to carry out the reaction. Most found the requirement to state how they would reduce heat losses while the reaction occurred very challenging. Details of the apparatus and method of carrying out the experiment needed to be included.

The majority of candidates incorrectly added the alkali to the acid and then proceeded to take temperature readings at fixed intervals of time, while the temperature of the mixture was increasing. The stronger candidates understood that the initial temperature of the acid should be taken before adding the alkali, and then to wait and record the highest temperature reached by the mixture.

Most candidates were able to identify one control variable so that the comparison would be a fair one. The most popular correct chosen variable was the volume of the acid / alkali. Far less frequently did candidates realise that the same concentrations of acids / alkalis should be used and that the starting temperature for each experiment should be the same.

Credit was available for explaining how the readings taken could be used to make a comparison about the amount of heat given out in each reaction. This was seldom awarded, because candidates had carried out an incorrect procedure. What was required was that the temperature rise for each reaction be calculated. The greater the temperature rise, the greater the amount of heat given out during the reaction.

Question 3

(a) (i) The time for 20 oscillations was recorded by all candidates. Most candidates timed the oscillations accurately and recorded a value within the tolerance limits required.

(ii) The time T for one oscillation was calculated incorrectly by many candidates. Instead of dividing their answer in **(i)** by 20, many candidates divided their answer in **(i)** into 20.

(iii) The value for T^2 was usually correct. Answers were accepted to any number of significant figures.

(b) Credit was awarded for the accuracy of the measurements made here. Any calculated value of g of 10 ± 2 (m / s^2) gained credit. Additional credit was awarded for candidates expressing their answer to 3 significant figures, as asked for in the stem of the question. Many candidates did not follow this instruction and answers were quoted to a variety of significant figures.

(c) Most candidates gave a full set of values here. The majority of answers showed correctly that the value of the period T had increased.

(d) Most calculations were correct.

(e) A correct comparison between the two measured values of the acceleration due to gravity, *g*, was usually made, with candidates stating whether their values agreed, or not, with the actual value of 9.8 m / s^2. Far fewer candidates went on to state why they considered that there was / was not agreement between the values.

Answers such as "the values are very close / not too far apart / within 10% of each other" were accepted. The reverse argument applies if candidates stated that their values disagreed with the value 9.8 (m / s^2).

(f) (i) The frequency calculation was almost invariably done correctly.

(ii) Candidates found this final part challenging. Candidates needed to realise that if the oscillations take a longer time to complete, then any error in the timing or reaction time errors in starting and stopping the stop-clock would be less significant.

Question 4

(a) Candidates were awarded credit for drawing an enlarged, clear and continuous outline of the piece of fruit. Some further detail of the centre of the piece of fruit was also expected. To gain credit the diagrams needed to be carefully drawn and large enough. When candidates are asked to make an enlarged drawing, it is expected that their drawing will fill at least half the box provided for them to draw their diagram in.

(b) (i) The diameter of the piece of fruit provided was usually measured and recorded to the nearest millimetre. Occasionally candidates confused the unit mm with cm, and it was obvious that they had measured the diameter in centimetres, despite the unit mm being given on the answer line.

(ii) Usually, a measurement was provided for the diameter of the drawing. Despite the requirement stated in the question, that a line be drawn on their diagram to show this diameter, no line had been drawn by many candidates. In these cases, no credit could be awarded.

(iii) The calculation of the magnification was usually done correctly. Answers were accepted to any number of significant figures. A minority of candidates incorrectly divided the diameter of the actual fruit by the corresponding diameter on their drawing.

(c) The name of the reagent used to test for the presence of reducing sugar was well known, as was a colour that indicated a positive test for the presence of reducing sugar.

Question 5

(a) (i) Few candidates observed that effervescence occurred when aqueous sodium carbonate reacted with dilute nitric acid. Most did observe, however, the white precipitate formed when the aqueous sodium carbonate reacted with barium nitrate solution.

(ii) Most candidates observed that no reaction occurred when aqueous sodium sulfate reacted with dilute nitric acid and that a white precipitate was formed when the aqueous sodium sulfate reacted with barium nitrate solution.

(b) (i) About half the candidature used the results they had obtained correctly and were able to explain why barium nitrate solution, on its own, does not distinguish between the carbonate ion and the sulfate iron.

(ii) The stronger candidates knew that in qualitative analysis the problem in **part (i)** can be overcome by the addition of nitric acid to remove the carbonate first.

(c) This question discriminated well and produced the full range of marks for candidates' responses. The best way to identify the cation and the anion in substance **H** was to systematically add the given reagents to the solution **H**, noting the test carried out and any observations made in **Table 5.2**. Candidates needed to have made a plan, and when they added the reagents to make comments about what they observed each time.

Tables needed to be more clearly set out for the examiner to follow; this made it difficult to award credit for the various stages of the process.

The conclusions drawn by candidates for each test used, often did not match the expected results for the reagents added.

There was a number of well thought out methods used, where candidates correctly identified the anion and the cation in a minimum number of steps.

Question 6

(a) The unstretched length of the spring was almost always recorded. Occasionally it was obvious to the examiner that the candidate had used centimetres, despite the instruction to use millimetres and the unit mm also being given on the answer line.

(b) (i) The stretched length was almost always recorded and the extension of the spring calculated correctly.

(ii) The calculation of the spring constant *k* from the equation provided caused few problems. The most common error made in the question was the substitution into the equation of the mass of the object, 300 g, instead of its weight, 3 N.

(c) Most candidates were able to describe at least one valid way of avoiding errors in the measurement of the length of the spring. The most common correct response was to place the ruler close to the spring.

Other equally acceptable answers seen far less frequently were to view the ruler perpendicularly, to clamp the rule vertically or to use a set-square.

A very common incorrect answer given by candidates was to wait until the spring stops moving before taking a reading. This was not acceptable because good experimental practice dictates that the spring must be at rest before a measurement of its length is attempted.

(d) Sensible values of the stretched length of the spring and its extension when the stone was added were usually recorded.

(e) The equation supplied was usually used correctly by candidates to determine the mass of the stone. An error carried forward arising from an incorrect value of *k*, previously calculated was allowed.

(f) Sensible values of the stretched length of the spring and its extension when the stone was completely immersed in water were usually recorded.

(g) The calculation of the density of the stone by substitution into the given equation was very well done by the majority of candidates. Additional credit awarded here was given to those candidates who had carried out the experiment with care and had obtained a value for the density of the stone of 3.0 ± 1.0 (g/cm^3). It is pleasing to report that this credit was awarded to a majority of candidates.

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 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 the instruments was good, the expected accuracy can often be gleaned from the data already present in a table. The standard of graph drawing was generally high; 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. Knowledge of identification tests for ions was very limited.

Comments on specific questions

Question 1 – Heat Loss

(a) (i) Most candidates inserted the correct units. Common incorrect units included: m, s and sec,

(ii) Most candidates gained partial credit for 50.5. Candidates need to follow the data already present in the table; many gave 46 rather than 46.0.

(b)(i) Most candidates labelled the axes with quantity and unit, many only gained partial credit as they chose a scale where the plotted points covered less than half of the grid.

(ii) The points were usually plotted correctly. Candidates found the curves more challenging; they need to draw clear single lines and to label them.

(c) (i) Most candidates subtracted the values correctly.

(ii) Candidates found this challenging. Many answered in terms of temperature rather than rate of heat loss or thought the rate was the same for both tubes. Very few candidates considered the steepness of the curves.

(iii) Many candidates discussed the amount of energy needed by a growing baby animal compared to that needed by an adult rather than discussing heat loss.

Question 2 – Enthalpy of Reaction

The whole range of marks was gained and stronger candidates gave quite detailed answers with a small number gaining full credit.

Few candidates named an alkali. Lithium, sodium, magnesium, magnesium oxide, magnesium carbonate and calcium carbonate were common incorrect responses.

Most candidates used a suitable vessel for the reaction; few included a method for reducing the heat losses.

Many candidates used a thermometer to measure the temperatures few used apparatus to measure the volumes of solutions used.

Most candidates added the alkali to the acid and then took the initial temperature instead of taking the initial temperature before the solutions were added together. They then measured the temperature at fixed intervals of time for a set total time rather than measuring the maximum temperature reached by the mixture.

Most candidates could identify at least one control variable, usually volume of acid and / or alkali and a small number identified two.

Some candidates heated the mixture and some then measured the temperature as it cooled down.

The strongest candidates described the use of the results to make a comparison.

Question 3 – Measurement of free fall, *g*

(a) Stronger candidates indicated the distance correctly. Many measured to the top or the bottom of the bob and some measured to the middle of the clamp.

(b) (i) Most candidates calculated the average correctly and most then gave the value to three significant figures.

(ii) Most candidates calculated the value correctly.

(iii) Most candidates calculated the value correctly. A small number doubled rather than squaring.

(c) Most candidates calculated the value correctly.

(d) Most candidates calculated the value correctly. Double the value was seen a significant number of times.

(e) Stronger candidates compared the two values and discussed their closeness. Many thought their values were within experimental error but only quoted their values as a means of justification without an explanation. Values which are within 10 per cent can be regarded as being within the limits of experimental error.

(f) Stronger candidates appreciated that the errors are less significant over the longer time. Non-creditworthy responses included: fair results, greater range of results and increased reliability.

Question 4 – Drawing and Food Tests

(a) (i) Most candidates gained partial credit and many gained full credit. A few gave sketchy outlines, did not enlarge the drawing or missed the centre detail.

(b) (i) Whilst many candidates measured the apricot correctly some recorded the measurement in centimetres.

(ii) Many candidates needed to draw the line on their apricot to gain credit for the measurement.

(iii) The majority of candidates calculated the magnification correctly. Some inverted the division or subtracted the values

(c) (i) Benedict's and its colour for a positive test were well known, some gave blue as a positive result. A small number of candidates gave biuret and lilac.

(ii) Most candidates named a safety precaution and stronger candidates gained credit by explaining it.

(iii) Most candidates named a control variable, usually the amount of fruit.

Question 5 – Identification of ions

(a) (i) Many candidates gained credit. Some discussed the reaction being the same, which was not creditworthy.

(ii) Candidates found this challenging. Stronger candidates recognised the need for nitric acid with no explanation and the strongest were able to explain why it is needed.

(iii) The test for carbon dioxide was well known. The extinguishing of a lighted splint, a white emulsion with limewater and limestone were common non-creditworthy responses.

(b) (i) Many candidates gained credit. Common incorrect responses included: to increase solubility or to give a neutral pH.

(ii) Candidates found this very challenging. Common incorrect responses included: white precipitate, gas evolved and bubbling.

(iii) Candidates found this very challenging. Stronger candidates gained credit for test 4, a very small number gained credit for test 3. Many candidates repeated some or all of the list in test 1.

(iv) Candidates found this very challenging. The strongest appreciated the addition of nitric acid and a very small number explained why.

(v) Candidates found this very challenging. The strongest appreciated that aqueous ammonia itself gives off ammonia gas and so cannot be used to test for an ion whose positive result is the evolution of ammonia gas. Many candidates thought there would be no reaction.

Question 6 – Spring Constant

(a) Most candidates gained credit. A small number recorded the length in cm.

(b) (i) Most candidates subtracted the values correctly.

(ii) Many candidates calculated the value of *k* correctly. A significant number used 300.

(c) Stronger candidates appreciated that the ruler needed to be viewed perpendicularly, only the strongest could suggest a second reason, usually ensuring the ruler is vertical. Common incorrect responses included: viewing parallel, repeating, laying the spring flat, not including the loops, making sure the spring was still and having a friend help to measure.

(d) Most candidates calculated the value of *m* correctly. 22 500 was a common response following an incorrect **(b)(ii)**. A small number did not multiply by 100 or did not include *k* in the calculation.

(e) Most candidates calculated the value of ρ correctly.

(f) (i) Most candidates calculated the volume correctly. A small number calculated the surface area or added the dimensions.

(ii) Most candidates read the scale correctly. A small number gave 60.5.

(iii) Most candidates calculated the value of density correctly. A small number inverted the calculation.

(iv) Candidates found this challenging. Better rulers and displacement of water were common responses.

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. Drawings of apparatus should be done with a pencil and ruler and should be labelled. 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.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of a good standard, calculations were well executed and food tests were well known. The standard of graph drawing was generally high although candidates need to remember to include units on the axes and to draw a straight line of best-fit with a single line and a ruler. 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.

Comments on specific questions

Question 1 – Food tests

(a) (i) Food test colours were well known and many candidates gained full credit. Common errors included white precipitate for the fat test and no reaction for the negative results instead of the colour required.

(ii) The nutrients were well known. Common errors included carbohydrate instead of reducing sugar and reversing protein and starch.

Question 2 – Neutralisation reaction

(a) (i) Candidates found this very challenging and few of them gained credit. The accuracy of the values in the table and the apparatus being used needed to be followed, 14.2 and 14.3 were common non-creditworthy responses.

(ii) Most candidates gained credit. A small number gave beaker.

(b) (i) Most candidates subtracted the values correctly.

(ii) Many candidates chose the values which were the closest with the most common reason being the exclusion of the anomaly. Some thought that all four values should be used because that is the average of the results or because it included the full range of values or the lowest and the highest values.

(iii) Many candidates performed the calculation correctly. Some candidates added three values but divided by four.

(iv) Many candidates performed the calculation correctly with stronger candidates giving their answer to an appropriate number of significant figures.

(c) Stronger candidates gave a creditworthy explanation. Many thought universal indicator was more accurate than litmus or discussed giving a pH range.

(d) Candidates found this challenging. Many halved the value.

Question 3 – Resistance

(a) (i) The ammeter was read correctly by almost all candidates. A few readings of 1.6 were seen.

(ii) Almost all candidates read the voltmeter scale correctly.

(b) (i) Generally the graph was drawn well. The axes were usually labelled with the quantity but some omitted the unit. Some did not start their axes from 0,0 as requested, making it impossible to answer **3(c)** correctly, or gave non-linear scales. The plotting of the points was usually accurate. A small number reversed the axes.

(ii) The line of best fit was generally well placed. Some candidates ignored the points and put their line through the origin or drew multiple or feathery lines or gave "point-to-point" lines.

(c) The intercept was generally drawn and read quite well.

(d) The calculation was performed well; fewer candidates gained the credit for accuracy.

(e) Candidates found this very challenging.

Question 4 – Drawing and Magnification

(a) Most candidates gained partial credit and many gained full credit. A few gave sketchy outlines, did not enlarge the drawing or missed the surface detail.

(b) (i) Many candidates gained credit, some gave their answer in centimetres. Candidates needed to draw the diameter on their drawing to gain credit for the measurement.

(ii) Most candidates measured the diameter of the walnut in the figure correctly although some gave their answer in centimetres.

(iii) The majority of candidates calculated the magnification correctly. Some inverted the division or subtracted the values.

(c) Candidates found this very challenging. Common answers included: *the line does not go through the centre of the walnut*, *the walnut would need to be cut in half to measure the diameter* and that *the photograph was not to scale*.

Question 5 – Rate of Reaction

(a) Candidates found this challenging. Many diagrams had bungs in both test-tubes or had the delivery tube under the level of the acid or not under the level of the detergent solution. Labels were required.

(b) (i) Almost all candidates converted correctly the stop clock reading to seconds.

(ii) The relationship was generally described well, a significant number referred to time rather than rate.

(c) (i) Candidates found this challenging. Many discussed repeating, accuracy and reliability.

(ii) Stronger candidates gained credit. Common incorrect responses included: 10 and 0, 0 and 10, 5 and 5.

(iii) Stronger candidates gained partial credit, usually for repeats. A significant number changed the concentration or the temperature or changed the method totally.

(d) Many candidates substituted a gas syringe and stronger candidates measured the volume collected in a set time or the time for a set volume to be collected. Some candidates counted bubbles not appreciating that they would be given off too quickly to count.

Question 6 – Rate of Cooling

(a) Most candidates read the temperature correctly.

(b) (i) The units were well known. Common incorrect responses included m, C and cm^3.

(ii) Almost all candidates completed the time column correctly. A small number gave 140 or 160 in place of 150.

(c) Candidates found this quite challenging. Repeating, getting another student to measure as well and not touching the thermometer were common non-creditworthy responses.

(d) (i) Most candidates subtracted the two values correctly. 74.5 was a common error.

(ii) Most candidates performed the calculation correctly. 0.58 was a common error.

(e) Many candidates calculated the value correctly but then rounded their calculator value incorrectly.

(f) Many candidates described the relationship correctly, far fewer included the results data in their answer.

(g) Candidates found this challenging. Common non-creditworthy responses included: controlling the room temperature, increase the time intervals between readings and lagging.

Question 7 – Planning

The reagent was well known and stronger candidates appreciated the need to heat.

Use of a water bath as a safety precaution was not well known.

Most candidates could identify at least one control variable and a small number identified three.

A colour for a positive result was well known. Fewer candidates gave the colour for a negative result, some identified blue as being the colour for the least concentrated reducing sugar solution.

Stronger candidates gave the colours for the range of concentration of reducing sugar; some gave only the colours for the extremes of concentration or for the most concentrated solution.

The whole range of marks were gained and some candidates gave detailed answers gaining full credit.

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. Candidates should have performed identification tests on the range of substances detailed in the specification.

General comments

Candidates from some centres demonstrated good understanding of practical knowledge. The reading of the instruments was of an excellent standard. Candidates need to consider the number of significant figures required by calculations. Diagrams of apparatus are improving. Candidates must read the questions carefully so that they answer what is being asked by the question. Undertaking practical work helps the candidates to state observation and to interpret and evaluate experimental methods, techniques and results.

Comments on specific questions

Question 1 – Osmosis

(a) (i) Many candidates read the scale correctly. 10.5 was the most common incorrect response, 11 and 11.5 were also quite common.

(ii) Most candidates read the scale correctly.

(iii) Almost all candidates subtracted the values correctly.

(iv) Candidates found this a little challenging. Inverting the division was the most common error, a small number multiplied the values or divided by 100. Many gave an answer to an appropriate number of significant figures.

(b) Candidates found this challenging. Stronger candidates appreciated that the change was caused by the water moving into the partially permeable tube and of these many could name the process. Stronger candidates discussed the difference in concentration. Many candidates discussed the sugar not moving or repeated the question stem by referring to it or the sugar solution moving with no explanation.

(c) (i) Benedict's was generally well known. Biuret was the most common incorrect response; iodine was also seen.

(ii) The colour for a positive test was quite well known. Blue was the most common incorrect response, purple was also quite common.

(iii) The colour for a negative result was quite well known. Some candidates reversed **(c)(ii)** and **(c)(iii)** so red, orange, yellow and green were seen often. A significant number stated no change rather than a colour.

(d) Many candidates named one control variable with time being the most common correct response, stronger candidates named two. Common non-creditworthy responses included volume of water or just volume.

Question 2 – Identification of ions

(a) Candidates found this challenging. Common incorrect responses included: to increase solubility, to give a neutral pH, to make it fair and so that it doesn't react with **L**.

(b) (i) Stronger candidates recognised the test for copper(II) ions. Many different ions and elements were given with calcium, iron and nitrate being slightly more common.

(ii) Candidates found this challenging. The stronger candidates appreciated the difference in the amount of reagent used. The most common incorrect responses were sodium hydroxide being used or the concentration of the aqueous ammonia or solution **L** being different.

(c) (i) The test for carbon dioxide was well known. The extinguishing of a lighted splint and both hydrogen and oxygen tests were seen.

(ii) Stronger candidates gained credit. Many did not draw the delivery tube under the level of the limewater or label the apparatus.

(d) (i) Candidates found this challenging. Many candidates discussed barium or barium chloride giving a white precipitate with no further explanation.

(ii) Stronger candidates gained credit. Not adding sulfuric acid was quite common but no alternative was given. Many suggested not adding the barium nitrate or using a different reagent such as sodium hydroxide or silver nitrate.

(e) The chloride test reagents were not well known. Sodium hydroxide and litmus paper were seen commonly.

Question 3 – Resistance

(a) Candidates found this quite challenging. Many had a line through the centre of the voltmeter or put the voltmeter in series between the two lamps in series.

(b) Most candidates read the scale correctly.

(c) V and A were quite well known but Ω / ohm was seen more rarely. J and Watts were seen commonly.

(d) (i) Candidates found this very challenging. Many thought it was to avoid electrocution or the need to reset the initial values to 0.

(ii) Most candidates calculated the values correctly and recorded them to a consistent number of significant figures.

(iii) Over half of candidates chose the correct circuit. Circuit 2 was the most common incorrect response.

(e) Many candidates made a decision and quoted their values, stronger candidates justified their statement. The most common non-creditworthy responses either agreed or disagreed with no further explanation.

(f) (i) Many candidates drew a correct circuit. A significant number drew lines through the lamps and the ammeter, a small number left gaps in the circuit.

(ii) Stronger candidates gained credit.

Question 4 – Drawing

(a) Most candidates gained partial credit and many gained full credit. A few gave sketchy outlines, did not enlarge the drawing or did not label the stoma.

(b) (i) Many candidates measured the line correctly although some gave their answer in centimetres.

(ii) The majority of candidates gained credit; some gave their answer in centimetres. Candidates needed to draw the line 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. Candidates needed to give their answer to the nearest whole number.

Question 5 – Enthalpy of Reaction

(a) (i) Most candidates read the temperature correctly.

(ii) Most candidates subtracted the values correctly; many did not follow the data in the table and gave 10 rather than 10.0.

(b) (i) Generally the graph was drawn well. The axes were usually labelled with the quantity but some omitted the unit. Some gave non-linear scales or did not extend the vertical scale to at least 13.0. The plotting of the points was usually accurate. A small number reversed the axes.

(ii) Many candidates drew two good best-fit lines. Some drew point-to point lines or drew freehand lines.

(iii) Most candidates extended the lines and read the values of intersection correctly. A small number misread one or both axes. Candidates need to consider the scale carefully.

(iv) Many candidates subtracted correctly. Some chose values from the table rather than their value from **(b)(iii)**.

(c) (i) The calculation was generally performed well. Correct substitution into the formula but incorrect arithmetic manipulation of the numbers was quite common.

(ii) Candidates found this very challenging. Common non-creditworthy responses included: experimental error, maximum temperature estimated, lines of best-fit were used and the temperature should be higher.

Question 6 – Insulation

The whole range of marks were gained and stronger candidates gave quite detailed answers with a significant number gaining full credit.

Many used an insulator but some added this to the water rather than lagging the container. Some thought cotton wool was two different insulators. Many repeated the experiment with the different insulators.

Most measured the temperature at the start and either at regular intervals or after a specific time.

Most candidates could identify at least one control variable and many identified several. Volume of water, initial temperature of water and time to cool were the most common.

Most included a workable table; the units were sometimes missing.

Candidates found the conclusion more challenging, but many showed how the results could be used to determine the best thermal insulator.