CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice

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

General comments (Biology)

The questions fell well within the capabilities of the candidates. Some candidates found **Questions 3** and **10** challenging.

Comments on specific questions (Biology)

Question 2

Cell function can cause confusion, however the majority of candidates knew the correct functions both of red blood cells and of root hair cells and chose the key **A**.

Question 3

There appeared to be a high degree of guesswork in this question due to confusion between the pulmonary artery and pulmonary vein. Candidates should be reminded that knowledge of the main blood vessels comprising the circulatory system is an essential requirement of the syllabus.

Question 5

Candidates should be encouraged to read the questions carefully as a significant number of candidates incorrectly chose option **D** showing a large amount of water and fibre; while these are important in the diet, it is fat (and protein) that provide the energy and helps growth.

Question 6

There was evidence of uncertainty surrounding knowledge of food tests. A significant number of candidates appear to believe that a positive test with Benedict's solution (for reducing sugar) is a blue colouration and incorrectly chose option **C** or **D**.

Question 7

Candidates showed a sound knowledge of the structures comprising the respiratory system and this question was generally well answered.

Question 10

A fundamental and quite serious misunderstanding was exposed, believing that the uterus lining is at its thickest in the week *following* the week of menstruation rather than in the week *preceding* it, as many candidates incorrectly chose option **C**.

Question 12

The majority of candidates have a good understanding of food chains and chose the correct response to this question.

General comments (Chemistry)

Candidates found **Questions 14**, **20**, **21**, **24** and **27** easy with most answering these questions correctly.

However, **Questions 18** and **23** were challenging to most candidates.

Comments on specific questions (Chemistry)

Question 16

Candidates should be able to use the Periodic Table to identify copper as a transition metal and know that it forms coloured ions.

Question 17

Some candidates incorrectly chose option **A**, but as this option stated the substance was **not** listed in the Periodic Table, it could **not** be an element.

Question 18

Candidates found this question challenging with evidence of guessing. This question tests candidates recall that NaOH, an alkali, displaces ammonia gas from its salts, and that this gas is basic so will turn red litmus to blue.

Question 19

Candidates should recall that platinum is unreactive, and, as a transition metal, acts as a catalyst, increasing reaction rates. While many knew that ammonia is basic, they assumed that this question involved neutralisation.

Question 20

Candidates are reminded that powders react faster than lumps of solid or ribbon.

Question 22

Candidates often confuse the signs of the anode (positive) and cathode (negative); this could explain why many incorrectly chose option **B**, (hydrogen) instead of the key **A**.

Question 23

Candidates may have incorrectly *either* thought that carbon oxidises the metal oxide *or* they misread the question and thought that they were being asked what happens to the carbon. Only the most able correctly chose the key **D**; 'reduction'.

Question 25

Candidates should know that lime is a base, and as such it will neutralise acids in soil and raise the pH, rather than decrease the pH.

Question 26

Half the candidates chose the key, **D**, however a significant number incorrectly chose option **C**. Had the question not specified that an 'acid is added to an alkali until the solution is **just** neutral', option **C** would have been a valid choice as excess acid would have cooled down the reaction mixture.

Question 27

Candidates should be reminded of the difference between a molecular formula, and an empirical formula.

General comments (Physics)

Candidates found **Questions 32** and **35** challenging.

Comments on specific questions (Physics)

Question 28

While nearly half of the candidates correctly linked the distance / time graph to the appropriate speed / time graph, the same number incorrectly chose option **D**. Candidates should be able to convert from one type of graph to another.

Question 30

This question asked about the type of energy stored in water for use in a hydroelectric power station. Most candidates were unable to identify this as gravitational energy.

Question 32

Only the most able candidates knew that the temperature of a solid as it melts, and of a liquid as it boils would be constant. About half the candidates believed that the temperature would increase for both, incorrectly choosing option **A**.

Question 34

This was generally well-answered. The most common mistake was to choose option **B** which was the 'peak to trough' value, rather than the key **A**, which was the amplitude.

Question 35

This question required knowledge that the angles of incidence and reflection are measured between the ray and the normal, but the majority of the candidates did not know this; many chose the angle between the ray and the mirror instead.

Question 36

Specific examples of applications of electromagnetic waves are given in the syllabus, but almost one in three candidates thought that a television remote controller uses radio waves rather than infra-red.

CO-ORDINATED SCIENCES

Paper 0654/12
Multiple Choice

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

General comments (Biology)

The questions fell well within the ability range of the candidates. Some candidates found **Questions 1** and **6** challenging.

Comments on specific questions (Biology)

Question 1

A very common misunderstanding amongst candidates is the belief that 'plants respire by photosynthesis' and about half of the candidates chose the incorrect option **C** (respiration). About half of the candidates chose the key **B** (nutrition).

Question 4

A significant minority of the candidates to incorrectly chose option **D** possibly due to candidates being uncertain of the appearance of a transverse section of a stem and of a root.

Question 6

Candidates need to know the definitions of the terms 'haploid' and 'diploid' and to understand the advantage of sexual reproduction. There appeared to be quite a degree of guesswork in this question.

Question 12

The majority of candidates have a good understanding of food chains and chose the correct response to this question.

General comments (Chemistry)

The majority of candidates found **Questions 14** and **20** easy, with most questions within the candidates' abilities.

However, many candidates found **Questions 16**, **24**, **26** and **27** challenging.

Comments on specific questions (Chemistry)

Question 16

About the same number of candidates incorrectly chose option **C** as those who chose the key, **B**. Candidates may have confused 'the displacement of ammonia from its salts by warming with an alkali' with the 'acid-base reaction between hydrochloric acid and ammonia'. Candidates need to realise that ammonia and ammonium salts do not react in the same way as each other.

Question 24

Half the candidates chose the key, **D**, however a significant number incorrectly chose option **C**. Had the question not specified that an 'acid is added to an alkali until the solution is **just** neutral', option **C** would have been a valid choice as excess acid would have cooled down the reaction mixture.

Question 22

Candidates often confuse the signs of the anode (positive) and cathode (negative); this could explain why many incorrectly chose option **B**, (hydrogen) instead of the key **A**.

Question 23

Candidates may have incorrectly *either* thought that carbon oxidises the metal oxide *or* they misread the question and thought that they were being asked what happens to the carbon. Only the most able correctly chose the key **D**; 'reduction'.

Question 26

Just over half the candidates chose the key, **A**, but many incorrectly chose option **C**. These candidates realised that alloys are used in aircraft construction for greater strength, but did not know that alloys are mixtures of metallic elements in the form of atoms, not molecules.

Question 27

Over half of the candidates incorrectly chose option **A**, with the majority of the rest choosing the key, **C**. Candidates may have recalled that carbon dioxide is (weakly) acidic, and confused this with carbon monoxide, thereby choosing option **A**.

General comments (Physics*)*

Candidates performed well on **Questions 28** and **29**, but had difficulty with **Questions 35**, and **38**. **Question 36** was particularly challenging.

Comments on specific questions (Physics)

Question 34

This was generally well-answered. The most common mistake was to choose option **B** which was the 'peak to trough' value, rather than the key **A**, which was the amplitude.

Question 35

This question required knowledge that the angles of incidence and reflection are measured between the ray and the normal, but the majority of the candidates did not know this; many chose the angle between the ray and the mirror instead.

Question 36

Very few candidates knew that television links to a satellite using microwaves rather than radio waves; even though this specific example is given in the syllabus.

Question 38

Although the great majority of candidates were aware that the rod must be positively charged to attract the strip, very many of them did not appreciate that the rod must be an insulator if the charge is not to leak away to earth through the hand that is holding it.

Question 40

Most responses to this question on isotopes were correct, however a significant number incorrectly chose option **B**, believing that all isotopes must be radioactive.

CO-ORDINATED SCIENCES

Paper 0654/13
Multiple Choice

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

General comments (Biology)

The questions fell well within the capabilities of the candidates. Some candidates found **Questions 2**, **5**, **6** and **11** challenging.

Comments on specific questions (Biology)

Question 2

There appeared to be a high degree of guesswork in this question due to confusion between the pulmonary artery and pulmonary vein. Candidates should be reminded that knowledge of the main blood vessels comprising the circulatory system is an essential requirement of the syllabus.

Question 4

Cell function can cause confusion, however the majority of candidates knew the correct functions both of red blood cells and of root hair cells and chose the key **A**.

Question 5

There was clear evidence of uncertainty surrounding knowledge of food tests. A significant number of candidates appear to believe that a positive test with Benedict's solution (for reducing sugar) is a blue colouration and incorrectly chose option **C** or **D**.

Question 6

Candidates should be encouraged to read the questions carefully as a significant number of candidates incorrectly chose option **D** showing a large amount of water and fibre; while these are important in the diet, it is fat (and protein) that provide the energy and helps growth.

Question 9

Candidates showed a sound knowledge of the structures comprising the respiratory system and this question was generally well answered.

Question 11

A fundamental and quite serious misunderstanding was exposed, believing that the uterus lining is at its thickest in the week *following* the week of menstruation rather than in the week *preceding* it, as many candidates incorrectly chose option **C**.

Question 12

The majority of candidates have a good understanding of food chains and chose the correct response to this question.

General comments (Chemistry)

Candidates found **Questions 16**, **23**, **24** and **27** easy with most answering these questions correctly.

However, **Questions 19** and **22** were challenging to most candidates.

Comments on specific questions (Chemistry)

Question 14

Candidates should be able to use the Periodic Table to identify copper as a transition metal and know that it forms coloured ions.

Question 17

Some candidates incorrectly chose option **A**, but as this option stated the substance was **not** listed in the Periodic Table, it could **not** be an element.

Question 18

Candidates are reminded that powders react faster than lumps of solid or ribbon.

Question 19

Candidates found this question challenging with evidence of guessing. This question tests candidates recall that NaOH, an alkali, displaces ammonia gas from its salts, and that this gas is basic so will turn red litmus to blue.

Question 20

Candidates should recall that platinum is unreactive, and, as a transition metal, acts as a catalyst, increasing reaction rates. While many knew that ammonia is basic, they assumed that this question involved neutralisation.

Question 21

Candidates often confuse the signs of the anode (positive) and cathode (negative); this could explain why many incorrectly chose option **B**, (hydrogen) instead of the key **A**.

Question 22

Candidates may have incorrectly *either* thought that carbon oxidises the metal oxide *or* they misread the question and thought that they were being asked what happens to the carbon. Only the most able correctly chose the key **D**; 'reduction'.

Question 25

Half the candidates chose the key, **D**, however a significant number incorrectly chose option **C**. Had the question not specified that an 'acid is added to an alkali until the solution is **just** neutral', option **C** would have been a valid choice as excess acid would have cooled down the reaction mixture.

Question 26

Candidates should know that lime is a base, and as such it will neutralise acids in soil and raise the pH, rather than decrease the pH.

Question 27

Candidates should be reminded of the difference between a molecular formula, and an empirical formula.

General comments (Physics)

The best-answered question in the physics section was **Question 28**. Candidates had difficulty with **Questions 31**, and **32**. **Question 36** was particularly challenging.

Comments on specific questions (Physics)

Question 29

While nearly half of the candidates correctly linked the distance / time graph to the appropriate speed / time graph, the same number incorrectly chose option **D**. Candidates should be able to convert from one type of graph to another.

Question 31

Only the most able candidates knew that the temperature of a solid as it melts, and of a liquid as it boils would be constant. About half the candidates believed that the temperature would increase for both, incorrectly choosing option **A**.

Question 32

This question asked about the type of energy stored in water for use in a hydroelectric power station. Most candidates were unable to identify this as gravitational energy.

Question 35

This was generally well-answered. The most common mistake was to choose option **B** which was the 'peak to trough' value, rather than the key **A**, which was the amplitude.

Question 36

This question required knowledge that the angles of incidence and reflection are measured between the ray and the normal, but the majority of the candidates did not know this; many chose the angle between the ray and the mirror instead.

Question 37

Specific examples of applications of electromagnetic waves are given in the syllabus, but almost one in three candidates thought that a television remote controller uses radio waves rather than infra-red.

CO-ORDINATED SCIENCES

Paper 0654/21

Core Theory

Key Message

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. The idea of using the triangle consisting of three variables is a valuable tool to answering calculation questions but is not acceptable as a formula.

General comments

Most candidates attempted all questions, with only a few parts of some questions being inaccessible. Candidates generally gained credit in all questions.

Performance depends not only on scientific knowledge but on the ability of the candidates to both understand the question and to address their answer to the actual question asked.

There was little evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

This question was answered quite well. Some candidates found parts of the question challenging.

(a) (i) Many candidates answered this correctly. However, some candidates seemed confused with neutrons and electrons and a few thought that the mass number was the total number of protons, neutrons and electrons.

(ii) This was well answered by many candidates. However, many candidates gave an explanation about isotopes in terms of electrons.

(iii) This was not well answered. Although a number of candidates knew that the numbers of protons and electrons were equal, few went on to explain the significance of this in terms of charges.

(b) (i) Most candidates correctly answered covalent. Many different incorrect responses were seen.

(ii) Many candidates correctly explained why helium exists as uncombined atoms, usually by referring to a full outer shell of electrons.

(iii) Most candidates correctly suggested filling balloons or airships as a use for helium. A few incorrectly suggested hot air balloons.

(c) Many candidates gained full credit by referring to hydrogen being produced by the reaction of zinc and acid and being identified by the lighted splint pop test. Few candidates referred to zinc being more reactive than hydrogen.

Question 2

Parts **(b)** and **(c)** were only well answered by the more able candidates. However, most candidates gained partial credit in this question.

(a) Gravity was well known.

(b) Many candidates correctly wrote the formula to use but calculated the distance as 320 m, that is, they did not dividing this by 2 to give an answer of 160 m.

(c) (i) Many candidates gave vague answers referring to fossil fuels beings bad for the environment. Candidates who referred to the sustainability of renewable energy resources usually gained credit.

(ii) This was not well answered. A number of candidates described the energy changes in reverse using the generator to make waves. Very few candidates used the term kinetic energy in their answers.

(d) (i) Sea water was usually correctly identified.

(ii) Evaporation was well known.

(iii) Freezing was well known.

Question 3

Candidates found this question quite challenging.

(a) Many candidates gained full credit. The commonest mistake was to confuse the functions of the anther and stigma.

(b) Most candidates correctly identified water as a factor needed for germination. Fewer candidates identified warmth or oxygen. Many candidates incorrectly suggested light or nutrients.

(c) Only the most able candidates gained full credit correctly suggesting that asexual reproduction only requires one parent or produces no variation.

Question 4

(a) (i) Some candidates correctly drew an ethane molecule.

(ii) The main constituent of natural gas, methane, was not well known.

(iii) Many candidates clearly knew what happens when bromine reacted with an alkene, but they did not answer the question by stating what would be *observed* and were therefore unable to gain credit.

(b) (i) Fractional distillation was not well known. A number of candidates incorrectly referred to the blast furnace.

(ii) Carbon dioxide was well known as a product of complete combustion. Hydrogen was commonly incorrectly suggested rather than water.

(c) (i) This was not well known.

(ii) This was not well answered. Common errors were to describe covalent bonding and electrons being shared. Some candidates carelessly referred to atoms or ions being transferred.

(iii) Some candidates correctly suggested that the ions had opposite charges and that opposite charges attract. Many candidates repeated their answer to part **(ii)**.

Question 5

(a) The most common wrong answer was protein, this may have been due to candidates not checking the units carefully.

(b) Water was not commonly identified. There was no common incorrect answer.

(c) A number of candidates correctly identified protein being tested with biuret solution. The incorrect answers most often seen were carbohydrate and alkali.

(d) The test for starch was not well known.

(e) Most candidates knew the components of milk that provided energy. A number of candidates did not realise that there were three components.

(f) Most candidates correctly identified one way in which water-buffalo's milk was better for a person's health.

(g) Calcium was correctly stated, but many candidates incorrectly suggested that it did not need digesting because it went 'straight' to the teeth or bones (rather than it being small enough to be absorbed).

Question 6

(a) (i) The energy change was well known.

(ii) Kinetic energy changing into heat or sound was not well understood.

(iii) Many candidates realised that worker **Y** did more work because he lifted the bag higher.

(iv) Joules was well known.

(v) Many candidates correctly carried out the density calculation. Some candidates did not convert the mass from kilograms to grams. Candidates are reminded that they should check units, and that they are in the correct form.

(b) (i) This was well answered. The majority of candidates used distance = speed × time to carry out the calculation.

(ii) 240 seconds was commonly given as the correct answer.

(iii) Many candidates correctly identified boy **C** and many also correctly explained how the line on the graph showed that the boy was decelerating. This showed good data handling skills and thus many candidates were awarded credit.

Question 7

(a) (i) Few candidates knew the term alloy.

(ii) Most candidates knew that the 'alloy' would be harder or stronger, gaining credit.

(iii) Only a few candidates gave the correct answer of vanadium oxide. Many candidates knew that reduction is the loss of oxygen.

(iv) Many answers suggested vanadium was more or less reactive than magnesium. The commonest correct answer was a reference to transition metals having relatively high melting points.

(b) (i) The definition of a catalyst was well known.

(ii) Most candidates wrote down a correct word equation gaining credit.

(iii) Few candidates thought about this carefully, and gave creditworthy answers. Many made vague statements about something being bad for humans, and a few thought that the factory would explode.

Question 8

(a) Most candidates showed a good understanding of the terms producer, consumer, carnivore and herbivore, and gained credit.

(b) (i) This was not well answered. Very few discussed eutrophication, however some candidates gained some credit by correctly suggested that there might be toxins in the sewage.

(ii) References to climate change and global warming were commonly seen. Many candidates wrongly attempted to include damage to the ozone layer in their answers.

Question 9

(a) This part was well answered.

(b) (i) Some candidates were awarded full credit for their diagrams, but a few were awarded no credit. Common errors were not knowing the circuit symbol for a variable resistor and not connecting the voltmeter in parallel with the lamp.

(ii) Most candidates knew the correct formula and correctly calculated the resistance gaining credit.

(c) Very few candidates were able to explain the problems with contraction when the cables were cold, despite knowing that metals expand when heated.

Question 10

(a) Most candidates correctly gave four as the number of different elements present in sodium hydrogencarbonate.

(b) This part was not understood by most candidates. Candidates needed to explain that carbon dioxide was produced and that this produced an acidic solution.

(c) (i) Many candidates correctly calculated the temperature change as 7 °C. Fewer indicated that it was a 7 °C decrease, or -7 °C.

(ii) Only a few candidates correctly gave the term endothermic.

(d) Most candidates answered this by stating that powder had a higher surface area and therefore had a higher rate of reaction. Few candidates linked their answer to the low acid concentration.

Question 11

(a) Most candidates gained some credit, with the trachea being the most commonly identified structure. Some candidates confused bronchus and bronchiole, while many candidates did not know the larynx.

(b) (i) Few candidates were able to complete the table, not realising that the percentage of nitrogen and noble gases would be the same in inspired and expired air.

(ii) Many candidates correctly identified one noble gas gaining credit.

(iii) Candidates who just stated ‘breathing in oxygen and breathing out carbon dioxide’ were not awarded credit as more detail was required.

(iv) Most candidates found this part challenging. A few suggested that limewater would be used, but only a very few could describe a suitable method.

(c) (i) Many candidates knew that power was related to work or energy but only the most able explained that power is work done per second.

(ii) The question asked how the athlete's depth of breathing changed. A common candidate response was to vaguely state that more air was taken in. To gain credit candidates needed to explain that more air was taken in on each breath.

(iii) This part was answered well. Most candidates were able to explain that the breathing rate would be greater.

Question 12

(a) Many candidates appreciated that it was radiation. Some were able to explain that radiation did not require a medium to travel through.

(b) Refraction was quite well known. Diffraction was a common incorrect answer.

(c) Most candidates could identify two correct statements gaining partial credit.

CO-ORDINATED SCIENCES

Paper 0654/22

Core Theory

Key Message

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. The idea of using the triangle consisting of three variables is a valuable tool to answering calculation questions but is not acceptable as a formula.

General comments

Most candidates attempted all questions, with only a few parts of some questions being inaccessible. Candidates generally gained credit in all questions.

Performance depends not only on scientific knowledge but on the ability of the candidates to both understand the question and to address their answer to the actual question asked.

There was little evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

This question was answered quite well. Many candidates found part **(b) (ii)** to be challenging.

(a) (i) Potassium hydroxide was quite well known. Some candidates incorrectly suggested potassium oxide or wrote down an incorrect formula for potassium hydroxide.

(ii) The idea that reactivity increases down the alkali metal group was well known.

(b) (i) The idea that melting points increase down the halogen group was quite well known.

(ii) Only a few candidates were able to correctly describe the colour change and even fewer could explain why the colour changes.

Question 2

This question was generally well answered with many candidates gaining full credit.

(a) Force and distance were quite well known as the two quantities needed to calculate the work done.

(b) The formula for density was well known and the calculation was generally correct, however a number of candidates seemed to be confused by the volume being given as $5\,m^3$, and incorrectly gave their answer as $5\,m^3$, rather than 1000 (kg/m^3).

(c) (i) Many candidates were able to quote the audible frequency range for humans and therefore give a value lower than this. Only a small number of candidates gave a higher value.

(ii) The answer required was a definition of the term frequency as it applies to waves or vibrations. A general dictionary definition of the term was not creditworthy.

Question 3

Candidates found the later parts of this question challenging.

(a) Most candidates knew that chromosomes were threads of DNA and contained genes.

(b) (i) Many candidates correctly identified **Hh** as having no horns and **hh** has having horns. A number of candidates thought that **Hh** meant that there was a 50% chance of having horns and a 50% chance of not having horns.

(ii) Many candidates gained all available credit. A few candidates attempted to write down two gametes for the cow with horns.

(iii) All that was required here was the simple answer 'to see if any offspring have horns - if they do the bull has the **h** allele'. Many candidates attempted a much more elaborate explanation involving genetic diagrams and chances of getting each kind of offspring.

(iv) Only the most able candidates explained that genetic diagrams show the chances of getting each kind of offspring. The bull could have the **h** allele but with only a small number of offspring, they all could get the **H** allele, therefore the idea that if there were more offspring the greater the chance of having a calf with horns.

Question 4

(a) Many candidates gained credit for demonstrating an understanding of the ideas behind thermal energy transfer.

(b) Few candidates realised that they needed to show that they knew that energy was being supplied to the water for the five minute period. Most candidates gained credit for identifying the point at which the water started boiling. Very few candidates suggested what the energy was being used for once the water reached boiling point.

(c) While most candidates knew what the main features of the arrangement should many drew very poor diagrams. The particles needed be in a random arrangement and most particles needed to be touching. All the particles drawn should have been approximately the same size as the particle already drawn in the box.

Question 5

(a) (i) The compounds sodium chloride and sodium oxide were well known.

(ii) Many candidates gained full credit. A number of candidates incorrectly suggested that it is atoms, ions or protons which are transferred between sodium and chlorine.

(iii) The idea that the ions had opposite charges and would attract each other was well known.

(iv) Many candidates did not understand what the question was asking. The question asked about the differences in properties between ionic and covalent compounds. Most candidates stated that ionic compounds were formed from a metal and a non-metal, but that covalent compounds were formed from two non-metals. Although the statements are correct, no credit was awarded as these statements are not properties.

(b) (i) More than half the candidates labelled the wrong electrode. Candidates should take care when labelling the anode to label the actual anode and not the electrical wiring.

(ii) Most candidates correctly identified oxygen and hydrogen as the gases produced. A considerable number of candidates had them the wrong way round.

(iii) The tests for oxygen and hydrogen were well known. Candidates must make it clear whether the splint used in the oxygen test is a 'lighted splint' or a 'glowing splint'.

Question 6

This question was not well answered by most candidates.

(a) Many candidates repeated the question as their answer. To gain credit candidates needed to give more than just the statement 'red blood cells transporting oxygen', for example, a reference to the role of haemoglobin in the process.

(b) The function of white blood cells was not well known.

(c) Many candidates were able to describe a blood capillary but not outline the functions of a blood capillary.

Question 7

This questioned was well answered by most candidates.

(a) There were many correct answers. Even the candidates who did not give a correct formula managed to obtain the correct answer.

(b) (i) The circuit symbols for the lamp, cell and switch were well known.

(ii) Very few candidates were unable to draw a suitable series circuit.

(c) Almost all candidates gained some credit for identifying two of the forms of energy.

(d) The name of angle **b** was quite well known. Almost all the candidates wrote down the angle as 45°.

Question 8

(a) (i) The meanings of the terms gamete and fertilisation were quite well known, and many candidates gained full credit.

(ii) The sepal was not well known and the most common incorrect answer was petal.

(iii) It was specifically the ovary wall which was required. A number of candidates wrote down cell wall, but this was not deemed to be close enough.

(b) Few candidates read the question carefully enough to find more than one set as a prediction. Very few candidates pointed out that light was not necessary for germination.

(c) (i) The answer was *geotropism*. Most candidates suggested phototropism which was given some credit. However, most candidates then tried to use phototropism in their answer to part **(ii)**.

(ii) This was not well answered. A few candidates mentioned photosynthesis and the leaves needing more light. A few candidates mentioned the flowers or specific parts of the flowers which would be able to attract insects or which would help with wind pollination. A number of candidates incorrectly referred to the seed dispersal.

Question 9

(a) (i) Few candidates gave answers which showed that they really understood the differences between elements and compounds.

(ii) Many candidates drew an incorrect structure of one hydrogen atom surrounded by four carbon atoms.

(iii) Natural gas was not well as the main source of methane.

(b) (i) Most candidates correctly identified molecule **Z** as being ethane.

(ii) Only the most able candidates stated both molecules **X** and **Z** as being unsaturated. However many correctly gave one molecule, and were awarded partial credit if their explanation was valid.

(c) (i) The majority of successful candidates gained some credit by writing a simple sentence describing how ethene forms poly(ethene).

(ii) Polymerisation was well known but not *addition* polymerisation.

Question 10

(a) Almost all candidates gained partial credit with many gaining full credit.

(b) Many candidates described the effects of ionising radiation on the body rather than describing what ionising radiation was.

(c) Nuclear fission was not well known. Only the most able candidates described it as the splitting of a nucleus. Many explained that it happened in nuclear power stations.

(d) Candidates found this part challenging and only a few gained full credit.

(e) This part was well answered by most candidates. Both of the correct answers were frequently chosen.

(f) (i) Some candidates misread the horizontal scale and gave an answer of 4.5 rather than 5.

(ii) Most candidates were unable to explain how to use the apparatus correctly.

(iii) **idea 3** was frequently chosen and most candidates were able to correctly explain that the photographic badge only detects radiation, but does not reduce her exposure.

Question 11

(a) (i) Chlorophyll was well known as the substance in the leaves of a plant that absorbs the energy in sunlight. A number of candidates suggested that it was chloroplasts that did this.

(ii) Carbon dioxide was well known but was water was less well known.

(iii) Oxygen was very well known as the gas released during photosynthesis.

(b) Most candidates knew that a herbivore was an animal that only ate plants but only the most able gained full credit for explaining that the herbivore got *all* its energy from eating plants.

(c) Protein being used for growth and repair was well known. Only a few candidates knew another use for proteins.

(d) Few candidates appreciated that this question was about how heat was removed from the body. The consequence of arterioles dilating was not understood, nor how sweating removes heat from the body.

Question 12

(a) Most candidates gained some credit for this question. Very few candidates knew that a colourless gas would be given off by test-tubes **P**, **Q** and **R**.

(b) (i) Most candidates knew the pH range for an alkali.

(ii) This was well answered by many candidates.

(iii) Most candidates could not explain that the temperature increased as a result of heat energy being transferred to the mixture. A common answer was to suggest that chemical reactions caused the temperature increase.

(iv) Salt and water were quite well known.

(v) Many candidates could only identify one source of sulfur dioxide.

CO-ORDINATED SCIENCES

Paper 0654/23

Core Theory

Key Message

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. The idea of using the triangle consisting of three variables is a valuable tool to answering calculation questions but is not acceptable as a formula.

General comments

Most candidates attempted all questions, with only a few parts of some questions being inaccessible. Candidates generally gained credit in all questions.

Performance depends not only on scientific knowledge but on the ability of the candidates to both understand the question and to address their answer to the actual question asked.

There was little evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

This question was answered quite well. Some candidates found parts of the question challenging.

(a) Many candidates showed good data handling. Most candidates correctly identified at least two of the points.

(b) (i) Many candidates found the data provided difficult to understand. A number of candidates thought that the data was taken over two days. Full credit was awarded for a good description of how the energy output varied.

(ii) Many candidates repeated their answer to part **(i)** and did not give a reason why the energy output varied.

(c) Only a few candidates named a fossil fuel. Very few were able to describe how the energy is transferred from the fuel to the generator.

(d) This was fairly well answered.

(e) Many candidates seemed uncertain about the characteristics of a plane mirror and described why cars have mirrors, and were therefore unable to be awarded credit.

Question 2

This question was only well answered by the most able candidates. However, most candidates gained some credit.

(a) (i) This was not well answered. Many candidates gave vague answers referring to fuel for vehicles.

(ii) This was not well known. Many candidates incorrectly thought that hydrogen is a product of the complete combustion of hydrocarbons.

(iii) Correct explanations about oxidation were rarely given.

(b) (i) Cracking was not known by most candidates. Many different incorrect responses were seen.

(ii) Few candidates realised that unsaturated hydrocarbons were produced during cracking and few knew the bromine test for unsaturated hydrocarbons.

Question 3

(a) Most candidates answered this part well showing a good understanding of the terms producer, consumer, carnivore and herbivore.

(b) Few candidates were able to answer this correctly. None of three possible answers were well known to the candidates.

(c) Most candidates gained partial credit, usually for suggesting muscle contraction or digestion.

Question 4

(a) (i) Gas being produced and a temperature change were well known observations.

(ii) That hydrogen gas was produced was quite well known.

(iii) Only the most able candidates knew that an increase in pH meant that the solution was becoming less acidic as the acid was used up. Many candidates thought that the acid concentration was increasing.

(b) (i) Many candidates gained partial credit for their answer.

(ii) Many candidates correctly identified at least one variable. This was usually the temperature of the acid or the acid concentration.

Question 5

(a) (i) Infra-red was well known.

(ii) Many candidates knew that the waves in the different regions of the electromagnetic spectrum had different wavelengths and frequencies.

(b) Most candidates showed a good knowledge of refraction and total internal reflection and gained credit.

(c) (i) Very few candidates were able to describe an α-particle.

(ii) Very few candidates were able to name a source of background radiation.

(d) Many candidates wrote down a correct statement. Many thoughtful and original creditworthy answers were given.

(e) Most candidates were able to identify one of the pieces of equipment that detected radiations, although very few candidates identified both.

(f) This was well answered by many candidates.

(g) This was well answered.

Question 6

(a) Many candidates were awarded some credit in this question. All of the correct responses were equally accessible to the candidates.

(b) (i) Very few candidates were able to calculate the answer of 30 days from the graph.

(ii) Only the most able candidates used the data on the graph to answer this part of the question.

(c) (i) Very few candidates knew the term, Human immunodeficiency virus.

(ii) Most candidates were awarded some credit, usually for a reference to breastfeeding.

Question 7

(a) (i) Most candidates gained partial credit. Although references to corrosion gained credit, references to rusting are not creditworthy.

(ii) Transition metal was not well known. Many different incorrect responses were seen.

(b) (i) The term alloy was not known. Again, many different incorrect responses were seen.

(ii) Although the candidates did not know what an alloy was, many knew an advantage of an alloy compared to a pure metal. Many candidates answered either harder or stronger.

(c) (i) Electrolysis was fairly well known.

(ii) To be awarded credit the label for the cathode had to be drawn to the carbon electrode and not to the wire or power pack.

(iii) Very few candidates were able to identify copper chloride as the compound or give an explanation.

Question 8

(a) The majority of candidates were able to describe the energy transfers involved in the washing machine.

(b) (i) The idea of the random arrangement of both liquids and gases was well known and many candidates gained credit for their drawings. Candidates should be reminded to draw their particles with similar sizes, as drawing where the particle size differed too much were unable to gain full credit.

(ii) Many candidates explained that evaporation had something to do with the faster moving molecules breaking free and leaving the liquid, but were unable to develop this further to gain full credit.

(c) This was quite well answered, although many candidates were not awarded full credit, as an incorrect symbol for current was used. The accepted symbol is **I** not A.

Question 9

(a) (i) This was well answered, and most candidates gained some credit.

(ii) A significant number of candidates tried to write the word equation with a mixture of words and symbols. Candidates should be reminded that a word equation should not contain symbols.

(b) (i) To be awarded credit, candidates had to do more than just identify the features that help trap insects. They needed to state that the pitchers had spines so that the insects could not crawl out or that the pitchers had a slippery rim so the insects fall in.

(ii) The definition of digestion was not well known. Candidates needed to explain that large molecules are broken down so that they could be absorbed.

(iii) Only a few candidates suggested that enzymes must be present in the solution. Most candidates incorrectly suggested acid.

(c) (i) The idea that water was placed on both sides of some dishes as a control was not well understood.

(ii) A number of candidates correctly suggested that the results did support the scientist's hypothesis because insects moved towards the piece of rim. The most able candidates used data from the table to support their answer.

Question 10

(a) (i) This was not well answered by most candidates. Only the most able candidates knew that calcium carbonate is used to reduce acidity in the soil and potassium compounds increase plant nutrient levels.

(ii) The chemical test for carbonate ions was not well known. When a carbonate is mixed with a dilute acid, carbon dioxide is produced.

(b) (i) Many candidates correctly determined the total number of atoms as 15.

(ii) Few candidates realised that to form ammonium sulfate, sulfuric acid would be required for the neutralisation reaction.

(iii) The idea that the solution needed to be warmed gently to allow some of the water to evaporate was not understood.

Question 11

(a) Most candidates gained some credit. There seemed to a reasonable understanding of how enzyme activity is affected by temperature.

(b) (i) Most candidates gained credit for a reference to sweating. A number of candidates thought that the sweat gland was blocked in environmental condition **2**.

(ii) The idea that environmental condition **2** was hotter was well known.

(iii) The idea that muscle contraction would release heat was not well known.

CO-ORDINATED SCIENCES

Paper 0654/31
Extended Theory

Key Messages

Candidates are reminded to show their calculations to numerical questions. Credit is awarded for both the working and the result of the calculation. This means some credit can be given for the process, even though the final answer may have been incorrect.

Where a formula is used, it should be quoted either in words or using the conventional symbols as listed in the syllabus. A combination of words and symbols will generally not be awarded credit.

General comments

The most successful candidates arranged their answer to address all the points required by the question, mindful of the number of marks available and the space allowed for their response. They checked their work to avoid contradictions, and that they were not simply rearranging the information in the question.

Candidates should use the units as listed in the syllabus, using the correct case.

Comments on specific questions

Question 1

(a) (i) Most candidates showed they knew that the nucleon number was the sum of protons and neutrons, and that electrons were not involved and gained full credit. Nucleon number was sometimes confused with neutron number.

(ii) Successful candidates recognised that all isotopes of helium had two protons, or were able to define an isotope.

(b) (i) Most candidates gained full credit with a diagram of a hydrogen molecule showing a shared pair of electrons between two nuclei.

(ii) The majority explained that helium existed as single atoms because they were unreactive or had a complete electron shell.

(c) Most candidates realised that the 'pop test' indicated that hydrogen had been produced, and that only the zinc displaced hydrogen by reacting with the acid. To obtain full credit a statement about the reactivity of the metals relative to hydrogen was required.

Question 2

(a) (i) Nearly all candidates gave a correct formula for calculating the distance travelled by the sound to the fish. Only those who realised that the time taken was half that between sending the pulse and receiving the echo, gained full credit.

(ii) Successful candidates rearranged the formula for the speed of a wave and used hertz (Hz) as the unit of frequency.

(b) Most candidates made reference to the sustainability of renewable energy sources in some way. Statements that such sources could be 'reused' or 'renewed' were not creditworthy. To gain full credit there had to be the suggestion that emissions would not produce acid rain or contribute to global warming rather than making a vague statement about pollution and the environment.

(c) This question on the states of matter was well answered.

Question 3

(a) Most candidates could identify the male and female parts of the flower. There were many good descriptions of insect pollination with those gaining full credit explaining the position of the organs in relation to the nectary.

(b)(i) The most common suggestion for a fruit dispersed by the wind was the dandelion. To gain the credit candidates needed to highlight the feature which enabled wind dispersion in a drawing of the fruit and to suggest how this feature was adapted to enable such dispersion. Some candidates gave an example of wind **pollination**, which may have been correct, was not creditworthy in this context.

(ii) The best responses described how wind dispersion caused seeds to spread to new areas, reducing competition. Those who just stated that it was important for species survival did not gain credit.

Question 4

(a) The majority of candidates were able to draw the structure of the propane molecule gaining full credit.

(b) (i) Most knew that the temperature decreased up a fractionating column. A minority tried, generally unsuccessfully, to apply their knowledge of convection currents.

(ii) The best answers stated that the average boiling point of the fraction at **B** was lower than that at **C** because the molecules were shorter. This causes intermolecular forces to be smaller so that less energy is needed to separate molecules.
The forces were sometimes called 'bonds', but it was not always clear whether these were between or within molecules.

(c) (i) Most candidates knew that sodium and chlorine were too reactive to be found uncombined in the Earth's crust. Some went beyond what was required for by describing the electronic structures.

(ii) The best answers described the transfer of the outer shell electron of the sodium atom to a chlorine atom, filling its outer shell. Many candidates incorrectly suggested that the bonding between sodium and chlorine was covalent.

(iii) There were a few good representations of the cubic structure of a sodium chloride crystal. This did not need to be 3-dimensional. A simple diagram showing nine alternate charged sodium and chloride ions in a 'square' arrangement would have sufficed. Some candidates interpreted the question as requiring a diagram of the electronic structure of the ions.

Question 5

(a) (i) Those that noticed that the calcium content was given in mg units, recognised that it was present in the smallest quantity gaining credit.

(ii) Only a minority of candidates realised that water was the major constituent of milk.

(iii) This was well answered with most candidates knowing why higher calcium or protein intake was beneficial to health.

(iv) Most candidates explained that cow's milk was better because it contained less fat reducing the risk of heart disease or obesity. The term 'obesity' is preferable to 'being overweight'.

(v) Some candidates explained that calcium did not need to be digested because it consisted of particles small enough to be absorbed. Very few described the calcium particles as ions. Some suggested that calcium was absorbed into bones without passing through the alimentary canal.

(b) (i) (ii) To gain full credit candidates needed to explain that lactose conversion took place faster because the enzyme provided by the bacteria worked best at 40 °C, and that the yoghurt was chilled to slow down enzyme activity. Many candidates suggested that it was the bacteria, rather than the enzyme which it produced, that was responsible for the change.

(iii) Most candidates realised that the production of lactic acid would reduce the pH of milk.

Question 6

(a) (i) Most candidates quoted the correct formula for work done in order to make the comparison. A few used the weight rather than the mass of the bags, calculated the correct height and used joules as the unit of work.

(ii) Many quoted the formula for power to make the comparison. Others repeated the information in the question, such as changing the wording from 'more quickly' to 'in less time'.

(iii) This question was answered well.

(b) Many candidates knew that the current would increase when the temperature of the thermistor increased. It was rare to see an explanation in terms of the decreasing resistance of the thermistor and reference was seldom made to Ohm's law. There was some confusion between the resistance of the thermistor and that of the resistor. Some responses implied that the device acted as a digital switch turning the buzzer current on and off.

(c) (i) This question was answered well, either by using the formula for distance travelled at constant speed, or by measuring the area of the rectangle. It was helpful when the method used had been stated so that credit could be given when an arithmetic error gave an incorrect answer.

(ii) This question was answered well.

(iii) Good explanations for boy **C** slowing down made reference to the graph. Recognition that the line had a negative gradient, sloped downwards, or using of data from the graph, were creditworthy. Phrases such as 'his speed decreased' did not add to the information given in the question and was not awarded credit.

Question 7

(a) (i) Most word equations were correct although magnesium oxide was sometimes omitted. The inclusion of vanadium steel was incorrect.

(ii) Many candidates knew some differences between the properties of vanadium and magnesium.

(b) Many candidates could balance the equation, and knew that vanadium oxide was a catalyst in the Contact Process. A statement that 'it did not take part in the reaction' is inaccurate and not creditworthy.

(c) The best answers gave clear, concise calculations of the number of moles. Most candidates could find the molar mass of sulfuric acid. However, even when the correct method was suggested, the percentage of pure acid was not found, or the mass was left in kg.

Question 8

(a) Many candidates knew that acid rain was produced by a polluting gas interacting with atmospheric water. Only the most able candidates suggested the most likely source would be sulfur dioxide caused by the combustion of fossil fuels. The nature of the interaction was often vague or inaccurate, such as the gas condensed in the clouds, rather than the gas dissolved in or reacted with water. Several responses suggested that acidic gases found their way into the atmosphere when evaporation of polluted lakes occurred.

(b) There were some excellent answers to this question. Candidates recognised that eutrophication causes algal bloom, or increases growth of surface plants, shading those beneath; and that when these plants die, bacteria feed on the material, respire and remove oxygen from the water; and that fish would die as a result of the removal of oxygen. Some responses suggested that plants not photosynthesising caused the lack of oxygen or referred to the toxicity of the fertiliser.

(c) Many candidates knew that the removal of trees would cause less carbon dioxide to be removed from the atmosphere. This was not always explained by referring to the fact that there would be less photosynthesis. The best responses made the link between the addition of carbon dioxide by human activity and its removal by photosynthesis. Alternatively a description of photosynthesis would be given with an inaccurate statement that this would lead to an increase in the carbon dioxide concentration.

Question 9

(a) Where the transformer formula could be recalled, candidates generally rearranged it correctly and the number of turns was correctly determined. There was sometimes difficulty in choosing symbols for the voltages and numbers of turns. Sometimes it was not obvious which quantities were represented.

(b) The best responses explained that a transformer was used to step up the voltage at the power station in order to decrease the current in distribution cables, reducing energy loss. Most did know that the voltage was reduced near the point of use, although the reason for this was sometimes vague. The purpose of the transformer in the battery charger was sometimes described in place of those used in the large scale transmission of electricity.

Question 10

(a) The majority of candidates knew that limewater was the reagent used for testing for the presence of carbon dioxide.

(b) The point on the graph at which the reagents were mixed was usually correctly labelled. There was some confusion about when the reaction was occurring, leading to various estimates of the temperature difference. When the correct temperature change was calculated it was rarely shown to be a decrease. The increase in temperature was often attributed to a stage in the reaction rather than to heat energy flowing into the mixture from the environment. Because of this uncertainty the reaction was variously described as endothermic, exothermic or both. The conversion of heat energy from the mixture to chemical energy was described only in the best responses. There was some confusion between the terms temperature and heat.

(c) (i) Many candidates knew that carbon dioxide would affect the colour of the indicator and some explained this in terms of the acidity of the oxide. Some incorrectly thought that carbon dioxide was alkaline.

(ii) Most suggested that the gas was carbon monoxide but did not always write the chemical formula as required by the question. Responses gaining full credit showed the working in the calculation of relative formula mass.

Question 11

(a) The larynx and trachea were usually correctly located and labelled. The label for the bronchus was often placed on a branch of the bronchus, that is, on a bronchiole.

(b) Most candidates gained credit for stating that the large surface area alveoli ‘helps’ the rate of gas exchange. The best candidates also stated that a good blood supply was required - often this was described in terms of the number or proximity of capillaries. There was some mention of the role of moisture on the inner surface. The wall of the alveolus was correctly described by some as thin or one cell thick.

(c) There were a few very good creditworthy descriptions of nasal tissue, stating how goblet cells produced mucus which trapped specified substances such as pathogens or dust, and how cilia swept the mucus away from the lungs. A few candidates interpreted the diagram of the goblet cells as if they trapped and disposed of harmful substances themselves.

(d) (i) A minority of candidates explained that alpha radiation would have too great an ionising effect and specified the possible health risks. A comparison of penetrating powers was more common, but as this does not address the question asked, credit was not awarded.

(ii) A small majority of candidates correctly identified the three results showing that breathing smoke slowed down the rate at which the cells worked.

(iii) Though most candidates showed that they were aware of the dangers of smoking, few used their knowledge of the structure of the respiratory system to explain the mechanisms by which health was affected. The best answers explained the incidence of bronchitis as inflammation of airways associated with the over-production of mucus in which bacteria bred, or emphysema as the breakdown of alveolar walls rendering gas exchange less efficient. Marks were also awarded for the effect of tar or carbon monoxide, or for reference to another specific disease specifically related to smoking.

Question 12

Candidates are expected to have a ruler for this examination.

(a) A diagram representing a transverse and longitudinal wave was usually offered. Candidates needed to annotate the diagrams describing the relative directions of oscillation and wave propagation to gain credit. Candidates were often unclear about what was oscillating, describing this and the direction of energy transfer as wave motion. Motions described as ‘side to side’ or ‘back and forth’ were not helpful. Only the most able candidates gained credit for identifying compression and rarefaction in a longitudinal wave.

(b) (i) Most candidates correctly drew a ray diagram for a periscope. The ray needed to be accurate with angles of incidence and reflection approximately equal, and with the reflection occurring at a point on the surface of the mirror symbol. The ray should have been straight, that is drawn with a ruler. The arrows should have been drawn in the right direction and for clarity not on the mirror surface.

(ii) The definition of a virtual image, as one ‘that cannot be projected onto a screen’, was sufficient to gain credit. The most common, but inadequate, description seen was ‘an image that was not real’.

(c) (i) Most candidates showed evidence of recall of the ray diagram, although not all drew straight rays passing through one or both principal foci or through the optical centre, nor were all diagrams drawn with care. The best responses showed the top of the image at the junction of the rays with the bottom on the principal axis, while others just labelled the point as the image.

(ii) Generally most candidates took reasonably accurate measurements of the object and of their image.

(iii) The formula for magnification was not well known. The ratios of ‘measured to actual’ or ‘image to object’ were not precise enough. A few inverted the ratio of height of image to height of object.

CO-ORDINATED SCIENCES

Paper 0654/32
Extended Theory

Key Messages

Candidates are reminded to show their calculations to numerical questions. Credit is awarded for both the working and the result of the calculation. This means some credit can be given for the process, even though the final answer may have been incorrect.

Where a formula is used, it should be quoted either in words or using the conventional symbols as listed in the syllabus. A combination of words and symbols will generally not be awarded credit.

General comments

The most successful candidates arranged their answer to address all the points required by the question, mindful of the number of marks available and the space allowed for their response. They checked their work to avoid contradictions, and that they were not simply rearranging the information in the question.

Candidates should use the units as listed in the syllabus, using the correct case.

Comments on specific questions

Question 1

(a) Those candidates who answered in terms of metals and non-metals gained full credit. Those who referred only to electronic structure of the atoms or considered the halogens to all be gases were unable to gain full credit.

(b) (i) Most candidates identified the carbon allotrope as graphite and gave good accounts of the sliding of layers of atoms when explaining its use as a lubricant or in pencil leads gaining credit. Those who tried to explain its electrical conductivity found this more challenging.

(c) (i) Those candidates who used the formula for lead oxide as given in the question were able to produce a balanced equation although some did not realise that hydrogen is diatomic.

(ii) The majority of candidates knew that calcium was highly reactive but some compared it to lead rather than hydrogen.

Question 2

Most candidates gained credit on this question by knowing the correct formulae and using the correct units.

(a) There was a tendency for some candidates to use newton-metre as the unit which is not acceptable instead of joules.

(b) Several candidates, who had written a correct formula, did not then square the velocity resulting in an incorrect answer.

(c) Many candidates did not realise that the area given was only for one of the elephant's feet. Some had problems with the unit often using N/m^3.

(d) Some candidates unnecessarily converted the units to g/cm^3, which was awarded credit. Candidates should be aware the accepted unit is kg/m^3.

Question 3

(a) Most candidates referred to DNA but did not refer to genes. Instead they referred to genetic material which is not creditworthy.

(b) Many candidates did not relate their answers to the cell drawn in Fig.3.1 and answered in terms of the human cells giving 46 and 23. Many knew that after meiosis there would be half the number of chromosomes and this was given some credit.

(c) Most candidates knew that mitosis was for growth and repair but some stated it was for growth and repair *of cells* which is not creditworthy. Only a few confused this with meiosis and referred to forming gametes.

(d) (i) Most candidates were able to give the correct phenotypes but some simply repeated the genotype.

(ii) The most able candidates recognised that a standard **test cross** was required and answered accordingly but often did not label diagrams adequately. Some drew several possible combinations of punnet squares but then did not relate these to their answer. Many did not realise that only those with the phenotypes with horns could be identified as having the **hh** genotype when selecting a cow for breeding. Many candidates attempted to use knowledge of the parents, grandparents and / or siblings but this was generally not creditworthy.

Question 4

(a) The most able candidates recognised that the input of energy from the microwave did not raise the temperature during boiling because the energy was being used to separate the molecules. It was generally recognised that the water was boiling after two minutes. Most candidates had the idea of molecules having sufficient energy to leave the liquid.

(b) Most candidates were able to perform this calculation correctly with only a few mixing words and symbols in the formula.

(c) Most candidates gained credit for adding the power of the grill to that of the microwave and many multiplied power by time. Some candidates did not convert the time from minutes to seconds or the power from kilowatts to watts to match their unit of joules. Many candidates tried to use the formula: power = current × voltage despite being given neither in the question.

(d) Most candidates referred to the circuit being complete or incomplete with the most able realising that the reed relay was acting as the switch and was operated by the proximity of the magnet. To gain full credit candidates had to make it clear that the magnet in the door was not itself completing the circuit when the door was closed.

Question 5

(a) (i) Most candidates were aware that bonding usually resulted in eight electrons in the outer shell of both atoms and there were some good descriptions of electron transfer. It was generally appreciated that each sodium atom would lose 1 electron and that the oxygen atom would gain 2 electrons. A significant number of candidates referred to covalent bonding and / or sharing electrons.

(ii) Many candidates described the electronic changes which occurred during bonding appearing not to understand the term 'properties' in this question. Of those who gave properties, they often attributed high melting point to covalent compounds and / or did not refer to the need for ionic compounds to be molten or dissolved to conduct electricity.

(b) (i) Most candidates correctly identified gas **P** as oxygen.

(ii) Most candidates performed this calculation well and stated the units correctly gaining full credit.

(iii) The majority of candidates had the right idea for this calculation, but many did not realise that the molar volume was given in dm^3.

(iv) The most able candidates deduced a quantitative relationship between the volume of hydrogen produced and the current and relate this to the electron flow and the subsequent discharge of ions. Many candidates referred to the electrons and / or the ions moving faster at high current and there were a number who thought that the electricity was splitting the sulfuric acid into ions.

Question 6

(a) (i) Most candidates identified the red blood cell stating that it contained haemoglobin which carried the oxygen but did not always make it clear that they were chemically combined. Attempts to describe transfer of oxygen from the lungs to the cells in the body were generally too imprecise to be gain credit.

(b) Many candidates used the term 'thin' but often did not make it clear whether this was the wall or the diameter of the capillary. Most referred to the transfer of blood but did not always use the term diffusion.

(c) Most candidates wrote in general terms about white blood cells and did not identify this cell as a phagocyte. Answers in terms of lymphocytes and antibodies were not creditworthy. A number of unacceptable terms for the micro-organisms dealt with were used e.g. germs, viruses, diseases.

Question 7

(a) The majority of candidates performed this calculation correctly. Some used the formula for resistances in series and some failed to invert the calculated figure to give the final answer.

(b) (i) Most candidates were able to correctly categorise the energy sources as renewable or not-renewable.

(ii) The good candidates were able to identify this as a nuclear reaction but only a few knew that it was a fusion reaction. A variety of other answers such as combustion, exothermic and solar power were given.

(iii) The majority of candidates knew that there were no particles in space to transfer the heat. Some thought that only solids could conduct and a few thought that the Earth would get too hot.

(c) Most candidates referred to the magnetic field of the magnet and the movement of the magnet within the coil. Many had the idea of the coil cutting the lines of magnetic force causing induction. The majority referred to current being induced rather than e.m.f. or voltage. Some candidates confused magnetic flux with magnetic field.

Question 8

(a) (i) Many candidates knew what a gamete was but some gave answers with lots of detail about chromosomes rather than gametes. For fertilisation insufficient detail was given and many did not refer to fusion of the nuclei of the gametes.

(ii) Many candidates identified part **A** as a sepal but most referred to it protecting the flower rather than the bud. Some thought it was a petal. Part **B** was usually named correctly as stamen or anther although some put filament which was not creditworthy as the label was clearly on the anther. Many did not associate the stamen with production of the pollen.

(iii) Most candidates identified part **C** as the ovary with few adding that it was the ovary wall. There was some confusion between ovule and ovary.

(b) (i) Many candidates thought this was **photo**tropism even though the question clearly stated that the light was coming from all sides. Where candidates wrote '–trophism' the 'trophism' part gained partial credit whereas '-trophic' was not creditworthy as it has another meaning.

(ii) Most candidates responded in terms of receiving more light to photosynthesise rather than use idea of sexual reproduction as asked in the question, tending to refer to raising the plant rather than the flower.

(iii) Most candidates were aware that auxin is responsible for accelerated growth and linked higher auxin concentration to increased growth of the lower surface. Many candidates referred to light again, often when they had put geotropism in part **(ii)**. A number of candidates referred to auxin making the cells grow upwards rather than the plant.

Question 9

(a) (i) Most candidates were familiar with the term monomer.

(ii) Most candidates had some idea of joining the molecules together but the majority did not include sufficient of the features of the monomers to be awarded credit. Some candidates included continuation bonds and a few put in an amide linkage.

(iii) Most knew it was polymerisation but not that it was *condensation* polymerisation. The majority identified the by-product as water.

(b) (i) Most candidates knew that amino acids polymerised to form proteins.

(ii) Most candidates named enzymes in response to this question, rarely stating the conditions and therefore credit was not awarded.

(**iii)** Most candidates named this as digestion rather than giving a type of **chemica**l reaction.

Question 10

(a) The majority of candidates knew that electrons were removed by ionising radiation, however to gain full credit, only the most able candidates linked this to atoms forming ions.

(b) (i) The majority of candidates knew how to work out the half-life from the graph. The main error arose from an incorrect reading of the initial count rate with several using the top figure on the count rate scale. Some candidates calculated half the initial count rate but did not read the equivalent time from the graph.

(ii) Many candidates were able to perform this calculation correctly. Some calculated the percentage that would have decayed rather than what was remaining.

(c) (i) Most candidates gave a correct answer. Some attempted to give a range e.g. 0 – 5 cm, or gave the units as d / cm.

(ii) Many simply stated they would measure the count rate and move the source until there was a zero count without details. Candidates who indicated that they would measure distances, take several readings at each distance and take into account background radiation gained credit.

(iii) Most were able to identify **idea 3** as not giving protection, generally because it would only measure the amount of exposure. The most able candidates explained what protection **idea 1** and **idea 2** would give.

Question 11

(a) Most candidates knew that photosynthesis was the process by which plants converted carbon dioxide and water into glucose using energy from sunlight but they were less clear in linking this to chemical energy. Many knew that the light energy was absorbed by chlorophyll.

(b) Those candidates who wrote: ‘energy is lost by respiration in the form of heat’ gained full credit. There were other ideas that could have gained credit, but these were rarely seen.

(c) The more able candidates mentioned respiration and the release of energy from glucose, often at the end of their answer. Most candidates described the processes of digestion and absorption even though the question said **after** the food has been digested and absorbed.

Question 12

(a) Most candidates gained partial credit for this question, most commonly for turning red when excess acid was added or producing a gas which popped when ignited. Very few candidates realised that there were three tubes which would give off a colourless gas.

(b) (i) The majority of candidates noted that the pH decreased when more acid was added and many also noted that there was a change in the rate of decrease when the acid reached a certain volume.

(ii) Most candidates realised that that neutralisation was indicated by a pH value of 7, although a considerable number thought it was at the steep part of the curve.

(iii) Most candidates had the idea that the ratio of the concentrations of the two solutions was related to the ratio of the volumes needed for neutralisation. Many did not realise that the stronger acid required a smaller volume and arrived at an answer of $0.2\,mol/dm^3$ rather than $5\,mol/dm^3$.

CO-ORDINATED SCIENCES

Paper 0654/33
Extended Theory

Key Messages

Candidates are reminded to show their calculations to numerical questions. Credit is awarded for both the working and the result of the calculation. This means some credit can be given for the process, even though the final answer may have been incorrect.

Where a formula is used, it should be quoted either in words or using the conventional symbols as listed in the syllabus. A combination of words and symbols will generally not be awarded credit.

General comments

The most successful candidates arranged their answer to address all the points required by the question, mindful of the number of marks available and the space allowed for their response. They checked their work to avoid contradictions, and that they were not simply rearranging the information in the question.

Candidates should use the units as listed in the syllabus, using the correct case.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly labelled the part of the graph when the car was accelerating.

(ii) The total distance travelled by the car was usually calculated by measuring the area under the graph. Some candidate tried to estimate the average speed, those that explained this method gained partial credit for the process even when the answer was incorrect.

(b) (i) The best answers explained the varying energy output from the solar panels in terms of the varying light energy input. Those who made statements such as 'the Sun moves or goes in' were unable to be awarded credit.

(ii) Many candidates correctly measured the time for which the solar cells could run the car.

(iii) Some candidates rearranged the efficiency formula usually obtained the correct numerical value for energy input, however the unit J / s needed to be used to be consistent with the stated value of the output.

(iv) Many candidates quoted the formula for kinetic energy and correctly substituted the data gaining full credit.

(c) (i) To measure the voltage across the cell, candidates placed the voltmeter in parallel and in series in roughly equal numbers. A non-standard symbol was sometimes used.

(ii) The formula for electrical power was well known and most candidates correctly calculated the answer, gaining credit.

Question 2

(a) Many candidates correctly gave the full name of the separation process as fractional distillation.

(b) (i) The formula of the alkane was usually quoted correctly as C_8H_{18}. The explanation given often involved balancing the equation, however in to gain full credit, a statement about the need for atoms of each element to be the same on each side of the equation was required.

(ii) Many diagrams of the bonding of ethene showed the correct element symbols, a shared electron pair at each C–H single bond and two shared pairs at the C=C double bond.

(c) (i) To calculate the number of moles in 480 cm^3 of carbon dioxide, some divided by the molar volume but few candidates remembered to convert this to cm^3.

(ii) The molecular mass of ethene was often calculated correctly. Few candidates found the number of moles of ethene used from the equation and their answer to part **(i)** or to calculate the mass used from this data. It was rare to see a strategy for the calculation written in the answer space.

Question 3

(a) (i) A number of candidates knew that producers transfer chemical energy to herbivores. Some incorrectly wrote about the material which stored the energy.

(ii) The percentage of energy transferred from producers to carnivores was often correctly calculated as 1%. A common incorrect answer was 10%, suggesting that the question had been misread.

(iii) Many candidates gave at least one way in which energy was lost from the food chain. Some answers were too general, such as 'through life processes' to gain credit. The term *excrete* appeared to be misunderstood.

(b) Many candidates knew that the removal of trees would cause less carbon dioxide to be removed from the atmosphere. This was not always explained by referring to the fact that there would be less photosynthesis. The best responses made the link between the addition of carbon dioxide by human activity and its removal by photosynthesis.
Alternatively a description of photosynthesis would be given with an inaccurate statement that this would lead to an increase in the carbon dioxide concentration. The link between increased carbon dioxide content and global warming was not always made.

Question 4

(a) (i) The formulae for magnesium and hydrochloric acid were well known. A significant number of candidates used 'MgCℓ' in their equation, thus preventing completion of the equation and therefore candidates were unable to be awarded full credit.

(ii) Some candidates described the reaction as exothermic. The terminology used for the transfer of heat energy into the mixture was often inaccurate. Heat energy needed to be specified and terms such as 'given off' are not creditworthy. The transformation from chemical to heat energy was not often discussed.

(b) (i) Where an attempt was made at calculating the average rate of gas production at 40 °C, the correct result was usually obtained. Other responses involved the calculation of the average of the rates or the average time taken.

(ii) The most able candidates gave accurate and concise explanations of the effect of temperature on rate of reaction. Credit was sometimes lost by candidates referring to the 'decrease in motion of particles' rather than in their 'speed or kinetic energy'. The requirement for collision to bring about reaction was seldom stated. The importance of collision frequency was recognised by some. Reference to collision energy or its link to chance of reaction was not often seen.

Question 5

(a) (i) Only a minority of candidates knew the speed of light and were able to convert the units.

(ii) As well as infra-red, the most common suggestions for the radiation used in remote control devices were radio and microwave.

(iii) Wavelength or frequency was often correctly suggested as a differing property of waves in the electromagnetic spectrum, with amplitude also being common.

(b) This was generally done well.

(c) Most candidates showed their working and many obtained a good estimate for the half-life. Some had difficulty reading the scales or when they apparently attempted to compensate for background radiation.

(d) (i) Many correctly chose the polonium isotope as having the highest count rate due to its longer half-life.

(ii) Fewer selected the polonium and radon isotopes as being the most ionising because they both emitted alpha radiation. Some candidates thought that gamma radiation was the most ionising.

(e) The medical tracer was most often chosen to require an isotope with half-life of six hours, however many candidates were unable to give a creditworthy explanation.

Question 6

(a) Most candidates knew the direction of flow in at least one pair of blood vessels, usually the maternal artery and vein or the umbilical artery and vein.

(b) (i) Carbon dioxide was often suggested as a substance that passed from the fetus's blood to the mother. General terms like 'waste' were sometimes used.

(ii) Water was occasionally chosen as the substance that passed from the mother's blood to the fetus's blood. Examples were often chosen from materials that had not been digested such as protein.

(c) (i) Most candidates knew that oxygen was carried in red blood cells, often associated with haemoglobin. Only the most able candidates implied that this is a chemical combination.

(ii) Most candidates could select at least one or two reasons why the rate of absorption across the lungs was more than that across the placenta. The term diffusion was not often used.

Question 7

Very few candidates showed confidence in discussing the structure of metals and electrolytic processes.

(a) Many candidates knew that copper was less reactive than sodium and magnesium. Examples of reactions between metals and water or oxygen were less common than descriptions of changes in electronic configuration, sometimes involving covalent bonding.

(b) (i) Very few candidates knew that bronze was an alloy.

(ii) The very few candidates who realised that the tin atoms disrupted the metallic structure of copper were more likely to describe the extra energy required to make atoms move past each other than was required to make **layers** of atoms slip.

(iii) Some answers suggested that an alloy was a compound because its different elements were bonded, rather than because **atoms** of different elements were bonded.

(c) (i) There were a few good answers describing the attraction between copper ions and the steel cathode. Of these only the most able were able to explain the discharge of the ions by each gaining two electrons.
Many candidates confused the roles of atoms, ions and electrons in the electrolysis process.

(ii) Candidates were most likely to suggest carbon dioxide for the gas produced at the carbon anode.

(iii) Ideas for obtaining evidence for the electrode dissolving often included weighing. Other methods were more likely to opt for measuring length than a more precise thickness measurement. It was rare that the expected result of the measurement was stated.

Question 8

(a) (i) Of the candidates who knew the formula for power and could rearrange it, only a few converted the power to watts before multiplying by time. Fewer converted the time to seconds.

(ii) Some candidates correctly argued that reducing energy consumption in the machine would reduce carbon dioxide emissions because electricity could be produced by burning fossil fuels. They stated that this released carbon dioxide. They made the link between reduction of demand for electricity and fossil fuels, and the reduction of carbon dioxide emissions. Other candidates suggested that washing machines emit carbon dioxide directly.

(b) (i) Many candidates used Ohm's law to calculate the resistance. Some candidates were unable to be awarded full credit as the units were not given in their answer.

(ii) The formula for charge was not well known, and when it was used the time was not always converted to seconds.

(c) (i) Most candidates correctly drew a diagram representing the arrangement of particles in a gas, thereby gaining partial credit. The representation of a liquid often did not show the particles in contact.

(ii) Most responses only mentioned the change of state of a liquid to a gas. Explanations often stated that heat caused particles to move faster but did not make it clear that it was the faster particles that left the liquid. Few responses made reference to the work done against attractive forces or the heat energy transferred from the surroundings.

Question 9

(a) (i) Many descriptions of how leaves obtained carbon dioxide mentioned the role of the stomata. It was often assumed, but not stated, that the gas came from the air. A diffusion mechanism was seldom included.

(ii) The best responses specified that water was obtained from the soil, and was absorbed by 'root hairs' rather than just 'roots'. The mechanism of transfer was given as osmosis rather than just absorption. Movement up the stem was said to be via the xylem and not the phloem. Transpiration was rarely mentioned.

(b) (i) To gain full credit candidates definitions of digestion had to make it clear that molecules were broken down chemically for absorption rather than food particles being broken down mechanically.

(ii) Some candidates correctly suggested an enzyme that would digest proteins. Others suggested that an acidic solution would be sufficient.

(c) (i) Some candidates understood that the experiment was a control.

(ii) Those who gained credit in this question understood that they had to use the data to describe how responses to a stimulus provided protection.

(iii) The features of the plants that helped them catch insects were often described in full. Features were sometimes assumed without evidence from either the figure or the data.

Question 10

This question covered some fundamental chemistry topics which many candidates found challenging.

(a) (i) The use of calcium carbonate in reducing soil acidity was not well known. Potassium was generally recognised as a plant nutrient but its role in supporting plant growth was not always made clear.

(ii) A number of candidates who derived the charge on the carbonate ion by considering charge balance with the K^+ ion sometimes did not show the formula as CO_3^{2-} as required by the question.

(b) (i) The catalyst used in the Contact Process was not well known.

(ii) Most candidates correctly stated that catalysts increased the speed of the reaction. Some knew that, in the case of the Contact Process, the catalyst did in practice allow the reaction to occur.

(iii) Very few could suggest an acid that would produce a nitrate in a neutralisation reaction.

Question 11

(a) Most graphs of enzyme activity showed an increase and decrease over a suitable temperature range. Some made a sensible suggestion for the temperature at which maximum activity would occur.

(b) (i) There were many good suggestions for the location of temperature receptors in the body.

(ii) Many wrote that the contraction of muscles or shivering would cause body temperature to return to normal. It was more appropriate to describe heat energy being released rather than created. Reference to friction was common but not acceptable.

(iii) There were a few successful attempts to explain the meaning of negative feedback using a specific example of homeostasis. They correctly described how the system responded to a 'sensed change' to return it to normal.

CO-ORDINATED SCIENCES

Paper 0654/04

Coursework

(a) Nature of tasks set by Centres.

Several Centres provided a very comprehensive portfolio of practical exercises. In most Centres all the tasks set were appropriate to the requirements of the syllabus and the competence of the candidates.

Most Centres have provided coursework in previous years and have acted on advice given. Centres are reminded to check the requirements of the syllabus when choosing pieces of work to submit.

The standard of candidates work was of a similar standard to previous years.

(b) Teacher's application of assessment criteria.

In almost all Centres the assessment criteria are understood and applied well for all of their activities. There has been a steady improvement in the Centres' application of assessment criteria. Centres are reminded that is difficult to assess candidates for both following instructions and planning in the same assignment.

(c) Recording of marks and teacher's annotation.

Tick lists remain popular with particularly skill C1.

Many Centres write brief summaries on each candidate's script. Centres are reminded when annotating scripts, to annotate the script at the place where the marks are awarded.

(d) Good practice.

Many Centres have developed a booklet of tasks and dedicated assessment criteria.

CO-ORDINATED SCIENCES

Paper 0654/51

Practical Test

Key message

When plotting graphs it is important to use as much of the grid as possible however awkward scales should be avoided as these can introduce errors especially when gradients and intercepts are required.

General comments

Candidates were able to complete this paper in the time available and generally the exercises were carried out well. So that candidates are not disadvantaged, it is important that Supervisors record results for all questions and that the experiments are carried out using the same equipment, apparatus and solutions as the candidates.

Candidates are reminded that each question should be 'read through' at least once before starting the experiment. This is particularly important where values have to be recorded and / or graphs drawn.

Comments on specific questions

Question 1

Most candidates were able to make a suitably large and neat pencil drawing of the flower but not all could label the stamen and carpel correctly. The male and female labels were sometimes confused. A variety of colours were given for part **(a)(iii)** although most candidates identified the pollen. Part **(a)(iv)** was not well done. In some cases it was because of a bad cut. In others it was due to poor labelling and many candidates wrongly assumed the question was looking for xylem and phloem. There was a wide range of creditworthy responses given in part **(a)(v)**.

The drawings for part **(b)** were usually satisfactory. Only the most able candidates gained credit for part **(b)(iv)**. Many candidates gained partial credit for part **(b)(v)** but full credit was rarely awarded. Many candidates did not realise that the colours in the Benedict's test can vary and therefore did not appreciate that yellow could indicate sugars. Most were only looking for red / brown.

Question 2

Candidates rarely scored in part **(a)(ii)**. Some candidates misunderstood the question, describing how the centre of the mass is found rather than its position on the rule. Those who were provided with slotted weights were able to see the position of the centre of the mass through the slot. Obtaining a set of results was usually well done and, although calculating values of $1/x$ proved to be a simple task, the instruction to record $1/x$ to three decimal places was sometimes missed. The main error in part **(a)(v)** was incorrect rounding. The ability to round off numbers correctly is an essential skill.

Plotting of graphs was usually adequate although those who used awkward scales made it more difficult. Credit was not awarded where candidates had not shown on the graph how the gradient was calculated. Some candidates counted squares to calculate the gradient rather than using the scales on the axes. The instruction in part **(c)** to record the mass to two significant figures was often missed.

Question 3

This experiment produced consistent results which were able to be analysed suitably. The first most common error was not recording the times to the nearest second.

Once again there was often inconsistent rounding of the 1/time values. The graphs were well plotted, however a significant number of candidates did not seem to understand the term *origin*.

The most common answer to part **(c)(i)** was 'the rate increases as **A** increases'; very few candidates used the word *proportional*. The question asked 'how the rate of reaction depends on the volume of reactant **A** used', so answers in terms of time were ignored. A significant number of candidates appreciated the reason for varying the volume of water.

Most candidates gained some credit in part **(d)** for 'keeping the volume of **A** constant'. Only the most able went onto suggest that 'the volume of **B** and water should be varied' to gain full credit.

CO-ORDINATED SCIENCES

Paper 0654/52

Practical Test

Key message

When plotting graphs it is important to use as much of the grid as possible however awkward scales should be avoided as these can introduce errors especially when gradients and intercepts are required.

General comments

Candidates were able to complete this paper in the time available and generally the exercises were carried out well. So that candidates are not disadvantaged, it is important that Supervisors record results for all questions and that the experiments are carried out using the same equipment, apparatus and solutions as the candidates.

Candidates are reminded that each question should be 'read through' at least once before starting the experiment. This is particularly important where values have to be recorded and / or graphs drawn.

Comments on specific questions

Question 1

Careful preparation of the samples for **Question 1** was essential and this was done in the majority of cases. Where candidates followed the instructions the experiment worked well. Many candidates gained full credit in part **(a)**, however the most frequent omission was not drawing the veins on the leaves. A small number of candidates drew with a pen rather than a pencil as instructed. Although it was usually clear where the strips of black paper had been, the labelling of diagrams was sometimes poor or non-existent. Answers to part **(b)** and **(c)** were generally satisfactory but were both affected by poor preparation of samples. Responses to part **(d)** were good but some candidates' responses were derived from 'theoretical knowledge' rather than the results of the experiment. There was a wide variety of answers to part **(e)** with many candidates not appreciating the need to remove chlorophyll in order to be able to see the colour of iodine clearly.

For part **(f)** the idea of a 'fair test' was not well understood and answers were often expressed in terms of the leaf rather than the plant.

Question 2

In parts **(a)**, **(b)** and **(c)** instructions were given regarding the level of accuracy required when taking measurements. When asked to record to the nearest millimetre candidates should be reminded that they should record 55.0. A significant number just wrote 55. Many missed the instruction to record their times to the nearest second whilst others missed the 2 decimal places for values of T^2 in part **(c)**. A number of candidates did not realise that the period T was found from the time for 20 oscillations.

Graph plotting was generally good although those who used awkward scales made it more difficult. A large number only realised that an intercept value was required when it was too late. Candidates should be reminded to read through what is required before commencing the experiment and before selecting axes for graphs. The same comment applies to part **(d) (ii)** where an indication of the values chosen to calculate the gradient needed to be shown on the graph. Part **(e)** was usually successfully answered where an intercept could be read.

The concept of experimental error is an integral part of science experiments and where possible such errors should be identified. Very few candidates gained credit for their response in part **(f)**.

Question 3

Generally observations were well presented in the grid and the experiment gave the expected results.

Confusion of certain words and phrases may have resulted in some candidates gaining less credit than they could have.
'Milky' and 'cloudy' are not acceptable alternatives for 'precipitate'.
'Clear' is not the same as 'colourless'; for example: copper sulfate solution is blue and clear, whereas sulfuric acid is colourless and clear.

In this experiment 'no change' was not always the same as 'no reaction' because in part **(a)(iv)** addition of copper sulfate solution to solution **C** and solution **D** changed a colourless solution to a blue solution by mixing; so although there was no reaction there was a change in colour.

A small number of candidates could not differentiate between solution **A** and solution **B** with copper sulfate, perhaps because they added too much copper sulfate.

In parts **(b)(ii)** to **(v)**, a variety of explanations were creditworthy and so many candidates were awarded some credit for their responses. The most common response to part **(b)(vi)** was the use of litmus paper but to gain full credit candidates also needed to state the expected results, as they are an essential part of the answer.

CO-ORDINATED SCIENCES

Paper 0654/61
Alternative to Practical

Key Message

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, to have used standard laboratory apparatus and be able to read the values from measuring cylinders, thermometers stopwatches etc.

General comments

Candidates from many Centres demonstrated their practical knowledge and techniques; others showed a poorer appreciation of the principles and practice of practical science, especially in **Questions 2** and **5**.

Other general points include the drawing of graphs. These are usually drawn very well but candidates should ensure that they use up as much of the grid provided as possible without using awkward scales.

A further general point is the use of significant figures or decimal places in calculations. Often, the number of significant figures required is specified in the question; at other times, when completing a table for instance the candidate should follow the precedent set in the values already there. Sometimes a candidate may have to choose the appropriate value themselves. Figures quoted to the nine or ten decimal places shown on a calculator indicate a lack of uncertainty far greater than most school experiments can justify. Another problem that some candidates have is rounding. An answer of 56.7777… for instance should be recorded as 57, 56.8 or 56.78 and never 56 or 56.7.

Comments on specific questions

Question 1

This question investigated the role of sugar in the pollination of a flower.

(a) Most drawings seen were satisfactory, although some candidates needed to make a better use of the space available.

(b) Some weaker candidates suggested that the reagent to be used was iodine but most knew that Benedict's solution or reagent had to be added to the petal. Few candidates stated that heat was required.

Most candidates were aware that the function of the petals is to attract pollinators, but were unable to interpret the results of the Benedict's test and how the results helped this function. The petal turned red at the very base of the petal, after the test, showing that sugar (nectar) is present there. This means that the insect, attracted by the sugar will burrow its way to the base of the petal, following the guide lines, with the pollen subsequently adhering to its body.

Question 2

(a) The labels on the components in the photographs were covered and the connecting wires deliberately coiled in order that candidates considered the photograph carefully before drawing a circuit diagram. Weaker candidates often drew the apparatus rather than use the correct circuit diagram symbols; most candidates connected the pieces by straight lines, removing the coils.

As there is no symbol for an orange, candidates came up with their own symbol, or drew an orange or a cell. All of these responses gained credit. Most candidates gave *'the lamp lights'* and a reading on one or both meters as an observation.

The reading of the diagrams of the scales of the voltmeters gave some candidates problems. A few gave 1.525 V for the second reading, although the scale cannot be read to this accuracy, a value of 1.52 V or 1.53 V was expected.

(b) Candidates had to draw up a table recording the results given in the text. Many candidates found this challenging. Colleagues are reminded that candidates should be given the opportunity to design tables for recording the results of practical work during the course.

(c) Some candidates tried to place two metals at each position while others had copper as more reactive than magnesium.

Question 3

This question was about an investigation to see how the concentration affects the rate of reaction.

(a) An experiment was outlined and the candidate asked to read two stop clocks and record the values to the nearest second in a table. Despite this instruction a number of candidates wrote 17.3 and 1.05.

(b) Candidates were expected to follow the pattern in the table and record their values to three decimal places.

The grid size given for the graph was selected so that a correctly chosen scale would use the entire grid. Candidates should be reminded that they need to select non-awkward scales to fill as much of the grid as possible.

(c) Many candidates correctly stated that the rate of reaction increases as the volume of potassium iodate increases. Candidates that gave answers in terms of time were unable to be awarded credit as they were not answering the question asked.

Candidates were then asked for an observation that showed iodine was formed when potassium iodate was reduced; candidates were expected to realise that the observation that the iodine solution turns a blue-black colour could be found in the experimental details given at the start of the question.

Finally, candidates had to explain why different volumes of water were used in each experiment. Candidates whose answer was either *'to keep the volume of liquid constant'* or *'to vary the concentration'* gained credit.

Question 4

A study of pectinase and its role in producing fruit juice was investigated in this question.

(a) Most candidates correctly read the volumes of fruit juice depicted.

The best candidates labelled the axes with units; candidates should be reminded that almost all graphs require labelled axes with units. The optimum pH value was 5 (or where the candidate's maximum was drawn). Many candidates realised that this value could only be an estimate as no values of the pH were tested between pH 5 and pH 6. Vague answers such as *'has not tried all pHs'* or *'has only tested between 3 and 7'* did not give sufficient detail to be awarded credit.

(b) The best candidates described a control experiment that would prove that the enzyme was responsible for the production of fruit juice as one with all factors the same but using water instead of the pectinase or leaving out the enzyme.

(c) The candidate was asked to suggest a different method to increasing the rate of reaction, explaining why it would work. As the enzyme is a biological catalyst, candidates who suggested '*a catalyst*' could not gain credit; this is not another method. Candidates were expected to give one of three answers: increasing temperature (as the frequency of collisions increases), increasing concentration (collisions again) or to make the pieces of apple smaller to increase the surface area. Candidates should be reminded to give an explanation when asked as a few candidates simply suggested that the 'temperature could be changed'; these were unable to be awarded credit as a change in temperature could mean cooling or heating.

Question 5

In this question candidates were asked to draw the apparatus for four experiments. It was expected that the pieces were joined up and arranged as they would be in use. Diagrams needed to be reasonably accurate and labelled. Some candidates produced well thought-out diagrams and scored highly. A number of candidates drew impossible apparatus. Colleagues are reminded that candidates should be made familiar with common laboratory apparatus through practical work during their lessons.

(a) Both a filter funnel and filter paper were required here, along with a receiving vessel.

(b) A piece of filter paper suspended in a solvent was required. In this case 'before' and 'after' drawings were acceptable.

(c) The collection of gas must be by gas syringe as the gas, ammonia, is highly soluble in water.

(d) A simple distillation was all that was required but the many candidates who drew a fractionating column and a condenser also gained credit.

(e) A written description of fractional distillation was required in the final part.

Question 6

In this question candidates were finding the value of an unknown mass by balancing it against a range of known masses.

(a) The best candidates used the information given in the instructions and diagrams on how the unknown *x* is measured. Candidates who gave answers of 77.9 and 75.5 were not creditworthy. These figures are far from the others in the table, and candidates should be reminded that if their answers look 'odd', they should check their work to ensure that they are following instructions correctly.

Candidates were then required to calculate the reciprocal of *x* for each value and record the answers to three decimal places. A number of candidates did not follow this instruction and were not awarded full credit.

(b) The axes for this graph were already labelled; most candidates had little problem plotting the graph and drawing the best straight line. Those candidates that had entered incorrect values into the table were unable to draw a straight line and, in some cases, needed to extend the graph to include values off the grid. Where axes are given, candidates whose answers 'do not fit' should check that they have not made a mistake in their answers.

Many candidates showed how to calculate a gradient, with a 'triangle' below the line; others were simply using small dots on the line. The instruction states that candidates should show *clearly* how the gradient is calculated.

(c) The mass was generally correctly calculated by candidates who had worked out the gradient.

(d) The answer *'It's difficult to measure'* was insufficient to gain credit; it does not add extra information to that given in the question stem.

CO-ORDINATED SCIENCES

Paper 0654/62
Alternative to Practical

Key Message

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, to have used standard laboratory apparatus and be able to read the values from measuring cylinders, thermometers stopwatches etc.

General comments

Candidates from many Centres demonstrated their practical knowledge and techniques; others showed a poorer appreciation of the principles and practice of practical science, especially in **Questions 3** and **6**.

Other general points include the drawing of graphs. These are usually drawn very well but candidates should ensure that they use up as much of the grid provided as possible without using awkward scales.

Another general point is the use of significant figures or decimal places in calculations. Often, the number of significant figures required is specified in the question; at other times, when completing a table, for instance, the candidate should follow the precedent set in the values already there. Sometimes a candidate may have to choose the appropriate value themselves. Figures quoted to the nine or ten decimal places shown on a calculator indicate a lack of uncertainty far greater than most school experiments can justify. Another problem that some candidates have is rounding, an answer of 56.7777… for instance should be recorded as 57, 56.8 or 56.78 and never 56 or 56.7.

Comments on specific questions

Question 1

This question investigated photosynthesis.

(a) The first part of the question required candidates to label the different areas on Fig. 1.2 to show the colours expected after each leaf was tested with iodine. This was often missed by candidates. Correct labelling was all brown for leaf **A** and a brown band in the middle of a black leaf for **B**.

(b) The leaf was placed in hot water to kill or soften it. The alcohol removes the chlorophyll, not the chloroplasts, so the colour of the iodine can be seen clearly.

(c) It is suggested that the black paper may have prevented gas exchange as well as blocking light, therefore photosynthesis was not taking place because of a lack of carbon dioxide. This suggestion could have been tested by covering the other parts of the leaf with a transparent material, thus allowing light to get to the leaf, but having the same effect on gas exchange as the black paper. A second modification of using different leaves on the same plant would remove the variable of having different plants which may have different photosynthesis rates etc. Few candidates appreciated this.

(d) Unfortunately, many answers involved killing a leaf, by boiling it then removing the chlorophyll with alcohol and then comparing it with a growing leaf. An answer using a variegated leaf was expected. This could be named or described.

Question 2

In this experiment a candidate is investigating the period of a simple pendulum.

(a) After reading two stopwatches candidates had to record the values then calculate the time of a single swing (by dividing by 20) and then squaring the answer. Most managed this with few problems.

(b) The axes for this graph were already labelled; most candidates had little problem plotting the graph and drawing the best straight line. Those candidates that had entered incorrect values into the table could not draw a straight line and, in some cases, needed to extend the graph to include values off the grid. Where axes are given, candidates whose answers 'do not fit' should check that they have not made a mistake in their answers.

Many candidates showed how to calculate a gradient, with a 'triangle' below the line; others simply used small dots on the line. The instruction states that candidates should show *clearly* how the gradient is calculated.

Reading the intersect on the vertical axis proved difficult for some candidates, who gave 2.5 instead of 2.05.

Question 3

This question tested the candidates' knowledge of chemical qualitative tests.

(a) Candidates need to know that the Universal Indicator turns purple in alkaline solutions and red or pink in acids.

(b) Candidates need to know that when silver nitrate solution is added to dilute hydrochloric acid (a chloride) a white precipitate forms.

(c) When barium chloride solution is added to dilute hydrochloric acid nothing happens. Candidates were instructed to answer 'no change'.

(d) Candidates need to know that when copper sulfate solution is added to aqueous sodium hydroxide a blue precipitate is formed. When aqueous ammonia is used the blue precipitate will dissolve in excess producing a dark blue solution.

(e) Candidates need to know that hydrogen is evolved when magnesium is added to acid but there is no reaction when magnesium is added to alkali.

Question 4

A study of osmosis in dandelion stalks.

(a) Values of 10 mm and -11 mm should have been entered in the table, fitting in to the established trend. A smooth curve was produced on the graph when the correct points were plotted. The few candidates that had made mistakes in the measuring found that far from a smooth curve was produced, with lines going up and down like a rollercoaster.

Candidates were then asked to measure the curvature of the stalk before immersion in any solution. Many measured correctly, giving 6 mm as their answer; wrong answers varied from 0 mm to 12 mm.

(b) This was answered very well by a number of candidates. Many weaker candidates thought that sucrose entered the cells.

Question 5

This question looks at electrolysis and copper plating.

(a) Candidates were given a list of electrical components and asked to draw a circuit diagram. A number of candidates did not know the correct symbols for the components indicated, or what was meant by *'a circuit diagram'*.

Most candidates were able to read the balance windows and plot the graph accurately. Candidates were then asked to continue the line to the horizontal axis and find the time at this point. Some candidates did not extend their lines or continued them to an intersect off the grid; these candidates were unable to gain credit.

(b) Only the best candidates knew that the colour of the copper chloride solution changes due to copper ions being removed from the solution.

(c) Candidates had to explain why aqueous copper chloride conducted electricity but solid copper chloride does not. Many candidates gave answers in terms of moving electrons. The better candidates realised that the current was due to the movement of the charge on the ions.

Question 6

This question looked at various aspects of gases.

(a) The candidate was supplied with a number of words and phrases and asked to construct a table showing the gas with its test and the positive result that identifies it. Many candidates found this challenging. The construction of tables was poor and a number of candidates were unable to connect the tests with the correct gas. Colleagues are reminded that candidates should be given opportunity to design and construct tables during practical exercises.

(b) This was generally answered well. Some candidates named sodium hydroxide as the acid and the carbonate was often left blank.

(c) The candidate had to draw the apparatus required to react an acid and carbonate together to produce and measure the carbon dioxide evolved. It was expected that the pieces were joined up and arranged as they would be in use. Diagrams needed to be reasonably accurate and labelled. Some candidates produced good well thought-out diagrams. A number of other candidates drew impossible apparatus. Colleagues are reminded that candidates should be made familiar with common laboratory apparatus through practical work during their lessons.

(d) Finally, candidates had to name a metal that reacts with an acid to produce hydrogen safely. Most candidates chose magnesium or zinc; a few candidates named sodium or potassium, ignoring the description *'safely'*.

CO-ORDINATED SCIENCES

Paper 0654/63
Alternative to Practical

Key Message

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, to have used standard laboratory apparatus and be able to read the values from measuring cylinders, thermometers stopwatches etc.

General comments

Candidates from many Centres demonstrated their practical knowledge and techniques; others showed a poorer appreciation of the principles and practice of practical science, especially in **Question 6**.

Other general points include the drawing of graphs. These are usually drawn very well but candidates should ensure that they use up as much of the grid provided as possible without using awkward scales.

Another general point is the use of significant figures or decimal places in calculations. Often, the number of significant figures required is specified in the question; at other times, when completing a table, for instance, the candidate should follow the precedent set in the values already there. Sometimes a candidate may have to choose the appropriate value themselves. Figures quoted to the nine or ten decimal places shown on a calculator indicate a lack of uncertainty far greater than most school experiments can justify. Another problem that some candidates have is rounding, an answer of 56.7777… for instance should be recorded as 57, 56.8 or 56.78 and never 56 or 56.7.

Comments on specific questions

Question 1

This question investigated the effect of temperature on the rate of yeast respiration.

(a) Most candidates followed the instruction to give the answer to the nearest whole number.

(b) A grid was provided for candidates to plot a graph of the average number of bubbles per minute against temperature. Candidates were told to join the points with straight lines (as you cannot have a fraction of a bubble). Some candidates used only a fraction of the grid. The size of grid provided is chosen so that candidates, choosing the most appropriate non-awkward scale, can use the maximum area for a clear large graph.

(c) Most candidates realised that this is due to the molecules having more energy at 40 °C or that the rate of collisions between particles had increased. Most were also aware that at 80 °C the enzyme would be denatured or the yeast killed.

(d) The candidate then had to explain the reasons behind three experimental details. The majority of candidates explained the first two points well. Some candidates gave confused answers to the final experimental point, missing the fact that the yeast would be killed and so unable to be used again.

(e) Many candidates suggested using limewater as a test for carbon dioxide.

(f) Some candidates appeared to misunderstand what is meant by ‘a control experiment’. The best candidates explained that the experiment should be repeated without yeast or with dead yeast.

Question 2

In this question a candidate is investigating a converging lens.

(a) Candidates had to measure the focal length of the lens with a ruler. Some answers suggested that those candidates did not have a ruler.

(b) This diagram was a scaled down drawing so candidates had to multiply their measurements by ten before filling in the table. Candidates should have noted that other values given in the table were given to one decimal place and therefore the answer 24.0 was required. Some candidates had difficulty in calculating the other required figures in the table. Error carried forward was applied if the candidate had only made one error.

(c) The axes for this graph were already labelled; most candidates had little problem plotting the graph and drawing the best straight line. Those candidates that had entered incorrect values into the table could not draw a straight line and, in some cases, needed to extend the graph to include values off the grid. Where axes are given, candidates whose answers 'do not fit' should check that they have not made a mistake in their answers.

Many candidates showed how to calculate a gradient, with a 'triangle' below the line; others were simply using small dots on the line. The instruction states that candidates should show *clearly* how the gradient is calculated.

(d) Candidates who had calculated an incorrect gradient could not give the expected answer of *'half life-size'*. They gained credit, however, if they managed to calculate a relationship between their incorrect gradient and the diagram length.

Question 3

This question was about an investigation to see how the rate of reaction between magnesium and an acid is affected by the surface area of the solid.

(a) Most candidates followed the instructions and entered correct values into the table. A few candidates did not subtract the ten seconds.

(b) Most candidates noted that the greater the length of the magnesium strip, the faster the reaction and the greater the surface area the faster the reaction. Unfortunately, many candidates made calculation errors and were unable to gain any credit for the calculation in part **(i)**. Few candidates noticed that if you compare the times for 1 cm and 2 cm the teacher's statement is true, but if the times for 2 cm and 4 cm are compared the statement is false.

(c) There were many varied and valid suggestions as to why the candidate waited ten seconds before adding the acid, including the difficulty of adding the acid and starting the clock at the same time.

(d) Most knew the test for hydrogen.

Question 4

A study of pectinase and its role in producing fruit juice was investigated in this question.

(a) Candidates were expected to notice that, after incubation, tubes **1** and **2** had become lighter or less cloudy with a bigger effect in tube **3**, due to the increased temperature increasing the rate of reaction.

(b) The test for starch was reasonably well known and many candidates were able to name an appropriate enzyme to break it down. Candidates were less comfortable with ideas to modify the experiment to produce clear fruit juice. Examiners were expecting descriptions that included some experimental detail, for example, '*a tube is set up with both pectinase and <named> enzyme along with the apple paste and incubated at a set temperature e.g. 40 °C*'. Credit was awarded for those candidates who gave some idea of control or stating the volumes involved. Candidates are

reminded that the number of marks awarded for an answer is often a guide to the amount of detail expected.

Question 5

This question looked at acceleration in a test run of a motor car.

(a) Candidates were shown a test track and two diagrams showing the position of a car after 5 and 7 seconds. By studying the scales, most candidates were able to correctly fill the table.

Most candidates were able to use the results to plot a graph with a smooth curve to show that the car was accelerating. Many candidates found it more challenging to correctly calculate the average speed of the car.

(b) Run **C** shows the car coming to a stop at **X** as the distance does not change over time; this could have been caused by a crash or some mechanical failure. Many candidates thought that the flat line meant that the car was now travelling at a constant speed.

Question 6

In this question candidates had to construct a table of anions and then 'make' some copper sulfate crystals.

(a) The candidate was supplied with a number of words and phrases and asked to construct a table showing the anions with their tests and the positive result that identifies them. The best candidates ignored the 'dummy' phrases included in the diagrams and presented well-constructed tables. Many candidates found this exercise challenging, with poorly constructed tables that did not connect the tests with the correct anion. Colleagues are reminded that candidates should be given opportunity to design and construct tables during practical exercises.

(b) The question states that a candidate is preparing a solution of copper sulfate from sulfuric acid and powdered copper oxide. The question then asks how the solution is prepared using these chemicals. Many candidates ignored the information given in the stem and started with copper sulfate that was either reacted in some way or simply dissolved in water. The term evaporation and the colour blue were reasonably well known.

(c) When asked to name the group of chemicals to which the compounds copper sulfate, barium chloride and silver nitrate belong, few candidates gave the name 'salts'.