CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice

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

General Comments: Biology

Candidates had most difficulty with **Question 4**. **Question 13** investigated an area where candidates are usually most confident, and this proved no exception.

Comments on Specific Questions

Question 2

The majority of candidates identified the correct option **A.** Some candidates did not realise that there are millions of unicellular organisms whose growth does not involve an increase in cell numbers and chose option **D**.

Question 3

The majority of candidates chose the incorrect option **A**, suggesting they were unable to apply their mathematics skills to solve a logical problem. Some candidates may have incorrectly identified the cells.

Question 4

Questions often prove difficult when there is more than one step in the requisite thought process. In this case, candidates needed to know that enzymes are made of protein, and then that protease is needed to digest protein. If asked these two questions separately, it is likely that a far greater number would have achieved correct answers to both questions than answered this question correctly. Perhaps surprisingly, the most popular choice was bile – not an enzyme at all.

Question 9

A third of candidates did not believe the evidence of their own experience in suggesting that they did not breathe more deeply during exercise.

Question 13

Candidates were most comfortable with making the link between deforestation, global warming and an increase of carbon dioxide levels, but, unlike **Question 4**, this was likely to have been a specific taught link rather than one they had to deduce from knowledge acquired in different syllabus areas.

General Comments: Chemistry

Questions 17, **18** and **26** were straightforward for the candidates. **Question 23** and **Question 24** were the most challenging.

Comments on Specific Questions

Question 17

This question showed that candidates can distinguish between physical and chemical changes.

Question 18

The vast majority of candidates can use diagrammatic representations of the structures of simple molecules to deduce the formulae of compounds.

Question 20

Option **D** was a popular distractor, with the majority of candidates choosing this option. The vast majority of candidates recognised that lime (also known as quicklime and calcium oxide) is used to neutralise the acidity in soil. However, many, including some of the more able candidates, thought that heating limestone is an exothermic, rather than endothermic, change.

Question 23

Most of the candidates correctly chose a compound containing iron(II), but less than half correctly chose a compound containing sulfate. This suggests that the test for iron(II)/iron(III) ions is better known by candidates than the tests for sulfate and for chloride ions.

Question 24

Candidates chose all four options in roughly equal numbers. Candidates were required to recognise that metals, and not non-metals, conduct electricity. They then had to use the proton numbers to identify the four elements as either metals or non-metals. It is suggested that the conductivities of metals/non-metals would have been known by most candidates, and that many candidates then did not understand how they could use the proton numbers to identify the metals/non-metals.

Question 25

Option **C** was a popular distractor. This suggests that some candidates thought that, together with sulfur dioxide, carbon dioxide, rather than the more acidic nitrogen dioxide, causes the erosion of buildings. Candidates should appreciate that the acidity of carbon dioxide is insignificant in comparison with that of the oxides of nitrogen (and with sulfur dioxide).

Question 26

Most candidates know the chemical name for limestone.

General Comments: Physics

Question 34 was the most challenging for candidates. **Question 30** was answered well.

Comments on Specific Questions

Question 28

The most common error in this question on distance/time graphs was choosing option **D**; candidates making this mistake treated the graphs as speed/time.

Question 31

A large proportion of weaker candidates opted for distractor **B**, knowing that gravitational energy was involved, but not taking into account that the question asked which form of energy was increasing.

Question 32

Here the common mistake was to believe that air molecules themselves expand when heated.

Question 34

The popularity of option **B** in this question on convection was probably due to candidates considering the natural direction of smoke from the taper without the taper being close to the apparatus beneath.

Question 36

The topic here was image formation by a converging lens, and many less able candidates appeared to resort to guessing.

CO-ORDINATED SCIENCES

Paper 0654/12
Multiple Choice

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

General Comments: Biology

None of the biology questions proved to be especially demanding for candidates although **Question 2** was the most difficult. Candidates found **Question 1** relatively unchallenging.

Comments on Specific Questions

Question 1

This was the easiest of the biology questions. No doubt this was related not just to information learnt while following the syllabus material, but also to common experience. For a first question on the paper, it served well to gently introduce candidates to the test as a whole.

Question 2

This proved to be the most difficult of the biology questions. Its apparent difficulty had its foundations in a widely-held misconception amongst the candidates, with over a third of them believing that oxygen moves by osmosis.

Question 4

It is likely that over a quarter of the candidates confused the colours of iodine solution when in contact, and not in contact with a starch solution. It is also likely the test results as presented in the question caused candidates to overlook an answer that they would otherwise have known – namely that at 95 °C, enzymes have been denatured and are inactive.

Question 5

Over-hasty candidates may have opted too quickly for the palisade cell as the site of photosynthesis (option **A**). More careful inspection would have shown that the label line **A** indicated the vacuole of the cell, while option **C** indicated, with more accuracy, the chloroplast of a cell.

Question 8

While having their own teeth as available specimens to provide a check, a good deal of guess-work was evident when deciding which teeth occur in the lowest numbers in the human mouth.

Question 10

There was a fundamental inaccuracy in the knowledge of over a quarter of the candidates who believed that the prostate gland supplies the hormones that control adolescence.

Question 11

There was a quite widely-held belief that adrenaline has the effect of decreasing, rather than increasing, blood glucose concentration – albeit amongst those who, generally, did not perform well on the paper.

General Comments: Chemistry

Question 14 and **18** were the easiest for the candidates. **Question 20** and **Question 24** were the most difficult.

Comments on Specific Questions

Question 14

Candidates were able to use the terms *atom* and *element* without any difficulty, and to recognise these within structural diagrams of the molecular compounds.

Question 18

Candidates were able to deduce the formula of propane from its displayed structure, and to identify it as an alkane.

Question 20

Equal numbers of candidates chose the correct answer, **B**, and the incorrect option **D**. This indicates that the majority of candidates recognised that lime (also known as quicklime and calcium oxide) is used to neutralise the acidity in soil. However, many, including some of the more able candidates, thought that heating limestone is an exothermic, rather than endothermic, change.

Question 24

Candidates found it difficult to identify the correct element. The majority of candidates chose the wrong answer, with all of the incorrect options attracting a significant number of candidates.

General Comments: Physics

Candidates found **Question 36** easy, but **Question 33** caused difficulty for many.

Comments on Specific Questions

Question 28

The most common error in this question on distance/time graphs was choosing option **D**; candidates making this mistake treated the graphs as speed/time.

Question 29

The topic here was mass and weight. Almost as many candidates chose option **D** as chose the correct answer, believing that the balance showed weights to be equal, but not necessarily masses.

Question 32

Most candidates chose the correct answer in this question on evaporation, but there was evidence of guessing by some candidates.

Question 33

This question on change of state caused widespread problems, with less than one in four responses correct. Candidates mainly opted for **C** or **D**, not taking into account that ice still remained in the beaker after 15 minutes. More able candidates generally chose **D**, being a graph that looked familiar to them.

Question 37

As in echo questions on previous papers, a majority of the candidates forgot to halve the distance travelled by the sound, and therefore arrived at distractor **D** as the answer.

Question 39

Although most candidates knew that the two ammeters would show the same reading, a significant proportion of them thought that the higher value resistor would have a smaller p.d. across it.

CO-ORDINATED SCIENCES

Paper 0654/13
Multiple Choice

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

General comments: Biology Section

Candidates found the biology section somewhat challenging. Indeed, one question (**Question 3**) did not perform well, with only a small proportion of candidates selecting the correct answer, and not all of them necessarily being amongst the best candidates taking the paper. Candidates were generally far more at ease with all the remaining biology questions, performing particularly well on **Question 12**.

Comments on Specific Questions

Question 2

The problem encountered here was the belief held by more than half the candidates, that diffusion can happen only in a solution. Apart from steering them away from the correct answer, it also exposed a fundamental misunderstanding.

Question 3

Candidates traditionally find the interpretation of graphs difficult. In this case, the information was so presented – referring to time taken for substrate breakdown rather than to the rate of enzyme action – that the correct graph did not have a shape that would have been familiar to many of the candidates. The effect of this was for them to select a recognisable shape of graph rather than work out what it was that they were being asked.

Question 6

This question required simple knowledge of the positions of xylem and phloem in a root and in a leaf. Unfortunately, a majority of candidates just did not possess that basic knowledge.

Question 7

It was perhaps surprising that almost a quarter of the candidates thought that the oesophagus is in the form of a coiled tube.

Question 11

Sound knowledge of botanical anatomy was again tested here, with almost a third of candidates believing that the stigma is part of the stamen.

Question 12

This proved the easiest of the biology questions, but candidates regularly display a sound knowledge of food chains and food webs and this question was no exception.

General Comments: Chemistry Section

Candidates performed well on **Questions 16**, **17**, **24** & **26**. **Question 19** and **Question 23** were most challenging.

Comments on Specific Questions

Question 14

Slightly more candidates chose the (simple) distillation, rather than the fractional distillation, apparatus as appropriate for the separation of two miscible liquids. Whilst simple distillation apparatus is, understandably, more commonly seen than that for fractional distillation, candidates do need to be aware of the subtle difference between the two.

Question 16

Most candidates understand diagrammatic representations of atoms, elements, molecules and compounds.

Question 17

Candidates were able to deduce the formula of a molecular compound from its displayed structure.

Question 19

More candidates chose distractor **D** than the correct option, **B**. The majority of candidates recognised that lime (also known as quicklime and calcium oxide) is used to neutralise the acidity in soil. Many, including some of the more able candidates, thought that heating limestone is an exothermic, rather than endothermic, change.

Question 23

Candidates chose all four options in in roughly equal numbers. Candidates were required to recognise that metals, and not non-metals, conduct electricity. They then had to use the proton numbers to identify the four elements as either metals or non-metals. It is suggested that the conductivities of metals/non-metals would have been known by most candidates, and that many candidates then did not understand how they could use the proton numbers to identify the metals/non-metals.

Question 24

Most candidates were able to recall methods of producing carbon dioxide and, by extension, how this gas is **not** made.

Question 26

The vast majority of candidates can recall *fractional distillation* as the method used to separate petroleum.

General Comments: Physics Section

Questions 33 and **39** caused more difficulty than others. Candidates performed best on **Question 30**.

Comments on Specific Questions

Question 28

It is probably predictable that the most common error in this question on distance/time graphs was choosing option **D**; candidates making this mistake treated the graphs as speed/time.

Question 29

The topic here was mass and weight. Able candidates had very little difficulty, but a significant number of candidates appeared to resort to guessing.

Question 31

Lower ability candidates here failed to appreciate that a certain quantity of work done in a longer time relates to reduced power, and as a result they opted for **D**.

Question 32

In this question on evaporation, more than one in four candidates chose distractor **D**, believing that the average speed of molecules remaining in the liquid would increase.

Question 33

This question required candidates to recognise from results in a table that a solid had melted (at 31.1 °C), and had subsequently reached its boiling point. Many failed to look at all the data in the table, and opted for **B**.

Question 34

Candidates who chose wrongly in this question on convection did not notice that the ice packs were being used to keep the food cool, and would therefore need to be at the top of the box; option **A** was therefore relatively popular.

Question 39

More candidates here opted for **C** than the key. They were unaware that adding a resistor in parallel (as in the correct option, **A**) would reduce the total resistance and therefore cause the lamp to be brighter than in circuit **C**.

CO-ORDINATED SCIENCES

Paper 0654/21
Core Theory

General Comments

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

Candidates should look carefully at the mark allocation for part questions and write a response corresponding to the mark allocation. For example if three marks are available, a good response would make at least three valid points.

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

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

Comments on Specific Questions

Question 1

This question was quite well answered by most candidates. Some parts of the question proved difficult to different candidates. Most candidates gained some marks.

(a) (i) Group V was very well known.

(ii) Many candidates correctly suggested the neutron.

(iii) Fewer candidates knew that the electron had the lowest mass.

(b) There was much confusion with the reactivity of the elements. There was also confusion with the number of electrons in the outer shells of the atoms. Few candidates correctly identified the trend from metals to non-metals and therefore decreasing electrical conductivity.

(c) (i) Covalent bonding was not well known.

(ii) Many candidates correctly described the effect of removing the catalyst from the reaction.

(d) (i)(ii) Many candidates knew that nitrogen was the important element present in ammonium nitrate. Similarly, many candidates correctly identified phosphorus and potassium as the other two elements in NPK fertiliser. To gain the mark, candidates had to identify both of these.

Question 2

This question was quite well answered. Candidates scored marks on most parts of the question.

(a) The parts of the plant cell were well known.

(b) Carbon dioxide and water were well known as the two substances used up during photosynthesis. A number of candidates suggested light or sunlight instead of water, which was not accepted as the question asked for substances.

(c) Many candidates gained at least one mark here. This was usually for identifying oxygen as the product of photosynthesis. Carbon dioxide as a product of respiration was less well known.

(d) (i) Many candidates knew one of the functions of xylem tissue. Transport of water or minerals was usually the response.

(ii) Few candidates realised that xylem cannot photosynthesise because it has no chloroplasts.

Question 3

Candidates found parts of this question difficult.

(a) Few candidates were able to link the surface area of the object to pressure.

(b) (i) Reflection of sound waves was well known.

(ii) Many candidates calculated the correct distance but some did so by incorrectly manipulating the figures.

(iii) Many candidates correctly calculated the speed of sound.

(c) (i) This was not well answered. The complete correct answer was not given by many candidates. Many knew that either the particles were randomly arranged or touching. Few knew both.

(ii) Similarly, many candidates knew that either the particles were touching or regularly arranged but few knew both.

(d) The process of evaporation was not well known. Few candidates gained any marks here.

Question 4

Few parts of this question were answered well.

(a) The term recessive was not well known. Very few candidates were able to give the definition of recessive as stated in the syllabus.

(b) (i) NN and nn were not given by many students.

(ii) Nn was better known.

(c) Many candidates gained some marks usually for naming the gametes and completing the Punnett square.

(d) A few candidates correctly suggested that the flies would be less able to find food or escape predators but very few went on to explain that this would mean that they were less likely to survive or reproduce.

Question 5

Few parts of this question were answered well.

(a) (i) This was correctly answered by some candidates.

(ii) Many candidates only suggested one compound **Y** or **Z**, but were able to describe a hydrocarbon. This response was awarded one mark.

(b) (i) Few candidates knew the difference between an alkane and an alkene.

(ii) Many candidates reversed the observations.

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

(ii) Very few candidates were able to identify the white solid as poly(ethene).

(d) (i) Carbon dioxide was frequently identified as the gas.

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

Question 6

Most parts of this question were well answered.

(a) Many candidates drew an accurate diagram. A few candidates lost marks by not showing clearly enough that the ray of light reflected off the wall of the optical fibre.

(b) Chemical energy was not well known. However, most candidates correctly identified kinetic energy.

(c) Very few candidates were able to suggest gamma radiation was either less ionising or more penetrating than the other two radiations.

(d) The popular answer was X-rays and their use, although a number of candidates were able to describe a use for infra-red radiation.

Question 7

This question was not well answered.

(a) Few candidates managed this. Most candidates incorrectly labelled the brain or spinal cord.

(b) (i) Few candidates gained a mark here. Most candidates simply described it as a quick action, which was information given in the question.

(ii) Very few candidates were able to describe how the peripheral nervous system was involved in a reflex action. There were very few references to impulses, receptors or effectors.

(c) Many candidates gained full marks here for suggesting that adrenaline was carried in the blood and destroyed in the liver.

Question 8

Few parts of this question were answered well.

(a) (i) Many candidates explained how the magnet helped.

(ii) Many candidates knew that aluminium is not magnetic.

(iii) Some candidates were able to explain that all the paint reached the panel because the opposite charges attracted but fewer could explain the paint was evenly spread because the like charges on the paint droplets repelled each other.

(b) (i) The correct circuit diagram was often drawn. Common errors were connecting the two lamps in series and not using the correct symbols.

(ii) Few candidates were able to draw a voltmeter connected in parallel across the battery.

(iii) Many candidates gained full marks for the calculation showing good data handling skills.

(iv) This was not well understood. Most candidates guessed at 5 ohms. No candidates knew that the combined resistance of two resistors in parallel was less than the resistance of either resistor by itself and that therefore the possible value for the combined resistance had to be 1.25 ohms.

(v) Some candidates correctly identified an electric current as a flow of either electrons or charge.

(c) Conduction and convection were not widely known.

(d) Few candidates recognised the situation as a problem of the expansion of materials.

Question 9

Candidates found parts of this question difficult.

(a) (i) Electrolysis was very well known.

(ii) Few candidates were able describe a brown gas as the observation if bromine was produced in the experiment.

(iii) This was not well understood. The idea that the ions were no longer mobile was rarely described.

(b) Some candidates were able to explain that the sodium atom lost an electron when it was converted into a sodium ion.

(c) (i) Hydrogen was usually identified as the gas produced.

(ii) Most candidates were able to describe the correct chemical test for hydrogen. Some candidates failed to score both marks because they referred to the test as the pop test and then explained that the hydrogen went pop. There needed to be some reference to a lighted splint.

(iii) This was quite well understood. Some candidates correctly suggested that the solution became alkaline. Others correctly suggested that sodium hydroxide was produced.

(d) (i) A number of candidates wrongly suggested that the reason was that the alloy was less resistant to corrosion or rusting.

(ii) Most candidates correctly explained that aluminium was less dense than steel and therefore the mass of the aircraft would be lower.

Question 10

Some parts of this question were answered well. However other parts were less well answered.

(a) Most candidates were able to use the data to answer the question.

(b) (i) Some candidates managed to indicate a possible position where the pollution occurred.

(ii) Few candidates were able to explain why stonefly nymphs might be killed in a river polluted by either sewage or chemical waste. The only common correct idea was that the chemical waste might be toxic.

(c) (i) Few candidates were able to describe global warming as an increased average temperature of the Earth.

(ii) The idea that carbon dioxide in the atmosphere was produced by burning carbon containing fuels was not well known.

(iii) This was quite well understood. Most candidates were able to describe at least one way in which the carbon dioxide concentration in the atmosphere could be reduced.

Question 11

Some parts of this question were well answered.

(a) Many candidates gained at least one mark for either force or distance. Few gained both marks.

(b) Many candidates correctly completed the calculation, showing good data handling skills.

(c) (i) Few candidates could explain that the frequency needed to be below 20 Hz, which is the lowest frequency heard by humans.

(ii) Some candidates were able to define frequency. Candidates needed to give a definition which described the frequency of a wave.

(iii) This was well done by many candidates. Most gained at least one mark here.

Question 12

This question was not well answered.

(a) Few candidates gained full marks, but many gained one or two marks. A common error was to have carbon as one of the products in the third reaction

(b) (i) Endothermic was not well known.

(ii) Many candidates suggested using an indicator but few explained how the student would know that the mixture was neutral.

(c) Many candidates gave answers to describe changes that would decrease the time taken for gas syringe to fill. Other candidates did not specify what change in concentration or temperature was required.

(d) Many candidates correctly suggested that calcium carbonate was added to water in lakes to decrease its acidity.

Question 13

Some parts of this question were well answered.

(a) The definitions were well known and many candidates gained full marks.

(b) (i) The anus was quite well known.

(ii) Fibre or roughage was less well known.

CO-ORDINATED SCIENCES

Paper 0654/22
Core Theory

General Comments

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

Candidates should look carefully at the mark allocation for part questions and write a response corresponding to the mark allocation. For example if three marks are available, a good response would make at least three valid points.

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

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

Comments on Specific Questions

Question 1

This question was quite well answered by some candidates. Most candidates gained some marks.

(a) Decomposition was quite well known.

(b) (i) Most candidates gained at least one mark here, usually for carbon dioxide rather than water.

(ii) Some candidates were able to name two suitable mineral ions. A common error was to state phosphorus or sulfur rather than phosphate or sulfate.

(iii) A few candidates correctly suggested that the compost needed to be aerated or kept warm.

(c) (i) Methane and carbon dioxide were well known as a greenhouse gases. A common incorrect answer was carbon monoxide.

(ii) Many candidates correctly described the effect of increasing amounts of greenhouse gases in the atmosphere.

Question 2

Some parts of this question were quite well answered. Candidates scored marks on most parts of the question.

(a) (i) Hydrogen was well known as the gas produced when metals react with dilute hydrochloric acid.

(ii) Most candidates were able to describe the correct chemical test for hydrogen. Some candidates failed to score both marks because they referred to the test as the pop test and then explained that the hydrogen went pop. There needed to be some reference to a lighted splint.

(iii) Few candidates gained both marks. The metal placed in the correct position most often was copper.

(iv) This was not well understood. Popular incorrect answers were that sodium and potassium were unreactive or that potassium and sodium were non-metals. Very few answers referred to safety.

(b) Many candidates correctly suggested that the alloy was stronger than pure gold. A number of candidates referred to cost despite the question asking for one other advantage.

Question 3

This question was quite well answered by most candidates. Most candidates gained some marks.

(a) (i)(ii) These parts were well answered by most candidates, who showed good data handling skills.

(b) (i) Many candidates either stated or described air resistance correctly.

(ii) The correct answer of 30 000 N was usually calculated.

(c) (i) Chemical energy was not well known. Common incorrect responses were thermal energy or potential energy.

(ii) Thermal energy or sound energy were common correct responses.

(d) Few candidates recognised the situation as a problem of the expansion of materials.

(e) (i) Few candidates were able to calculate the volume as 0.125 cm^3. Many candidates incorrectly tried to use the value for the density of steel in their calculation.

(ii) Many candidates knew the correct formula for calculating density but were unable to rearrange it to work out the mass of an object from its density and volume.

Question 4

Few parts of this question were answered well.

(a) Petroleum or crude oil were not well known. A number of candidates simply stated oil. This was not considered precise enough. A few candidates failed to notice that a liquid fossil fuel was required and gave coal as their response.

(b) (i) Fractional distillation was the required response. A number of candidates simply stated distillation This was not considered precise enough.

(ii) The use of mixture **P** as a fuel for heating or cooking was quite well known.

(iii) Gasoline or petrol was quite well known as the name of mixture **Q**.

(c) (i) Ethane and its formula were well known.

(ii) Many candidates correctly drew a carbon – carbon double bond. Fewer correctly placed only four hydrogen atoms around the two carbon atoms.

(d) (i) Cracking was the commonest answer. A few candidates suggested the Haber Process and other industrial processes.

(ii) Few candidates were able to correctly suggest bromine as the required test. Consequently they were unable to gain any marks. The few candidates who did suggest bromine frequently reversed the results expected for an alkane and an alkene.

Question 5

Candidates found parts of this question very difficult.

(a) (i) Many candidates demonstrated good data handling skills in this part. The percentage at the start of the training session was the value often wrongly determined.

(ii) Few candidates were able to make one correct statement to explain why the amount of glycogen changed during the training sessions.

(iii) Many candidates misunderstood the question and seemed to be comparing the two training sessions rather than describing what happened between the two training sessions.

(iv) This was found to be really difficult by the candidates. Very few candidates showed any understanding of what was going on.

(b) (i) The responses of the candidates were very varied. Few candidates gained all three marks, although most gained at least one mark.

(ii) Glucose was not well known as the molecules that form the basic units of a large glycogen molecule.

(c) (i) The possible role of adrenaline in glycogen breakdown was not known.

(ii) A number of candidates were able to correctly suggest that adrenaline would increase the heart rate.

Question 6

This question was poorly answered.

(a) Few candidates were able to give one characteristic of an image seen in a plane mirror. Magnified, real and inverted were common wrong answers. Many candidates attempted to describe lateral inversion but were unable to do this accurately enough.

(b) (i)(ii) Despite the clues in the question, very few candidates recognised this as a case of total internal reflection in **(i)**. Consequently they were unable to draw a satisfactory ray diagram in **(ii)**. Many candidates seemed confused by the normal drawn and made it into a reflected ray.

(c) Many candidates were able to explain that the air particles in the tyre collided with the tyre walls. Very few were able to go further and suggest that air particles were in constant motion in the tyre or that the force of the collisions with the tyre wall exerted a pressure.

(d) The candidates found this part very difficult. There were five marking points available and very few candidates scored even one mark. There was very little understanding of the process of evaporation and cooling.

Question 7

Only one part of this question was well answered.

(a) (i) The positions of the urethra and sperm duct were not well known.

(ii) The testis was well known. Very few candidates were able to identify the prostate gland.

(b) Sperm production was a well-known function of the testes. Production of hormones was less well known.

(c) (i) The very popular correct response was 20 °C.

(ii) Some candidates were able to describe how decreased sperm mobility reduces a man's fertility by suggesting the sperm would be less likely to be able to reach the egg and that this would lessen the chance of fertilisation.

(iii) Few candidates were able to explain that by having the scrotum outside the main body cavity, there would be a lower temperature and that this would help maintain sperm mobility.

Question 8

Some parts of this question were answered quite well.

(a) Radiation was not well known. Many candidates incorrectly suggested solar energy.

(b) (i) The correct circuit diagram was rarely drawn. However most candidates were able to show four lamps connected in parallel and label them as headlights and rear lights. Placing the switches in suitable positions was found to be extremely difficult.

(ii) Most candidates completed the calculation correctly. Many candidates were unable to write down a suitable formula. There were examples of formulae comprised of units and formulae using incorrect symbols.

(iii) Most candidates were able to calculate the combined resistance of the two lamps in series.

(c) (i) Most candidates only gained one mark here. The expected range was 20 Hz to 20 000 Hz.

(ii) Some candidates were able to define frequency. Candidates needed to give a definition which described the frequency of a wave.

(iii) Many candidates calculated the answer as 68 cm because they did not divide the distance calculated by 2.

Question 9

Candidates found parts of this question difficult.

(a) (i) Most candidates knew that a nitrogen atom contained seven electrons.

(ii) This part was poorly answered. Few candidates mentioned neutrons whilst many candidates suggested electrons.

(iii) Many candidates failed to answer the question. It was not sufficient to state that the nitride ion had gained three electrons. The answer needed to explain that the nitride ion contained three more electrons than protons.

(b) (i) Many candidates were able to complete the word equation. A few included iron as either a reactant or product.

(ii) The test for ammonia was not well known. Few candidates suggested using red litmus paper and even fewer described the expected colour change correctly.

(iii) Many candidates were able to describe a catalyst as a substance that increases the reaction rate. Fewer were able to suggest that it was not used up during the reaction.

(c) Sulfuric acid was not well known.

Question 10

Some parts of this question were answered well. However other parts were less well answered.

(a) (i) Few candidates were able to explain the meaning of the term efficiency.

(ii) Few candidates knew that the nuclei of uranium-235 split during the fission process.

(b) (i) Most candidates knew that gamma radiation was part of the electromagnetic spectrum.

(ii) Most candidates knew that gamma radiation did not have an electric charge.

(iii) Many candidates were able to suggest at least one harmful effect from ionising radiation

(iv) A variety of correct suggestions were made for protecting the workers from ionising radiation.

Question 11

Candidates found most parts of this question difficult.

(a) This was not well known. A few candidates correctly suggest that the surface had a large surface area.

(b) (i) Most candidates correctly suggested carbon dioxide as the gas entering the cells of the leaf.

(ii) Diffusion was not known. Some candidates incorrectly suggested photosynthesis.

(c) Some candidates were able to name one other type of cell that leaves contained. Very few were able to name two or three. Palisade and phloem cells were the most popular response.

Question 12

This question was not well answered.

(a) (i) Very few candidates were able to describe either an element or a compound.

(ii) The colour change for the indicator was quite well known but few candidates were able to explain that the solution became alkaline or that potassium hydroxide had been produced.

(iii) Very few candidates suggested that the potassium melted because it was an exothermic reaction. A few candidates confused melting and dissolving.

(iv) Few candidates seemed to realise that lithium would react more slowly and give a suitable observation.

(b) (i) Few candidates were able to explain that the bonding would be covalent due to the presence of non-metallic elements. This was possibly due to a lack of familiarity with a chloramine molecule.

(ii) Some candidates were able to suggest that chloramine might kill harmful microorganisms.

(iii) Filtration and chlorination were well known as water purification processes.

CO-ORDINATED SCIENCES

Paper 0654/23
Core Theory

General Comments

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

Candidates should look carefully at the mark allocation for part questions and write a response corresponding to the mark allocation. For example if three marks are available, a good response would make at least three valid points.

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

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

Comments on Specific Questions

Question 1

Most parts of this question were very well answered. However two parts were less well answered. Good data handling skills were shown in many parts of the question.

(a) (i) Most candidates were able to deduce that the substances that are present in goat's milk at higher concentrations than in cow's milk are fat, protein and calcium. A number of candidates suggested energy, which was not credited as it is not a substance.

(ii) Most candidates correctly suggested iron as the mineral ion that is present in cow's milk at higher concentrations than in goat's milk. A common wrong answer was vitamin C.

(iii) The idea that goat's milk has more fat than cow's milk was well worked out by many candidates.

(b) (i) Many candidates were able to complete the calculation and determine the volume of milk required so that an adult could get all of their daily vitamin C requirement.

(ii) Many candidates were able to explain that six litres of milk each day is not a sensible way to get their daily vitamin C requirement.

(iii) Some candidates were able to state that scurvy is the deficiency disease resulting from a lack of vitamin C. Many others were able to describe the symptoms of scurvy. Many candidates referred incorrectly to rickets and it's symptoms.

(c) (i) Few candidates were able to describe the importance of fibre in the diet. The required answers were either that fibre prevents constipation or that fibre promotes peristalsis. Many candidates vaguely stated that fibre helps with excretion or digestion.

(ii) There were obviously many different correct answers, with cereals, fruits and vegetables all very popular. The most common response was papaya.

Question 2

Most parts of this question were well answered but two parts were less well answered.

(a) (i) The idea of greater precision or accuracy was well known.

(ii) Neutralisation was also well known.

(iii) Salt and water were both well known, but more candidates correctly suggested water than suggested salt.

(b) (i) Many candidates were able to work out that the pH decreased in both situations. Some were able to quantify the pH changes others were able to describe the rate of the decrease.

(ii) The popular correct answer was 40 cm^3.

(iii) Many candidates did not seem to understand what they needed to explain here. A simple answer such as 'take 20 cm^3 of alkali and add 40 cm^3 of acid' would have gained full marks.

(iv) This should not have been as difficult as many of the candidates found it. A simple response such a white solid or solid sodium chloride would have been sufficient.

Question 3

Candidates found parts of this question difficult.

(a) (i) Few candidates were able to place all four radiations in the correct positions. The position of radio waves was well known.

(ii) Few candidates knew that it was microwaves that are used for mobile phone communications.

(b) (i) Many candidates correctly labelled the principal focus of the lens.

(ii) Few candidates were able to measure the focal length of the lens accurately. Some gave the value in centimetres.

(c) Many candidates were able to explain that the air particles in the cylinder collided with the cylinder walls. Very few were able to go further and suggest that air particles were in constant motion in the cylinder or that the force of the collisions with the cylinder wall exerted a pressure. Some candidates attempted to describe why the pressure in the water increases with depth.

(d) Most candidates knew at least one of the quantities needed to calculate pressure. Weight was more commonly known than area.

(e) This was not well answered. A complete answer was not given by many candidates. Many knew that either the particles were randomly arranged or they were touching. But few knew both.

Question 4

This question was poorly answered.

(a) (i) Few candidates were able to use the information and construct the correct word equation for the reaction. A number of candidates introduced carbon monoxide as a product.

(ii) Most candidates attempted this part but few were able to explain why the reaction was described as reduction and oxidation.

(b) (i) Candidates needed to label the actual anode to gain the mark.

(ii) This was not well answered. Many candidates stated the name of the substance formed at the anode as chloride and gave its formula as Cl^-.

(c) (i) Neither carbon nor carbon dioxide were well known here.

(ii) Few candidates seemed to be able to describe a simple test for a metal such as electrical conductivity.

Question 5

Candidates found parts of this question very difficult.

(a) (i) Asexual was well known

(ii) Some candidates were able to explain that, as the new plant was genetically identical to the parent plant, it would produce exactly the same type of strawberries.

(b) (i) Photosynthesis was well known.

(ii) Sexual reproduction was not well known. Many candidates were able to suggest that the flowers were needed for pollination. This was not considered precise enough.

(c) (i) Anther or stamen were well known. Many candidates suggested stigma however.

(ii) The sepal was less well known. The leaf was often suggested.

(d) Some candidates were able to explain that if the weevil destroyed some of the strawberry flowers, reproduction would not occur and fruits would not develop from the flowers.

Question 6

Some parts of this question were well answered.

(a) (i) Most candidates were able to identify the four times at which the motorcyclist travelled at 9 m / s.

(ii)(iii) Good data handling skills were shown in these parts. Most candidates were able to state that the motorcyclist reached 9 m / s for the first time after 14 seconds in **(ii)** and in **(iii)** they were able work out that the motorcyclist travelled at 18 m / s for 20 seconds.

(iv) Many candidates were able to state a section of the graph where the motorcyclist was slowing down and explain that it was because the graph was going down that they knew this.

(b) (i) Most candidates found this very difficult. Many confused thermal conduction with electrical conduction.

(ii) Few candidates were able to describe convection.

(iii) Many candidates gave good descriptions of wavelength. Some candidates were able to define frequency. Candidates needed to give a definition which described the frequency of a wave.

(c) (i) Most candidates completed the calculation correctly. Many candidates were unable to write down a suitable formula. There were examples of formulae comprised of units and formulae using incorrect symbols.

(ii) Most candidates were able to calculate the combined resistance of the two lamps in series.

Question 7

This question was not well answered.

(a) Few candidates knew that the tissue that had been stained by the coloured water was xylem. Most candidates suggested the stem.

(b) Most candidates found this very difficult. Few candidates scored more than one mark.

(c) The idea that the coloured water would not move as far was not understood by many candidates.

Question 8

Some parts of this question were answered well.

(a) Petroleum and fractional distillation were well known.

(b) (i) Few candidates were able to suggest both carbon dioxide and water. Carbon monoxide and methane were common errors.

(ii) Few candidates referred to either incomplete combustion or the production of carbon monoxide.

(c) (i) The results of testing hydrocarbons with bromine was not remembered by many candidates. Many of the candidates who did seem to know the test, reversed the results.

(ii) This was well answered. Most candidates correctly placed four hydrogen atoms and many drew a carbon – carbon double bond.

Question 9

Most parts of this question were well answered.

(a) Many candidates new that the forces were equal and opposite because the submarine was travelling at constant speed and therefore there was no resultant force.

(b) Most candidates attempted this and many drew some accurate ray diagrams.

(c) (i) Any suitable material was accepted here – lead or concrete for example.

(ii) Few candidates suggested a suitable instrument to check radiation levels.

Question 10

This question was answered well.

(a) (i) Deforestation was well known.

(ii) Many candidates were able to give two reasons why humans cut down large numbers of trees.

(b) A variety of correct answers was seen in this part.

(c) (i)(ii) Most candidates were able to use their understanding of food chains and webs to answer this.

Question 11

Most parts of this question were well answered.

(a) (i) Neon was commonly given. Some candidates were confused by the negative temperatures.

(ii) Proton number and atomic number were popular correct answers.

(iii) Many candidates knew that the nucleus contains protons and neutrons. A number of candidates were able to deduce the correct numbers of protons and neutrons. A number of candidates incorrectly stated that there were electrons in the nucleus.

(b) (i) Sodium chloride was well known.

(ii) Some candidates referred correctly to a loss of electrons.

(iii) This was answered quite well, particularly by the weaker candidates.

(c) The test for chloride ions was not well known. Few candidates chose silver nitrate and fewer were able to describe the result.

Question 12

Some parts of this question were answered well.

(a) (i) Most candidates correctly calculated the resultant force as 5 000 000 N.

(ii) The idea that an upward resultant force was needed was not understood by many candidates.

(iii) Some candidates correctly identified all three forms of energy. Most candidates correctly identified two.

(b) (i) The idea that sound waves would not be able to travel through space because they need a medium to travel through, was not well known.

(ii) Many candidates correctly calculated the speed of radio waves, showing good data handling skills.

(c) (i)(ii) Candidates found it difficult to describe background radiation in **(i)** and most were unable to state another source of background radiation on Earth in **(ii).**

Question 13

Some parts of this question were not well answered.

(a) (i) Increased rate of breathing and increased depth of breathing were both quite well known. A number of candidates confused the graph with a wave diagram and then referred to the amplitude and wavelength of the wave.

(ii) This was not well answered. Few candidates were able to suggest any of the possible answers – less oxygen, more carbon dioxide, more water vapour or warmer. Many candidates did suggest breathe in oxygen and breathe out carbon dioxide but this was not an accepted response.

(b) (i) Few candidates were able to suggest either an increased heart rate or increased blood glucose.

(ii) The definition of a hormone was not well known. Few candidates were able to gain more than one mark here.

CO-ORDINATED SCIENCES

Paper 0654/31
Extended Theory

Key message

Where diagrams were required, they were usually drawn with care to give an unambiguous answer. The most successful candidates added a labelled diagram to clarify their written answer or made use of the space provided themselves. Several questions on this paper required candidates to indicate their answer on a diagram supplied. A relatively large number did not respond to these questions. This emphasises the need to read all the information on the paper, even where an answer line is not provided.

General comments

The use of English in demonstrating understanding was generally good. The most successful candidates avoided ambiguity by using the terminology employed in the syllabus when giving definitions. They were careful not to simply repeat information given in the question.

Mathematical processes were usually carried out free of error. Formulae were written in the working space and could be expressed in words or symbols. Candidates who performed less well used a mixture of words and symbols in formulae or units.

Comments on specific questions

Question 1

(a) (i) Most candidates counted the correct number of elements in Period 2.

(ii) The other sub-atomic particle was usually correctly identified.

(iii) Most diagrams of the electronic arrangement of phosphorus were drawn well.

(b) Candidates usually drew the covalent bonding diagram of ammonia with the correct numbers of bonding and non-bonding electrons, with atoms correctly identified.

(c) (i) The Haber process was usually recognised.

(ii) Those candidates who wrote the correct formula for hydrogen could often go on to balance the equation by deducing that carbon monoxide is the other product. Writing H_3 was a common mistake.

(iii) The role of iron as a catalyst was known by most candidates.

Question 2

(a) The part of the cell indicated was usually identified.

(b) Many candidates correctly wrote that photosynthesis involves the transfer of light energy to chemical energy, rather than the transfer of solar or thermal energy.

(c) (i) Most candidates explained that the production of oxygen in bright light is due to photosynthesis and many also knew that the production of carbon dioxide in the dark is due to respiration. The best answers realised that respiration occurs in light and dark conditions independent of photosynthesis. Those candidates explained that in dim light there would be no net release of oxygen or carbon dioxide when the rates of photosynthesis and respiration are equal.

(ii) Some responses correctly gave the lack of chloroplasts as the reason for photosynthesis not occurring in the xylem. Others mentioned the absence of chlorophyll, the lack of exposure to light or just described the function of the xylem.

Question 3

(a) The correct particle diagram of a liquid was usually correctly chosen. Fewer candidates correctly explained their choice by using the diagrams to show that the particles are in contact and in an irregular arrangement, rather than describing the movement of particles which was not evident from the diagrams.

(b) (i) Increasing temperature or surface area was usually given as correct methods of increasing the rate of evaporation.

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

(c) (i) The formula for calculating energy from power was usually quoted correctly; some candidates were misled into trying to involve the voltage data in the stem of the question. Many candidates were careful to select the correct unit of energy consistent with the unit of power they had used in the calculation.

(ii) Some answers showed that electrical energy transmission at high voltage involved lower current in the cables. The best responses stated that this led to less energy loss in the form of thermal energy.

(iii) Most candidates knew that a step-down transformer reduces voltage.

Question 4

(a) The definition of mutation was well known.

(b) (i) Many of those who had noticed that the question stated that it was the parents who had been exposed to the chemical went on to explain that mutation occurred in genes in the parents and that the mutation had been passed on to the offspring. Others implied that the offspring had been directly affected.

(ii) Better performing candidates specified that it is *ionising* radiation that can cause mutation.

(iii) It was usually correctly suggested that flies with small wings would not be able to fly as well. Better performing candidates stated that those flies would be less well suited to their environment because of difficulty in obtaining food or in avoiding predators.

(c) Most candidates successfully completed the question on adaptation.

Question 5

(a) (i) Many candidates knew that propane does not react with bromine and that propene does and were also able to recall the colour changes that would be observed.

(ii) The difference in the bonding of propane and propene molecules was well known.

(b) (i) Most responses explained that carbon dioxide turns limewater cloudy.

(ii) The relative molecular mass of glucose was usually calculated correctly.

(iii) Many candidates calculated the number of moles of glucose in the solution without going on to calculate the mass.

(c) (i) Nitrogen was usually recognised as an element in amino acids but not in ethanol.

(ii) Protein was the usual correct suggestion for the product of polymerisation.

Question 6

(a) Some candidates were able to use all the terms to correctly describe how light passes along optical fibres. Some candidates used a labelled diagram to clarify their description.

(b) (i) Most candidates correctly explained that gamma radiation is used in the diagnostic procedure due to its high penetration or low ionisation properties.

(ii) Many candidates realised that the time taken for the count rate to halve is the half-life value given in the question.

(iii) Successful candidates showed in their working that the count rate had halved four times, and then calculated the value of four half-lives.

Question 7

(a) Some candidates labelled one of the nerves shown; others labelled the brain or spinal cord or an external part of the body.

(b) (i) Some candidates were able to correctly defined a reflex action. Better performing candidates were careful not to use words in a definition similar to the term being defined, such as *reaction* to define a reflex *action*.

(ii) Better performing candidates gave a complete description of the involvement of the peripheral nervous system using precise terms such as *impulses* carried from *receptors* to the *central nervous system* and *impulses* carried from the *central nervous system* to *effectors*.

(c) (i) Most candidates knew that a response in the nervous system lasts a shorter time than in the hormonal control system.

(ii) Candidates who performed well stated that *chemicals* are carried in the *blood* in the hormonal control system and that information transfer is through *electrical impulses* in the nervous system. These candidates avoided terms such as *messages* or *signals*.

Question 8

(a) (i) Most responses indicated that steel is magnetic while plastic filler is not.

(ii) Many candidates realised that the method would not work with aluminium as it is not magnetic, while others suggested that aluminium is magnetic because it is a metal.

(b) (i) The majority of candidates knew the Ohm's Law formula and used the correct unit for current.

(ii) Those who knew the formula for charge obtained the correct result if they changed the units of time and realised that charge flow to both lamps was required.

(iii) Successful candidates correctly applied their particular method for calculating total resistance in parallel. Others simply added the two resistances or used a formula such as $R=1/R_1 + 1/R_2$ or implied it by writing just $1/R_1 + 1/R_2$.

(c) The formula for the amount of energy needed to change the temperature was often stated correctly. Errors included mixing symbols with words in the formula and using a mass of 1 kg.

Question 9

(a) Most recognised the process as electrolysis.

(b) (i) Most explained the migration of aluminium ions as due to their positive charge.

(ii) Those candidates who realised that conversion of ions to atoms involved transfer of electrons from the cathode often neglected to state that the ion is discharged or that three electrons are involved.

(c) (i) Many candidates attempted to find the charge on the iron ion by a method involving 'swapping' valency. Better performing candidates used a calculation based on charge balance such as:
3 x (–2) =(–6) is balanced by 2 x (+3) = (+6) because (–6) + (+6) = 0.

(ii) Some candidates used their knowledge of the reactivity series to deduce that aluminium reacts with copper oxide. Candidates who performed well also used the information from the question, such as the reaction showing that aluminium is more reactive than iron which in turn is more reactive than copper.

Question 10

(a) A suitable species was usually suggested to indicate slight pollution.

(b) (i) Many candidates correctly showed that pollution occurred at or before the decline of the mayfly larvae population. There was less ambiguity when the arrow was drawn to a point on the distance axis.

(ii) Better performing candidates explained that stonefly nymphs were killed by pollution by recognising that microorganisms such as bacteria or toxins had been introduced, rather than simply restating information in the question. There was some mention of oxygen depletion but its cause by respiration of microorganisms or its effect on respiration of the larvae was rarely included.

(c) (i) Satisfactory statements of what is meant by acid rain made reference to pH or an acidic pollutant dissolved in rain. Others wrote a variation of *rain containing acid*, which did not add to the information in the question.

(ii) The best ways of reducing the incidence of acid rain were based on methods of decreasing the use of fossil fuels or removing acidic oxides before entering the atmosphere. There was some confusion apparent in the idea that acid rain is caused by the over production of carbon dioxide.

Question 11

(a) Candidates who knew the kinetic energy formula usually calculated the correct answer.

(b) Candidates who knew the formula for work done usually calculated the correct answer.

(c) (i) Most candidates knew the formula for pressure and many candidates noticed that the force was distributed over all four of the elephant's feet.

(ii) Some candidates tried to calculate the number of N/cm^2 in 1 Pa but only a few used or derived the conversion: 1 Pa = 10 000 N/cm^2.

(d) (i) Most candidates made a good suggestion for an infrasound frequency. Better performing candidates gave further information by making a comparison with the lower threshold of hearing in humans.

(ii) Candidates described the propagation of sound by referring to compressions and rarefactions. Where particle vibrations were described, there was some difficulty evident in explaining that the vibrations occurred in the same direction or parallel to the direction of energy transfer. Better performing candidates included a labelled diagram to support their description.

(e) Most candidates could apply the formula for speed to obtain the time taken for sound to travel between the elephants. Some candidates realised that the sound had travelled twice the distance between the animals.

(f) When describing an experiment to measure the volume of the model the most successful candidates gave sufficient information for a candidate to repeat the process. Many described the displacement method, with some omitting to suggest an instrument to measure the volume of the displaced water. Some methods suggested measuring mass and applying the formula $d = mV$. This was acceptable if there was an implication that it would be necessary to look up the value for the density of gold.

Question 12

(a) Most candidates completed at least one of the acid reaction word equations correctly.

(b)(i) and **(ii)**
Some candidates did recognise that the energy transformation was from thermal to chemical energy and went on to explain that this was an endothermic reaction or that there was a decrease in temperature.

(c) (i) Successful candidates explained the shape of the graph as being caused by the cessation of gas production rather than simply that the volume no longer increased. They noted that the reaction had stopped or that the calcium carbonate had been used up. These candidates were careful not to imply that the acid was used up, recognising that it was in excess.

(ii) Those who successfully attempted this question realised that half the mass of carbon dioxide would yield no more than half the volume of carbon dioxide, causing the shape of the graph to be the same but with the volume never exceeding that in the first experiment.

(iii) Most candidates knew that a temperature rise would increase the energy or speed of particles and many concluded that this would cause an increase in the success of collisions or the rate of collision.

Question 13

(a) Those who attempted this question usually labelled the anther correctly.

(b) The pollen was usually correctly identified but it was not always recognised that pollen is the source of male gametes.

(c) At least one method of adaptation for insect pollination was usually described.

(d) (i) Most candidates suggested wind or animal dispersion of the fruits and gave explanations in terms of the shape of the fruit structure.

(ii) Most candidates knew that the fruit would contain seeds.

CO-ORDINATED SCIENCES

Paper 0654/32
Extended Theory

Key message

Candidates should take notice of key words such as *state, define, describe, explain* and *deduce* in deciding what response a question requires. This is particularly the case for questions asking candidates to *describe* or *explain* phenomena. Candidates frequently described phenomena when they should have been explained and vice versa.

Calculations were generally done well, with working shown. Better performing candidates gave formulae using the correct abbreviations, as listed in the syllabus. These candidates gave correct units with their answers and rounded their answers up or down to an appropriate number of significant figures.

General comments

Candidates showed good use of English in expressing their ideas in continuous prose. Candidates who performed well used the correct scientific terminology when answering extended questions. These candidates had learned the definitions specified in the syllabus.

When drawing diagrams or graphs, candidates should be reminded to take care to draw clearly and to use the correct labels and labelling lines.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to give the correct answer.

(ii) Many candidates could correctly name substances required by plants in fertilisers.

(b) (i) Most candidates were able to give carbon dioxide as one product of anaerobic respiration. Several were able to name ethanol or lactic acid.

(ii) Several correct suggestions were seen including ideas about increasing oxygen content and providing a suitable temperature.

(c) Vague responses suggesting that the ecosystem supplies all the nutrient needs were seen. Better performing candidates expressed the idea that nutrients were returned to the soil or that nutrient material was recycled.

Question 2

(a) (i) Many candidates were able to place the elements in the correct order of reactivity. Fewer were able to place element **J** in the correct position between zinc and hydrogen. A frequent error was the substitution of elements hydrogen and copper.

(ii) Better performing candidates explained that copper ions were reduced as they gained electrons to become copper atoms. Very few candidates were able to correctly state that copper ions were the particles that were reduced. Most candidates could express the idea that reduction was the gain of electrons.

(b) (i) There were few good particle diagrams of a gold alloy. Particle diagrams resembling a gas where none of the particles were touching were frequently seen. Some candidates incorrectly attempted to draw bonds between the particles.

(ii) Many candidates could correctly calculate the mass of diamond in grams. Fewer were able to carry out the second step required to give the number of moles. Better performing candidates took care when completing calculations; others transcribed the incorrect figures.

Question 3

(a) (i) Many correct calculations were seen. These were clearly laid out and correct units included. A common error was to calculate the area under the graph as a single rectangular value rather than the area of the rectangle and the area of the triangle.

(ii) Most candidates correctly stated and used the formula for calculating kinetic energy. A common error was not to convert joules into kilojoules, giving the incorrect value of 100 000 000 kJ.

(b) (i) Many candidates were able to correctly describe the effect on the particles in steel when the temperature increased. Many candidates related the correct description to density increasing, which was incorrect. Some candidates described the particles as expanding rather than the space between the particles increasing.

(ii) There were many correct responses seen. Some candidates incorrectly calculated the volume as 50 x 3 rather than 50^3. The conversion of grams to kilograms also proved troublesome for some candidates.

Question 4

(a) Most candidates were able to give the correct answers of petroleum or crude oil.

(b) This question was answered particularly well. Many candidates could relate the sizes of molecules to differences in boiling point and different heights of collection in the fractional distillation tower. Some candidates incorrectly referred to differences in melting or evaporating points rather than boiling points.

(c) (i) Most candidates correctly recognised this process as cracking.

(ii) Many candidates could correctly describe the test and result for identifying an alkene. Most candidates used the correct terminology of decolourisation. A minority of candidates described the result as turning clear.

(ii) The idea of how to show that cracking produced alkenes proved challenging for candidates. Very few were able to suggest that the test should be carried out both before and after cracking and that only after cracking would alkenes be produced. The majority of candidates suggested applying the test after the cracking process and stated the expected result.

Question 5

(a) Some candidates were able to give a correct definition of the term *nutrition*.

(b) (i) Many candidates described malnutrition as the total lack of nutrients rather that an imbalance of certain aspects of diet.

(ii) Many candidates recognised that obesity was caused by consumption of too much energy but fewer were able to relate this to the storage of this as fat in the body. There was some confusion with Kwashiorkor's disease.

(c) (i) This question was answered particularly well, with some excellent descriptions of data shown. It was encouraging to see that many candidates quoted data from the graph to support their descriptions.

(ii) Many candidates were also able to provide a reasonable suggestion for the increase in childhood obesity.

(iii) Several correct health problems were seen including diabetes and coronary heart disease. Candidates who performed less well, provided vague answers such as heart problems.

(d) (i) Most candidates were able to correctly state the function of vitamin D in the body. Better performing candidates referred to building of bone or bone strength rather than healthy bones.

(ii) Milk was the most common correct answer given. The most common incorrect answers being vegetables and oranges.

(iii) Many candidates were able to describe the effects of a vitamin D deficiency and to give the name of the disease as rickets. Some incorrect response relating to scurvy and vitamin C deficiency were seen.

Question 6

(a) Most candidates drew a line representing the mirror at the correct angle. Better performing candidates used a ruler when necessary.

(b) Good explanations of the reason why light would not leave the prism at point **P** were given. Most candidates explained that the angle of incidence was greater than the critical angle.

(c) A wide variety of responses were seen to this question, few candidates opted for the simple method of using a magnet. A number of candidates incorrectly suggested rusting or measuring the mass.

(d) (i) Candidates had to show that the volume of air required was 3200 cm^3. Unfortunately, many candidates simply rearranged only some of the values to achieve 3200 cm^3. Candidates that did this usually stated 1600 x 2 = 3200 cm^3 without any evidence of method used. Better performing candidates clearly stated the formula used and the rearrangement of the formula with the values to show the answer of 3200 cm^3.

(ii) Most candidates were able to complete the correct calculation. Many candidates rounded the value incorrectly to 35 rather than 36.

Question 7

(a) Better performing candidates used a ruler and took care when labelling diagrams. Their label lines did not include arrow heads and were drawn with a ruler. When labelling the cell membrane, their label line stopped on the line of the cell membrane itself rather than at the cytoplasm.

(b) Many candidates were able to describe differences between male and female gametes. There is some confusion evident between the difference between release and production of gametes. It should also be noted that male gametes contain X or Y chromosomes and not X and Y.

(c) (i) The vast majority of candidates could use the graph to state the correct temperature.

(ii) Many correct responses relating sperm mobility to less respiration at lower temperature were seen. Fewer candidates mentioned the effect of temperature on the enzymes involved.

(d) Many candidates simply gave descriptions, where explanations were required.

(i) Many candidates correctly described that the sperm mobility would be decreased. Fewer explained that this would be due to an increase in temperature.

(ii) Many candidates correctly identified that the temperature would be lower. Fewer related this to sperm mobility. Some related the temperature to sperm production rather than sperm mobility.

(iii) Many candidates correctly described that fertility would decrease. Fewer explained that this would be due to a decrease in sperm mobility.

Question 8

(a) (i) The majority of candidates gave the correct answer of radiation.

(ii) Nearly all candidates identified car **A** as the car that would have the greatest temperature difference. Fewer were able to give a correct explanation. Candidates who performed well, used the correct terminology. Many candidates described the black car as attracting heat or light rather than absorbing more radiation.

(b) (i) Most candidates were able to use the formula R = V/I to show the correct answer.

(ii) Fewer candidates were able to use a correct formula to calculate the resistance. The most common error was not to calculate the reciprocal when required, giving the incorrect answer of 0.8 Ω.

(c) (i) Many candidates recalled the range of audible frequencies as 20 Hz to 20 000 Hz.

(ii) The correct formula of distance = speed x time was frequently correctly applied. The majority of candidates did not appreciate that the distance needed to be halved, so many gave the incorrect answer of 68 cm rather than 34 cm.

(iii) Fewer candidates were able to correctly recall and apply the formula of velocity = frequency x wavelength. Those candidates that did apply the correct formula occasionally misplaced the decimal point to give the incorrect answer of 0.85 m.

(iv) This question was answered well. Many candidates recognised that compressions would be further apart and that wavelength would be larger. A few candidates incorrectly described the compressions and rarefactions as swapping positions.

Question 9

(a) (i) The correct electron configuration of 2, 5 was frequently seen. The most common error was to give the total number of electrons of 7.

(ii) Most candidates recognised that the nitride ion had gained three electrons to complete its outer shell. Fewer were able to explain that the charge was caused by there being three more electrons than protons.

(iii) The correct formula of Mg_3N_2 was commonly seen. Very few candidates were able to show how they arrived at the correct formula. Some candidates incorrectly showed charges being swapped with two arrows.

(b) (i) The correct balanced equation was frequently seen. It was clear that some candidates struggled with the balancing of the equation. Some candidates stated that there were two atoms of nitrogen '2N' rather than stating that nitrogen is a diatomic molecule N_2.

(ii) Many candidates gave the correct chemical test and result of damp red litmus paper turning blue. A few candidates gave the wrong colour litmus paper and result.

(iii) Most candidates recognised that iron in many small pieces would increase the surface area of the iron catalyst. Only some candidates were able to explain that this would increase the frequency of collisions. A significant number of candidates incorrectly explained that increasing the surface area of the catalyst would increase the energy of the collisions. Better performing candidates knew that it is the frequency of the collisions that would increase rather than the number of collisions.

Question 10

(a) (i) A wide variety of formulae were seen. Candidates who performed well, used the formula as specified in the syllabus. Most candidates were able to use the formula they had stated to correctly calculate the efficiency.

(ii) The correct answer of nuclear fusion was commonly seen.

(b) (i) Most candidates gave the correct type of radiation as gamma.

(ii) Most candidates could state that gamma radiation was not made up of charged particles. Some candidates rewrote the question to state that gamma radiation was not deflected by an electric field.

(c) (i) This question was answered particularly well, with many candidates explaining that higher voltage resulted in lower current and less energy loss.

(ii) It was evident that many candidates did not fully understand how transformers work to change voltage. Very few were able to describe the significance of a changing magnetic field.

Question 11

(a) (i) Candidates could state ways in which the surfaces were adapted to gas exchange. A common misconception was that the cell wall is thin rather than the wall of the alveolus and mesophyll cells.

(ii) The majority of candidates were able to recognise that the alveolus had an associated blood capillary where the mesophyll cells did not.

(b) (i) Most candidates gave the correct answer of carbon dioxide. The most common incorrect answer given was oxygen.

(ii) Many candidates gave the correct answer of diffusion. Many candidates also gave incorrect answers. Osmosis and photosynthesis were examples of the most common incorrect answers, with respiration occasionally seen.

(c) (i) Some candidates were not precise enough in their responses; vague references to not being able to breathe were seen. The best responses related emphysema with the reduction of surface area of the alveoli and the resulting decrease or slowing of gas exchange or oxygen uptake. Better performing candidates stated the specific gases involved in gas exchange rather than referring to air.

(ii) Several correct harmful effects of smoking on the gas exchange system were seen. Common correct answers were lung cancer, bronchitis and increased mucus.

Question 12

(a) (i) Many candidates could give a correct example of an element from the equation. Candidates struggled to explain why their given example was an element. The best answers referred to there being only one type of atom. Several candidates did not go far enough in their explanations, stating that compounds consisted of different types of atoms but not including that they were bonded together.

(ii) Many candidates understood the meaning of a balanced equation but were not able to express themselves fully. Many candidates referred to the total number of atoms being equal on both sides of the equation rather than the number of atoms of each element being equal.

(iii) Many candidates seemed unaware of the meaning of the state symbols, particularly the state symbol (l). Several candidates stated the meaning of (l) to be an indicator. The meaning of the state symbol (aq) was more likely to be answered correctly with some good descriptions seen.

(iv) Candidates were able to recall that potassium reacting with water would result in an alkali solution, turning the indicator from green to blue. Some candidates described potassium oxide being formed rather than potassium hydroxide. Very few stated an incorrect colour change.

(v) A minority of candidates were able to correctly describe the reaction as exothermic. Very few candidates stated that hydrogen was produced and that it was the hydrogen that burned to produce a flame.

(b) (i) Most candidates correctly identified a shared pair of electrons. Better performing candidates drew label lines with care by ensuring their label lines ended at one of the covalent bonds.

(ii) Many candidates were able to describe the sharing of electrons to enable each atom to have a complete and stable outer shell.

CO-ORDINATED SCIENCES

Paper 0654/33
Extended Theory

Key message

Candidates sitting this paper achieved a wide range of marks. Higher achievers were able to write continuous prose to explain scientific phenomena. They showed that they had practiced the application of basic principles to describe the mechanism of a process occurring in nature or in a man-made device. There was little evidence that candidates had insufficient time to complete the paper, but it was apparent that some had not reviewed their answers to check for obvious mistakes.

General comments

The use of English in demonstrating understanding was generally good. Better performing candidates avoided ambiguity by using the terminology employed in the syllabus when giving definitions. They were careful not to simply repeat information given in the question.

Mathematical processes were usually carried out free of error. Formulae were written in the working space and could be expressed in words or symbols, but not in units. Candidates who performed well ensured that units of one quantity were compatible with the others substituted into the formula. These candidates also ensured that the units of the result were converted to those specified on the answer line.

Comments on specific questions

Question 1

(a) (i) Fat and vitamin D were identified by most as substances present in breast milk in higher concentrations.

(ii) The information was usually used correctly to calculate the volume of bottle milk required. Errors were caused by calculating the number of 100 cm^3 units or by using the breast milk data.

(b) and **(c)**
There was evidence that some candidates confused these two distinct questions. Part **(b)** asked why bottle milk is not necessarily a better source of *nutrients*, **(c)** asked for advantages of breast milk, *apart from nutrient content*. Some candidates appreciated that nutrients may be in excess of what a baby needs. Fewer mentioned inefficient absorption or destruction during preparation. More candidates could suggest at least one advantage of breast feeding

Question 2

(a) (i) and **(ii)**
Most candidates recognised this as a neutralisation reaction and appreciated the advantage of using an electronic pH meter.

(b) (i) Many successfully calculated the number of moles of sodium hydroxide, with the most common error being to neglect to change units from cm^3 to dm^3.

(ii) The correct volume of acid was chosen by many as that which brought the pH to 7; others took neutrality to occur when the pH started to fall or had become constant.

(iii) A few candidates were able to calculate the concentration of the acid and explain their result in terms of the stoichiometry of the reaction.

Question 3

(a) Many candidates completed the diagram of the electromagnetic spectrum correctly.

(b) Many candidates explained that a black surface is the better absorber of radiation. Candidates who performed less well gave explanations involving the absorption of just light or the implication that radiation is attracted.

(c) (i) The principal focus was often labelled accurately. Better performing candidates ensured that label lines could not be confused with representations of light rays.

(ii) Some candidates correctly distinguished a real from a virtual image by stating that a real image can be projected onto a screen. A few explained that rays of light converge on a real image. Others made inaccurate generalisations about the positions and sizes of the images.

(d) (i) Most candidates knew the formula for pressure and noticed that the force was distributed over both of the penguin's feet.

(ii) Some candidates tried to calculate the number of N/cm^2 in 1 Pa; only a few used or derived the conversion 1 Pa = 10 000 N/cm^2.

(e) (i) Some candidates described how gas molecules exert pressure by colliding with the walls of the container. A few good answers mentioned the force acting on the container due to each collision.

(ii) Candidates who knew the formula usually calculated the new pressure of the air correctly. There were some good answers, which recognised that the product of pressure and volume is constant if the temperature is not changed.

Question 4

(a) Those candidates who could transcribe the information into a chemical equation were often able to balance it. The state of magnesium oxide was often given as a gas rather than a solid.

(b) (i) Most explained the migration of magnesium ions being due to their positive charge and their attraction to the oppositely charged cathode. Those candidates who realised that conversion of ions to atoms involved transfer of electrons from the cathode often neglected to state that the ion is discharged or that three electrons are involved.

(ii) A few candidates realised that hydrogen is produced in preference to the more reactive magnesium when aqueous magnesium chloride is the electrolyte.

(iii) Of those candidates who knew that chlorine is produced at the anode, some gave it's formula as Cl rather than Cl_2.

Question 5

(a) The majority of candidates answered this question on cell division correctly.

(b) Most candidates could name at least one process that depends on cell division. Examples of sexual reproduction rather than asexual reproduction were sometimes given in error.

Question 6

(a) There were some good answers for the distance obtained from the speed / time graph, in which working was clearly shown.

(b) Candidates who knew the formula for work done usually calculated the correct answer.

(c) (i) Candidates who knew the formula for electrical power usually calculated the correct answer. Some used a method based on proportionality and clearly explained their reasoning.

(ii) The majority of candidates knew the Ohm's Law formula and obtained the correct value for the resistance.

(iii) Successful candidates correctly applied their particular method for calculating total resistance in parallel. Others simply added the two resistances or used a formula such as $R=1/R_1 + 1/R_2$ or implied it by writing just $1/R_1 + 1/R_2$.

Question 7

(a) Many candidates knew that it was the xylem that had been stained.

(b) A few candidates could use all four terms in the correct context to describe the mechanism of water uptake. Others used the term *transpiration* to cover the whole process, or described *cohesion* as a property of bulk water rather than its molecules. Candidates found difficulty in ascribing causation in the process.

(c) (i) and **(ii)**
Some candidates appreciated that more humid and cooler conditions would reduce the rate of transpiration and slow the rate of movement of the coloured water.

Question 8

(a) Most responses showed that petroleum is separated by fractional distillation. Crude oil was acceptable as the raw material but oil was too vague.

(b) (i) Some candidates knew that nitrogen and oxygen combine at the high temperature in a car engine. Many candidates wrote that nitrogen is supplied by the air, while implying that oxygen came from the fuel.

(ii) It was well known that nitrogen oxides contribute to acid rain. The effect on respiratory systems was mentioned less often.

(iii) Several candidates knew that oxides of nitrogen are removed from exhaust gases in the catalytic converter.

(c) (i) The majority stated that an alkane contains only single bonds, and correctly described it as a hydrocarbon or as a compound of hydrogen and carbon. The clearest answers confirmed that *only* hydrogen and carbon are present.

(ii) The structural formula of butane was usually drawn correctly.

(d) Candidates appeared less confident in drawing the molecular structures of oxygen and water. Those who succeeded usually balanced the equation correctly.

Question 9

(a) (i) A suitable shielding material was usually suggested.

(ii) Successful candidates showed in their working that the count rate had halved three times, and then calculated the value of three half-lives.

(b) There were a few good descriptions of the working of a generator.

(c) The best responses stated that iron is easier to magnetise or demagnetise than steel, rather than comparing the strength of magnets formed.

(d) Candidates who knew the formula usually calculated the charge correctly, with the correct units.

Question 10

(a) (i) Most candidates could give at least one result of the loss of habitat.

(ii) This question was answered well. Candidates appreciated the reasons for forest clearance. Some candidates gave two statements that addressed the same marking point.

(iii) Other undesirable effects of forest clearance were well known.

(b) There were some good suggestions for preventing extinction. Candidates should take care to add to the information supplied in the question.

(c) Most candidates knew that conservation is important to other organisms because the okapi is part of a food chain.

Question 11

(a) (i) Better performing candidates clearly indicated the range of variation. For example *the melting point increases from lithium to carbon*, rather than *the melting point increases in the solids*.

(ii) The majority used knowledge that elements within a group have similar properties to predict that silicon would have the highest melting point in the third period.

(b) Very few candidates knew that the allotropes of carbon have different densities.

(c) Most candidates drew the correct electron arrangement of sulfur.

(d) (i) Most knew that lithium fluoride, a compound of a metal and a non-metal, has ionic bonding.

(ii) Many candidates explained correctly that each lithium atom donates a single electron to a fluorine atom, completing the electron shells, and forming Li^+ and F^- ions in LiF. These responses were often clarified by good diagrams of the electronic arrangements. Candidates who performed less well contracted what they had written by providing a diagram of a covalent molecule.

Question 12

(a) A minority of candidates realised that mass is independent of gravitational field strength.

(b) Candidates who knew the formula for kinetic energy, usually calculated the correct answer in joules. Better performing candidates converted this results to kilojoules, as indicated on the answer line.

(c) (i) Most candidates understood that sound requires a medium and will not propagate through empty space. A minority explained the impossibility of using sound communication in terms of the speed of waves.

(ii) Those candidates who applied the formula for the speed of radio waves and converted the distance to metres usually arrived at the value given in the question.

(iii) A minority of candidates knew that radio waves and infra-red radiation travel at the same speed.

Question 13

(a) Better performing candidates based their responses on the syllabus definition of aerobic respiration.

(b) (i) and **(ii)**
Some candidates knew that anaerobic respiration differs from aerobic respiration by not using oxygen and by releasing less energy.

(c) (i) Many candidates suggested bacteria as examples of the microorganisms that would interfere with the brewing process.

(ii) Some candidates wrote that yeast is responsible for alcohol or carbon dioxide formation, while the process of anaerobic respiration was rarely mentioned.

(iii) High temperature was often incorrectly given as the reason why yeast dies at the end of fermentation, rather than lack of glucose or poisoning by alcohol.

CO-ORDINATED SCIENCES

Paper 0654/04

Coursework

Key Messages

Choice of tasks must be made very carefully, to ensure that the task allows candidates to demonstrate their full abilities within the chosen skill area or areas.

Work should be fully marked by the teacher and details of each task must be provided for external moderation.

General Comments

Centres are reminded that the external Moderators need to have complete information about how the assessment of candidates was carried out. This should include full details of the tasks that were set. This could be copies of the worksheets provided to the candidates, or a summary of oral instructions that were given to them.

It is important that the samples of candidates' work have been fully and clearly marked by the teacher carrying out the assessment. This may involve writing on the work itself by hand, or if the work has been submitted to the teacher electronically, adding comments either electronically on the work or in a separate document. Original work, marked by the teacher, is expected. It is not appropriate for 'fair copies' of the work to be used for assessment or submitted for external moderation.

For C1, no written work by the candidate will be produced, but the Centre should provide some evidence for the way in which the mark has been obtained. This is generally done in the form of a checklist, completed 'live' as the candidates work through the task.

Centres are generally good at providing tasks that allow candidates access to the full range of marks. Occasionally this is not the case. For example, non-quantitative tasks make it almost impossible to achieve high credit for C3, and problems that do not involve the effect of one variable on another do not allow the award of high credit for C4. Guidance on the selection and design of appropriate tasks is provided in the *Coursework Training Handbook*.

CO-ORDINATED SCIENCES

Paper 0654/51

Component Name

Key Message

When a question asks for a reference to the results obtained during the experiment, then this must form part of the answer.

General Comments

The majority of candidates were able to carry out all three practical exercises. Clearly the lack of graph plotting removed some time pressure. Where there were problems with chemicals or apparatus, such as the starch in question 2, allowances were able to be made during the marking process.

Comments on Specific Questions

Question 1

Most candidates were able to record the colour of the cobalt chloride paper and the appearance of the limewater in **part (a)**. Some stated that the limewater remained the same. This was not accepted as there was no description of the limewater in the question. On re-testing the contents of the test-tube after the food had been burned, most candidates observed that the cobalt chloride paper turned a pink colour and correctly deduced that this indicated the presence of water. Fewer candidates observed the correct change in the appearance of the limewater. In **part (c)**, only the more able candidates could give two correct observations to show that energy is released when food is burned. The most common response was heat. Many candidates tried incorrectly to relate their answers back to their observations in **part (b)**.

Correct answers to the more demanding **part (d)** were rare. Very few candidates realised that the tests were to deduce that water and carbon dioxide were not already present. The term 'control' was rarely seen. In **part (e)**, respiration was well known. The correct word equation was less well known and water or carbon dioxide were often seen on the left of the equation, presumably confusing this with photosynthesis.

Most candidates were able to state a sensible safety precaution. Credit was not given for precautions shown in the diagram or described in the body of the text. Although there were a number of acceptable responses to the fair comparison question in **part (g)**, few candidates scored both marks. In the second part of **(g)**, most candidates recognised heat loss as a source of inaccuracy. Incomplete burning was rarely given as an alternative.

Question 2

Most candidates recorded a time in excess of 10s for the solution to turn blue-black. Times recorded varied greatly from 20 s to 1500 s, which suggested that the starch had not been freshly prepared in some cases. Candidates were not penalised for this. The addition of the Fe^{2+}, Fe^{3+} and X^{2+} ions generally resulted in candidates correctly recording much shorter reaction times. Inappropriate precision was often used. Calculation of reciprocals rarely caused difficulty. It was surprising to see a minority of candidates recording 1/t values as fractions and not attempting to calculate the reciprocal in decimal form.

The majority of candidates correctly concluded that the metal ions were acting as catalysts for the reaction. Many were able to use their results to explain why they had arrived at their conclusion.

Only the most able candidates were able to make a sensible comment about the reliability of the experiment by comparing the results they had obtained when no metal ion was present. The term reliability was often confused with the term fair test. Very few candidates understood that if the results on repetition were close (within 10%), then they could consider their results to be reliable. In **part (e)(i)**, most candidates understood the need to maintain a constant volume but very few were able to propose a sound modification. In **part (e)(ii)** relatively few candidates, after having being told to observe the reaction again, and to observe it carefully, were unable to record the formation of a precipitate and its colour. Many candidates were able to observe that the reaction occurred very quickly or instantaneously. **Part (f)** produced good results and metal **X** was usually identified. In this case Cu^{2+} was accepted as an alternative to copper.

Question 3

This straightforward measuring exercise was performed competently by the majority of candidates. When measuring the diameters of the top and bottom of the cup and the height of the cup, candidates were expected to quote their measurements with an accuracy which reflected the resolution of the ruler they had used. A significant minority of candidates wrote down distances which were to the nearest centimetre which was not accepted. A relatively small number of candidates wrongly took their measurements from the diagram of the cup that appeared in the question paper.

The average diameter and the volume of the cup were usually calculated correctly in **part (a)**. The volume was very often quoted to an unacceptably large number of decimal places or significant figures. Most candidates missed the clue in the stem of the question, namely to calculate the approximate volume, to quote their answer to the nearest cm^3.

Part (b) appeared to be carried out well despite some candidates encountering difficulties with the total volume of the measuring cylinder and with the lack of scale at low values of volume. The most common correct sources of inaccuracy suggested by candidates were that either water was spilled on transfer or that it was difficult to judge when the cup was full. A significant number of candidates misread the question and made a comment about the procedure carried out in **part (a)**.

V and V_w were stated as answers to **(b)(iii)** fairly equally. This was despite being told in **part (a)** that the method was an approximate one. Of those candidates who correctly chose the second method, many could not produce an acceptable explanation.

A few candidates used the string to measure the diameters in **part (c)** and then calculate the circumferences. This was not accepted as a ruler could have been used directly for this method, as in the first method. Of those who wrapped the string around the cup, few used more than two readings and many used just one, making averaging impossible. There were a significant number of correct answers using the diameters of the top and bottom of the cup. If just the middle of the cup was chosen, it was expected that candidates should wrap two or more loops around the cup and calculate the average. The easy calculation in **part (c)(iii)** was made more rigorous by demanding two or three significant figures in the answer. Good candidates gave the answer to this accuracy.

CO-ORDINATED SCIENCES

Paper 0654/52

Practical Test

Key message

In Chemistry, a lack of effervescence with the addition of an acid should be reported as this indicates the absence of the carbonate ion.

General comments

Candidates were able to carry out all three practical exercises in the allocated time. The standard of graph plotting was high and there were fewer difficult scales.

Comments on specific questions

Question 1

For food test questions, it is important to know which food group is identified by which test. Benedict's test is for reducing sugars so the answer 'sugars' is not enough. In part **(d)**, allowance was made for incorrect responses in part **(a)**. When recording observations of food tests, candidates should record final colours and avoid responses such as 'no change'. This experiment generally gave useful results although some Centres encountered negative biuret test results.

The test for fats in part **(e)** was not well known. Many candidates knew that ethanol was involved but did not know how the whole test should be carried out. The positive result of a fat test was usually recorded accurately. Not every candidate was able to explain why the fat test would be difficult to carry out on milk.

Question 2

Although **P**, calcium ethanoate (acetate), is not a chemical that is routinely analysed at this level, the tests in this question are frequently encountered by candidates. Relatively few candidates observed the blue flame of propanone (acetone) burning and the darkening of the solid. Condensation was often recorded.

In part **(b)** the correct change in the colour of the litmus was often seen. The lack of effervescence on adding the acid and its significance were rarely recorded. This test, indicating the absence of the carbonate ion, has now appeared several times in practical tests.

Candidates coped better with the negative result of the sulfate test in part **(c)** and both marks were often scored. A number of candidates incorrectly assumed that the use of the barium chloride reagent indicated the presence of the sulfate ion.

The reaction between **P** and nitric acid produces calcium nitrate and **Q** which is ethanoic acid (acetic acid). Many candidates performed well in part **(d)** and often identified ethanoic acid by its smell, although the identification was not required at this level. Ethanoic acid is a weak acid so reacts with calcium carbonate less vigorously than hydrochloric acid of the same concentration.

The solid **R**, formed in part **(a)** by heating **P**, is calcium carbonate. In part **(e)**, most candidates observed the white precipitate in the limewater. The effervescence produced by adding acid to **R** was rarely recorded. Nearly all candidates correctly deduced the presence of carbonate but not all prefixed this with 'calcium' which was needed to identify compound **R** fully.

Question 3

This electrical exercise produced good sets of results. Most errors in part **(a)** were either the omission of units, transposing voltage and current readings or recording readings to inappropriate numbers of decimal places.

Plotting of points for the graph was generally done well and choosing sensible scales always helps with this. Scales should result in at least half of the grid being used for plotting the points. Most candidates drew a suitable straight line although curves and poorly sketched lines were seen.

Candidates continue to use less than half of their line to calculate the gradient and so not obtain the first mark. Also too many do not indicate on the graph, either with a triangle or with coordinates, which values were used. A small number of candidates used data from the table which is only valid if the line passes through these points. The calculation of the gradient was usually correct and many candidates chose the appropriate number of significant figures, two or three, for the answer in part **(d)**.

The reading of the meter scales was rarely given as possible source of inaccuracy in part **(e)**. More commonly candidates commented on the wire or the crocodile clips. Answers referring to the measurement of the length of the wire were accepted. It was rare to see both marks scored in this part.

CO-ORDINATED SCIENCES

Paper 0654/53

Practical Test

Key message

Best-fit curves, like best-fit straight lines, do not necessarily pass through every point plotted on the graph. The Biology and Physics practical exercises consistently gave useful results. The Chemistry practical could give confusing results if the instructions were not followed accurately.

General comments

Candidates were able to carry out all three practical exercises in the allocated time, despite having to plot two graphs. The Biology and Physics practical exercises consistently gave useful results. The Chemistry practical could give confusing results if the instructions were not followed accurately.

Comments on specific questions

Question 1

Headings for tables should include the physical quantities being measured and the units. In many cases temperature or ^{o}C was omitted, despite both being given on the y-axis of the graph. Temperature measurements to the nearest 0.5 ^{o}C should end in .5 or .0. Frequently results were wrongly recorded to the nearest degree. Most candidates generated good results and scored at least 4 marks in part **(b)**.

The scales for graphs should result in at least half of the grid being used for plotting the points. Relatively few candidates used suitable scales, often because they started the temperature axis at zero. Points were plotted well, partly because the scale of the x-axis was given. This usually allowed two curves to be drawn relatively easily. Best-fit curves, like best-fit straight lines, do not necessarily pass through every point plotted on the graph. Many candidates forced the curve to go through every point.

In part **(d)**, the candidates had to refer to their results. Good answers were often given without referring to the results so the maximum mark for this part was then one.

Correct responses in part **(e) (i)** were limited to the start temperature, not reading the thermometers simultaneously and not reading the temperature of all of the test-tubes in beaker **A**. Responses relating to the difference between the temperature of the laboratory and the temperature of the Antarctic were not credited. Very often a suitable suggestion to reduce the source of inaccuracy was given whenever a correct source of inaccuracy was identified.

Part **(f)** was about the reliability of the results. This is the consideration of whether repeating an experiment will give similar or identical results. So repeating the experiment several times and deleting anomalous results would produce closer results which could then be averaged. Many candidates discussed accuracy rather than reliability.

Question 2

In this experiment the exothermic reaction between zinc and copper sulfate was investigated. Addition of **X**, sodium hydroxide solution, to the copper sulfate solution resulted in the precipitation of copper hydroxide. Consequently there was less copper sulfate in solution to react with the zinc and less heat was produced. A significant number of candidates could not have carried out the instructions carefully enough because the change in temperature did not decrease as more **X** was used.

In part **(a)**, most candidates scored the two marks for the temperatures but few recorded correct colour changes for the solution and the solid. If a colour change was noted it was usually the brown appearance of copper.

A blue precipitate was usually seen in part **(b) (i)**. About half of these candidates were able to go on to identify **X** as sodium hydroxide. This required the consideration of qualitative analysis in reverse.

Nearly all candidates were able to make a conclusion in part **(d) (ii)** and error carried forward was applied for incorrect results. A good explanation of the relationship was rarely seen.

Part **(e)** was well answered.

Question 3

This experiment was generally carried out well and the results generated allowed a graph to be plotted on the scales provided.

Part **(a)** attracted high marks. Common errors were suggesting that handling the apparatus was a difficulty when measuring the height of the shadow. Very occasionally the *h* value for *d* = 35 cm was out of the allowed range.

Most candidates were able to access all three marks for the graph. A straight line was only allowed if a straight line was clearly more appropriate than a curve. Extrapolation of the line was often poor, either due to sketching or due to unsmooth extension of the line. If the mark for **(c) (i)** was not awarded because of this, candidates could go on to score the remaining marks in part **(c)**.

Most candidates recognised that the image would be too big for the screen or too blurred in response to part **(d)**.

CO-ORDINATED SCIENCES

Paper 0654/61
Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques and to have carried out experiments similar to the ones shown in the paper. Candidates should have used standard laboratory apparatus and be able to read values from measuring cylinders, thermometers, stopwatches etc. Candidates should have performed identification tests on the range of substances detailed in the specification. Candidates need to enter data into tables to the same number of significant figures as the data already there.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of an excellent standard. The drawing of chemical apparatus proved very challenging for many candidates. The standard of graph drawing was generally high but drawing of curves proved challenging for some candidates. Designing an experiment proved to be very difficult for many candidates. Knowledge of identification tests for ions was limited.

Comments on Specific Questions

Question 1

(a) Many candidates gained credit. Common incorrect responses included: acid, carbon dioxide and oxygen.

(b) A majority of candidates gained credit.

(c) Some candidates gained credit. Common responses which were not creditworthy included to test for water, to test for carbon dioxide, to see if limewater goes milky.

(d) Many candidates gained credit. Digestion was a common incorrect response.

(e) More able candidates gained credit. Many candidates discussed the criteria for chemical change.

(f) Many candidates gained credit but some answers were of a vague "stay away from..." type without an explanation of how.

(g) (i) Some candidates gained partial credit with some gaining full credit. Some answers lacked the detail to be creditworthy such as "do it carefully" or "repeat".

(ii) More able candidates gained credit.

Question 2

(a) Many candidates gained credit. Incorrect responses included iodine and water.

(b) (i) More able candidates gained credit. Incorrect responses included beaker and flask.

(ii) Many candidates gained credit although test tube was seen quite often.

(c) Most candidates gained partial credit and many gained full credit. The value for experiment 3 was often given as 3.9.

(d) The majority of candidates gained credit. A few chose Fe^{3+} and some didn't give a reason.

(e) (i) More able candidates gained credit. Common incorrect responses included zinc, iron and potassium and many omitted this question.

(e) (ii) Many omitted this question and few gained credit. A wide variety of answers were seen but more common responses included copper oxide, copper sulfate, sodium hydroxide and ammonia.

(f) Very few correct responses seen. Many omitted the question. Many added a metal ion or a catalyst solution.

Question 3

(a) (i) A large majority of candidates measured the height correctly.

(ii) A large majority of candidates measured the diameter correctly.

(iii) A large majority of candidates measured the diameter correctly.

(iv) Many candidates calculated correctly. Some candidates averaged **(i) (ii)** and **(iii)**.

(v) Many candidates calculated correctly.

(b) (i) A large majority of candidates read the volume correctly.

(ii) Most of the candidates who gained credit in **(b)(i)** also gained credit here.

(c) More able candidates gained partial credit usually for spillage of water but few gained full credit.

(d) More able candidates gained credit with many candidates subtracting the masses but not relating the answer to the volume.

Question 4

(a) Most candidates gained partial credit with many gaining full credit. Light was a very common incorrect response.

(b) Few candidates appreciated that all of the seedlings would grow and so most added the leaves to the stems already drawn rather than extending them and so did not gain credit. Almost no candidates gained credit for Dish **C**.

(c) More able candidates gained credit with the most common incorrect responses being photosynthesis and geotropism.

(d) Many candidates gained at least partial credit but many candidates described the test for starch.

(e) More able candidates gained partial credit usually for the idea of one or some of the seeds being damaged. Few gained full credit. Averaging was a common non creditworthy response.

Question 5

(a) The diagram proved challenging for many candidates and few gained credit. Incorrect responses included people blowing into the delivery tube, a sealed collection vessel and the delivery tube not going into the water. Those that drew the correct apparatus often missed gaining credit as they bubbled the gas into limewater instead of water.

(b) (i) Few candidates gained credit. Watching carefully was a common non-creditworthy response. Putting a cross and watching through the solution until the cross disappears does not give an indication of when the precipitate begins to form.

(ii) Many candidates read the volumes correctly but some didn't record all of the values to 0.1 cm^3.

(iii) The majority of candidates averaged the volumes correctly.

(c) More able candidates gained credit. Dividing by the sum of the volumes was a common error.

(d) More able candidates gained credit for their choice of indicator but many candidates then gave the incorrect colour change as they didn't appreciate that carbon dioxide is slightly acidic and so gave the colour for a strong acid.

Question 6

(a) More able candidates gained credit. Most candidates gave vague and generalised answers usually about sharing the tasks so that every member has a job.

(b) The vast majority gained credit.

(c) (i) Most able candidates gained partial credit with few gaining full credit. Dividing 4.9 by 3.5 was a popular incorrect response.

(ii) Most able candidates gained some credit. Many candidates quoted the times and then restated the question stem and many omitted this question**.**

(d) Very few candidates gained credit. Most candidates thought that the trolley would travel more quickly because it was heavier.

(e) Many candidates appreciated that the trolley would travel more quickly but few could explain why this would make the results inaccurate.

(f) Many candidates gained credit. Common incorrect responses included starting with chemical energy or the correct energy change returning to gravitational potential energy at the end.

CO-ORDINATED SCIENCES

Paper 0654/62
Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques and to have carried out experiments similar to the ones shown in the paper. Candidates should have used standard laboratory apparatus and be able to read values from measuring cylinders, thermometers, stopwatches, etc. Candidates should have performed identification tests on the range of substances detailed in the specification. Candidates need to enter data into tables to the same number of significant figures as the data already there.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of an excellent standard. The drawing of chemical apparatus proved very challenging for many candidates. The standard of graph drawing was generally high but drawing of curves proved challenging for some candidates. Designing an experiment proved to be very difficult for many candidates. Knowledge of identification tests for ions was limited.

Comments on Specific Questions

Question 1

(a) Many incorrect responses had colours for the reagents rather than the reagent name.

(b) Some candidates gained partial credit often for the starch iodine colour.

(c) (i) Some candidates scored partial credit for ethanol but few also included water.

(ii) More candidates gained credit for the observation. Precipitate was a common incorrect response.

(iii) Some candidates gained credit. Incorrect responses included liquid and contains fat.

Question 2

(a) A very small minority of candidates gained credit. Most gave the test for either hydrogen or oxygen.

(b) (i) Most candidates gained credit for the result of the test but few gained credit for the diagram. Incorrect diagrams included sealed receiver vessels and delivery tubes not going into the limewater.

(ii) Many candidates gained credit although hydrogen was seen quite often.

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(c) Some candidates gained credit. Calcium chloride was a popular incorrect response.

(d) (i) Many candidates chose a correct indicator and gave the correct colour change but some reversed the colour change.

(ii) Few candidates gained credit. Popular incorrect responses included the reaction being too fast or the tube breaking.

(e) More able candidates gained credit for monitoring the gas often by use of a syringe but very few appreciated the use of a specific time or a time for a specific amount of gas. Common incorrect responses included timing until the reaction was complete or choosing the one in which the bubbles stop first.

Question 3

(a) Some candidates read the ammeter dials correctly but many candidates values had a difference of 0.1 from the actual value. Most candidates read the voltmeter dials correctly.

(b) (i) Many candidates gained full credit for the plotting and the line.

(ii) Some candidates indicated the values on the graph but many did not. When calculating the gradient of a line over half of the line should be used and the triangle used should be drawn. Many candidates inverted the division.

(iii) More able candidates gained credit.

(c) (i) Few candidates gained credit.

(ii) Most able candidates gained credit. To make sure the current or voltage didn't run out was a popular incorrect response.

Question 4

(a) More able candidates measured the total length of the pollen tube in the image correctly. Many candidates divided the value by 100.

Few candidates calculated correctly the actual length of the pollen tube.

(b) Most candidates gained credit. A very small minority summed the values but did not divide by three.

(c) (i) While many candidates labelled the axes with the variable being plotted many did not include the units. Many candidates gained credit for the scale and the plotting of the points. The best fit line proved more challenging, feathered lines or use of a ruler did not gain credit.

(ii) Many candidates gained credit.

Question 5

(a) (i) Most gained credit.

(ii) Many candidates gained credit. A significant number thought the nail would rust albeit more slowly.

(iii) More able candidates gained credit. The most popular answer gave paint as the reason without saying what the paint does to prevent the rusting.

(b) (i) Many candidates gained credit. Some candidates omitted the lighted splint or used a glowing splint. A small number used limewater.

(ii) More able candidates added a correct reagent but although they had the correct colour of the product they frequently omitted precipitate**.** A number of candidates omitted this part.

(iii) Many candidates gained credit.

(iv) Few candidates gained credit.

(c) More able candidates gained some credit with a few candidates gaining full credit. Many candidates discussed a Hooke's Law experiment with the wire extending rather than bending or repeated the stem of the question or discussed their knowledge of the relative strengths of iron and steel.

Question 6

(a) Many candidates gained credit.

(b) (i) Many candidates read the measuring cylinders correctly but some did not record the values to 0.5 cm^3.

(ii) Many candidates gained credit with a few reversing the order.

(c) More able candidates gained partial credit with a few gaining full credit. The chemical tests given included drinking the water or using an indicator. The physical tests included boiling (with no temperature) or seeing if it is a colourless liquid.

(d) (i) Some candidates gained partial credit, usually for mass, and a few gained full credit. Common incorrect responses included beaker, ruler or cylinder for volume and rule or beaker for mass. Some thought density could be measured directly with a balance or a cylinder.

(ii) Many gained credit. A small number inverted the division.

CO-ORDINATED SCIENCES

Paper 0654/63
Alternative to Practical

Key Messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental techniques and to have carried out experiments similar to the ones shown in the paper. Candidates should have used standard laboratory apparatus and be able to read values from measuring cylinders, thermometers, stopwatches, etc. Candidates should have performed identification tests on the range of substances detailed in the specification. Candidates need to enter data into tables to the same number of significant figures as the data already there.

General Comments

Candidates from many Centres demonstrated good understanding of practical knowledge and techniques. The reading of the instruments was of an excellent standard. The standard of graph drawing was generally high but drawing of curves proved challenging for some candidates. Evaluation of experimental methods proved to be very difficult for many candidates.

Comments on Specific Questions

Question 1

(a) Most candidates knew the correct units. A common incorrect response was 2 minutes.

(b) Many candidates labelled the axes with the quantity but far fewer included the correct units. A significant number of candidates incorrectly used m for minute. The majority of candidates correctly plotted both sets of data. The curves proved to be more difficult for many candidates. A best fit curve should be smooth, close to as many points as is appropriate and be one continuous line.

(c) Many candidates discussed the huddling penguins but far fewer made reference to the results of the experiment.

(d) (i) More able candidates were able to identify a source of inaccuracy.

(ii) Most of the candidates who identified a source of accuracy in **(d)(i)** could suggest a suitable improvement. Many candidates discussed repetition and reliability and so didn't gain credit. A significant number incorrectly suggested performing the experiment on live penguins or using the temperatures found at the Pole.

(e) Reliability was well known.

Question 2

(a) (i) The vast majority of candidates read the temperatures correctly. A small number read the temperatures to integer values rather than to the required nearest 0.5 °C.

(ii) Although most candidates could accurately calculate the temperature changes the vast majority did not give all of the values to one decimal place.

(b) Some candidates answered the questions in terms of the required temperature change but many answered in terms of the temperature decreasing and so didn't gain credit.

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(c) More able candidates could name solution X. Common incorrect responses included: copper hydroxide, sulfuric acid, zinc, zinc nitrate and zinc sulfate.

(d) Many candidates gained credit but many discussed cracked or exploding glass beakers and so did not gain credit.

(e) Candidates found this very difficult.

Question 3

(a) (i) Most candidates measured the height correctly.

(ii) Most candidates understood how a shadow is formed. However, a small but significant number had the light bending around the object.

(b) Most candidates measured the shadows correctly but some measured to the edge of the blurred part of the shadow.

(c) (i) The vast majority of candidates plotted the points correctly but many found drawing the curve more challenging.

(ii) Most candidates marked the relevant line on the graph but few used the numbers to explain their conclusion.

(d) (i) The majority of candidates extrapolated the line and read the value correctly. A small number didn't extend the line but gave a height and so didn't gain credit.

(ii) Many candidates understood the consequences of the smaller distance. Incorrect responses included blocking the light completely so that no shadow is formed or the shadow not fitting onto the graph.

Question 4

(a) Most candidates gained credit.

(b) (i) Many candidates read the scales correctly.

(ii) More able candidates gained credit**.** Many candidates added the distances together.

(c) (i) Few candidates appreciated the possible temperature change but many answered in terms of the soda lime absorbing the carbon dioxide already in the air.

(ii) Few candidates gained credit. Many suggested removing the bag of soda lime or removing the air altogether and so didn't gain credit.

(d) Many candidates gained at least partial credit here with some candidates gaining full credit. Some candidates thought incorrectly that the woodlice taking in the oxygen would be the reason for the oil drop moving.

(e) Most candidates gained credit. Some candidates referred to carbon dioxide rather than the oil drop.

Question 5

(a) (i) Most candidates read the scales correctly. 135 cm^3 was a common error.

(ii) Most candidates gained some credit and the more able candidates gained full credit. The drawing of the curve proved difficult for many. Common misplots were 90 cm^3 and 112.5 cm^3.

(b) Few candidates gained credit. Most candidates discussed the lightness or low density of hydrogen and so didn't gain credit.

(c) Most candidates gained at least partial credit with the most able gaining full credit.

(d) Many candidates gained credit. Some candidates answered in vague terms such as magnesium reacting better or more.

Question 6

(a) Most candidates read the scales correctly.

(b) (i) More able candidates gained credit. Candidates often referred to looking at the difference in volumes at the two temperatures or allowing the water bath to warm up.

(ii) The majority of candidates gained credit. Some candidates put the ice and / or salt into the syringe.

(c) Many candidates appreciated the gain in energy and so gained partial credit but few could explain a consequence of this. Commonly candidates discussed the particles expanding or stated that the pressure would increase with increasing temperature.

(d) More able candidates gained credit. Many discussed the particles coming closer together or an increase in density without reference to the state change.

(e) More able candidates gained at least partial credit. Many candidates discussed the absence of clamping and so didn't gain credit.

(f) More able candidates gained credit. Many candidates put the clamp on the barrel of the syringe or below the level of the beaker or the water. Many candidates omitted this part altogether.