CO-ORDINATED SCIENCES

Paper 0654/11
Multiple Choice (Core)

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

General comments

This paper in general was reasonably well answered.

In the physics section, **Question 34** was challenging for many candidates and **Questions 28** and **36** were found to be particularly challenging.

Comments on specific questions

Question 4

Candidates must read the question carefully. A majority of the candidates incorrectly thought that the iodine test will show that starch has been digested. They did not recognise that the product of digestion needs to be tested.

Question 6

This question was very well answered.

Question 9

Many of the candidates correctly identified a receptor as being in the skin of the hand. However, a substantial number confused the terms effector and receptor, and chose the muscles of the arm.

Question 10

This question asked which part of a pea flower was the ovary. The most common incorrect response identified the ovules as the ovary.

Question 11

Candidates were asked to order some of the stages involved in natural selection. Candidates found this question challenging.

Question 13

Slightly less than half the candidates correctly answered this question on the carbon cycle. Many of them confused photosynthesis and respiration, and some implied that fossil fuels respire.

Question 14

More candidates chose the incorrect **D** than the correct answer, **B**. Candidates are expected to be able to identify physical and chemical changes and understand the differences between them.

Question 18

More candidates chose the incorrect **C** than the correct answer, **A**. Candidates need to be able to use experimental data to identify exothermic and endothermic changes, and to deduce the extent of each change by considering the magnitudes of any temperature change.

Question 19

More candidates chose the incorrect **B** than the correct answer, **A**. Candidates need to know the effect of a catalyst on the rate of a chemical reaction, and also that catalysts do **not** affect the total amount of product formed at the end of the reaction.

Question 21

More candidates chose the incorrect **C** than the correct answer, **D**. Candidates should know that sodium and potassium are Group I metals, and that they react with water in a similar manner.

Question 23

More candidates chose the incorrect **A** than the correct answer, **B**. Candidates need to be able to describe the chemical test for water using anhydrous cobalt(II) chloride.

Question 27

More candidates chose the incorrect **B** than the correct answer, **C**. Candidates need to know that alkenes, which are unsaturated compounds, decolourise aqueous bromine.

Question 28

In this question on measuring length, candidates were required to read a rule, subtract the reading at one end of a string as it was not aligned with zero, then divide the length of the string by six to determine the circumference of a pencil. This proved too challenging for most.

Question 30

It was very widely known that the energy transfers involved when a ball is falling are gravitational potential and kinetic. The majority opted for the correct answer. A substantial minority of candidates chose the wrong direction of energy transfer (option **D**).

Question 34

The topic here was the law of reflection of light. Although many knew that there were two equal angles, most of them took 20° as the angle of incidence. This led them to choose the incorrect option **A**.

Question 35

Many candidates could identify the diagram showing the formation of a real image, but a common error was to believe that option **A** was correct. This was likely to be a familiar diagram but showed parallel refracted rays that would not form an image.

Question 36

Candidates generally knew that the rod in this question was positively charged, but a large proportion thought that it was an electrical conductor, they did not realise that rubbing a conductor with a dry cloth does not cause it to become charged.

Question 39

Although this question on fuses was reasonably well answered, the most common incorrect responses were **A** and **D**.

Question 40

The shape of the magnetic field around a current-carrying wire was well known, but slightly more candidates chose the wrong direction for the field lines than the correct one.

CO-ORDINATED SCIENCES

Paper 0654/12
Multiple Choice (Core)

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

General comments

This paper in general was well answered.

In the physics section, **Question 38** was particularly well answered, while **Questions 29** and **33** were challenging for many candidates.

Comments on specific questions

Question 2

Almost all the candidates could correctly identify the nucleus as a structure found in both plant and animal cells.

Question 4

In this question candidates were asked for the correct labels for the axes of a graph showing the effect of temperature on an enzyme-controlled reaction. While most identified the correct labels, many did not place the labels on the correct axes.

Question 7

Candidates were asked to identify the pulmonary vein on a diagram of the heart. Almost all candidates identified an artery, but a substantial minority incorrectly identified the aorta. Candidates need to know about the role of veins and arteries, and that only some veins carry deoxygenated blood.

Question 11

When asked for the phenotypic ratio resulting from crossing a heterozygous plant with a homozygous recessive one, many candidates chose a ratio of 3:1. In questions of this type, candidates could sketch a Punnett square to help them visualise the consequences.

Question 13

Many candidates correctly answered this question on the carbon cycle. Some of them confused photosynthesis and respiration, and some implied that fossil fuels respire.

Question 15

More candidates chose the incorrect **D** than the correct answer, **B**. Candidates need to be able to describe differences in volatility, solubility and electrical conductivity between ionic and covalent compounds.

Question 17

A substantial minority of candidates chose the incorrect answer, **C.** Candidates need to be able to identify the anode and the cathode used in electrolysis, to identify the products of electrolysis of specified substances, and to also know the colours of the Group VII elements.

Question 18

The correct answer, D, was chosen by many of the candidates but the incorrect answer, **C** was also popular. Candidates need to be able to describe the meaning of exothermic and endothermic changes.

Question 19

Many candidates chose the correct answer, **C**. Candidates need to know the effect of solid particle size and of reactant concentration on the rate of a reaction and be able to relate this to the reaction time.

Question 23

Most candidates chose the correct answer, **A**. However, many candidates confused the colour change of anhydrous copper(II) sulfate with that of anhydrous cobalt(II) chloride.

Question 24

More candidates chose the incorrect **C** rather than the correct answer, **D**. Candidates need to recall the chemical reactions that produce carbon dioxide, and that respiration also produces this gas. They should also be able to describe the process of rusting.

Question 25

Many candidates chose the correct answer, **A**. Candidates need to know that limestone, calcium carbonate, is a base, and that bases neutralise acidic substances.

Question 26

Half of the candidates chose the correct answer, **A**. Candidates need to be able to draw the structure of ethanol and, by implication, to be able to identify the structure of ethanol.

Question 28

This question required knowledge that an object that is freely falling without air resistance moves with uniformly increasing speed. Many candidates chose option **C**, which represented constant speed.

Question 29

The majority of candidates did know the correct definition of the moment of a force. More chose option **B** than the correct option **C**, possibly linking the word ‘moment’ with time.

Question 33

The topic here was the law of reflection of light. Although many knew that there were two equal angles, a large majority of candidates took 20° as the angle of incidence; this led them to choose the incorrect option **A**.

Question 34

The force between pairs of magnets was well understood.

Question 35

It was widely known that the rod in this question was positively charged, but a large proportion of candidates incorrectly thought that it was an electrical conductor. Rubbing a conductor with a dry cloth does not cause it to become charged.

Question 37

In this question on current in a series circuit, the incorrect options **B** and **C** were popular choices.

Question 38

This question on electrical safety was very well answered, challenging only a few.

Question 40

Several candidates confused protons with neutrons, stating that nuclides P and R, are isotopes of the same element (option **B**).

CO-ORDINATED SCIENCES

Paper 0654/13
Multiple Choice (Core)

There were too few candidates for a meaningful report to be produced.

CO-ORDINATED SCIENCES

Paper 0654/21
Multiple Choice (Extended)

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

General comments

This paper was generally well answered, with only one question proving challenging for the majority of candidates.

In the chemistry section, **Question 17** and **Question 23** proved most challenging.

In the physics section, **Questions 31**, **35, 38** and **39** were challenging for many candidates.

Comments on specific questions

Question 6

This question about nutrient content of citrus fruits was very well answered.

Question 7

Candidates chose open **A** as often as option **B**. This suggests that candidates knew that both the heart valves could not be in the same state during atrial contraction but were unsure which were open and which were closed.

Question 8

This question, involving a trace of rate and depth of breathing before and during exercise was very well answered.

Question 15

More candidates chose the incorrect **B** rather than the correct answer, **C**. Candidates need to be able to convert the volume of a gas produced in a reaction to the number of moles of the gas. They also need tp be able to use the relative molecular mass of the gas to convert the moles to mass.

Question 17

Candidates chose the incorrect **A**, **B** and **C** more often than the correct answer, **D**. Candidates need to interpret data, including data in graphical form, from experiments investigating rates of reaction. They should also appreciate that by halving the amount of reactant that is not in excess, the amount of product formed will also be halved.

Question 18

Although the correct answer, **D**, was chosen most often, nearly as many candidates chose the incorrect **A** and **C**. Candidates need to be able to describe redox in terms of oxygen loss or gain, and to define it in terms of electron transfer, and identify such reactions from simple reaction equations.

Question 22

More candidates chose the incorrect **D** rather than the correct answer, **C**. Candidates need to describe and explain sacrificial protection of steel in terms of the reactivity series and recognise that the sacrificial metal block does not prevent oxygen from reaching the steel.

Question 23

This question was challenging for many. Candidates need to be able to describe, in outline, how a catalytic converter removes nitrogen monoxide by converting it to nitrogen and oxygen.

Question 24

This question was challenging for many. Candidates are expected to know the essential conditions and reactions in the Contact process, and to know that the reaction of sulfur dioxide with oxygen forming sulfur trioxide is a reversible reaction.

Question 28

In this question on the extension of a spring, many candidates multiplied force by extension to find the spring constant, leading them to choose the incorrect option **B**.

Question 29

Many of the candidates thought that a mouse would exert the least pressure on the ground, probably because it was lighter than the other three animals. The calculation of pressure shows that the correct answer was **C**, a duck.

Question 30

It was very widely known that the energies involved in a ball falling are gravitational potential and kinetic, with a large majority opting for the correct answer. However a fair number candidates chose the incorrect direction of energy transfer (option **D**).

Question 31

Only a few candidates correctly calculated the efficiency of the system. The incorrect options **C** and **D** were each as popular as the correct option **B**.

Question 34

Here candidates were required to recall the range of frequencies of sound audible to a human, then to identify options **B** and **C** as being in that range. Finally they had to choose which of these two frequencies corresponded to the larger wavelength (i.e. the lower frequency). Several candidates answered correctly.

Question 35

The topic here was the law of reflection of light. Although many knew that there were two equal angles, more than half the candidates took 20° as the angle of incidence; this led them to choose the incorrect option **A**.

Question 36

A good majority of candidates identified the diagram showing the formation of a real image, but a significant minority chose option **A**. This diagram was likely to be familiar but showed parallel refracted rays that do not form an image.

Question 38

Candidates generally knew that the rod in this question was positively charged, but a large proportion incorrectly thought that it was an electrical conductor. Rubbing a conductor with a dry cloth does not cause it to become charged.

Question 39

Determining the direction of the force on a current-carrying conductor in a magnetic field was found challenging, with many candidates believing that the force acts in the same direction as the current (option **C**).

Question 40

A few candidates recalled that alpha particles are deflected in both electric and magnetic fields. However, a similar number incorrectly stated that gamma rays are deflected in an electric field.

CO-ORDINATED SCIENCES

Paper 0654/22
Multiple Choice (Extended)

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

General comments

This paper was generally well answered.

In the chemistry section, candidates performed very well on **Question 14** and **Question 21**. No questions proved to be particularly challenging for the candidates.

In the physics section, **Questions 32** and **33** were particularly well answered, with **Questions 36** and **38** being most challenging.

Comments on specific questions

Question 2

Very few candidates failed to identify that the nucleus was a structure found in both plant and animal cells.

Question 4

Candidates had no difficulty in identifying what is happening during an enzyme-controlled reaction as temperature is increased, and correctly ordered the three steps given.

Question 8

Candidates easily identified an increase in rate and depth of breathing during exercise from a graph.

Question 10

Another well answered question asking which substances are exchanged between mother and fetus, and in which direction.

Question 14

Candidates were able to identify physical changes and chemical changes easily.

Question 16

More candidates chose the incorrect **D** than the correct answer, **B**. Candidates need to be able to construct and use symbol equations, including ionic equations.

Question 21

Candidates knew the properties of transition metals well, and they were able to interpret the data in the table to identify the transition metals.

Question 23

More candidates chose the incorrect **D** rather than the correct answer, **C**. Candidates need to describe and explain sacrificial protection of steel in terms of the reactivity series and recognise that the sacrificial metal block does not prevent oxygen from reaching the steel.

Question 25

More candidates chose the incorrect **C** than the correct answer, **B**. Candidates need to be able to describe the manufacture of sulfuric acid by the Contact process, including the essential conditions and reactions. They should recognise that oxidation of sulfur dioxide to sulfur trioxide in this process uses a catalyst.

Questions 32 and 33

Few candidates found difficulty in calculating efficiency or identifying which change of state is condensation.

Question 34

The topic here was the sensitivity of a thermometer. Although it was widely known that a narrow capillary bore was needed, many candidates opted for the incorrect **A**. Thermometer B had a larger bulb and would therefore show a greater change in length for a given temperature rise.

Question 35

In this question on the law of reflection of light, almost all knew that there were two equal angles. However, many of the candidates took 20° as the angle of incidence, leading them to choose the incorrect option **A**.

Question 36

The topic of this question was internal reflection, as opposed to total internal reflection. Many candidates thought that all the light would emerge into the air, with no partial reflection (option **A**), and several others believed that the refracted light would travel along the edge of the block (option **D**).

Question 38

A large majority of candidates knew that the rod in this question was positively charged, but a very large proportion of these thought that it was an electrical conductor. Rubbing a conductor with a dry cloth does not cause it to become charged.

CO-ORDINATED SCIENCES

Paper 0654/23
Multiple Choice (Extended)

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

General comments

This paper was generally well answered.

In the physics section, only **Question 37** was found particularly challenging.

Comments on specific questions

Question 1

Candidates easily identified that woodlice were showing sensitivity when placed on a dish with dark and light areas.

Question 6

A substantial number of candidates incorrectly identified an enzyme with an optimum pH of 2 as being amylase secreted in the stomach. This suggests that they knew the pH of the stomach was low but did not realise that amylase is secreted by the pancreas.

Question 8

Many candidates selected an incorrect answer to this question, which involved rate and depth of breathing after running upstairs. These candidates correctly said that rate of breathing increased but believed that depth decreased.

Question 9

Although many candidates got this question about the muscles of the eye correct, the rest were fairly equally divided between the other three answers.

Question 18

Some candidates chose the incorrect **C** rather than the correct answer, **B**. Candidates need to be able to describe and explain the effect of changing the concentration a reactant on the rate of a reaction. They should also understand that halving the volume and doubling the concentration of a reactant means that there are the same number of reactant particles present.

Question 20

More candidates chose the incorrect **D** than the correct answer, **A**. Candidates need to be able to define acids and bases in terms of proton (H^+) transfer in aqueous solution.

Question 23

More candidates chose the incorrect **D** than the correct answer, **C**. Candidates need to be able to describe and explain sacrificial protection of steel in terms of the reactivity series and recognise that the sacrificial metal block does not prevent oxygen from reaching the steel.

Question 29

In this question on pressure a several candidates incorrectly stated that a car sinks less because of a reduction in the downward force on the sand (option **C**).

Question 31

Here many candidates incorrectly calculated a value for efficiency by dividing the wasted energy by the energy supplied, arriving at a figure of 76 per cent.

Question 32

This question on change of state was very well answered, with few being unable to identify condensation.

Question 33

A large majority of candidates were also familiar with the process of thermal conduction in a metal.

Question 34

In this question on the law of reflection of light, almost all knew that there were two equal angles. However most of these candidates took 20° as the angle of incidence, leading them to choose the incorrect option **A**.

Question 35

The direction of vibration of the molecules was very widely known, but many opted for **C**, confusing longitudinal with transverse waves.

Question 36

Very many candidates knew that the rod in this question was positively charged, but a large proportion of these thought that it was an electrical conductor. Rubbing a conductor with a dry cloth does not cause it to become charged.

Question 37

This question concerned a potential divider and was found challenging. A minority of candidates did not realise that only circuits **A** and **B** would react to a temperature change, confusing an LDR with a thermistor. Others generally opted for **B**, not realising that the p.d. across its thermistor would decrease with increasing temperature.

Question 38

Approximately half the candidates answered this correctly. However, several believed that a fuse decreases the current to its rated value (in this case 10 A) and therefore chose the incorrect option **A**.

Question 39

In this question on the direction of the force on a current-carrying conductor in a magnetic field, all incorrect options were equally popular.

CO-ORDINATED SCIENCES

Paper 0654/31
Theory (Core)

Key messages

Candidates generally had a good understanding of what the questions were asking.

A good standard of scientific knowledge was displayed by many candidates and some candidates gave excellent, clear and accurate responses.

Calculations were frequently done well with working shown.

General comments

Most candidates attempted all the questions. Some candidates answered most of the questions well. There was a good range of marks on every question. Few gained no marks on any question but very few gained full marks on any question. Performance depended not only on scientific knowledge but on the ability of the candidates to understand the question and express themselves clearly.

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

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

A number of candidates seemed to doubt their original answers and ended up crossing out a correct answer and replacing it with an incorrect answer.

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

Comments on specific questions

Question 1

(a) (i) Most candidates correctly determined the length of a sperm cell in animal B.

(ii) Most candidates correctly identified animal A as the animal with the shortest length of sperm.

(iii) Many candidates needed to give more specific answers to describe the evidence provided.

(b) There were many correct responses seen, usually cell membrane and cytoplasm. A number of candidates suggested nucleus, but this information was given in the question.

(c) Most candidates gained most of the available credit. The least well-known part of plant and function was the vacuole.

(d) Diffusion was not well known. Osmosis was often suggested.

(e) A number of candidates correctly explained that respiration releases energy, but few explained that this energy was needed for muscle contraction. Many candidates concentrated on the role of oxygen in respiration.

Question 2

(a) (i) Some candidates found this question challenging. Common products in the word equation were calcium and carbon. A few candidates attempted a balanced symbol equation but this was rarely correct.

(ii) Candidates found many correct uses of limestone.

(iii) Most candidates correctly stated that there are three elements present in calcium carbonate.

(iv) Few candidates described a chemical change as one in which new substances are produced or one which cannot be reversed. Many candidates referred to changes in physical state or structure.

(v) **C**andidates need to be able to describe an endothermic reaction as one in which thermal energy is taken in.

(b) (i) Candidates need to know the definitions of an element and a compound. A common incorrect answer was to state that an element contained one atom rather than one type of atom.

(ii) Many candidates gained partial credit. This was usually for correctly describing the separation of particles.

(c) (i) Diamond was usually identified as structure **A**.

(ii) Graphite was usually identified as structure **B**.

(iii) Some candidates were able to explain that the bonding between the carbon atoms in diamond is covalent because it involves two non-metal atoms bonding.

Question 3

(a) (i) Care must be taken when drawing circuit diagrams. Some candidates gained partial credit for showing the lamps in a parallel connection. Candidates need to ensure they know all the circuit symbols. Very few candidates knew where to place the switch.

(ii) Some candidates were able to explain the advantage of connecting the lamps in parallel.

(b) (i) Conduction was not well known as the method of thermal energy transfer. A common incorrect answer was the metal base.

(ii) Visible light was often given as the part of the electromagnetic spectrum emitted by the lamp.

(c) (i) Many candidates incorrectly labelled the incident ray and the reflected ray rather than the angles.

(ii) Few candidates were able to explain that the ray of light changes direction because of a change of speed.

Question 4

(a) Most candidates gave at least one correct answer. The part that was least correctly identified was the part which secretes the fluid that sperm swim in, which was part **C**.

(b) The part of the female reproductive system that releases gametes was well known as the ovary. Ovum and ovule were sometimes incorrectly suggested.

(c) Few candidates knew more than one of the three answers required. Very few knew all three.

(d) The diagram was interpreted by some candidates as referring to plant cuttings. However, a good proportion scored well on this question.

(e) Many candidates were able to give two characteristics of living things. Sometimes these included respiration or reproduction, which the candidates were given as examples in the question.

Question 5

(a) (i) Very few candidates suggested transition elements or transition metals. Most gave an example of a transition metal.

(ii) Many candidates correctly stated the number of electrons in the atom as 26. A number of candidates stated the number of neutrons instead.

(iii) Some candidates referred to the iron oxide losing its oxide rather than oxygen.

(b) (i) Alloy as a mixture of metals was quite well known.

(ii) Many candidates knew that steel was either stronger than iron or less likely to rust than iron.

(iii) Many candidates correctly determined the percentage of iron as 7 per cent.

(c) Many candidates gave unclear answers which did not really explain why the nails rusted or did not rust. A common misconception was to suggest that the painted nail in test-tube Z did not rust because the test-tube was open to the air and so all the water would escape.

Question 6

(a) (i) Most candidates confused the set up with that of an electric motor or generator and so gave answers in terms of increase the current or magnetic field rather than reverse them.

(ii) A current was not well known as a flow of electrons.

(b) (i) More candidates were able to state the meaning of isotopes than radioactive decay.

(ii) Candidates are urged to try and use the correct symbols for alpha and beta rather than A and B.

(c) (i) There were many misconceptions here such as positive electrons being involved or heat causing the charges to form. Some candidates did not use the word electron in their answer.

(ii) Row 4 was the correct answer but also the least popular answer.

Question 7

(a) (i) Homozygous and recessive were the correct responses. Most responses were equally popular.

(ii) Many candidates used words from list in **part (i)** to try and answer this question. All that was needed was GG and Gg.

(b) (i) Most candidates correctly completed the genetic diagram.

(ii) The percentage chance of offspring having the genotype gg was often stated correctly.

(c) (i) Most candidates found this part of the question very challenging.

(ii) Male (incorrect) and female (correct) were both suggested frequently.

Question 8

(a) (i) Coal was suggested by some candidates. Many suggested oil or crude oil, suggesting that they did not know that petroleum is crude oil.

(ii) Mixture and distillation were well known as the two correct words here.

(iii) Candidates needed to make the connection between gasoline and hydrocarbons in order to state that the two products of the complete combustion of gasoline are carbon dioxide and water.

(b) (i) Many candidates were able to explain that an unsaturated hydrocarbon contains a carbon-carbon double bond.

(ii) The test for an unsaturated hydrocarbon using aqueous bromine was well known.

(c) (i) Few candidates described the formation of a polymer from monomer units.

(ii) A number of candidates correctly suggested polyethene as the polymer formed from ethane, many other substances were incorrectly suggested.

Question 9

(a) A number of candidates correctly suggested convection as the main method of thermal energy transfer in the refrigerator. Condensation was a commonly given incorrect answer.

(b) Many candidates correctly calculated the mass of air in the refrigerator.

(c) (i) Mercury and alcohol were commonly suggested as a suitable liquid to use in the thermometer. Water was a commonly stated incorrect answer.

(ii) The physical property of the liquid that changes with temperature in the thermometer was not well known.

(d) (i) Many candidates were able to describe the amplitude or the frequency.

(ii) The unit of frequency was well known.

(e) (i) Most candidates were able to determine the combined resistance of the two lamps.

(ii) Many candidates incorrectly used $I = R / V$ rather than V / R

Question 10

(a) Fossilisation was the correct answer. Many candidates stated decomposition.

(b) (i) A wide range of suitable answers were given. The two most popular were habitat destruction and soil erosion.

(ii) Many candidates correctly suggested plant more trees. Candidates less often mentioned reducing the use of fossil fuels.

(c) Many candidates scored almost full credit on this question. The most common error was to suggest that respiration produces carbohydrates.

(d) (i) Xylem was well known. A few candidates incorrectly suggested phloem.

(ii) Most candidates gained at least partial credit in their description of transpiration. Few scored full marks. Stomata was the most commonly correct word used.

Question 11

(a) Most candidates suggested a suitable melting point for potassium.

(b) (i) Most candidates found this challenging, especially the diagram of the potassium ion. Candidates needed to show a full outer shell of electrons on each diagram.

(ii) Many candidates gave correctly balanced symbol equations.

(c) (i) The pH of water was well known.

(ii) Few candidates selected a suitable pH (between 8 and 14). Few candidates chose a suitable colour for the indicator (blue/purple).

(iii) Many candidates incorrectly suggested that lithium is more reactive than potassium.

Question 12

(a) Many candidates correctly determined the resultant force as 7 000 000 N. A number of candidates incorrectly added the forces together and produced a resultant of 57 000 000 N.

(b) (i) Solar was a common error in the sentence. Electrical was a common error in the second sentence.

(ii) Many renewable energy resources were suggested.

(c) Candidates needed to convert 72 hours into 259 200 seconds.

(d) Candidates need to be clear about the difference between mass and weight.

(e) (i) Many candidates located radio waves correctly. Others placed it between visible light and microwaves. Candidates are reminded that there is no need to fill in the whole electromagnetic spectrum.

(ii) A reference to sound waves needing a medium was required for this question.

(iii) The double headed arrow needed to go from one peak to the next. It is very important that the arrow is accurately placed. A number of candidates indicated the amplitude instead.

CO-ORDINATED SCIENCES

Paper 0654/32
Theory (Core)

Key messages

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

A good standard of scientific knowledge was displayed by many candidates and some candidates gave excellent clear and accurate responses.

Calculations were usually done well with working shown.

General comments

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

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

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

A number of candidates seemed to doubt their original answers and ended up crossing out a correct answer and replacing it with an incorrect answer.

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

Comments on specific questions

Question 1

(a) (i) This was usually answered correctly. The only common error was suggesting that an animal cell has a cell wall.

(ii) This was well answered.

(b) Many candidates knew that the nucleus contains genetic material.

(c) Most candidates worked out that a palisade cell is eleven times bigger that a red blood cell.

(d) (i) Few candidates were able to name the type of neurone shown.

(ii) Candidates needed to realise that sensory neurones need to be very long in order to transmit impulses over large distances.

Question 2

(a) Few candidates gained full credit here. Candidates needed to use the data to predict the melting point of potassium and the reactivity of lithium with water.

(b) This part was found to be challenging. A few correctly suggested that the gas made was hydrogen. Other gases were often suggested and even some Group I metals were mentioned.

(c) (i) Some candidates suggested that the reaction was exothermic. Fewer used the clues given in the question to explain why.

(ii) Candidates need to know the test for chloride ions. Some candidates described the test for chlorine gas.

(iii) More candidates incorrectly suggested covalent bonding than suggested ionic bonding.

(d) Few candidates suggested either hydrogen or chlorine. Some candidates suggested sodium. Candidates are reminded that chloride is not an acceptable alternative to chlorine.

(e) (i) Filtration was well known.

(ii) Many candidates correctly suggested either evaporation or crystallisation.

Question 3

(a) Reflection was the most common and the correct response.

(b) The position of visible light in the electromagnetic spectrum was well known.

(c) (i) This calculation was done well by most candidates.

(ii) A reference to sound waves needing a medium was required for this question, described correctly by about half the candidates.

(d) (i) Most of the double headed arrows were incorrectly contained within the lens. Very few candidates showed the focal length as the distance between the centre of the lens and the principal focus.

(ii) Most candidates showed the principal focus as the centre of the lens or the position where the rays converged. Neither was correct.

(e) (i) This was well known.

(ii) There were few correct answers.

Question 4

(a) There were very few correct answers for A, B or C. Many candidates gave no response.

(b) Most candidates gained credit here. The first blank seemed to be the most challenging with many candidates suggesting skin rather than blood.

(c) Many candidates incorrectly made more than one link from a box on the left to a box on the right. There were few correct answers.

Question 5

(a) (i) There were some correct answers and some that were far from correct.

(ii) Many answers were not specific enough to gain credit. The key point was the incomplete combustion of a hydrocarbon or gasoline.

(iii) Some correct answers were seen but there were many imprecise answers referring to lung damage.

(b) (i) The majority of the candidates gave a suitable pH.

(ii) Answers needed to be clear and precise.

(iii) Many correct answers were seen but there were also answers referring only loosely to oxygen.

Question 6

(a) (i) Most candidates correctly calculated the resistance as 16Ω.

(ii) 4Ω was the correct and most common answer. However, candidates found explaining their choice challenging.

(iii) Many candidates correctly showed the parallel connection. However, there were very few candidates who put the switch in a suitable place.

(b) (i) This was found to be very challenging. Few candidates managed to draw a convection current.

(ii) Few candidates mentioned convection.

(c) A few candidates mentioned friction, but the idea of electron transfer was generally missing.

Question 7

(a) The word equation for photosynthesis was well known.

(b) (i) Area **B** was usually suggested but reasons for choosing area **B** were often less clear. Area **B** was the area with the most chloroplasts.

(ii) Most candidates drew an arrow pointing to or going through the stomata. However, most arrows were pointing the wrong way. The arrow needed to start at the surface of the mesophyll cells.

(iii) Some candidates correctly suggested the cuticle. A more common response was cell wall.

(c) Candidates found this question challenging. The ideas that magnesium is required to produce chlorophyll and that chlorophyll is required for photosynthesis were rarely mentioned. Very few candidates explained the link between photosynthesis and the production of carbohydrates.

(d) Some candidates correctly explained that nitrate ions are needed to produce amino acids or proteins.

Question 8

(a) (i) Some candidates correctly stated what is meant by the term nucleon number. However, many incorrect responses included the number of protons and neutrons or protons and electrons or electrons and neutrons. Some candidates imprecisely suggested that it was the number of nucleons.

(ii) Many candidates drew clear diagrams to show the electronic structure of an aluminium atom.

(b) (i) Candidates need to know that Bauxite is an ore of aluminium. Iron or iron ore were sometimes suggested instead.

(ii) Chemical change was not well described. Few candidates mentioned that a chemical change is irreversible or that new substances are produced.

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

(ii) Many candidates correctly suggested that aluminium alloys are used in aircraft parts because they have a low density.

(iii) Many candidates correctly suggested that aluminium is used in the form of alloys rather than as pure aluminium because the alloy is stronger.

(iv) Many sensible descriptions of the uses of aluminium were given.

Question 9

(a) Few candidates gained full credit on this question. Kinetic energy was rarely suggested to complete the first sentence. Potential energy was commonly suggested.

(b) There were many correct answers, usually for referring to no production of carbon dioxide or that wind was a renewable energy source.

(c) (i) There were few correct definitions of frequency.

(ii) Many candidates correctly suggested a suitable frequency.

(d) Some candidates were able to draw the pattern of the magnetic field lines but very few showed their correct direction.

(e) (i) Very few candidates knew the nature of beta particles.

(ii) Many candidates knew that the nucleus of an atom splits during nuclear fission.

Question 10

(a) Most candidates correctly identified the two incorrect words in the definition of an enzyme as fats and chemical.

(b) The only commonly correct answer given was that proteins are the large molecules made from amino acids.

(c) Carbon, hydrogen, and oxygen were well known as the three chemical elements that make up fats.

(d) (i) There were many imprecise answers to this question. The essential points that needed mentioning were that the enzyme activity increases and then decreases as temperature increases and that the peak was at 33 °C or that the range was 20 °C to 40 °C.

(ii) This was well answered. Many candidates were awarded full credit and most scored at least partial credit.

Question 11

(a) Some candidates correctly identified carbon dioxide as a greenhouse gas. An equal number incorrectly suggested carbon monoxide.

(b) Many candidates were able to balance the symbol equation.

(c) The majority of candidates found this question challenging.

(d) (i) Candidates needed to know that natural gas is the fossil fuel containing mainly methane.

(ii) Coal was correctly identified as another fossil fuel by most candidates.

(e) (i) Alkenes having a double carbon-carbon bond was well known.

(ii) Aqueous bromine was selected by most candidates.

(f) Some candidates recognised that the presence of an oxygen atom in ethanol means that ethanol is not a hydrocarbon.

Question 12

(a) (i) Most candidates correctly determined the resultant force as 300 N, although 500 N was a commonly given incorrect answer.

(ii) Slowing down or decreasing speed was well known.

(b) All parts of **(b)** were well understood and answered by most candidates.

(c) Descriptions of a high pitch and large amplitude needed to be clearer and more precise.

(d) Many candidates were able to explain that the air particles move faster as the temperature increases. Fewer described the increase in collisions with the tyre wall.

CO-ORDINATED SCIENCES

Paper 0654/33
Theory (Core)

There were too few candidates for a meaningful report to be produced.

CO-ORDINATED SCIENCES

Paper 0654/41
Theory (Extended)

Key messages

For candidates to show that they have a good knowledge of the science topics on this syllabus they need to

- ensure that they are clear about the requirement of each question and give an answer consistent with the mark allocation
- communicate the meaning of scientific terms used at this level
- analyse data rather than repeating information given
- show working to gain credit for every stage in a calculation.

General comments

The standard of written communication was good. Candidates who did well in the examination responded to every item on the paper. Some candidates could have taken more care reading the questions, to avoid misinterpreting information, such as in **Question 1(b)** where the graph was interpreted as showing the relationship between age and number of smokers or in **Question 9(a)(i)** where the air molecules inside the tube were confused with those outside it.

Mathematical operations were usually conducted well. Many gained some credit in calculations despite an error. They showed their working by writing a version of the correct formula, showing its rearrangement and substitution, and giving the arithmetic steps used to get the answer. Candidates need to know that formulae work on fundamental quantities using the metre, kilogramme, second (SI) system. Candidates would do well to practice unit conversion.

Candidates need to distinguish between mass and weight. Some candidates did well by setting out their calculations so that they could be easily followed by the examiner, and drawing diagrams accurately, with a ruler. Careless drawing of the wavelength label in **Question 3(c)(i)** and the ray diagram in **Question 3(d)(i)** meant that some credit was not awarded.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified all three parts of the gas exchange system. However, some mistook the intercostal muscles for ribs.

(ii) Many could state that alveoli are efficient gas exchange surfaces because they are thin and have a large surface area.

(b) There were some good descriptions of the COPD results, which were supported by the quotation of two comparative items of data. Some consisted simply of a list of readings from the graph with no conclusion, or made statements not proved by the results such as: smoking causes COPD. Several candidates incorrectly interpreted the graph as showing the relationship between age and the number of smokers.

(c) (i) Only very few candidates knew that goblet cells produce mucus which traps bacteria, or that unhealthy ciliated cells do not move the mucus out of the lungs, allowing bacteria to remain and reproduce.

(ii) Nicotine was well known as the addictive substance in tobacco smoke.

Question 2

(a) There were many correct statements of the meaning of a reversible reaction.

(b) Many candidates knew that unreacted nitrogen and hydrogen are recycled in the Haber process while others thought they were discharged into the atmosphere.

(c) There were some correct explanations for the use of an iron catalyst to increase rate of reaction without affecting the yield, and the use of high pressure to increase yield and rate of reaction. Very few candidates appreciated that elevated temperature increases the rate of reaction but decreases yield, and that the choice of temperature is a compromise between reasonable rate and sufficient yield.

(d) There were some good diagrams showing the bonding in a molecule of nitrogen. Candidates need to have a good understanding of the role of electron sharing in covalent bonding.

(e) Those candidates who described how the equation can be used to predict a reacting mass were likely to arrive at the correct answer. The question asked for working to be shown and a format like the following would obtain credit even when an arithmetic mistake had been made.
1 mole of ammonia = 17 g, 1 mole of sulphuric acid = 98 g
2 moles of ammonia react with 1 mole of sulfuric acid
2×17g of ammonia react with 98 g of sulfuric acid
68 g of ammonia react with $\frac{98}{34} \times 68 = 196$ g of sulfuric acid

Question 3

(a) (i) Of those who knew the speed of light, many omitted the units. Some candidates thought that light cannot pass through a vacuum and gave an answer of zero.

(b) (i) Many placed visible light in its correct position in the spectrum.

(ii) Gamma radiation was often correctly identified as having the highest frequency with radio waves being a common incorrect suggestion.

(c) (i) Those candidates who correctly labelled the wavelength, drew a double headed arrow precisely between two adjacent crests, troughs, or zero crossings. However, others drew arrows to a region near, but not at, the consecutive points.

(ii) Some could write a representation of the relationship between frequency, speed and wavelength.

(d) (i) Several candidates gained full credit for the ray diagram by using a ruler to show the predictable paths of two rays from the top of the object to the top of the image, and by drawing the image between the focus and the principal axis.

(ii) A few candidates knew that a real image can be focussed on a screen.

(iii) There were many good suggestions of a use for a converging lens.

Question 4

(a) (i) Most candidates stated which antibiotic is most effective.

(ii) Most also identified the antibiotic that the bacteria are most resistant to.

(b) (i) The sentences describing the development of strains of bacteria with antibiotic resistance were often completed correctly. Other attempts were not based on a genetic explanation of evolution.

(ii) Only very few described the difference between natural selection and artificial selection in terms of whether there is selection of traits by humans.

(c) The advantages and disadvantages of asexual reproduction were quite well known.

Question 5

(a) The equation for the reaction was often correct. Those not earning full credit usually contained a balancing error.

(b) (i) The vast majority found the correct time from the table.

(ii) Candidates who noticed from the table that the acid was used to excess, explained that equal masses of magnesium carbonate produced equal volumes of gas. However, most thought that equal volumes of acid were responsible.

(iii) The limewater test for carbon dioxide was quite well known.

(iv) Those who knew that molar gas volume is the volume occupied by one mole usually attempted to find the mass by correctly dividing the volume by the molar volume. A common error was to not change the units of volume or to make an arithmetic error in the conversion. Most credit was obtained by those who showed their working, as requested.

(c) Most candidates knew that increasing concentration increases rate of reaction. Some explained this in terms of rate of collision of particles, rather than vaguely as an increase in collisions. Few answers referred to particles being more crowded or closer together. Some thought that the speed of particles increases.

Question 6

(a) No candidates described both the conditions of equilibrium as stated in the syllabus, namely that there is no resultant force **and** no resultant turning effect. Many described balancing the beam as described in the question.

(b) (i) Most knew the formula $W = mg$ for determining weight. Candidates needed to convert the unit of mass to kilogrammes.

(ii) Successful candidates equated the clockwise and anticlockwise moments before embarking on their calculation. They used $m = W/g$ to find the mass of the stone from the weight. However, some used the wrong distances to calculate moments.

(c) Most correctly described the displacement method of determining the volume of an irregular object. The best answers referred to the use of a measuring cylinder rather than just a beaker or container.

Question 7

(a) (i) Most candidates identified the epithelial cell on the diagram of a villus. Some could correctly name and identify the parts that absorb fats and transport nutrients.

(ii) The way in which villi aid digestion by increasing the surface area for absorption was quite well known. However, some candidates suggested that their function is to move material through the intestine.

(b)(i) Most candidates identified all three parts of the alimentary canal. Candidates need to be clear about whether bile is produced in the pancreas or the liver.

(ii) Many stated that bacteria cause dental decay. Candidates did not gain credit for plaque.

(c) The few statements of the effect of bile increasing the pH of gastric juice answered the question correctly. Many candidates who suggested that bile has a neutralising effect were also given credit.

Question 8

(a) (i) Most knew that the negative electrode is the cathode.

(ii) Many identified the gas as chlorine.

(iii) Often an appropriate indicator was suggested to show that sodium hydroxide is an alkali.

(b) The highest achieving candidates were able to construct the ionic half equation.

(c) Very few candidates correctly related boiling point to the energy required to overcome attractive forces. The best responses showed an awareness of the types of bonding in the two materials and compared the strong attractive forces between ions in sodium chloride to the weak intermolecular forces in hydrogen.

Question 9

(a) (i) Many descriptions of the cause of pressure correctly included collision of air molecules with the walls of the raft, rather than collision of molecules with each other. Fewer mentioned the force exerted on the walls as a result of each collision. Some candidates interpreted the question as asking how the motion of molecules outside the boat or motion of the boat itself gives rise to pressure.

(ii) Those who were aware that collision of air molecules with the walls of the raft causes pressure knew that increasing temperature increases the rate of collision with the walls of the raft, which results in increased pressure.

(b) (i) Most candidates could rearrange the pressure formula and calculate the correct area.

(ii) Many candidates knew the formula for kinetic energy. Fewer realised that the mass could be derived from the weight given in the stem of the question.

(iii) Several candidates stated correctly that tides are caused by the moon, with wind being an incorrect but popular answer.

Question 10

(a) Several candidates knew that plasma transports hormones. Many suggested other constituents of blood.

(b) There were a few good attempts at completion of the glucose control flow chart. Candidates need to be able to distinguish between glycogen and glucagon.

(c) The correct term describing blood glucose control was sometimes provided.

(d) Some knew that adrenaline is a hormone which also increases glucose concentration in blood.

(e) The table comparing hormonal and nervous control was often completed correctly.

Question 11

(a) Most candidates could find the numbers of protons and neutrons in the iron atom.

(b) Many candidates gave a straightforward description of the difference in properties of iron and steel by referring to their relative resistance to corrosion. Others suggested a less obvious difference in a physical property.

(c) The empirical formula of iron sulfide was usually given as FeS_2. Incorrect attempts simply added all the atoms in the structure.

(d) There were a few complete explanations of how elements form ionic bonds. They recognised that electrons move from metal atoms to non-metal atoms to form positively and negatively charged ions, which are attracted. Others attempted an explanation without reference to ions or used the concept of electron sharing.

(e) Successful explanations of why carbon can be used to extract iron involved its reactivity relative to iron, rather than oxygen, and described the displacement of iron from its oxide.

Question 12

(a) (i) The transformer core was recognised by a few candidates, while others suggested the involvement of a magnet or gave the name of a metal.

(ii) Many knew that the core is made from iron, while steel and copper were common suggestions.

(b) (i) Those who showed their working in rearranging a correct formula, usually calculated the correct voltage.

(ii) Good explanations of ways to increase the output voltage included increasing the secondary turns or decreasing the primary turns rather than just increasing or decreasing the turns. Increasing the power supply was not a sufficient description of increasing the primary voltage.

(c) The statements about the operation of the transformer were often placed in the right order with the majority realising that the changing magnetic field in the secondary produces an alternating potential difference.

(d) Some candidates knew that 95 per cent of the input energy is useful output, or 5 per cent is wasted, while others commented on the reliability of the device.

CO-ORDINATED SCIENCES

Paper 0654/42
Theory (Extended)

Key messages

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

- Calculations were generally well done. An important skill that candidates should practise is the conversion of units and the rearrangement of formulae when completing calculation questions. This was particularly evident in **Questions 8(c)(ii)**, **9(a)(i)** and **12(c)**.
- When completing calculations, candidates should remember to state the formula used, show the working, express the value to an appropriate number of significant figures and include units where instructed. These were important skills which aid in accessing the full credit available in **Question 8(c)(ii)**.
- Candidates should learn definitions and key terms that are stated in the syllabus. Definitions can gain marks directly as well as being useful for longer prose explanations. This practice would have been useful in particular for **Questions 1(a)** and **4(a)(iii)**.

General comments

It is important for candidates to read all the stimulus material carefully and complete all the instructions contained within the question. There were occasions where candidates could not access the full marks available or gave irrelevant responses due to not reading the question thoroughly or answering a question of their own devising.

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

It is important to pay attention to the command word used in each question. The command words of describe, explain, and compare all require different responses. Misunderstanding the command word prevents candidates being able to access all of the marks available. It would be beneficial for candidates to practise the different types of responses that are required for each different command word.

Comments on specific questions

Question 1

(a) Some candidates did not know the definition of the term enzyme and instead gave the function of an enzyme or the definition of a catalyst. Candidates generally either recognised an enzyme as a biological catalyst or that it was made from protein but relatively few candidates gave both parts of the definition.

(b) (i) The vast majority of candidates identified the optimum temperature for the enzyme from the graph.

(ii) There were several accurate and detailed explanations seen. Many candidates explained the reason for no enzyme activity at extreme pH in terms of shape and fit of the active site and substrate using correct terminology.

(iii) Most candidates linked enzyme **A**'s activity in low pH conditions to the stomach. Occasional incorrect responses, including the mouth and the small intestine, were seen.

(iv) The correct response of protease or pepsin was frequently seen. Occasional incorrect responses of amylase and lipase were also seen.

(c) (i) Some candidates were inexact in their responses and identified the intestines or parts of the large intestine, rather than the small intestine. Occasionally other incorrect responses were seen that included the oesophagus, lungs, and liver.

(ii) The function of the lacteal was not well known. Some responses were too imprecise and referred to absorption of nutrients rather than absorption of fats.

Question 2

(a) It was evident there was some confusion between the role of different pollutants and their effects. Too many candidates tried to explain this in terms of global warming or acid rain. The best responses identified a correct health impact of carbon monoxide.

(b) Some candidates misinterpreted the question and described the combustion of hydrocarbons without giving additional detail that carbon monoxide is produced by incomplete combustion due to a limited supply of oxygen.

(c) A variety of incorrect equations were seen, with several candidates including other elements such as nitrogen, magnesium and iron. The best responses recognised that carbon dioxide would be the compound produced when carbon monoxide was reacted with oxygen and took steps to balance the equation. On occasion some candidates did not recognise that oxygen existed as a diatomic molecule.

(d) The effects of different air pollutants proved to be challenging for some candidates and there were many vague responses referring to global warming or the ozone layer. Several responses recognised the lessening impacts of acid rain. Fewer candidates linked the use of catalytic converters to a reduction in smog or respiratory illnesses.

(e) Most candidates stated the correct response of transition elements. Group 1 elements was the most common incorrect response.

Question 3

(a) The component symbols and names were known by many candidates. The most common misconception was to confuse the symbol for thermistor with the variable resistor.

(b) (i) The majority of candidates were able to use the graph to identify the correct temperature. Very occasionally inaccuracies in reading from the graph were seen.

(ii) A few candidates multiplied the resistances to give 25 kΩ rather than the correct response of 10 kΩ.

(iii) Some candidates found calculating the total resistance in a parallel circuit more challenging than in a series circuit. Occasionally candidates gave the total resistance in a series circuit. Another common mistake was to not invert the fraction, giving an incorrect value of 0.4.

(c) The calculation of the charge was generally well done. Occasionally candidates attempted to divide the values rather than multiply. Stating the correct unit was less often correct. Frequently seen units were Q, watts, V and A.

Question 4

(a) (i) This question proved very challenging for all but a few candidates. When asked to compare the effect of a variable, candidates need to comment on both the similarities and differences in their effects. Most candidates did not recognise that initially as light intensity increases, the increase in rate of photosynthesis is the same at both temperatures. Some candidates misinterpreted the graph and stated that X represented the lower temperature and Y the higher temperature. Some responses incorrectly referred to photosynthesis stopping rather than identifying that the rate of photosynthesis became constant. The best responses were able to identify the similarity in initial rate, followed by the difference in the rate of photosynthesis at the two different temperatures as light intensity increased further.

(ii) Candidates should be reminded to be specific in their responses and use the labels included in the graph stimulus material to help them. The correct response was light **intensity** rather than just light. Temperature was the most common incorrect response.

(iii) Most candidates understood the process of photosynthesis, however there were some inaccuracies noted. There were a few candidates that confused chloroplasts with chlorophyll. Most candidates identified the correct energy transfer. There were some imprecise responses made by candidates when identifying the synthesis of carbohydrates made during the photosynthesis process. Inaccurate responses including food and nutrients were seen in addition to other irrelevant compounds.

(b) Candidates should be reminded to read the question carefully as many candidates attempted to provide the symbol equation rather than the word equation. Common misconceptions included the addition of energy as a product and/or light as a reactant.

(c) The majority of candidates identified the correct answer of palisade mesophyll cells.

Question 5

(a) Some candidates misinterpreted the question and gave the general formula for alkanes. Some candidates confused alkanes with alkenes and some candidates did not give the formula of the alkane that was also a product.

(b) Many candidates were able to identify the correct row as **D**.

(c) The most common misconception was that one of the products was hydrogen rather than water. Balancing skills were generally accurate, but many candidates did not give the products formed during a combustion reaction.

(d) A variety of responses were seen, with only a few candidates correctly identifying water. Incorrect responses included nylon and other polymers.

(e) There were two key ideas tested by this question. The first being that the repeating unit would only contain single bonds and the second was the formula of the repeating unit. Inaccuracies were seen in both respects, most commonly the inclusion of a double bond. Other inaccuracies included the additional of at least one extra carbon atom and inclusion of atoms outside of the brackets.

(f) (i) Most candidates described a correct observation. There were some inaccurate responses such as reference to a clear solution rather than colourless.

(ii) Many candidates struggled to complete an accurate energy level diagram. Many drew a straight ruled line between the products and the reactants. There were several inaccuracies in the drawing of the lines to represent the activation energy and the energy given out, usually the arrows were too short or pointed to the wrong area of the diagram. The arrow for the energy given out occasionally incorporated the activation energy.

Question 6

(a) Candidates generally gained partial credit by identifying the least gravitational potential energy from the diagram. Identifying the part of the graph where the car experienced the most kinetic energy proved the most problematic.

(b) (i) On occasion, candidates attempted to use the speed rather than the gravitational field strength in their calculations giving the incorrect value of 54 000. Some candidates omitted the gravitational field strength in their calculation altogether and some did not consider the height of the car.

(ii) Calculating the kinetic energy was generally well done. Common errors included omitting to halve the value and not squaring the velocity.

(iii) This question proved challenging for most, with few giving the correct answer of 0J.

(c) (i) Most candidates used the graph provided to calculate the change in speed correctly. Very occasional inaccuracies in subtraction skills were seen.

(ii) Candidates generally scored highly on this question, with the majority correctly calculating the acceleration of the car using their answer in **part (c)(i)**.

(iii) Some candidates did not gain full credit as their responses were too vague. Many candidates identified that the motion of the car was decelerating. Several candidates also recognised that the deceleration was constant from 2 seconds. Only a few candidates correctly described the non-uniform deceleration between 0 seconds and 2 seconds. Many candidates correctly referred to the times when the motion of the car changed using data from the stimulus graph provided.

Question 7

(a) (i) The parts of the eye and their functions were generally well known. Some candidates needed to read the information in the table more carefully as a common mistake was to state that **the lens** refracted light entering the eye rather than the **cornea**. The position of the retina was well known by candidates but fewer were able to give an accurate function.

(ii) The **parts E** and **F** were commonly identified. Some candidates identified the iris and some only identified one part rather than two.

(iii) Candidates should take care to spell keywords correctly. Some candidates referred to radical muscles, which did not gain credit. This question was commonly omitted altogether.

(b) Examples of voluntary actions were commonly identified by candidates. Very occasionally candidates did not read the question carefully enough and identified reflex actions.

Question 8

(a) Most candidates interpreted the diagram and identified that a solid electrolyte would not be able to conduct electricity. Fewer candidates were able to explain this in terms of the movement of ions and many referred instead to electrons.

(b) Many candidates correctly explained this in terms of mobile or a sea of free electrons. Fewer candidates described the structure of graphite as being covalently bonded in layers. There were some candidates that confused ionic with covalent bonding.

(c) (i) Many candidates could state the correct test and result for chlorine gas. Some of the candidates incorrectly gave the test and result for carbon dioxide or hydrogen gas.

(ii) Few candidates scored all of the marks available. For longer type calculation questions, candidates should be reminded to lay all workings out clearly and state the formulae of their choice. Particular challenges included the conversion of units between cm^3 and dm^3. Several candidates did not take into account that chlorine exists as a diatomic molecule.

Question 9

(a) (i) Conversion of units proved challenging for many candidates, with many omitting the conversion to give a value of 65. It would be useful for candidates to practice conversion of units to aid answering calculation questions that include this skill.

(ii) The majority of candidates could recall the correct formula and complete the calculation to give the correct answer. Very occasionally candidates divided rather than multiplied the values provided.

(iii) This question proved challenging for some candidates with many simply repeating the answer that they had given for **part (a)(ii)**.

(b) (i) The colour black was most commonly stated, with a few incorrect responses of red also seen. The explanation was often less successful, with vague references to emission or reflection of heat. The explanation needed to be comparative and responses stating that black absorbs heat energy were not detailed enough to gain credit.

(ii) There were some detailed explanations seen, with some excellent responses relating the speed of movement of the particles to the collision frequency and resultant increase in pressure inside the balloon. There was confusion amongst some candidates who attempted unsuccessfully to explain the increase in volume of the balloon in terms of an increase in rate of reaction.

Question 10

(a) (i) Almost every candidate calculated the correct difference in energy.

(ii) A number of candidates did not gain credit due to a lack of precision in their responses. Some candidates did not refer to energy and instead talked about nutrients. The best responses linked the need for energy to growth of the fetus.

(b) This question asked for a food group. Some candidates gave the names of individual fruits. The ideal answer was fruit or vegetables.

(c) At least one of the other components of a balanced diet was stated. Some candidates gave named examples of vitamins or minerals, including calcium and iron and sometimes sugar. These were not sufficient to gain credit.

(d) The parts of a pregnant female's body were generally well known. Occasionally the uterus and the placenta were confused.

(e) The correct answer of carbon dioxide was the most common response. However, other incorrect gases were also seen including hydrogen and oxygen.

Question 11

(a) Candidates displayed a good understanding of the electronic structure of an element and how this relates to which group it is in, in the periodic table.

(b) The recall of the formulae of ions was rarely successful. The formula for an oxide ion proved most problematic with the formula for a hydroxide ion often given. Some candidates did not include charges on the ions.

(c) A common omission was to only include one pair of shared electrons between the oxygen and the carbon atoms. It would be beneficial for candidates to check that each atom has eight electrons in their outer shells, including the shared electrons.

(d) The majority of candidates identified the correct row as **D**.

(e) Most candidates could calculate the relative molecular mass of aluminium sulfate. On occasion, there were inaccuracies in addition.

Question 12

(a) (i) Most candidates could correctly state the speed of visible light in a vacuum. A small number of candidates stated the speed of sound.

(ii) Most candidates were able to recall the correct formula and calculate the frequency of red light.

(b) (i) The correct answer of refraction was commonly seen. A small number of candidates incorrectly suggested total internal refraction or reflection.

(ii) Many candidates could describe the refraction of light occurring at the boundary between two different media. Fewer were able to explain this in terms of a change in the speed of light between the two media. There were many vague references to the bending of light in different media.

(c) There were many instances of 80 per cent of 1200 Watts being calculated correctly. However, it was clear that this formula was not as well known by the candidates as some of the other formulae tested in this paper. Candidates should make sure to learn all the formulae required and be able to rearrange them.

CO-ORDINATED SCIENCES

Paper 0654/43
Theory (Extended)

Key messages

In general, candidates showed a good level of understanding of the syllabus content and were able to apply their knowledge to unfamiliar contexts. Most candidates were able to articulate their ideas well and give clear and concise responses.

When completing calculations, candidates should remember to state any formula used, show the working and ensure that quantities given in non-standard units are correctly converted. These are important skills which aid in accessing the full credit available, such as in **Question 5(b)(iv)**.

Candidates should learn definitions and key terms that are stated in the syllabus. Definitions can gain marks directly as well as being useful for longer prose explanations. This practice would have been useful in particular for **Questions 1(c), 4(a)** and **6(c)(i)**.

General comments

It is important for candidates to read all the stimulus material carefully and complete all the instructions contained within the question. There were occasions where candidates could not access the full marks available or gave irrelevant responses due to not reading the question thoroughly or answering a question of their own devising.

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

Comments on specific questions

Question 1

(a) Almost all candidates were able to use the data provided to determine the change in length correctly. Most candidates included a positive sign to indicate that the length had increased.

(b) Only some candidates correctly identified the concentration of sugar solution inside the cells as being the value for which the change in length would be zero. A few candidates incorrectly identified this value as either 0.6 or 0.8 mol dm^{-3}.

(c) A large number of candidates were able to correctly identify osmosis as the process by which water moves into the potato strip. Many incorrectly identified the water potential inside the potato as being lower than the sugar solution. Many candidates described water moving through a cell membrane rather than a semi-permeable membrane and credit was given for the use of the word cell.

(d) (i) This question asked candidates to describe and explain the appearance of a cell. Responses often lacked detail and correct scientific terminology, with very few candidates making reference to plasmolysis in their response and even fewer explaining that this was because of water moving out of the cell by osmosis. Some candidates were awarded a mark for giving a description in terms of the cell membrane coming away from the cell wall.

(ii) Most candidates correctly identified a concentration of either 0.8 or 1.0 mol dm^{-3}.

(e) The majority of candidates were able to give photosynthesis as a use for water in a plant, however fewer were able to identify a second use. Common incorrect responses included growth and reproduction.

Question 2

(a) The majority of candidates correctly identified the two products as potassium chloride and bromine.

(b) (i) Some good explanations were seen where candidates showed a good understanding of the role intermolecular forces play in the determination of boiling points. Many candidates incorrectly referred to covalent bonds or simply unqualified bonds which was not credited. Only a small number of candidates were able to expand on their response to include a reference to the energy required to break these bonds.

(ii) The vast majority of candidates were able to state that litmus paper will turn red in the presence of dilute hydrochloric acid.

(iii) Only some candidates were able to identify the ion present in acids as being H^+. Many incorrect responses included attempts at writing ionic half-equations.

(c) Very few candidates were awarded full marks for a correct calculation. Many candidates failed to convert the volume from cm^3 to dm^3 and also showed little understanding of how to use a volume and concentration to determine the mass of hydrogen chloride.

(d) (i) The correct carbon-bromine bonds were generally identified using clearly drawn circles on the diagram provided.

(ii) Many candidates were able to state that energy is released during exothermic reactions, however very few were able to apply this to the context of the question. Candidates were required to link energy being taken in to bond breaking and energy being given out to bond making. However, often explanations only included one of these points. Very few candidates were able to give a full explanation stating that more energy is given out than is taken in by the process hence making it exothermic.

Question 3

(a) The majority of candidates were able to correctly state the meaning of the term isotope.

(b) A large number of candidates were able to correctly add the atomic number and proton number for nitrogen to the incomplete equation, however fewer were able to use the correct nuclide notation to include a beta particle. Some candidates used the symbol for an electron rather than a beta particle, which was accepted.

(c) The vast majority of candidates correctly calculated the half-life of carbon-14 using the graph provided.

(d) (i) The vast majority of candidates knew that gamma rays are found at the end of the electromagnetic spectrum, however many candidates incorrectly placed it next to microwaves rather than on the far left hand side of the diagram. A small number of candidates were able to correctly complete the whole electromagnetic spectrum which was not necessary for this question.

(ii) Most candidates were not able to correctly state the speed of gamma rays. Those that knew the correct value often did not include any units in their response. A statement that gamma rays travel at the speed of light was not sufficient.

(iii) The equation linking wave speed, frequency and wavelength was generally well known by candidates. Only some candidates were unable to correctly rearrange the equation to determine the frequency and almost all correctly stated the units for frequency.

(iv) This question required candidates to match forms of electromagnetic radiation to their uses. The vast majority of candidates were able to do this, with a few incorrect responses seen where infrared was confused with microwaves.

(e) Where candidates knew the difference between transverse and longitudinal waves, their responses included enough detail to gain this mark. However, a significant minority of candidates incorrectly attempted to answer based on the speed, wavelength or frequency of the waves.

Question 4

(a) This question required candidates to fill in missing keywords in the definition of an ecosystem. Few candidates correctly identified 'organisms' and 'interacting' as given in the definition found in the syllabus, instead using words such as 'species' and 'living' which was not sufficient to gain credit.

(b) (i) Most candidates were able to state that there are 4 tropic levels shown in the food web. The most common incorrect response was 3.

(ii) The vast majority of candidates correctly identified the first trophic level as containing producers.

(iii) Only some candidates correctly interpreted the food web and gave the answer of blackbirds. The most common incorrect response was owl while a significant number of candidates tried to answer more generally in terms of consumers rather than using the figure provided in the question.

(iv) In order to gain full marks in this explanation, candidates needed to state that energy is lost between each trophic level, give a reason why this is the case and link this to the amount of energy available to the highest trophic level. Many candidates stated that energy was lost between the levels but were unable to give a reason for this. Only a small number of candidates linked the energy losses to a lack of energy at the highest trophic level. In some cases incorrect responses were given in terms of predator numbers rather than a lack of energy to support a larger population.

(c) The vast majority of candidates correctly ordered the statements about artificial selection.

(d) Only a small number of candidates were able to state two differences between artificial and natural selection however some candidates were awarded one mark for one correct difference. The most common difference given related to the time for artificial selection being shorter than natural selection. Very few candidates identified that artificial selection requires humans to select the desired traits, often giving unqualified responses relating to human involvement.

Question 5

(a) This question required candidates to state two properties of transition metals. While some candidates identified the high melting points or application as a catalyst, most responses given stated properties of all metals such as electrical and thermal conductivity.

(b) (i) Most candidates identified the hazard associated with the reaction as being related to the carbon monoxide. The correct explanation of carbon monoxide being a toxic gas was commonly seen, however some candidates simply stated carbon monoxide as their response without adding any further detail, which was not sufficient to award the mark.

(ii) Most candidates could correctly explain reduction in terms of electron gain.

(iii) The correct half equation was commonly seen. Where candidates could identify the charge on the iron ion, they were able to then correctly balance the equation gaining full marks. Incorrect responses showed a lack of understanding over what is meant by a half equation, with many candidates attempting to write an equation containing iron oxide.

(iv) Only the most able candidates were able to gain full marks for this calculation and explanation. Many candidates were able to calculate the relative formula masses of iron oxide and carbon monoxide, however most were then unable to correctly calculate the number of moles of each substance, often forgetting to convert the mass from kilograms to grams. While most candidates, who attempted to explain why the iron oxide was the limiting reactant, gave an explanation in terms of there being more moles of carbon monoxide, very few were able to quantify this using the 3:1 ratio given in the equation.

Question 6

(a) (i) Most candidates were able to circle two non-renewable energy sources. A small number of candidates only circled one answer.

(b) (i) The vast majority of candidates correctly calculated the efficiency of the power station.

(ii) Some candidates were able to describe the advantage of geothermal power stations in terms of release of carbon dioxide, climate change or global warming. Commonly seen incorrect responses related to the finite nature of coal or an unqualified statement of renewability.

(c) (i) Very few candidates were able to give a definition for electromotive force. Candidates showed very little knowledge of this section of the syllabus and their responses did not use the key terms outlined in the syllabus.

(ii) Only the most able candidates were able to describe how a generator produces an a.c. output in enough detail to be awarded these marks. Many candidates simply repeated the information given in the question rather than describing how the coil interacts with the magnetic field. Some candidates mixed up the generator with a d.c. motor and gave an answer in terms of the current causing the coil to turn.

(iii) Most candidates were able to correctly name the component as the slip ring. Occasionally the component was incorrectly identified as a split ring, again showing confusion between a generator and a motor. Fewer candidates were able to describe the function of the slip rings with many incorrect responses referring to the slip rings providing an alternating current for the coil or providing a connection between the coil and a battery.

Question 7

(a) (i) Some candidates were able to identify the part of the sperm cell as the membrane. Many candidates identified **X** as the head of the sperm, which was an acceptable answer. A common incorrect response was the acrosome.

(ii) This question required candidates to compare the relative size, motility and relative number released for sperm and egg cells. Marks were awarded for a correct comparison indicating that the sperm is smaller than the egg, the sperm is motile while the egg is not and the number of sperm cells is larger than the number of egg cells. Exact quantities were not required, however a large number of candidates attempted to quantify their answers. These responses gained marks where the comparison was qualitatively correct even if the given values were not accurate.

(iii) Very few candidates were able to state an adaptive feature of an egg cell, although the answer of a jelly-like coating was seen on occasion.

(b) This question was generally well answered, with the majority of candidates matching up the three correct boxes. The most common mistake made was to select diploid in place of haploid.

(c) Most candidates could state zygote as the name given to the cell produced after fertilisation.

Question 8

(a) Almost all candidates knew that alkenes are unsaturated hydrocarbons.

(b) The candidates that were able to identify that bromine (water) can be used to distinguish between propane and propene, could generally then go on to identify the result with propane and propene. Some candidates incorrectly suggested a test using litmus paper while a significant number of candidates gave incorrect results using bromine.

(c) Most candidates gained marks for drawing a double bond between the carbon atoms in propene and a single bond between the carbon atoms in the polymer. The trailing bonds on the polymer were less commonly seen and other incorrect structures of propene often contained a bond drawn between the left-hand carbon atom and the letter n.

(d) The most able candidates often gave an answer in terms of condensation polymerisation producing a small molecule, or a named molecule such as water. Very few candidates were able to give a second difference in terms of the number of monomers involved in each reaction. Most responses showed very little understanding of this section of the syllabus.

Question 9

(a) (i) The majority of candidates correctly drew the two sections of the speed-time graph. Occasionally errors were seen with the interpretation of the speed axis, where the first stage of the graph was drawn at 11 m/s instead of 12 m/s. Almost all graphs were drawn with a ruler and were clear in their intent.

(ii) Most candidates correctly selected the values of 12 m/s and 25 s from the stem of the questions and could show how these values give an acceleration of 0.48 m/s^2. A small number of candidates chose different values from their graph and used the gradient to determine the acceleration. Where this was done correctly, it was awarded the mark.

(iii) The equation F = ma was well known and candidates were able to input the given values to calculate the force.

(iv) Most candidates showed knowledge of the equation W = fd and could use it to determine the work done by the force.

(b) The majority of candidates were able to identify the energy transfer from kinetic energy, however the second energy store was less commonly seen. Some candidates incorrectly stated energy stores such as chemical, while others named forces, such as friction, rather than energy stores.

Question 10

(a) (i) This question required candidates to explain the results given in a graph. A significant number of candidates were able to correctly identify the key ideas behind the increase in muscle contraction causing an increased need for oxygen due to the increased rate of respiration. Some marks were lost where candidates made no reference to muscles, simply stating that the body needs more energy or oxygen during exercise without giving a fully developed explanation as to why. A small number of candidates made no attempt to explain the results, instead describing the data given in the figure.

(ii) Most candidates correctly stated the name of a chamber of the heart, the most popular being ventricle and the idea of contraction was commonly seen. Often the relevant keywords were found amongst incorrect explanations of the order in which the chambers contract.

(iii) Most candidates correctly named the valves.

(b) (i) Most candidates correctly stated that the blood vessel shown was an artery.

(ii) The majority of candidates showed some knowledge of the thick walls being related to the high blood pressure found in arteries, however only a relatively small number of candidates explicitly stated that the thick walls prevent bursting or implied their role in withstanding high blood pressures. Very few candidates were able to explain the role of the narrow lumen in maintaining high blood flow.

Question 11

(a) Most candidates were able to correctly write a balanced symbol equation for the reaction. A common mistake was for candidates gave the incorrect formula for hydrogen as 2H

(b) (i) Almost all candidates were able to deduce that reaction **2** took the longest to finish.

(ii) Some candidates included a reduction in temperature in their description and the most able linked this to a decrease in collision rate due to the molecules having less kinetic energy. Many candidates did not read the information given in the question carefully enough and chose one of the listed control variables as their answer. A response attempting to change the volume of hydrogen produced as a variable was also commonly seen.

(iii) Some candidates correctly suggested a 0.5g mass of zinc.

(c) Almost all candidates knew that structure **D** showed the structure of brass.

(d) Most candidates answered in terms of either a sea of free or delocalised electrons. In fewer cases was it made clear that these electrons are free to move through the material. A response which simply stated that the metal contains electrons which can move was not enough to gain these marks.

Question 12

(a) (i) Most responses were phrased in terms of molecular motion and collisions, the best of which concentrated on the collisions between the molecules and the walls of the container. Only a relatively small number of candidates made the link between the collisions with the walls and the exertion of a force causing pressure inside the gas.

(ii) An encouragingly large number of candidates were able to rearrange the formula for kinetic energy correctly to find the speed of an oxygen molecule. Most candidates were able to use the data given in the stem of the question and correctly interpreted the use of standard form.

(b) (i) The vast majority of responses included a statement indicating that as the temperature of the gas increases the pressure also increases. Fewer candidates were able to describe the linear nature of this relationship using the correct mathematical terminology.

(ii) Most candidates correctly identified that the volume or size of the balloon would increase as the gas was heated and showed understanding of the need for a fixed volume in order to see a clear relationship. A few candidates were not awarded this mark for giving simple responses relating to the risk of the balloon popping.

CO-ORDINATED SCIENCES

Paper 0654/51
Practical Test

There were too few candidates for a meaningful report to be produced.

CO-ORDINATED SCIENCES

Paper 0654/53
Practical Test

There were too few candidates for a meaningful report to be produced.

CO-ORDINATED SCIENCES

Paper 0654/61
Alternative to Practical

Key messages

Although this is an Alternative to Practical paper, candidates are expected to be familiar with experimental technique and to have carried out experiments similar to the ones shown in the paper. The bullet points in the planning question are there to help candidates structure their plan into the sections required. Candidates should be able to draw clear and labelled diagrams of assembled apparatus.

Candidates need to read the questions carefully so that they answer what has been asked. Examples include **1(b)(ii)** where a significant number of candidates did not draw the line and **1(d)** where many candidates did not show their working.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques. The standard of graph drawing was generally good although candidates need to remember that axes need to be labelled, linear and large enough for the plotted points to cover at least half of the grid.

Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results.

Comments on specific questions

Question 1 Flower drawing

(a) (i) Diagrams were generally well drawn by most candidates. Some had feathery outlines rather than a single clear and continuous line and the carpel was sometimes omitted. A small number drew a flower from memory which was not the flower they had been given.

(ii) Approximately half the candidates labelled the anther correctly. Common errors included labelling the filament and the stigma. Label lines need to touch what they are labelling.

(b) (i) The majority of candidates drew the line and measured it correctly. Common errors included omitting the line, and not using the correct units of mm.

(ii) Many candidates drew the line and measured it correctly. A significant number did not draw the line. This meant their quoted length could not gain credit as it could not be verified. Others gave an answer either ten times too large or ten times too small.

(iii) The calculation was generally performed well. However, a small number of candidates inverted the division. Rounding proved to be a challenge for many candidates who incorrectly truncated their value.

(c) Candidates found this very challenging. Common responses not worthy of credit included: it is an image, it is magnified, it is a drawing, it is a photograph and it is not a real flower.

(d) Whilst most candidates did calculate the average correctly, a significant number did not show their working and so could not gain the credit available for the correct formula.

Question 2 Nutrient Testing

(a) (i) Many candidates named a suitable piece of apparatus. Common incorrect responses included: test-tube, beaker, cylinder, ruler, measuring tube and pipette. The pipette needed to be qualified as being a graduated pipette.

(ii) The more able candidates chose the correct reagent. Biuret was the most common incorrect response. Since the question asked for test solution, ‘sugar test’ was too vague.

(iii) The most able candidates identified all of the nutrients and gave a correct comparison for reducing sugar content. Many omitted ‘reducing’ and a comparison of the reducing sugar content. Fats and calcium were incorrectly added to some responses.

(b) (i) The most able candidates stated both reagents correctly. A significant number only gave ethanol or gave a different testing solution alongside ethanol. Some chose two reagents from Table 2.1. More able candidates gave the observation in both parts as white and emulsion. Precipitate and solution were quite common incorrect responses.

(ii) Candidates found this challenging. Incorrect responses included the milk is liquid, the ethanol reacted with the milk so couldn’t be used in the test, the two liquids didn’t mix or milk contained fat.

Question 3 Effect of dissolved impurity on the boiling temperature of water

(a) (i) Most candidates recorded the two temperatures correctly. A significant number either rounded 103.5 to 103 or omitted the .0 from 104.0.

(ii) Candidates found this challenging with the more able opting for repeating and averaging. Almost no candidates appreciated that neither the volume of water nor the mass of salt had been measured. Incorrect responses included using the same temperature, adding more salt, and insulating the beaker.

(b) (i) The standard of graph drawing was quite good. Many omitted the units on the temperature axis and a small number reversed the axes. Some scales were non-linear, particularly where the origin was marked as 0,0 and the next division for temperature was 100. Sometimes the plotted points did not cover at least half of the grid and some candidates mis-plotted the 0.5 as 0.05.

(ii) The line of best fit proved to be very challenging. Candidates need to know that when the question does not specify either a straight line or a curve then they need to look at the points and decide how to draw the line. In this case the line had a slight curve up to 5 minutes and then was a horizontal straight line. Many candidates used a ruler or drew one straight line.

(iii) Just over half of the candidates described the first part of the graph correctly. Some candidates quoted values from the graph rather than describing the relationship. A small number of more able candidates appreciated the levelling off to a maximum value for boiling point. However, many thought this showed the reaction between the salt and water had stopped.

(iv) The majority of candidates estimated the temperature correctly but of these a significant number did not show any markings on the graph. A vertical line from 3.5 and a horizontal line from where this line touches the graph is the best way of showing the estimate.

(v) Candidates found this quite challenging. Many thought there had been a reaction which had now stopped Other incorrect responses included the boiling point of salt had been reached or that this was a maximum temperature.

Question 4

(a) (i) Candidates found this question to be challenging, with a significant number gaining no credit. Many candidates selected the necessary apparatus but did not describe how to assemble it. The Bunsen burner and tripod were frequently omitted; the flask and beaker were often reversed and there were some large gaps in the apparatus so that it was not airtight. Sometimes extra, unnecessary pieces of apparatus were added.

(ii) The majority of candidates labelled the thermometer and condenser correctly.

(ii) Candidates found this very challenging, often showing the path of the methanol from the mixture to the receiving vessel. Those that indicated the water flow in the condenser, usually had it reversed.

(b) (i) This was well known; Q was the most common incorrect response.

(ii) The more able candidates gave a correct explanation. Responses not worthy of credit included: they are cooler, they are the same as 65, they are not above, and those which did not refer to temperature.

Question 5

(a) (i) Many candidates recorded the distance correctly. Common errors included 39, 390, 4.9 and 3.95.

(ii) Candidates found this challenging with many not measuring to the centre of the lens or leaving large gaps at both ends of their arrow.

(iii) Most calculated the value correctly; a small number divided by five.

(iv) The more able candidates calculated the value correctly. A small number did not use the value from **(a)(iii)** and many struggled to understand the brackets in the equation.

(v) The more able candidates measured the height correctly. The most common error was measuring one of the sides and some gave the value as 2.6 or 260.

(b)(i) Most candidates calculated the value correctly.

(ii) Many candidates recorded the height correctly. Common errors included 0.9, 90 and measuring one of the sides.

(c) Candidates found this a little challenging; many summed but omitted to divide by two; some multiplied or divided the numbers.

(d) Most candidates calculated the value correctly. Correct rounding proved to be a common obstacle for many candidates who simply truncated their value.

(e) Candidates found this very challenging. The most common error was to state that the numbers were the same because they could be rounded to 3. It is expected that candidates will perform a 10 per cent calculation to ascertain whether the two values are within 10 per cent of each other.

(f) Many candidates appreciated that the images were different sizes but often gave the similarity of triangular shape rather than that both were inverted or of the same orientation as each other.

(g) Candidates found this challenging, the most common creditworthy response being to repeat and average. Many discussed parallax or thought the question was asking for a safety precaution and so discussed goggles.

Question 6 Pendulum planning question

A small number of candidates omitted the question and a significant number did not address any of the bullet points from the question.

The whole range of marks was seen and some more able candidates gave quite detailed answers with some gaining full or almost full credit.

Many candidates used a timer (stop-watch or stop-clock) but some discussed timing without naming the apparatus they would need to do this.

Methods were often brief with little structure or logical sequence. Very few attached the bob to the string. Some used a spring rather than string and many timed only one oscillation.

Some candidates drew a table for the results and were thereby able to score credit for points that were not explicitly described in their method, such as showing repeats and averaging.

Control variables were well known although a significant number incorrectly suggested controlling the mass of the bob.

Drawing conclusions is often a challenge for candidates. Many gave a conclusion rather than showing how the results they obtained would be used to draw a conclusion. Looking for a pattern is insufficient. Many described drawing a graph without specifying what would be plotted on each axis.

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 technique, to have carried out experiments similar to the ones shown in the paper.

The bullet points in the planning question are there to help candidates structure their plan into the sections required.

Candidates should be able to draw clear and labelled diagrams of assembled apparatus.

Candidates need to read the questions carefully so that they answer what has been asked.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques.

The standard of bar chart drawing was generally good although candidates need to remember that axes need to be labelled and be large enough that the plotted bars cover at least half of the grid.

Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results and also to formulate a logically sequenced plan citing the apparatus used. Flame tests should be included with qualitative analysis experiments.

Comments on specific questions

Section A

Question 1 Gravitropism

(a) Almost all candidates recorded both distances correctly. A small number were one or two mm beneath the accepted range.

(b) Many candidates interpreted the diagram correctly. Common incorrect responses included: right, against gravity and towards the light.

(c) Almost all candidates measured the length correctly.

(d) (i) Almost all candidates calculated the values correctly.

(ii) Candidates found this more challenging with many describing the rate as being the same rather than how the data shows the rates to be the same. Some incorrectly described the direction of growth. Other incorrect responses included: gravity pushing the same amount and having the same force.

(e) **The more** able candidates appreciated that different species may grow at different rates. Many candidates stated: fair test or for greater accuracy which were insufficient explanations.

(f) Iodine was well known with a small number of candidates giving an incorrect colour including brown, blue, red and orange. A small number chose Benedict's.

Question 2 Heart rate

(a) Almost all candidates calculated the average correctly and, like the data in the table, gave the answer to the nearest whole number.

(b) Bar charts were generally well drawn with few incorrect bars seen. A large number of candidates did not label the axes with sufficient detail. A small number chose a scale where the bars did not cover at least half of the grid.

(c) Almost all candidates interpreted the bar chart correctly.

(d) (i) The more able candidates spotted the anomalous result. Responses not worthy of credit included: too few samples, same Daphnia, chemicals dissolved in the water, Daphnia are small so challenging to count the heart rate and Daphnia normally live in water.

(ii) The more able candidates appreciated that anomalous results should not be included in the calculation of the average. Responses not worthy of credit included: use more Daphnia, use more water and monitor the temperature of the water.

(iii) Candidates found this quite challenging with many discussing accuracy or the water being a controlled variable.

(e) Many candidates analysed the data well, appreciating the increase in the heart rate. Answers were sometimes confused; some arguments for disagree were given to explain an agree statement.

(f) Candidates found this quite challenging, reliability and fair test were the most common non-creditworthy responses.

Question 3 Gas preparation and freezing point depression

(a) (i) Many candidates named a suitable piece of apparatus. Test-tube and beaker were common incorrect responses.

(ii) Candidates found this challenging with a significant number gaining no credit. Many selected the apparatus needed but could not draw it assembled without large gaps which would make it not airtight. The collecting vessel was often a beaker, measuring cylinder or gas syringe rather than the test-tube. Many candidates added a superfluous condenser and the reagents were often unlabelled. Where a collecting test-tube was drawn it was often sealed with a stopper or was upright in air.

(iii) The more able candidates appreciated that the ammonia would dissolve into the water. Many repeated the stem quoting it being soluble or thought it to be flammable.

(b) (i) Most candidates recorded the temperatures correctly.

(ii) Many candidates ordered the solutions correctly, the reverse order being very common.

(iii) The more able candidates appreciated the lowering of the freezing point. Incorrect responses included: it melts the ice, reacts, gets hot and speeds up melting.

Question 4 Qualitative Analysis

(a) The more able candidates looked for the differentiating tests in the table. Many used other tests not from the table including litmus, lighted split, glowing splint, limewater, dilute nitric acid and flame test with a variety of observations from them.

(b) Candidates found this very challenging. Flame tests require the solid to be on a clean wire or the solution to be soaked into a splint and then placed into the top of a blue flame. Many placed the solid onto a spatula or spoon, between tweezers or in a test-tube or beaker and then heated or described a flame test as the tests for oxygen or hydrogen.

Question 5 Chromatography planning question

A small number of candidates omitted the question and a significant number did not address any of the bullet points from the question.

The whole range of marks was seen and some more able candidates gave quite detailed answers gaining full or almost full credit.

Few candidates extracted the colouring from the boiled sweet such that it could be placed onto the chromatography paper. Many discussed putting the colourings onto the paper but very few candidates named the apparatus suitable for doing this or placed a lid onto the container of solvent. Some drew a diagram with some unlabelled spots without discussing what they were or how they got there.

Drawing the base line in pencil was well known but placing all of the colourings and the colouring from the sweet on it and making sure the solvent was below the baseline were less well described. Few removed the paper from the solvent when the solvent was close to the top of the paper or left the chromatogram to dry.

Few candidates discussed measuring the distance of the spots so that they could be compared with many opting for a comparison by eye.

Drawing conclusions is often challenging for candidates. Many gave a conclusion rather than showing how the results they obtained would be used to draw a conclusion.

A significant number of candidates discussed variables and drawing graphs of results, neither of which were creditworthy for this practical.

Question 6 Rate of cooling

(a) Many candidates recorded the temperature correctly. The most common incorrect response being 87 rather than 87.0.

(b) (i) Units were well known. Some incorrectly stated C°.

(ii) Candidates found this very challenging. Common responses not worthy of credit included: water needing to stop bubbling, water too hot at the start, for accuracy or reliability or a restatement of the question stem.

(iii) Only the more able candidates gained credit. Common responses not worthy of credit included: to spread the temperature and to find an average temperature.

(c) (i) Many candidates calculated both the temperature difference and rate correctly but did not give their final answer to two significant figures. Rounding was a common obstacle with many candidates truncating their final value or giving 0.06 as two significant figures.

(ii) The majority of candidates calculated the value correctly. Incorrect responses included: 73 ÷ 300 and 73 ÷ 60.

(iii) Candidates found this question exceptionally challenging. Most answered by relating rate to time rather than rate to temperature.

(d) Many candidates named one factor and the more able candidates named two. Temperature, volume and surface area all unqualified are too vague to gain credit. Volume of water, temperature of surroundings or surface area of beaker were needed.

Question 7 Resistance

(a) (i) Most candidates recorded both values correctly. 8.5 was a common incorrect response for the potential difference.

(ii) Most candidates calculated the value correctly and knew the units. A small number gave R for the unit.

(b) (i) The majority of candidates drew the rearranged circuit correctly. The most common error was omitting the power supply or drawing a parallel circuit.

(ii) Only the more able candidates gained credit. A significant number of candidates described death by electrocution.

(iii) Most candidates calculated the value correctly.

(c) Many candidates calculated either $4R_1$ or $R_2 \div 4$. Fewer calculated the 10 per cent to show whether the values were within the range. Answers such as: they are the same because they are very close are insufficient, the data needs to be used in calculations.

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 technique, to have carried out experiments similar to the ones shown in the paper.

The bullet points in the planning question are there to help candidates structure their plan into the sections required.

Candidates should be able to draw clear and labelled diagrams of assembled apparatus.

Candidates need to read the questions carefully so that they answer what has been asked.

General comments

Candidates from many centres demonstrated good understanding of practical knowledge and techniques.

The standard of graph plotting was generally good but candidates need to remember to put linear scales on axes.

Undertaking practical work helps the candidates to interpret and evaluate experimental methods and results and also to formulate a logically sequenced plan citing the apparatus used, for example, how to maintain the temperature of a water bath or the apparatus used to collect a dry gas. Flame tests should be included with qualitative analysis experiments.

Candidates should understand the use of significant figures either directly from a question or from looking at existing data in a table of results.

Comments on specific questions

Question 1 Amylase action on starch

(a) Many candidates named a suitable piece of apparatus. Common incorrect responses included: beaker, test-tube, cylinder, dropper and ruler. Pipette needs to be qualified as a volumetric pipette or a graduated pipette.

(b) (i) Candidates found this a little challenging with many either reversing the conclusions or stating colours rather than conclusions. A small number gave: low or little starch for A.

(ii) The more able candidates appreciated that the enzyme breaks down the starch. Responses such as: removes, absorbs or gets rid of starch are all insufficient.

(iii) Candidates found this very challenging. Common responses not worthy of credit included: fair test, keep it pure, keep volumes the same and it is neutral.

(c) (i) The ideas of keeping the temperatures the same or at the optimum temperature for the enzyme were quite well known. Responses not worthy of credit included: fair test, speed up the reaction and increase the activation energy.

(ii) The majority of candidates gave answers which implied an even distribution of the reagents. Faster reaction and to combine them were common non-creditworthy responses.

(d) (i) Only the more able candidates recorded the temperature correctly. The most common incorrect responses were 20 and 19.5. 20.5 was also seen.

(ii) The question required a discussion of the results and many candidates discussed the conclusion that could be reached, such as slower reaction and has less starch. Other insufficient responses it included: different results, lower temperature and it had cooled.

(iii) The most common non-creditworthy response was: use a thermometer. Others included: heat it (with no qualification of how this would be achieved) and keep it at room temperature.

(e) The answer required the results expected which candidates found quite challenging. Common responses not worthy of credit included: no reaction, stops working and starch not broken down.

(f) Biuret was quite well known. The most common incorrect response was Benedict's solution.

Question 2 Stain removal planning question

A small number of candidates omitted the question or did not address any of the bullet points from the question.

The whole range of marks was seen with a significant number giving detailed answers gaining full or almost full credit.

Many candidates cited the apparatus provided in the question without including the other apparatus needed, often referring to the same amounts of powder / water / egg stain or the same temperature but with no means of measuring these.

Methods were often in a logical sequence. However, a large number of candidates added no water to the washing mixture.

Many candidates did not consider a means of measuring or comparing the amount of stain, removed or remaining, on the cloths.

Control variables were very well known.

Drawing conclusions often prove challenging for candidates. Many gave a conclusion rather than showing how the results they obtained would be used to draw a conclusion or else they omitted the use of the results.

Question 3

(a) (i) Many candidates recorded the two values correctly. Candidates need to look at the data in the results table to ascertain the number of significant figures required; the most common mass recorded was 75.258. Incorrect temperatures included: 37 and 47.5.

(ii) Most candidates calculated the change in mass correctly.

(iii) Most candidates calculated the change in temperature correctly.

(b) (i) The majority of candidates calculated the energy correctly; far fewer gave the answer to three significant figures.

(ii) Candidates found it a challenge to identify improvements to the experiment. Only the more able candidates gained credit. Insufficient responses included: more precise thermometer, larger amount of water, more heating, higher temperature, repeating and rounding measurements.

(c) Carbon dioxide test was quite well known. Common incorrect responses included: hydrogen test, water and the extinguishing of a burning splint.

Question 4 Qualitative Analysis

(a) The more able candidates looked for the differentiating tests in the table; a small number omitted excess ammonia. Many used other tests not from the table including: litmus, flame test, silver nitrate, iodine solution, biuret and Benedict's.

(b) Candidates found this very challenging. Flame tests require the solid to be on a clean wire or the solution to be soaked into a splint and then placed into the top of a blue flame. Many placed the solid onto a spatula or spoon, between tweezers or in a test-tube, beaker or evaporating basin and then heated or described a flame test as the tests for oxygen or hydrogen.

(c) Only the more able candidates gained credit. Copper was more well known than sulfate. Incorrect responses included: copper chloride, iron, copper and chlorine.

Question 5

(a) Candidates found this very challenging with a significant number gaining no credit. Many selected most of the apparatus needed but could not assemble it without drawing large gaps that would prevent the apparatus from being airtight. The flask was often round bottomed rather than conical and the collecting vessel was often a test-tube or beaker rather than a measuring cylinder. Where a collecting measuring cylinder or test-tube was drawn it was often sealed with a stopper or was upright in air. Many candidates added a superfluous condenser or burette and the reagents were often unlabelled.

(b) Only the more able candidates gained credit. Measuring cylinder and pipette were frequently chosen. Those that chose syringe often did not label it.

Question 6 Determining *g* using a pendulum

(a) (i) The majority of candidates measured the distance correctly. 6.1 and 4.9 were common incorrect responses.

(ii) Many candidates calculated the value correctly. The most common error was to round the value to a whole number, 59 becoming 50 or 60.

(b) Almost all candidates recorded the time correctly.

(c) The idea of repeating was quite well known. Common incorrect responses included: round the value, divide by 20, divide time by number of oscillations and parallax error.

(d) (i) The majority of candidates divided by 20. Dividing by 10 was the most common error.

(ii) The majority of candidates calculated T^2 correctly with many not giving the answer to one decimal place. A significant number doubled T rather than squaring it.

(e) (i) Graphs were generally well drawn. The most common error was a non-linear x-axis with 0, 10, 20, 25 and 30 on successive major grid lines.

(ii) Many candidates drew a good best-fit line through the points they had plotted. A significant number drew multiple lines.

(f) A significant number omitted this question. Many candidates did not indicate the values on their graph and so were unable to gain credit as the values chosen could not be verified. The clearest way to indicate is to draw a triangle on the graph line. Those who did indicate on their graph often did not use at least half of the line between the highest and lowest point plotted so did not gain credit. Many inverted the division for the gradient.

(g) The majority of candidates calculated the value correctly using their value of the gradient.

Question 7 Energy stored in a spring

(a) Most candidates measured the length correctly. 5.1 was the most common incorrect response,

(b) (i) Most candidates calculated the two extensions correctly. The most common error was to subtract L from l resulting in 8.6 and 12.

(ii) Whilst most candidates calculated the values correctly, many did not give their answers to two significant figures. 0.0205, 0.02, 0.08, 0.09 were all common.

(c) Candidates found this challenging. It is expected that the energy stored for 1 cm is multiplied by four, or the value for 2 cm is divided by four and then the values compared. Answers such as: they are the same because they are very close are insufficient; the data needs to be used in a calculation.

(d) Many candidates suggested that the experiment needed to be repeated but fewer appreciated that this should be for different loads. Other common responses not worthy of credit included: use a longer spring or a different spring.

(e) The majority of candidates cited a safety precaution but some did not explain why it should be used. The most common non-creditworthy response was wearing gloves so that hands could not be trapped in the spring.