COMBINED SCIENCE

Paper 0653/12
Multiple Choice (Core)

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

General comments

Candidates performed very well on **Question 7** and **Question 12** in the biology section, **Question 16** and **Question 24** in the chemistry section, and **Question 32** and **Question 39** in the physics section. **Question 5**, **Question 14**, and **Question 31** proved most difficult for candidates.

Comments on specific questions

Question 1

Most candidates chose the correct option, however, some opted for option **A** or **C**. Option **D** was dismissed by almost all candidates.

Question 2

Most candidates chose the correct option. Some candidates chose the incorrect option **B** (cytoplasm), with a few incorrectly opting for the nucleus (option **C**).

Question 5

Some candidates found this question challenging. The most common incorrect option selected was option **B**, indicating that candidates knew that magnesium deficiency led to a decrease in chlorophyll, but did not make the link from a decrease in chlorophyll to the effect that this would have on growth rate.

Question 6

Most candidates chose the correct option. All candidates dismissed a fat deficiency link to a lack of red blood cells. Some candidates incorrectly chose either calcium or glucose.

Question 9

Most candidates chose the correct option. Some candidates chose the incorrect option **B** (bronchus).

Question 11

Most candidates chose the correct option. The most common incorrect option selected was Option **B** (fusion of a female zygote and a male gamete).

Question 13

Most candidates chose the correct option. Several candidates incorrectly opted for **A** (combustion and fossilisation).

Question 14

Candidates chose the incorrect option **B** more often than the correct option **C**. They were expected to understand that as the pressure of a gas increases, the particles move closer together without any change in the speed of movement of the particles.

Question 15

Many candidates chose the correct option. The most common incorrect option selected was Option **D**.

Question 19

Most candidates understood that the addition of oxygen to a substance is an oxidation process (Option **B**). Some candidates chose the incorrect option **C** (neutralisation).

Question 20

Some candidates chose the incorrect option **D** rather than the correct answer, **A**. Option **B** and **C** were also selected by some candidates. They were expected to know that acids react with metals to produce hydrogen gas, as well as the positive test for this gas.

Question 23

Some candidates chose the incorrect option **B** rather than the correct option **C**. They were expected to know that molten ionic substances, such as sodium chloride, and metals or mixtures of metals, such as brass, are electrical conductors. They should also know that naphtha is a hydrocarbon, and that as hydrocarbons contain only covalent bonds, they are not electrical conductors.

Question 30

A few candidates chose either option **A** or **B,** both of which suggested that rotating the block changes the force it exerts on the table. The force, of course, does not change and most candidates gave an answer consistent with this understanding. The most frequently chosen answer was the correct option **C,** which stated that the pressure decreases. However, there were candidates who gave option **D**. It is possible that there was some confusion caused because the area of contact increases or perhaps the diagram was misinterpreted.

Question 31

This question asked about the work done *W* and this depends only on the force exerted and the distance moved. The time taken does not affect the work done. The correct answer **D** was the most commonly chosen, but option **C** was selected almost as frequently. Some candidates chose **A** or **B**, but these were less popular.

Question 34

The most straightforward approach to this question was to deduce from the graph the fact that water at the point indicated passes through a complete cycle in 0.20 s. It then follows that in 1.0 s, the water oscillates up and down through five complete cycles and that this corresponds to five wavelengths passing through the point. The correct answer was the most popular option selected. The other options were selected by a similar number of candidates as each other, with **A** just slightly more commonly selected than **B** or **C**.

Question 38

The correct answer, option **B**, was the most commonly chosen and the other option that suggested a decrease in the current (option **A**) was also selected by several candidates. Only a small number of candidates gave an answer that suggested that an increase in the resistance would produce an increase in the current. Those candidates who realised that the ammeter reading would decrease but thought the voltmeter reading would increase may have not fully understood which voltage was being read by the voltmeter or may have been attracted by the pattern of a decrease paired with an increase.

Question 40

Most candidates selected the correct option **C.** A small number of candidates selected either **A** or **B**. Some candidates chose option **D**, which suggested that the fuse supplies a current in the circuit.

COMBINED SCIENCE

Paper 0653/22
Multiple Choice (Extended)

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

General comments

This paper is designed to test the entire subject content of the syllabus and not just the extension material.

Candidates performed very well on **Question 1**, **Question 3** and **Question 9** in the biology section, **Question 14**, **Question 25** and **Question 26** in the chemistry section, and **Question 28** and **Question 30** in the physics section.
Question 7, **Question 16**, and **Question 34** proved most difficult for candidates.

Comments on specific questions

Question 4

Candidates usually picked the correct option **B**. However, some candidates incorrectly thought that **A** was the temperature at which the enzyme worked best. A very small number of candidates chose **C**, and **D** was the least selected.

Question 6

Most candidates chose the correct option **C** (pancreas). Some candidates incorrectly chose option **B** or option **D**. Very few candidates selected option **A**.

Question 7

Most candidates chose the correct option **A**. Option **C** was chosen by some candidates. Candidates should be reminded that the pulmonary artery takes deoxygenated blood from the heart to the lungs.

Question 10

Most candidates chose the correct option **B**. Some candidates incorrectly opted for **C**, thinking that male flowers lacked petals.

Question 11

Most candidates chose the correct option **A**. Some candidates incorrectly thought that an egg cell has a flagellum.

Question 13

Most candidates chose the correct option **C**. Some candidates incorrectly thought that combustion removes carbon dioxide from the atmosphere.

Question 21

Candidates were able to use a reaction equation to determine which substance is reduced during the reaction. They also understood the meaning of oxidising agent and reducing agent.

Question 22

Candidates knew very well where metals and non-metals are positioned within a period of the Periodic Table.

Question 23

Candidates were expected to know that alloys are mixtures of a metal with another element, and that the presence of the metal makes alloys electrical conductors. They are also expected to know that solid salts contain ions that are not free to move, and that these salts only conduct electricity in the molten or the aqueous state.

Question 27

Many candidates were able to complete the equation for the cracking of octacosane, $C_{28}H_{58}$, by choosing from the list of suggested other products.

Question 31

More candidates selected the incorrect option **B** than selected the correct option **D**. The two options were the two energy stores that relate to the situation, namely the gravitational potential energy store and the thermal energy store. The parachutist is falling and so the energy in the gravitational potential energy store is decreasing rather than increasing. It is probable that candidates who selected the gravitational potential energy store realised that it is involved in some way but did not relate the constant speed of the parachutist to the presence of air resistance. The work done against air resistance is the mechanism that transfers energy from the gravitational potential energy store to the thermal energy store.

Question 32

This question required knowledge of and the application of the equation KE = $\frac{1}{2}mv^2$. Many candidates were able to do this and then to select the correct option. The only incorrect option chosen by a significant number of candidates was option **A**. To obtain this answer, it was necessary to subtract the initial speed from the final speed and then to square the answer. This is not mathematically identical to squaring the speeds before performing the subtraction and so it generated an incorrect answer.

Question 34

The way in which this question was answered illustrated a common and widespread misunderstanding of the role of electrons in thermal conduction in metals. Most candidates realised that options **A** and **B** both suggested the translation of atoms within the structure in some way and were incorrect. Of the two options that involved electrons in the conduction process, a majority opted for the incorrect option **D**. This option suggested that thermal energy is conducted in a metal by vibrating electrons transferring energy to their neighbours. This is essentially a description of a mechanism similar to that of the mechanism by which atoms transfer energy in both metals and non-metals but with electrons substituted for atoms. The transfer of thermal energy by electrons is more accurately described by the correct option **C**.

Question 35

The most commonly selected option was the correct option **A**. A noticeable number of candidates choose option **D** which, in terms of the arrangement of options, is the exact opposite answer. These candidates probably knew that black and dull surfaces are good absorbers of thermal radiation and then incorrectly suspected that good emitters of thermal radiation will have the opposite properties since emission is the opposite of absorption. Good emitters of thermal radiation are also, of course, good absorbers. Few candidates chose either of the other two options.

Question 36

When light passes through a thin converging lens, it is possible to draw a diagram with three rays that can be drawn exactly without any other rays being drawn first. Of these, the ray that first passes through the nearer focal point, then changes direction as it passes through the lens and which then emerges parallel to the principal axis, is the one needed to answer this question. This was the lower of the two rays shown and it passes through the principal axis at the focal point. Hence option **A** was correct. This was the most popularly selected answer, although some candidates choose either option **B** or option **C**. Option **D** was only very rarely selected.

COMBINED SCIENCE

Paper 0653/32
Theory (Core)

Key messages

Candidates who did well on this paper:
- read the questions carefully
- were familiar with the contents of the syllabus
- were able to express their responses in a clear way
- showed their working in numerical answers
- were able to apply their knowledge to unfamiliar situations.

General comments

Many candidates had prepared well for the examination and produced very good answers. There was evidence that other candidates were not fully familiar with the contents of the syllabus.

The use of space on the paper was good. Very few candidates repeated the question, and most responses were written within the allocated answer lines in the paper.

Comments on specific questions

Question 1

(a) This question was generally well answered. The most common error seen was vacuole matched with site of photosynthesis. Candidates should be reminded that photosynthesis occurs in the chloroplasts which are in the cytoplasm. The large vacuole in plant cells pushes the cytoplasm outwards so that it forms a thin lining inside the cell wall. This pressure of the vacuole against the cytoplasm and the cell wall keeps plant cells firm and provides them with support.

(b) (i) Most candidates stated testes, the correct response. There was no pattern to the incorrect answers. Most incorrect responses referred to other parts of the male reproductive system, for example sperm duct and prostate gland.

(ii) Many candidates were familiar with this type of calculation and scored full credit. Others multiplied the magnification by the length to give the answer 18 000 mm.

(c) (i) Most candidates stated oviduct to gain credit. Ovary was the most common wrong answer.

(ii) Most candidates completed the sentences correctly. Errors included stating gamete for the first response and zygote for the second response. Candidates should be aware that the fertilised ovum is called the zygote which then divides into the ball of cells called the embryo.

Question 2

(a) This question was generally answered well.

(b) Most candidates found this question challenging. The answer required a description of the loss of an electron by a lithium atom. There were many incorrect answers, including changes in electrons, the gain of an electron, both loss and gain of electrons, ionic bonding and that it shares electrons.

(c) (i) Many candidates completed the equation correctly. The most common error in balancing was stating 2Li instead of 4Li on the left-hand side of the equation. Candidates are reminded that there are two atoms of lithium in Li_2O, and to balance the oxygen atoms in the equation, $2Li_2O$ must be formed, therefore needing 4 atoms of lithium to react.

(ii) This question was generally answered well.

(iii) Most candidates answered this question correctly. Some candidates were not familiar with the term exothermic, and many of their responses were descriptions of the chemical reaction described in the stem of the question.

(d) Most candidates answered this correctly.

(e) Most candidates gained credit by using their knowledge of Group I metals and information given in the question. Uncreditworthy answers included references to the lithium exploding, and that lithium is a poor conductor of heat.

(f) Generally, candidates found this question challenging. A few responses referred to the finite supply of metals and gained credit. Responses that were not awarded credit included vague references to recycling being better for the environment, descriptions of the practical advantages of recycling and the fact that it is cheaper. The question indicated that cost should be excluded from the answer, so careful reading of the question would have avoided these incorrect answers.

Question 3

(a) Some candidates stated nuclear fission correctly. Others stated nuclear fusion, nuclear power, combustion, thermal energy, or exothermic reaction. It was important for candidates to have the correct spelling and clear handwriting in this response. A response such as nuclear fuission did not gain credit as it was not clear whether (nuclear) fusion or fission was intended.

(b) (i) Most candidates drew the correct symbol for a fuse. Incorrect responses included symbols for switches, heaters and variable resistors. Candidates should be aware that the syllabus contains a list of electrical symbols required for the examination.

(ii) Some candidates found this question challenging. The main misconception was stating that the role of a fuse was to control the current instead of preventing the current from getting too high, therefore protecting the circuit.

(iii) The main point here was for candidates to state that the insulation was damaged, leaving the bare wire exposed. Many candidates stated short circuit but there was not sufficient evidence to show how that could arise.

(c) (i) Most candidates did the calculation correctly. Some candidates did not state the correct unit, **Ω**, instead writing R or W.

(ii) Candidates found this question challenging. Many responses stated that a parallel circuit allows one branch to continue operating if the other branch fails. This information was provided in the introduction to the question, so was discounted from responses. Candidates are reminded that the current in a series circuit is the same throughout the circuit. A series connection would not allow the currents to be different.

Question 4

(a) (i) Many candidates stated white blood cells and gained credit. Others stated red blood cells and haemoglobin.

(ii) Many candidates gained credit for this question. Incorrect responses included pulmonary vein, vena cava, and just artery and vein. The blood vessel that transports blood from the heart must be an artery, since the blood vessels leaving the heart must be arteries, and since the artery is going towards the lungs, it is the pulmonary artery.

(iii) Candidates who were familiar with the syllabus completed this question well. Others responded with a range of answers. Examples for the first response included (A hormone is a chemical substance produced by a …): heart, brain, DNA, organ. For the second response (Hormones alter the activity of a specific …….. organ) the range of incorrect answers included: body, reproduction, human and tissue.

(b) (i) Most candidates answered this correctly.

(ii) Most candidates labelled the diaphragm correctly. There was no consistent pattern to the incorrect responses. Some candidates mislabelled other parts of the respiratory system. Others did not attempt this question.

(c) (i) Candidates found this question challenging. Many candidates stated that the water vapour is lost from the leaves by transpiration without demonstrating any knowledge of the process of transpiration, the diffusion of water vapour through stomata in the leaf. A common error was stating osmosis instead of diffusion. Osmosis occurs in a liquid medium and during transpiration the diffusion of water vapour is a gas.

(ii) The inverse relationship between transpiration rate and humidity was stated correctly by most candidates.

Question 5

(a) Most candidates identified nitrogen and oxygen correctly. Fewer candidates gained credit for the white area in the pie chart, with carbon dioxide and water vapour being the least chosen responses.

(b) Many candidates gained credit for stating an adverse effect of carbon monoxide. Fewer knew an adverse effect of oxides of nitrogen. There were many vague responses that did not gain credit, for example, affects plants, breathing problems, bad for health, or dangerous to humans.

(c) (i) Most candidates could interpret the information in the question to complete the word equation with the correct reactant and products. Some candidates tried to write the equation using symbols. Candidates are reminded to read the question carefully before answering.

(ii) Most candidates chose a pH value in the acceptable range. Incorrect responses included pH values of 7 or above.

(d) Many candidates gained full credit for this question. Partial credit was awarded to those candidates who showed one pair of electrons being shared. Incorrect responses included two pairs of electrons in the bond and incorrect or missing electrons in the rest of the molecule.

Question 6

(a) (i) Many candidates stated **Q** to gain credit for this question. The most common error was **S**. Force **S** represents the frictional forces that oppose the movement, whereas force **Q** is the driving force which makes the boat move to the right.

(ii) Many candidates successfully stated weight to gain credit. Gravity, stated by some candidates, was not accepted. Candidates are reminded that the force labelled **R** is the weight, which is the product of the mass and the gravitational field strength.

(iii) This question was challenging for most candidates. Forces **S** and **Q** must be equal and opposite so that the boat will not accelerate or decelerate. If there was a difference between the value of the forces the speed would change. Incorrect responses included that the boat won't move if the forces are the same, and that the boat might overturn if the forces aren't balanced.

(b) Many candidates calculated the resultant force correctly, but they did not describe the direction of the force accurately. The direction of movement of the force was towards the boat so that the fish can be retrieved when caught.

(c) (i) Most candidates correctly interpreted the positive gradient of the graph as increasing speed.

(ii) Candidates found this question more challenging. Many stated that the speed of the fish was decreasing. These responses did not gain credit. A decreasing speed would produce a line on the graph with a negative slope. The graph shows that at 2 sec the speed goes directly to zero. Therefore, the fish must have stopped.

(d) (i) Most candidates knew that there would be a decrease in temperature of the fish as thermal energy is transferred from the fish to the ice. The ice, in turn, will gain thermal energy and start to melt. Some candidates stated that the temperature of the ice increases. This response did not gain credit because thermal energy from the fish would be used to change the state of the ice before raising the temperature. There would not be enough thermal energy given out by the fish to melt the ice in the bucket and then raise the temperature.

(ii) Many candidates did well in this question. The equation $\rho = m/V$ was known by most candidates and credit was awarded for this. Before the equation could be applied to the data, the mass of the bucket had to be subtracted from the total mass of the bucket and ice. Some candidates did not do this.

Question 7

(a) (i) Many candidates found this question challenging. The key to obtaining a correct answer involved interpreting the diagram. Incorrect responses included respiration, decomposition and fossilisation. Some of these terms are often found at the bottom of other diagrams of the carbon cycle, but they do not represent process **B**.

(ii) The equation for photosynthesis was well known by many candidates. A common error was sunlight as the second reactant, rather than water. Candidates are reminded that sunlight is a necessary condition for photosynthesis to take place, not a reactant.

(iii) This was generally answered well.

(b) (i) Some candidates found this question challenging, stating food chain instead of food web. A food chain does not have any branches, but a food web does contain branches, showing that more than one organism can feed on the same food.

(ii) Most candidates answered this correctly.

(iii) Only a few candidates drew the arrow the wrong way round. Candidates should be aware that the arrow shows the direction of energy flow, in this case from the gazelle to the lion.

(c) Most candidates stated a suitable environmental condition for germination. A few candidates stated warmth as a condition. Careful reading of the question excluded this as a response, as it had already been mentioned.

Question 8

(a) The first part of the question needed an explanation stating that the hydrocarbon contains a double bond. Common errors included that the hydrocarbon contains only single bonds, or a statement that the molecules are unreactive. Some candidates described unsaturated in terms of a solution which can dissolve more solvent. This was the wrong context for the term unsaturated, which in this case is the topic alkenes. More candidates gave a correct definition of the term hydrocarbon. Candidates are reminded that the hydrocarbon molecule consists of only hydrogen and carbon atoms. There are many molecules that contain hydrogen, carbon, and other elements. These are not hydrocarbons.

(b) Most candidates gained at least partial credit for this question. They expressed their answers in a variety of ways. The important points to make were the random arrangement of particles in a gas and that they move quickly. Candidates who referred to the word ‘packed’ were not given credit because this implies that the particles are close together.

(c) Candidates found this question challenging. This was because they had to visualise the state of ethene at a temperature below its melting point. A common error was to say that –190°C was a higher temperature than –169°C, disregarding the negative sign in front of the numbers.

(d) Many candidates gained credit in this question by stating combustion. Incorrect responses included reduction, and various attempts to write either word or symbol equations.

(e) Many candidates gained credit for this question. Ethene is an unsaturated hydrocarbon, so addition polymerisation is possible.

Question 9

(a) (i) The first part of the question was generally well answered. Candidates stated the electromagnetic spectrum for the regions of visible light and infrared radiation. The second part of the question was more challenging. Successful candidates recalled that the frequency of visible light is higher than infrared. Incorrect responses included lower, longer and shorter.

(ii) Many candidates gained credit for this question. Some candidates stated that radiation is the only way in which energy is transferred through space, without stating why conduction and convection cannot be transferred through space.

(b) (i) Most candidates used the average speed = total distance/time equation successfully. Some candidates were not successful in converting the days to hours, so only partial credit could be awarded in these cases.

(ii) This question was generally answered well.

COMBINED SCIENCE

Paper 0653/42
Theory (Extended)

Key messages

Candidates who did well on this paper:

- had learned the syllabus material thoroughly, including definitions of important terms
- read the questions carefully and avoided irrelevant material in their answers
- used the allocation of marks for each question to guide the level of detail they should include in their answers
- in calculations, set out their working clearly and included the symbolic relationship between the relevant variables.

General comments

Many candidates demonstrated strong knowledge with understanding in each of the science disciplines and wrote clear, well-organised answers. Candidates usually showed their working in calculations, whether instructed to do so or not, and this is good practice. Working was often set out very clearly which made it easier to award partial credit for correct steps even if the final answer was incorrect.

Candidates generally had no difficulty in finishing the paper in the time allowed.

In Biology, candidates showed good knowledge of the human digestive system **Question 1**, were often able to interpret data in the biological contexts in **Question 4**, and were familiar with human reproduction and the dangers of smoking in **Question 7**.

In Chemistry, many candidates were able to draw a dot-and-cross covalent bonding diagram in **Question 2**, and stronger candidates showed excellent understanding of the reasons for differences in boiling point in terms of particle interaction. Candidates showed that they understood electrolysis at the particle level in **Question 5**, and many were familiar with word and balanced chemical equations. Many candidates showed good knowledge of organic chemistry in **Question 8**.

In Physics in **Question 3**, many candidates were familiar with the use of relationships involving speed, distance and time and also wave speed, frequency and wavelength. In **Question 6**, many candidates completed an electrical power calculation accurately and showed that they had learned that the currents in the branches of a parallel circuit combine to give the overall current. Stronger candidates were familiar with the process of nuclear fusion and fission. Most candidates were successful in most parts of **Question 9**, which tested understanding of a force diagram, the calculation of the area under a speed/time graph and the calculation of kinetic energy.

Comments on specific questions

Question 1

(a) (i) Most candidates correctly identified the liver. However, some candidates did not seem to realise that they had to label the liver on the diagram.

(ii) Most candidates correctly identified the pancreas.

(b) In answering this question, candidates needed to be careful in their choice of words. Any word which meant 'pieces' was accepted for the first space. 'Molecules' was not accepted. There were no alternatives for 'molecules' in the second space. Credit was not awarded for the word 'particles'.

(c) The function of amylase was familiar to many candidates. Credit was not awarded for stating that 'carbohydrates' rather than 'starch' were broken down. Credit was awarded for the digestion products glucose and maltose. Some candidates suggested sucrose or maltase.

(d) Stronger responses made the two key points that the environment in the stomach is acidic, and that enzyme **A** works best in acidic conditions. Many candidates were awarded partial credit because they stated only one of the key points, possibly because they thought that they had given enough information to gain full credit. Stronger responses avoided vague answers such as "the enzymes in the stomach are acidic" or "enzyme **A** has a low pH".

Question 2

(a)(i)-(iv) Candidates generally had few difficulties gaining credit. Candidates knew **(i)** and **(ii)** very well with **(iii)** and **(iv)** proving to be equally familiar for some candidates.

(b) Many candidates were familiar with the bonding diagram of a nitrogen molecule.

(c) This was a challenging question for many candidates. The best answers referred to the structural differences between potassium nitrate and nitrogen, the difference in the attractive forces in these substances and the difference in the energy required to separate particles. Candidates needed to refer to both substances when making these comparisons and so full credit could not be awarded for a description of only one of them even if the description included correct information. Common misconceptions included the ideas that potassium nitrate must have a higher boiling point because it contains a metal or that it was a compound, whereas nitrogen is only an element. Some candidates did not appear to realise that their answers needed to explain the reasons for the difference in boiling point. This was revealed in answers such as "potassium nitrate is a crystalline solid but nitrogen is a gas and so they must have different boiling points".

Question 3

(a) Many candidates were awarded full credit. Most used the relationship *time* = *distance* ÷ *speed* to find the time in hours, 2250. The instruction in the question to 'show that the time is 94 days' meant that candidates needed to state how 2250 hours converted to days. Some candidates missed this final step and wrote "2250 hrs = 94 days".

(b) Most candidates suggested 'white' and 'shiny'. Alternative suggestions such as 'a light colour' and 'smooth' were accepted but answers such as 'made of metal' or 'reflective' were not.

(c) (i) Most candidates correctly stated visible and infrared.

(ii) Most candidates knew that they had to use the relationship *wave speed* = *frequency* × *wavelength*. Many candidates omitted to convert the wavelength to metres but if their working was clear they were awarded partial credit. Candidates who selected 470 nm rather than 800 nm could also gain partial credit if clear working showed this was the only mistake.

Question 4

(a) This proved to be quite a challenging question. Some candidates stated that "the root was the stem and the stem was the root" but this gained only partial credit. Credit could not be awarded for vague answers such as "root and stem". Some candidates missed the point that the root and stem diagrams were interchanged and made suggestions such as "the stem should not have projections". Others described features that they assumed had been omitted from the diagrams.

(b) Some candidates were very well-prepared for this question and some excellent answers were seen. Most candidates were awarded partial credit for describing the pattern shown on the graph, others went on to explain it.

(c) (i) Most candidates had learned the balanced equation for photosynthesis and were awarded full credit.

(ii) The question asked candidates for a cell structure and not the type of cell where photosynthesis occurs. The required answer, chloroplast, was given by many candidates but a similar number suggested palisade mesophyll. The other most common incorrect answer was chlorophyll.

(d) Most candidates answered this question about feeding relationships very well. The most common reasons for full credit not being awarded were that the musk ox was assigned to trophic level 1 and the snowy owl was assigned to levels 2 and 3.

Question 5

(a) (i) In general, candidates were familiar with the importance of mobile ions in electrolysis. Some candidates stated that atoms or molecules had to be mobile. Others made simple statements such as “zinc chloride has to be a liquid for electrolysis to work” or “solid zinc chloride does not conduct”. Some others suggested that zinc chloride had to be molten to avoid unwanted products from an aqueous electrolyte.

(ii) Most candidates correctly expressed the idea that the electrodes must not react. Any wording that suggested this idea was accepted. Answers such as “the electrodes must have a full outer shell” were not accepted.

(iii) Candidates had to refer directly to the gain of electrons by positive ions. The wording in the question was intended to prompt candidates to mention electrons but this was often missed. Some candidates suggested that electrons were gained by chloride ions or the electrode. Credit was awarded for a correct electrode equation showing electron gain by zinc ions.

(b) Some candidates were familiar with halogen displacement and gained full credit. However, some candidates wrote ‘bromide’ rather than ‘bromine’ or omitted the products altogether. Some candidates mistakenly included water in the equation. Partial credit was awarded for a fully correct balanced equation, but candidates should be advised that if a word equation is requested, this should be given.

(c) Many candidates knew the meaning of the term ‘diatomic’, but their answers needed to express the idea that diatomic molecules contain only two atoms bonded together. Answers such as “for example Cl_2” without explanation did not gain credit.

(d) Many candidates were familiar with this equation. The credit available for correct balancing depended on correct chemical formulae.

Question 6

(a)(i)-(ii) The terms ‘fusion’ and ‘fission’ were familiar to many candidates, but they were often reversed. Other common incorrect suggestions for both fusion and fission included thermal energy, solar power, radiation, radioactivity and combustion.

(iii) Most candidates found it challenging to define fusion and fission and any wording that showed candidates understood that fusion involved a joining process and fission involved splitting was credited. Wording that suggested that chemical bonds were being formed or broken was not accepted. One type of answer that was not credited was the suggestion that fusion was a natural process but fission was man-made.

(b) Most candidates were very familiar with the relationship *power = p.d.* $\times$ *current* and could use it to find the power supplied to the heater. Common errors included forgetting to convert 1920 W to kW and incorrect forms of the formula for power.

(c) (i) Most candidates identified the circuit symbol for a motor. The most common mistake was to suggest meter.

(ii) Many candidates understood that the currents in the parallel branches add to give the current in the main circuit and were awarded full credit. Some candidates did not realise that this was a straightforward question and attempted complicated calculations involving resistance in parallel circuits even though no values of resistance were given.

(iii) Many candidates wrote answers that were statements of Ohm's Law. Credit was awarded to candidates who realised that ammeter **A1** showed the total current in the main circuit and that changing the resistance in one of the branches would change the overall resistance, therefore changing the main current.

Question 7

(a) This was answered very well and many candidates gained full or partial credit. One mistake which was frequently made was to suggest that sperm cells rather than egg cells contain an energy store.

(b) Many candidates had learned the functions of the placenta and were awarded credit for describing the transfer of nutrients to the fetus and the removal of waste from the fetus. The term 'food' was not accepted as an alternative for nutrients. Some candidates also referred to the placenta preventing the transfer of toxins to the fetus. A common reason why some candidates did not gain credit was that they described the functions of the uterus and amniotic fluid rather than answering the question set.

(c) Generally, this question was very well answered. Many candidates identified either carbon monoxide or tar as the toxic components affecting gaseous exchange. The reduced oxygen uptake by red blood cells caused by carbon monoxide was familiar to many candidates as was the damaging effect of tar on the lungs generally and the alveoli in particular. Candidates needed to specify that tar is associated with lung cancer rather than simply stating "cancer".

Question 8

(a) (i) Most candidates recognised fractional distillation. Of the few incorrect answers, cracking or simple distillation were the most common suggestions.

(ii) This was answered very well by many candidates. Some candidates reversed the properties of the two fractions.

(b) Many candidates had learned the definition of homologous series and so were awarded full credit. It was important to avoid phrases such as "compounds that have the same properties" which was not accepted as an alternative for "similar chemical properties".

(c) (i) Most candidates were awarded credit for this question.

(ii) Most candidates were familiar with at least one condition needed for cracking and many gained full credit. Unqualified answers such as temperature or heat were not accepted.

(iii) The strongest answers stated clearly that saturated hydrocarbon molecules contain only single bonds or contain single bonds between the carbon atoms. Answers such as "compounds with single bonds" were not accepted. Answers that attempted to describe the relative unreactive nature of saturated hydrocarbons, without reference to bonding, were not accepted.

Question 9

(a) (i) Most candidates correctly stated force **S**. The most common incorrect answers were **R** and **Q**.

(ii) Almost all candidates answered this correctly.

(b) (i) There were many excellent answers to this calculation. Credit was awarded for evidence that candidates knew that distance was related to the area under the graph. This could have been a direct statement or evidence from arithmetic expressions. Clear working allowed some candidates to be awarded partial credit for correct steps in the calculation.

(ii) Many candidates used the relationship *energy* = *power* × *time* and included all the steps required to show that the total energy was 300 kJ. Answers that showed the energy in J were accepted if the units were clearly stated.

(iii) The relationship, $KE = \frac{1}{2} \times m \times v^2$ was familiar to most candidates, many of whom gained full credit. A common mistake was to state the answer in J rather than kJ.

COMBINED SCIENCE

Paper 0653/52
Practical Test

Key messages

- It is essential that confidential instructions are carefully followed. For **Question 1**, some candidates did not start with water which was hot enough to collect data of sufficient quality to process.
- Candidates need to take careful note of instructions given in the questions. Where they are instructed to record answers 'to the nearest 0.5 °C', for example in **Question 3(a)(i)** and **(ii)**, it is essential that values are given to one decimal place, which may be .0 or .5.
- To gain full credit in the planning question, it is important for candidates to read the question carefully and investigate the variables stated in the question. It was common for candidates to choose to vary incorrect variables. It is also essential that all bullet points in the question are addressed. Not addressing some of the bullet points prevents full credit from being awarded.

General comments

It appeared that some candidates did not make use of the 'Notes for use in Qualitative Analysis', which are provided at the back of the paper and are in the syllabus. It is essential that chemical observations are made in line with these notes, and that observations are recorded to give both a colour and a state.

Guidance for the requirements for the practical component can be found at the back of the syllabus. Teachers are referred to Section 4.

It should be further noted that guidance on the proper presentation of graphs is given in the 'Mathematical requirements' and 'Presentation of Data' sections at the back of the syllabus.

Comments on specific questions

Question 1

In some cases, the water provided by centres was not at a high enough temperature. The starting temperature for some experiments was below 50 °C. In addition, the starting temperature for the two tubes was often very different, implying either that different sources of water were used or that the candidates took too long setting up their experiments. It is essential that the confidential information is followed carefully to ensure that candidates can record high quality data.

(a) (i) Almost all candidates correctly entered data to show a decrease in temperature in both tubes. Some included units (°C) in the body of the table. This is not good practice but was ignored in this question.

(ii) Most candidates correctly calculated the change in temperature for both test-tubes.

(iii) In order to draw a conclusion for results, candidates needed to refer to the aim of the original investigation. The information at the start of the question referred to the student investigating the effect on heat loss of standing in a huddle. Therefore, to draw a full conclusion, candidates needed to link the temperature changes to heat loss. The strongest answers identified that heat loss was lower in the huddle. However, some candidates only referred to temperature change being greater. This only described the results and did not make a conclusion so could not be awarded credit. Another common error was to only describe the change, stating that "temperature decreases". Again, this was not a conclusion for this investigation.

(b) The strongest answers identified that the initial temperature of the two test-tubes was not the same. It should be noted that candidates need to avoid giving generic phrases. Some candidates gave vague answers such as "more reliable", "more accurate" or "easier to see".

(c) This question asked candidates to identify a variable. Stronger answers identified a variable that would differ between either individual penguins or between different huddles or would differ over time. Such answers referred to external temperature, the surface area of different huddles, wind speed or the thickness of the feathers on the penguins. Some candidates incorrectly listed an adaptation of penguins, which was likely to be the same for all penguins, rather than a variable. These answers did not gain credit. Such answers included comments such as "penguins have feathers" or "penguins are white".

Question 2

Some candidates gave brief answers to the planning question and others left some or all of the question unanswered. It was common for candidates to miss some of the bullet points and to only give a partial plan to address some of the aspects of the investigation.

There were two common reasons why full credit could not be awarded for the planning question. Some candidates did not refer carefully to the factor that they were asked to investigate (in this case intensity of exercise). Many answers did not clearly vary the exercise intensity or develop a clear method of doing so. It was also quite common for candidates to plan an investigation of other variables**,** such as age or fitness level, or to vary more than one factor at a time. Best practice is to consider the bullet points carefully and to use these to structure answers. For full credit it is essential that content is included against each of the bullet points.

Apparatus: Most candidates suggested the use of a stop-clock or timer, but not all candidates clearly described how it would be used to measure pulse rate. Fewer candidates suggested appropriate exercise equipment such as a treadmill or fitness weights.

Method: The minimum viable method was to measure initial and final pulse rate before and after exercise of variable intensity. Some candidates stated that they would do this. Answers which did not investigate intensity of exercise as the main variable could not be awarded full credit.

A common error in the method included omitting measuring initial pulse rate, so basing the results only on the pulse rate after exercise. In addition, many candidates did not clearly state that they would vary the exercise intensity. As this was the main point of the investigation, such answers could not gain full credit.

Some candidates gave details of their method, and the strongest answers included a clear description of how the intensity of the exercise could be varied. Common suggestions included walking, jogging and running or the use of different speeds on a treadmill. Other answers suggested lifting weights for different numbers of repetitions. Some candidates identified the need for pulse rate to return to normal between periods of exercise and some gave clear safety precautions, such as the need to wear suitable shoes or to check the fitness of the individual before the test began.

Measurements: Some candidates gave a detailed description of how they would measure the exercise intensity. Examples included setting the speed on a treadmill or measuring the duration of the exercise. However, some candidates made errors in the use of units. Candidates are expected to use SI units. 'Min' is acceptable as an abbreviation for minutes, but 'm' is metres and so cannot be accepted as a unit of time. Similarly seconds or s are both acceptable, but 'secs' is not an accepted abbreviation for seconds. Several candidates did not make any clear point relating to the measurement of any of the variables.

Constant Variables: Candidates needed to refer back and double check the factor that they were asked to investigate and then identify other factors that needed to be controlled. A common error was to vary an incorrect factor, such as the person doing the exercise or the type of exercise, rather than keeping these constant so that only the intensity was changed. Stronger answers referred to varying the speed or number of repetitions within a fixed controlled time and identified the need to either use the same person or use people with the same characteristics such as age, sex, weight and fitness level.

Processing Results: This bullet point was often omitted, or vague references were made to drawing graphs without a clear statement of the identity of the axes. Some candidates included a sketch of the axes of a graph to process their results. This is good practice. Stating that it was necessary to take an average did not automatically earn credit unless it was clear that candidates would average several readings conducted under identical conditions.

Question 3

Throughout this question it appeared that some candidates did not make use of the qualitative analysis notes which are provided at the back of the paper. Observations should routinely include both a colour and a state, for example 'blue precipitate'. Vague descriptions such as 'cloudy blue' were not accepted.

(a) (i) The instructions stated that the temperature readings needed to be recorded to the nearest 0.5 °C, so the correct answer needed to show a '0' or '5' after the decimal point, for example 19.0 or 19.5. Many candidates ignored this instruction and gave answers to the nearest degree. A further error was to give values which did not show a '0' or '5' after the decimal point, such as 19.2, which cannot be a reading from a standard thermometer.

(ii) Almost all candidates correctly recorded a higher temperature at Step 5.

(iii) Most candidates gave a correct colour for the residue, but many either left the appearance of the filtrate blank or gave incorrect answers such as 'clear'. It should be noted that 'clear' is not an acceptable alternative for 'colourless' as coloured solutions are also clear.

(iv) Almost all candidates correctly subtracted the two values to calculate the temperature increase.

(v) Most candidates correctly substituted their temperature increase into the equation and calculated a final value. However, the instruction to 'give your answer to three significant figures' was often ignored. Some candidates quoted values to four or more significant figures.

(vi) The main reason for stirring in this experiment was to ensure that the temperature was even across the mixture before the measurement of temperature was taken. Some candidates stated this. Others made the reasonable points that stirring ensures complete reaction or speeds up the reaction. These answers were awarded credit. However, many candidates stated that stirring is to mix the reactants which did not explain why it is done sufficiently.

(vii) Most candidates suggested the use of insulation or a lid to prevent heat loss. A common error was to suggest an external source of heat, for example keeping it hot with a Bunsen Burner or heated water bath.

(b) Most candidates stated that a 'blue' colour was seen. This alone was not awarded credit. For descriptions of qualitative tests, it is essential that a colour and state are given, as modelled in the notes for qualitative analysis which are provided at the back of the paper. It is essential that candidates refer to these during the examination. To earn credit, candidates needed to clearly state 'blue precipitate' and 'dark blue solution'.

(c) (i) In common with **(b)**, candidates should have recorded qualitative test observations by recording a colour and a state. The correct answer here was 'white precipitate' (the colour of the solution was ignored and did not contribute to the answer). Some candidates instead attempted to give a visual description of the contents of the test-tube, describing cloudiness or layers. These answers were not accepted.

(ii) Most candidates identified the positive ion in the salt as a copper ion, but fewer were able to identify that the salt was a chloride. A number of candidates did not answer this question.

Question 4

It should be noted that guidance for the construction of graphs is given in the 'Mathematical Requirements' and 'Presentation of Data' sections at the back of the syllabus.

(a) (i) This question was usually answered well. Almost all candidates recorded their values for current to two decimal places and their values for voltage to one.

(ii) Most candidates recorded values showing the correct trend of voltage increasing with a decrease in current.

(b) This question was answered well. Most candidates correctly calculated resistance values. It should be noted that candidates were not instructed how many decimal places to use in their values, so any number were accepted. However, wherever appropriate, values should be rounded appropriately.

(c) (i) Most candidates chose suitable, linear scales which enabled the plotted points to cover at least half the grid. Almost all candidates plotted points correctly. Errors were usually due to incorrect values being entered on the axes and some candidates using non-linear scales.

(ii) The line of best fit was not well drawn by most candidates. Some attempted to join the points with a wavy line that went through all of the points. Thick, feathered lines or lines that were not clearly straight were not accepted.

(iii) This question was challenging for many candidates. Many omitted both the calculation and annotation on the graph. Some attempted to draw a triangle on the graph but this was often very small. Gradient triangles should occupy at least half the length of the line of best fit.

(iv) Some candidates gave the correct unit for resistance per unit length, but again, this question was often left unanswered. Ohms alone was the most common incorrect answer.

(d) Candidates needed to think about the practical difficulties they had encountered in the procedure. Expected answers included difficulty in placing the crocodile clip exactly on the metre rule. However, most answers were generic and referred to "not doing the experiment correctly" or "parallax error" or "human error" or "error when taking readings". Generic answers of this type were not accepted.

COMBINED SCIENCE

Paper 0653/62
Alternative to Practical

Key messages

- Candidates need to take careful note of instructions given in the questions. Where they are instructed to 'record your answer to the nearest 0.5 °C', for example in **Question 1(a)(i)**, it is essential that values are given to one decimal place, which were .0 or .5 in this case.
- To gain full credit in the planning question, it is important for candidates to read the question carefully and investigate the variables stated in the question. It was common for candidates to choose to vary incorrect variables. It is also essential that all bullet points in the question are addressed. Not addressing some of the bullet points prevents full credit from being awarded.
- When asked to record values in a table, it is essential that candidates use the other values in the table as an indicator of the resolution to which they should record their readings. For example, in **Question 4(a)(iii)** the value of the potential difference needed to be recorded to two decimal places.

General comments

In general, the performance on this paper was good. This was particularly the case in the quality of responses seen for the planning question. There were few omissions and almost all candidates attempted the planning question at some length.

Although the alternative to practical is a paper-based assessment, it is still intended that candidates have a substantial amount of practical work integrated into their course. The assessment is designed around written questions, but it is not intended that candidates only practise using written questions. Some candidates appeared to have had limited practical experience. Guidance for the requirements for this component can be found at the back of the syllabus in Section 4.

Comments on specific questions

Question 1

(a) (i) Almost all candidates read the thermometer correctly and recorded their value to 0.5 °C. A few candidates rounded their reading incorrectly to either 65 or 66.

(ii) Most candidates correctly calculated the change in temperature for both test-tubes. Resolution was not tested in this question; values expressed as 22 and 12 were accepted, but it should be noted that calculated differences in temperature should be recorded to the same resolution as the raw data, leading to the difference being expressed as 22.0 and 12.0.

(iii) In order to draw a conclusion for results, candidates needed to refer to the aim of the original investigation. The information at the start of the question referred to the student investigating the effect on heat loss of standing in a huddle. Therefore, to draw a full conclusion, candidates needed to link the temperature changes to heat loss. The strongest answers identified that heat loss was lower in the huddle. However, some candidates only referred to temperature change being greater. This only described the results and did not make a conclusion so could not be awarded credit. Another common error was to only describe the change, stating that "temperature decreases". Again, this was not a conclusion for this investigation.

(iv) The question asked candidates to predict the change in temperature. Some candidates did not read the question fully and suggested a final temperature for the test-tube, such as 60 °C, rather than suggesting a temperature change. For credit, candidates needed to justify their answer. Many answers only referred to the temperature of the outside tube in comparison to the middle tube of the huddle. Answers justifying a temperature change in the correct range were not always fully correct. Reasons such as "it would lose heat faster than the middle test-tube" only explained why the temperature change would be greater than 12.0 °C. A full reason needed to also justify why the temperature change would be less than 22.0 °C, by stating that less heat would be lost than by the single test-tube. Therefore, only answers that correctly referenced both test-tubes gained credit.

(b) The strongest answers identified that the initial temperature of the two test-tubes was not the same. Many candidates gave vague answers such as "more reliable", "more accurate" or "easier to see". Candidates needed to avoid giving generic phrases and should have referred to the data in the question.

(c) This question asked candidates to identify a variable. Stronger answers identified a variable that would differ between either individual penguins or between different huddles or would differ over time. Such answers referred to external temperature, the surface area of different huddles, wind speed or the thickness of the feathers on the penguins. Some candidates incorrectly listed an adaptation of penguins, which was likely to be the same for all penguins, rather than a variable. These answers did not gain credit. Such answers included comments such as "penguins have feathers" or "penguins are white".

(d) The relevant point was that both test-tubes would fall to room temperature or to the temperature of the surroundings. Some candidates stated this clearly. Others gave answers which were not awarded credit, such as that the test-tubes lose all their heat or cool down completely. These answers were incorrect as all their heat was not lost. Heat was only lost until the temperature became the same as the environment around the test-tubes.

Question 2

There were two common reasons why full credit could not be awarded for the planning question. Some candidates did not refer carefully to the factor that they were asked to investigate (in this case intensity of exercise). Many answers did not clearly vary the exercise intensity or develop a clear method of doing so. It was also quite common for candidates to plan an investigation of other variables**,** such as age or fitness level, or to vary more than one factor at a time. Best practice is to consider the bullet points carefully and to use these to structure answers. For full credit it is essential that content is included against each of the bullet points.

Apparatus: Most candidates suggested the use of a stop-clock or timer, but not all candidates clearly described how it would be used to measure pulse rate. Fewer candidates suggested appropriate exercise equipment such as a treadmill or fitness weights.

Method: The minimum viable method was to measure initial and final pulse rate before and after exercise of variable intensity. Many candidates stated that they would do this. Answers which did not investigate intensity of exercise as the main variable could not be awarded full credit.

A common error in the method included omitting measuring initial pulse rate, so basing the results only on the pulse rate after exercise. In addition, many candidates did not clearly state that they would vary the exercise intensity. As this was the main point of the investigation, such answers could not gain full credit.

Some candidates gave details of their method, and the strongest answers included a clear description of how the intensity of the exercise could be varied. Common suggestions included walking, jogging and running or the use of different speeds on a treadmill. Other answers suggested lifting weights for different numbers of repetitions. Some candidates identified the need for pulse rate to return to normal between periods of exercise and some gave clear safety precautions, such as the need to wear suitable shoes or to check the fitness of the individual before the test began.

Measurements: Many candidates gave a detailed description of how they would measure the exercise intensity. Examples included setting the speed on a treadmill or measuring the duration of the exercise. However, some candidates made errors in the use of units. Candidates are expected to use SI units. 'Min' is acceptable as an abbreviation for minutes, but 'm' is metres and so cannot be accepted as a unit of time. Similarly seconds or s are both acceptable, but 'secs' is not an accepted abbreviation for seconds. Several candidates did not make any clear point relating to the measurement of any of the variables.

Constant Variables: Candidates needed to refer back and double check the factor that they were asked to investigate and then identify other factors that needed to be controlled. A common error was to vary an incorrect factor, such as the person doing the exercise or the type of exercise, rather than keeping these constant so that only the intensity was changed. Stronger answers referred to varying the speed or number of repetitions within a fixed controlled time and identified the need to either use the same person or use people with the same characteristics such as age, sex, weight and fitness level.

Processing Results: This bullet point was often omitted, or vague references were made to drawing graphs without a clear statement of the identity of the axes. Some candidates included a sketch of the axes of a graph to process their results. This is good practice. Stating that it was necessary to take an average did not automatically earn credit unless it was clear that candidates would average several readings conducted under identical conditions.

Question 3

(a) (i) Most candidates correctly read the thermometer in step 5 at 55.5 °C, but many stated 24 as the reading for step 2. The instructions stated that the temperature readings needed to be recorded to the nearest 0.5 °C, so the correct answer was 24.0. 24 alone was not credited.

(ii) Almost every candidate correctly subtracted the two values to calculate the temperature increase.

(iii) Most candidates were able to substitute correctly into the provided equation and compute a correct value. Fewer candidates then correctly quoted this value to three significant figures, as the question requested. Some gave values to more than three significant figures and some made errors in rounding. These included adding unnecessary zeros, such as 1250.0 which was incorrect. Some gave only three figure answers, such as 125 rather than the correct value, 1250.

(iv) The main reason for stirring in this experiment was to ensure that the temperature was even across the mixture before the measurement of temperature was taken. Some candidates stated this. Others made the reasonable points that stirring ensures complete reaction or speeds up the reaction. These answers were awarded credit. However, many candidates stated that stirring is to mix the reactants which did not explain why it is done sufficiently.

(v) Most candidates suggested the use of insulation or a lid to prevent heat loss. A common error was to suggest an external source of heat, for example keeping it hot with a Bunsen Burner or heated water bath.

(vi) Candidates were asked for a labelled diagram to include the filtrate and residue. Most knew the basic set-up for a filter, with a funnel represented over a collecting vessel, but the fine detail of the diagram was sometimes missing. A few candidates drew other separation apparatus such as a set-up for simple distillation. There were some common errors in responses. Some candidates did not label the filtrate and residue. Some showed a funnel either without a filter paper or with the filter paper represented incorrectly. A correct diagram should have shown the filter paper as a distinct continuous line, without gaps, in a V shape inside the funnel. Many represented the filter paper incorrectly as curved or with a hole at the bottom. A fully labelled diagram should have had, at a minimum, a label for the filter funnel, filter paper and a suitable collecting vessel such as a test-tube, beaker or flask. Some candidates did not give all the necessary labels. It should be further noted that diagrams should be represented scientifically as two-dimensional line drawings. It is not correct to draw the top or bottom three dimensionally on the filter funnel.

(b) (i) Most candidates knew that initially a blue precipitate forms. However, many added that this was insoluble. Fewer identified the formation of a deeper blue solution on the addition of excess aqueous ammonia. It should be noted that it is incorrect to describe the precipitate as green-blue as this could be confused with iron(II).

(ii) Most candidates identified the anion as a chloride ion.

Question 4

(a) (i) Almost all candidates knew the correct symbol for a voltmeter, and many positioned it across the resistance wire correctly. Common errors included positioning the voltmeter in series in the circuit, in parallel to one of the components in the circuit or to represent it in parallel to the wire but with the connectors either too close together or too far apart. To be correct, the wires from the parallel circuit that included the voltmeter needed to meet the resistance wire at 0 cm and at the point of the crocodile clip. Some candidates represented the voltmeter correctly in parallel directly across the central part of the circuit.

(ii) Some candidates correctly identified that opening the switch prevents overheating of the wire. Danger from electric shock was a common incorrect answer.

(iii) When recording results in a table it is essential that candidates follow the pattern of resolution of the other values. In this case, all other values of the potential difference were recorded to two decimal places, so it was essential that a voltage of 1.10 was recorded for 45.0 cm. Many candidates did not follow the pattern, stating that this value was 1.1. Most candidates correctly gave the current to two decimal places.

(b) Almost all candidates substituted into the equation and correctly calculated the value of the resistance.

(c) (i) The graph question was answered well. Almost all candidates chose an appropriate scale so that the points plotted occupied more than half the available grid and plotted points correctly. Errors were usually due to incorrect values being entered on the axes. Some candidates gave non-linear scales, and some reversed the values on the axes, despite the axes being labelled in the question.

(ii) Most candidates gave an acceptable line of best fit based on their plots. Where the relationship was a straight line, it was expected that candidates use a ruler and that their pencil should be sharp. Thick, feathered lines that were not clearly straight were not accepted. The line needed to be single and continuous. Dot to dot lines between points were not accepted. Where there was a spread of data, candidates needed to draw their line to show the best trend, with any points not exactly on the line spread evenly on each side. Further guidance can be found in the syllabus.

(iii) Most candidates gained at least partial credit, either for a correct gradient calculation or by showing a triangle on the graph that was correctly drawn and occupied at least half the length of the line of best fit. A relatively common error was to misread the values from the graph to use in the calculation of the gradient. Some candidates counted squares rather than using the values on the axes. Many candidates drew very small triangles which did not occupy half the available line.

(iv) Most candidates gave the correct unit for resistance per unit length. Ohms alone was the most common incorrect answer.

(d) Only a few candidates answered this correctly. “To calculate an average” or “to avoid anomalies” were common incorrect answers. The strongest answers referred to using the repeated readings to check for and to identify and exclude anomalous readings from the data set. Some candidates correctly stated that repeated similar readings are an indicator of high-quality data.

(e) The strongest answers identified features of the practical procedure that were likely to result in a variation of results. For example, difficulty in placing the crocodile clip exactly on the metre rule. Some candidates identified differences between the equipment that different students might use for the procedure, such as differences in the diameter of wire. Weak, generic answers such as “parallax error”, “human error” or “error when taking readings” were not accepted.