PHYSICAL SCIENCE

Paper 0652/11
Core Multiple Choice

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

General comments

Questions 2, **3**, **8**, **17**, **20**, **21**, **26**, **29**, **30** and **40** were found the most difficult, with **Questions 27** and **35** being particularly well answered.

Comments on specific questions

Question 1

A large proportion of candidates recognised that dyes X and Z are present in the black ink.

Question 2

There was some evidence of guesswork particularly amongst weaker candidates. A significant proportion of even stronger candidates thought that elements are chemically combined in a mixture and chose option **C**.

Question 3

This question proved difficult for many candidates and there was evidence of guesswork even amongst stronger candidates. There was a misconception amongst many candidates that a proton has the same relative mass as an electron.

Question 4

A majority of candidates understood how an ionic bond is formed between sodium and chlorine.

Question 5

Many candidates were able to calculate the value of *y* in the equation but many of these candidates ignored the stoichiometry of the equation and chose option **A**.

Question 6

The idea that electrolysis decomposes an ionic compound was known by the vast majority of the candidates.

Question 7

Most candidates understood that a reaction that gives of heat to the surroundings is an exothermic reaction.

Question 8

Most candidates recognised that the concentration of the acid decreases as the reaction occurs but a large proportion of these candidates thought that the rate of reaction increases as the reaction occurs and chose option **D**.

Question 9

Many candidates understood the relationship between relative acidity and the colour of universal indicator.

Question 10

The test for ammonia was well known by candidates but there was some evidence of guesswork amongst weaker candidates.

Question 11

Many stronger candidates recognised that an ammonium salt produces a gas, ammonia, when they are warmed with aqueous sodium hydroxide.

Question 12

The position of non-metals in the Periodic Table was known by the vast majority of the candidates.

Question 13

The properties of transition elements were well known by stronger candidates.

Question 14

Most candidates were able to deduce that metal Z is the most reactive and metal X is the least reactive but the relative reactivity of metals Y and W proved more difficult for many of these candidates.

Question 15

The name of the raw material was well known by most candidates but its method of extraction as less well known even amongst stronger candidates.

Question 16

The properties of carbon dioxide were well known by a large proportion of candidates.

Question 17

There was evidence of widespread guesswork. The thermal decomposition of calcium carbonate to form calcium oxide was not well known.

Question 18

Stronger candidates were able to recognise the structure of ethene but there was evidence of guesswork amongst weaker candidates.

Question 19

The uses of the fractions and their position in the fractionating column were not well known by even stronger candidates.

Question 20

The properties of hexane, an alkane, were not well known by many candidates and there was evidence of widespread guesswork even amongst stronger candidates.

Question 21

The incorrect option **D** was a very popular choice. This was obtained by simply multiplying the total time by the maximum speed, rather than calculating the area under the graph.

Question 23

Here many candidates knew how to calculate density as a mass divided by a volume, but did not subtract the mass of the empty beaker from the total mass, arriving at option **C**.

Question 26

The topic here was the liquid-in-glass thermometer and it was widely believed that the fixed points were the values at each end of the scale, leading candidates to choose option **B**.

Question 27

This question on thermal conduction was generally answered correctly.

Question 28

A large majority of candidates knew which labelled distance represented the wavelength of a wave, but a significant proportion of them chose the peak-to-trough distance as the amplitude (option **D**).

Question 29

This question was challenging for many candidates. Generally, candidates seemed aware that there is an angle on the reflected ray side of the normal that is equal to an angle on the incident ray side, but very many opted for A. The angles of incidence and reflection are always measured to the normal.

Question 30

Converging lenses were challenging for many candidates. Although most candidates knew that the size of the image increases, many of them also thought that the distance from the image to the lens decreases (option **B**).

Question 35

Few candidates had any difficulty in reading the analogue scales on a voltmeter.

Question 38

Some candidates thought that different isotopes containing the same number of protons were different elements with the same number of neutrons.

Question 39

Many candidates confused alpha-particles with gamma-rays and opted for **B** (electromagnetic radiation) as a description.

Question 40

Half-life was the topic of this question. More candidates chose option **D** than the correct **C**. The correct answer was obtained by deducing that there are three half-lives involved, then dividing the initial number of atoms by three.

PHYSICAL SCIENCE

Paper 0652/21
Extended Multiple Choice

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

General comments

Candidates found **Questions 7, 9, 18, 26**, **28**, **29** and **37** the most challenging.

Comments on specific questions

Question 1

The vast majority of the candidates understood ideas about diffusion and the relationship between of rate of diffusion and relative molecular mass.

Question 2

A large proportion of candidates recognised that dyes X and Z were present in the black ink.

Question 3

Most candidates recognised that the nucleon numbers of isotopes are different but the reason for isotopes having the same chemical properties was less well understood.

Question 4

Many candidates answered this correctly.

Question 5

The structure and the properties of silicon(VI) oxide were well known by almost all candidates.

Question 6

Most candidates were able to determine the values of *x* and *y* in the equation.

Question 7

This question proved to be challenging for many candidates. They ignored the stoichiometry of the equation and chose option **B**.

Question 8

Most candidates knew that the products at the electrodes were sodium and chlorine but a significant number of even stronger candidates chose option **D** where the products are at the incorrect electrode.

Question 9

There was a misconception amongst many candidates that the activation energy of the reaction increases when the temperature of the reaction is increased.

Question 10

Almost all candidates understood the relationship between relative acidity and the colour of universal indicator.

Question 11

The test for ammonia was well known by candidates.

Question 12

The displacement reactions of the halogens were well known by most candidates.

Question 13

The properties of transition elements were well known by a large proportion of candidates.

Question 14

Many candidates were able to determine the relative reactivity of element Q.

Question 15

The vast majority of candidates were able to deduce that metal Z is the most reactive and metal X is the least reactive but the relative reactivity of metals Y and W proved more difficult for many of these candidates.

Question 16

Many candidates recognised that carbon monoxide and nitrogen monoxide are removed from car exhaust fumes but a significant number of weaker candidates thought that carbon dioxide is also removed and chose option **C**.

Question 17

The properties of carbon dioxide were well known by most candidates.

Question 18

The thermal decomposition of calcium carbonate to form calcium oxide was not well known. There was evidence of some guesswork amongst weaker candidates.

Question 19

Ideas about a homologous series were well known by most candidates.

Question 20

The fact that propene undergoes addition reactions was well known by stronger candidates. There was evidence of some guesswork amongst weaker candidates.

Question 21

The incorrect option **D** was a popular choice. This was obtained by simply multiplying the total time by the maximum speed, rather than calculating the area under the graph.

Question 22

Here, although a large majority of candidates knew that the speed of the ball was increasing, some of these candidates thought that the acceleration was also increasing, causing them to opt for the incorrect response **D**.

Question 24

This question required candidates to deduce the resultant force on each object, then to divide this force by the mass of the object. Option **D** was a common incorrect answer. This was found by dividing one force on the object by the other, arriving at $4.0\,m/s^2$ as the acceleration.

Question 25

Many candidates chose option **C** or option **D**, with an even split between these two incorrect options. To calculate these involves failing to take account that there are four legs (option **C**) or simply dividing the weight by four (option **D**). Some candidates divided the weight by the area of the seat, leading to option **A**.

Question 26

Here more candidates chose option **B** than the correct option, **A**. These candidates correctly found the work done by multiplying the force by the distance travelled, but failed to recognise that this must be subtracted from the initial kinetic energy to find the answer.

Question 28

The topic here was the liquid-in-glass thermometer and it was very widely believed that the fixed points were the values at each end of the scale, leading candidates to choose option **B**.

Question 29

Total internal reflection was challenging for many candidates, with only stronger candidates selecting the correct option, **C**. Options **A** and **B** were both more popular than this, with none of these candidates realising that the speed of light is less in medium 1 than in medium 2.

Question 36

A fairly common mistake here was to fail to convert the time from minutes into seconds, leading to a current of 30 A (option **D**).

Question 37

In this more challenging question on current and p.d. in a circuit, options **B**, **C** and the correct option **A** were all popular choices. Candidates making mistakes either believed that the current is not halved (option **C**) or the p.d. is not halved (option **B**).

Question 40

Half-life was the topic of this question. There was little confusion over the level of background radiation, but candidates did not always subtract this from the initial reading to find the count rate due to the source only. As a result, option **C** was as popular as the correct option, **A**.

PHYSICAL SCIENCE

Paper 0652/22
Extended Multiple Choice

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	A	11	D	21	C	31	D
2	B	12	B	22	C	32	A
3	B	13	D	23	B	33	C
4	C	14	C	24	D	34	B
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6	C	16	A	26	A	36	B
7	A	17	D	27	D	37	A
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9	D	19	D	29	C	39	D
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Candidates found **Questions 7, 9, 18, 26**, **28**, **29** and **37** the most challenging.

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The structure and the properties of silicon(VI) oxide were well known by almost all candidates.

Question 6

Most candidates were able to determine the values of *x* and *y* in the equation.

Question 7

This question proved to be challenging for many candidates. They ignored the stoichiometry of the equation and chose option **B**.

Question 8

Most candidates knew that the products at the electrodes were sodium and chlorine but a significant number of even stronger candidates chose option **D** where the products are at the incorrect electrode.

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There was a misconception amongst many candidates that the activation energy of the reaction increases when the temperature of the reaction is increased.

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Question 40

Half-life was the topic of this question. There was little confusion over the level of background radiation, but candidates did not always subtract this from the initial reading to find the count rate due to the source only. As a result, option **C** was as popular as the correct option, **A**.

PHYSICAL SCIENCE

Paper 0652/31
Core Theory

Key messages

Candidates should read each question carefully and follow the instructions.

A simple restatement of the information given in a question is not sufficient to earn credit. Candidates need to provide additional information or explain links between the pieces of information provided in the question.

General comments

Many candidates left questions unanswered including questions where they were asked to circle one option or to tick a box. Candidates are not penalised for getting questions wrong, so they should attempt all questions.

Questions on topics which are normally related to practical work e.g. tests for common gases, were frequently less well answered.

Some candidates struggled with technical language. The term ‘charge’ was frequently used where a reference to a (magnetic) pole would have been more suitable. There was also widespread misunderstanding of ‘open’ and ‘closed’ when used in relation to switches.

Comments on specific questions

Question 1

(a) Many candidates correctly determined the width of the 5 turns of rope as 5.5 cm. Far fewer divided by 5 to get the diameter of 1.1 cm.

(b) (i) Many candidates calculated the weight of the climber as 700 N. A significant number of candidates divided 70 kg by *g*.

(ii) Stronger candidates answered this correctly with most other candidates simply restating information given in the question without any further information.

(iii) Many candidates realised that the force exerted by the rope needed to be equal to the weight of the climber but most candidates gave an incorrect direction for the force.

Question 2

(a) This question was answered well. Some correct answers were crossed out and replaced. It is possible that candidates had not read the question carefully and they believed they could not use the answer “seven” twice.

(b) Potassium Fluoride was correctly given by most candidates.

Question 3

Many candidates stated that there was a greater force on Tyre **A**. The information given in the stem of the question states that the two tyres support the same weight of car. Candidates should be aware that a weight is a for.

(a) Candidates were expected to use the equation *pressure* = *force*/*area* and the ideas that it represents to state that to support the same weight of car with a lower pressure, a greater (contact) area (with the ground) would be required, or words to that effect. Very few answers of this type were seen. Credit was given for identifying that Tyre **A** had lower pressure and that its area in contact with the ground was greater. Many candidates were able to gain partial credit for identifying the lower pressure.

(b) Most candidates gained at least partial credit and many correctly gave both work and potential (energy) as their answers.

(c) (i) There were many good answers explaining a moment as being the turning effect of a force (about a point). Some other candidates came close to this in their answers but stated that the moment was the point about which a force had a turning effect, confusing ‘pivot’ with ‘moment’.

(ii) Most candidates gained at least partial credit for a larger force. Some gave the same answer twice, rephrasing ‘a larger force’ for their second answer. Candidates were expected to refer to physical quantities so answers like “use two hands” were not accepted unless those answers indicated that two hands would produce a larger force. A longer spanner or wrench was also allowed as implying this implied increasing the distance of the force from the nut.

Question 4

Parts (b)(i) and **(ii)** are examples of questions where candidate’s answers indicated that they needed to read the question more carefully.

(a) Stronger candidates answered this correctly. Some candidates did not attempt it at all. The two parts were marked independently so that even with no reagent or an incorrect one, partial credit could be obtained for the correct change in appearance.

(b) (i) The products of combustion are carbon dioxide and water. The question stated that there was excess oxygen so carbon monoxide was not an accepted answer.

(ii) The expected use was as a solvent. Many answers gave an example of how ethanol could be used as a fuel e.g. cooking/cars. The stem to this part-question states that ethanol can be used as a fuel and asked for one other use., so the answer ‘fuel’ was not accepted.

(c) Stronger candidates were able to name the class of materials as being hydrocarbons.

(d) (i) Most candidates drew a molecule containing two C atoms and four H atoms as instructed. A minority drew a double bond between the two C atoms.

(ii) A small proportion of candidates correctly named the compound as ethane. Those that had not drawn a double bond in **(i)** were unlikely to get the name correct.

Question 5

(a) (i) Many candidates correctly named the salt as zinc chloride. Fewer also identified hydrogen as the other product. ‘Water’ was a commonly seen incorrect response.

(ii) ‘Increasing the temperature’, ‘using a catalyst’, ‘increasing concentration’ and ‘increasing surface area’ were the expected answers. Less formal versions such as ‘adding heat’ were also credited. Candidates who did not state a direction of change e.g. simply giving ‘temperature’ without any idea of increase could not be awarded error. Another common error was reference to adding more rather than to increasing the concentration, so “add more acid” did not gain credit.

(b) (i) Many answers were too vague, for example “there was no more mass to lose”. Answers such as “all the hydrochloric acid had been used” or “the reaction was complete” were credited.

(ii) Credit was given to the few candidates that realised that initially the rate of reaction would be unchanged. Further credit was available for indicating that the final volume of gas produced would be half that of the original experiment. Credit was given for any straight horizontal line drawn on the graph indicating that less gas would be produced.

(c) Only a minority of candidates named the alloy of copper and tin as brass.

Question 6

This question was frequently answered by restating information given in the stem.

(a) **F**ew candidates stated that the vibrating tape caused the air around it to vibrate.

(b) Many answers described how the wave made its way to the eardrum but did not then go on to mention that the sound wave caused the eardrum to vibrate.

(c) This was not well known**.** Frequencies in the range 15 – 30 Hz were accepted.

(d) This was a more challenging question as it was about refraction but in an unfamiliar context. Candidates needed to recognise that the change in direction in refraction is linked to a change in speed. Many candidates answered correctly. Commonly seen incorrect answers included 'reflection' and 'diffraction'.

Question 7

(a) Almost all candidates gained at least partial credit for this part of the question. Commonly seen errors were naming the neutron as nucleon, reversing the charges on the proton and electron and getting the relative masses of the electron and neutron wrong.

Any relative mass given for the electron of less than 1/1000 was regarded as being close to zero and accepted.

(b) This question was answered well with most candidates giving a clear diagram showing an electronic configuration of 2,8,1

Question 8

(a) (i) While most candidates knew the boiling point of water, there were a significant number of incorrect answers.

(ii) The correct answer was often given but other answers suggested that the term 'thermal energy transfer (process)' was not adequately understood by many candidates.

(b) The expected answer was based on recognising that the task in both examples needs the same amount of energy (useful output) but with the lid on less (input) energy is needed and so the kettle was more efficient with the lid on. The very strongest candidates answered the question using the definition of efficiency. Partial credit was allowed for interpreting the information given and specifying that with the lid on, the kettle boiled in less time. Further credit was available for explaining this difference in terms of loss of (thermal) energy to the surroundings. Many candidates gained at least partial credit.

(c) The correct answer, radiation, was seen frequently.

(d) The expected answer was that the water in the kettle would remain hot so there would be no need to boil it again or less energy would be needed to boil it again. A few answers of this type were seen. Credit was also given for answers which more generally stated that less electrical energy was used by the kettle. Answers that did not refer to electrical energy savings were not creditworthy.

Question 9

This question was about a demonstration experiment to illustrate the magnetic force on a current carrying wire. Some candidates did not understand the terminology which refers to a switch being open or closed. Some candidates used the term ‘charge’ instead of the terms ‘pole’ or ‘field’.

(a) The copper rod stops or it carries on rolling (as per Newton’s 1st Law). A common error was to state that the rod would reverse direction or return to its starting point.

(b) Most candidates selected the correct answers. Some candidates did not attempt this question at all or only selected one option. The word ‘two’ was emboldened to prevent this.

(c) Candidates were expected to realise that once the copper rod rises vertically, it is no longer in contact with the copper strips and so no current flows in the rod. The second point was that with no current there is no magnetic field meaning that the copper rod would not be repelled by the magnet and, consequently, falls. Few candidates made either of these two points. Partial credit was given for saying that the force of gravity that causes the rod to fall. Further credit was available for stating that the copper rod had moved away from the magnet and the field (of the magnet) was too weak or non-existent at this point.

Question 10

(a) (i) Many candidates drew good diagrams of the electrons in the HCl covalent bond. Some ignored the instructions and drew all the electrons of chlorine when the question asked only for the outer electrons. Only the outer shell electrons were marked.

(ii) Most candidates were able to name water or hydrogen oxide as being a covalently bonded molecule of oxygen and hydrogen. A significant minority did not do so.

(b) (i) the meaning of volatile was not always understood. More (volatile) and less (volatile) were given in similar proportions.

(ii) Many candidates did not give a correct formula for sodium chloride and so were unable to correctly balance the equation. This question was answered well by only the strongest candidates.

Question 11

(a) (i) The expected answers were that the material for the electrodes is graphite/carbon. The reasons for using carbon are that it is a good conductor (of electricity) and it is inert (to the reactants and products). The reasons were marked independently of the stated material so a valid reason for the wrong material or for no specified material was given credit.

(ii) Many candidates correctly named the anode and cathode and so gained full credit. Partial credit was available for those who recalled the names but got them the wrong way round.

(b) (i) The pH of dilute sulfuric acid is pH1. Answers in the range of 0 – 3 were accepted.

(ii) Base or alkali were the expected answers. Limestone was seen on several occasions, and this was given credit.

Question 12

(a) (i) There were some correct answers but most candidates said that the background radiation was varying or changing. This was repeating the information given in the question and was not an explanation about why the readings varied.

(ii) Almost all candidates correctly calculated the average reading for the background radiation to be 12 counts per minute.

(b) (i) Most answers were quite vague and general, e.g. “to give more accurate results”, or similar. These were not given credit. Credit was awarded for answers which stated that subtracting the background radiation gave a reading for the radiation from the source only or words to that effect, e.g. that the reading includes background radiation and radiation from the source.

(ii) A large majority of candidates correctly selected 128 as the corrected count reading after one half-life had elapsed.

(iii) Many candidates correctly estimated the half-life to be 10 minutes. Answers in the range 9.5 to 10.5 minutes were allowed because candidates could choose values from the table which did not give an exact answer of 10 minutes. Some of the incorrect answers given appeared to be readings or changes in readings suggesting that these candidates did not know that a half-life was a time interval.

(c) This question was answered well by stronger candidates but many other candidates did not attempt it. Answers were often seen that are not a form of radioactive emission, e.g. transmission or nuclear fission.

Question 13

(a) The correct answers, infra-red and ultra-violet, were frequently seen. A significant percentage large number of candidates only named one of these two and gave additionally an incorrect type e.g. radio waves or X-rays.

(b) Few candidates gave the correct answer that all forms of electromagnetic radiation travel at the same speed (in a vacuum). Many wrote about the radiation having to penetrate the atmosphere, and others talked about the long distance or about the different types of radiation all setting off at the same time.

(c) (i) Stronger candidates drew the two incident rays emerging from the lens and meeting at the image of the sunspot. Many did not put arrows on their rays but this was ignored. The top ray, which passed through the focal point before entering the lens and emerging parallel to the axis was more frequently seen than the lower ray, which passes straight through undeflected. Some candidates drew their own image arrow at a different point along the axis and then arranged for the two rays to meet there.

(ii) Some correct answers were seen. Many candidates appeared to not understand the meanings of the terms. The correct answer was that the image was diminished and inverted. Many candidates chose two words which were contradictory such as 'diminished and magnified' or 'inverted and upright'.

PHYSICAL SCIENCE

Paper 0652/41
Extended Theory

Key messages

- Candidates should read the questions carefully to avoid giving information in answers that is given in the question.
- Stronger candidates included their working out in calculations so that partial credit could be awarded for a correct method even if the final answer was incorrect.

General comments

Candidates were not confident drawing dot-and-cross diagrams.

The explanation of an electric field was not well known.

There were a number of blank answers throughout the paper. Candidates are advised to attempt every question. They will not be penalised for a wrong answer.

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly determined the maximum speed as 27 m/s.

(ii) Common errors included 10 N and 84 N.

(b) (i) The expression for kinetic energy was generally well known. Some candidates did not include the expression or did not square the velocity. It was common for the mass to be left as 84 g rather than 0.084 kg.

(ii) Some vague answers were seen, such as “energy is lost” which repeated the question; “energy is transferred” which did not state to what the kinetic energy was transferred; and “energy transfers to the ground”. “Potential energy” was insufficient as the type of potential energy was not specified.

Question 2

(a) (i) Diffusion was known by most candidates. Occasionally, dissolving was given.

(ii) Some good responses were given, with particles moving slower in liquids being the most common correct response. Some answers were not comparative with gases.

(b) 158 was usually correctly given.

Question 3

(a) Most responses stated that a change of state was taking place. Some incorrect changes such as “boiling” were given.

(b) Candidates found this challenging and the similarities and differences between boiling and evaporation were not well known. Some candidates gave the same difference as two separate points, such as difference 1: "boiling occurs in all parts of a liquid" and difference 2: "evaporation happens at the surface only".

(c) (i) A few candidates referred to the range as the highest and lowest values without an indication that it is the difference between these two values.

(ii) Candidates were not familiar with the definition of sensitivity. References to speed of change, greater number of intervals and accuracy were commonly seen.

Question 4

(a) The majority of candidates circled green and yellow. Some candidates thought all the colours were present.

(b) The determination of an R_f value was not well known. Many expressions, if given, were reversed, the working out was not shown and some candidates attempted to determine the R_f value for spot 1 or spot 3 instead of spot 2.

(c) Candidates found it challenging to give concise answers on why crystallisation is not suitable to separate the coloured compounds.

Question 5

(a) (i) Most candidates could give at least one way the compounds are the same.

(ii) Candidates need to be clear that the words 'alkane' and 'alkene' refer to two different families of compounds despite the words appearing similar. Some answers were written so that it was unclear whether the word was alkane or alkene and could not be awarded credit.

(iii) Weaker candidates did not refer to the double bond being between two <u>carbon</u> atoms.

(b) (i) Many candidates did not know that the double bond becomes a single bond. Br_2 was often added to the end of one of the carbons.

(ii) Addition was well known. Occasionally, 'additional' was seen.

Question 6

(a) Candidates found this challenging. Some were able to show a single change of direction for the wavefronts and the wavefronts were often drawn as straight lines in the shallow water. The direction of refraction was often incorrect and very few wavefronts in the shallow water had wavelengths equal to each other and shorter than those in the deeper water.

(b) Stronger responses included the expression for frequency and working out. The unit was sometimes given as seconds or presented as 'hz' rather than 'Hz'.

(c) Candidates incorrectly used $\sin i$ and $\sin r$.

Question 7

(a) (i) The current was usually determined correctly. Stronger candidates included their working out.

(ii) It was common for the time to be left in minutes or incorrectly converted. Some responses did not include working out.

(iii) Resistor was a commonly seen incorrect response.

(iv) The potential difference was often correct.

(b) Candidates found this challenging. Many did not recognise that the resistance of the thermistor decreases. References to potential difference changes often needed to refer to where in the circuit the change occurred, such as "decrease in PD <u>across **Y**</u>" or "increase in PD <u>across the lamp</u>".

Question 8

(a) (i) Many candidates progressed no further than a determination of the *M*r of PbS and PbO. Others incorrectly thought the stoichiometric ratio should be used in an *M*r calculation.

(ii) Most candidates knew that acid rain was a consequence of sulfur dioxide emissions.

(iii) Weaker candidates gave vague statements such as "use less fossil fuels", which did not address how emissions are reduced once fossil fuels are combusted.

(b) Candidates were not confident identifying that it is the Pb in PbO that is reduced. Pb, C and CO_2 were all given as answers.

(c) Weaker answers stated that alloys have different properties compared to pure metals but did not explain that these properties are improved.

(d) (i) Many candidates knew that a metal more reactive than iron is used in sacrificial protection but fewer could progress beyond this statement.

(ii) Many candidates suggested painting. Weaker responses repeated sacrificial protection.

Question 9

(a) (i) Most candidates knew that isotopes have the same number of protons but a different number of neutrons. Occasionally, candidates reversed this statement.

(ii) The number of neutrons and protons was usually correct. A common error was to state 14 for the number of neutrons.

(b) Candidates struggled to complete the equation for the decay.

Question 10

(a) (i) The lack of reactivity of inert electrodes was well known.

(ii) **A** commonly-seen error was to state that the products were ions.

(b) Dot-and-cross diagrams were not well known. Many covalent representations were seen. The charges were often incorrect.

(c) This was well answered. A few candidates confused the direction of reactivity down Group II.

Question 11

(a) Most candidates could not explain concisely what is meant by an electric field.

(b) (i) The path of the alpha particle was sometimes shown deflected in the opposite direction or as a wavy line.

(ii) Most candidates stated that an electron path was opposite to that of an alpha particle. Fewer knew that the deflection was greater.

(c) (i) Smoke detector was known by a minority of candidates. Printers, X-rays and determining paper thickness were common incorrect answers.

(ii) Very few candidates stated the high ionising effect or low penetration ability of alpha particles were involved in their use in devices such as smoke detectors.

Question 12

(a) Thermal decomposition was well known. Occasionally, cracking or fractional distillation was seen.

(b) Most candidates knew that bases are proton acceptors.

(c) Candidates found this challenging. The shape for an exothermic change was often given, arrows for the energy change were often missing or double headed or pointing in the wrong direction. Labels for reactants and products were sometimes reversed.

PHYSICAL SCIENCE

Paper 0652/41
Extended Theory

Key messages

- Candidates should read the questions carefully to avoid giving information in answers that is given in the question.
- Stronger candidates included their working out in calculations so that partial credit could be awarded for a correct method even if the final answer was incorrect.

General comments

Candidates were not confident drawing dot-and-cross diagrams.

The explanation of an electric field was not well known.

There were a number of blank answers throughout the paper. Candidates are advised to attempt every question. They will not be penalised for a wrong answer.

Comments on specific questions

Question 1

(a) (i) The majority of candidates correctly determined the maximum speed as 27 m/s.

(ii) Common errors included 10 N and 84 N.

(b) (i) The expression for kinetic energy was generally well known. Some candidates did not include the expression or did not square the velocity. It was common for the mass to be left as 84 g rather than 0.084 kg.

(ii) Some vague answers were seen, such as "energy is lost" which repeated the question; "energy is transferred" which did not state to what the kinetic energy was transferred; and "energy transfers to the ground". "Potential energy" was insufficient as the type of potential energy was not specified.

Question 2

(a) (i) Diffusion was known by most candidates. Occasionally, dissolving was given.

(ii) Some good responses were given, with particles moving slower in liquids being the most common correct response. Some answers were not comparative with gases.

(b) 158 was usually correctly given.

Question 3

(a) Most responses stated that a change of state was taking place. Some incorrect changes such as "boiling" were given.

(b) Candidates found this challenging and the similarities and differences between boiling and evaporation were not well known. Some candidates gave the same difference as two separate points, such as difference 1: "boiling occurs in all parts of a liquid" and difference 2: "evaporation happens at the surface only".

(c) (i) A few candidates referred to the range as the highest and lowest values without an indication that it is the difference between these two values.

(ii) Candidates were not familiar with the definition of sensitivity. References to speed of change, greater number of intervals and accuracy were commonly seen.

Question 4

(a) The majority of candidates circled green and yellow. Some candidates thought all the colours were present.

(b) The determination of an R_f value was not well known. Many expressions, if given, were reversed, the working out was not shown and some candidates attempted to determine the R_f value for spot 1 or spot 3 instead of spot 2.

(c) Candidates found it challenging to give concise answers on why crystallisation is not suitable to separate the coloured compounds.

Question 5

(a) (i) Most candidates could give at least one way the compounds are the same.

(ii) Candidates need to be clear that the words 'alkane' and 'alkene' refer to two different families of compounds despite the words appearing similar. Some answers were written so that it was unclear whether the word was alkane or alkene and could not be awarded credit.

(iii) Weaker candidates did not refer to the double bond being between two <u>carbon</u> atoms.

(b) (i) Many candidates did not know that the double bond becomes a single bond. Br_2 was often added to the end of one of the carbons.

(ii) Addition was well known. Occasionally, 'additional' was seen.

Question 6

(a) Candidates found this challenging. Some were able to show a single change of direction for the wavefronts and the wavefronts were often drawn as straight lines in the shallow water. The direction of refraction was often incorrect and very few wavefronts in the shallow water had wavelengths equal to each other and shorter than those in the deeper water.

(b) Stronger responses included the expression for frequency and working out. The unit was sometimes given as seconds or presented as 'hz' rather than 'Hz'.

(c) Candidates incorrectly used sin *i* and sin *r*.

Question 7

(a) (i) The current was usually determined correctly. Stronger candidates included their working out.

(ii) It was common for the time to be left in minutes or incorrectly converted. Some responses did not include working out.

(iii) Resistor was a commonly seen incorrect response.

(iv) The potential difference was often correct.

(b) Candidates found this challenging. Many did not recognise that the resistance of the thermistor decreases. References to potential difference changes often needed to refer to where in the circuit the change occurred, such as "decrease in PD <u>across **Y**</u>" or "increase in PD <u>across the lamp</u>".

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(b) Most candidates knew that bases are proton acceptors.

(c) Candidates found this challenging. The shape for an exothermic change was often given, arrows for the energy change were often missing or double headed or pointing in the wrong direction. Labels for reactants and products were sometimes reversed.

PHYSICAL SCIENCE

Paper 0652/51
Practical Test

Key messages

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

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

When describing the colour changes when solutions are mixed together, candidates should be made aware that 'clear' is not a suitable description of a colour.

General comments

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

This year, only a minority of candidates entering this paper were able to demonstrate a good ability and understanding across the whole of the range of practical skills being tested. All parts of both practical tests were attempted and there was no evidence of candidates being short of time.

Comments on specific questions

Question 1

(a) Most candidates completed the table by adding the masses of the empty evaporating basin, the mass of the evaporating basin and sodium carbonate crystals before heating and the mass of the evaporating basin and sodium carbonate crystals after heating.

Despite the instruction to record the masses to the nearest 0.1 g, few candidates rounded off their answers to the nearest gram. Occasionally, candidates recorded a mass for the basin and anhydrous sodium carbonate which was greater than the mass of the basin and the crystals.

(b) (i) Most candidates selected the correct two masses to subtract to determine the mass of anhydrous sodium carbonate. A minority of candidates selected the wrong values to subtract and ended up with negative masses.

(ii) Candidates usually substituted correctly into the given equation in order to determine the number of moles/amount of sodium carbonate. Answers were frequently rounded to 1 significant figure even when recorded values of mass were to at least 2 or 3 significant figures.

(iii) Most candidates selected the correct two masses to subtract to determine the mass of water given off during the heating process. A few candidates selected the wrong values to subtract and ended up with negative masses.

(iv) Candidates usually substituted correctly into the given equation in order to determine the number of moles/amount of water given off. As stated above, answers were frequently rounded to 1 significant figure.

(v) The final division calculation was usually completed correctly. A minority of candidates substituted incorrectly and obtained the reciprocal of the required answer. No candidate rounded their final answer to an integer, which was expected since the value of *x*, the number of moles of water of crystallisation, was a whole number.

(c) (i) Candidates were asked to explain in detail why repeating the experiment and calculating an average increases the accuracy of the value of *x*. Few candidates gave the detail expected and most candidates did not understand that repeating and averaging identifies any anomalous results which can then be discarded.

(ii) Most errors and suggested improvements consisted of general comments about safety and other suggestions that could apply to any experiment. Answers needed to focus on the experiment that candidates had just performed. Stronger candidates suggested the need for the complete removal of the water in the given sample or a more accurate measurement of the masses involved in the experiment and also gave valid responses as to how the improvements could be made.

Question 2

(a) Most candidates recorded the correct observations when they added universal indicator to each of solutions **A**, **B** and **C** in separate test-tubes. Violet and purple were accepted as alternatives for blue.

(b) Only a minority of candidates gave the observation of a white precipitate/solid when dilute nitric acid and aqueous silver nitrate were added to solution **A**,. In all other 5 boxes in the table, candidates needed to indicate that no reaction had taken place. Stronger candidates indicated this by writing no reaction/colourless solution/no precipitate in the relevant boxes.

(c) Solution **A** was rarely identified as hydrochloric acid, even though it had turned universal indicator red and had given a positive test for chloride ions.

(d) Most candidates correctly recorded yellow or orange as the first colour seen when the wooden splint soaked in solution **B** was placed in a Bunsen burner flame.

(e) Candidates were required to add aqueous copper (II) sulfate to solutions **B** and **C** in a test-tube until it was in excess. Most observations were a mixture of light/dark blue solutions and light/dark blue precipitates but it was rare to see a script which had the correct observations in the correct box.

(f) A small number of stronger candidates were able to deduce, from the observations they had made while doing the experiment, that solution **B** was sodium hydroxide and solution **C** was ammonium hydroxide/ammonia solution.

Question 3

(a) Many candidates did not correctly mark the position of the voltmeter to measure the potential difference across resistor X. Despite this, many of these candidates went on to produce sensible values of potential difference in the results table for the experiment. This suggests that they had connected the voltmeter correctly, even though their circuit diagram said otherwise.

(b) (i)(ii) Most candidates produced a complete set of results with sensible values for the potential difference across the resistor and the current in the resistor. Occasionally the current values were not recorded to a consistent number of decimal places.

(c) (i) Very few scales with prime number increments such as 3 or 7 were seen. Choosing such scales makes the points much harder to plot by the candidates and more difficult for the plotted points to be checked. There were many excellent, carefully drawn, best-fit lines produced.

(ii) There were many graphs where the attempt at a best-fit line resulted in all points which did not lie on the drawn line being on the same side of the line. A sizeable minority of the lines drawn were forced through the origin. There were also some graphs where the points were joined dot-to-dot.

(d) (i) Although most candidates understood what the term 'gradient' meant, there were many poor gradient calculations. Candidates often used data points from the table that did not lie on their best-fit line or chose points which were too close together.

The instruction to indicate on the graph the values chosen to calculate the gradient, was frequently not followed.

(ii) The value of R_X was usually calculated correctly by substitution into the given equation. The instruction to give the answer to a suitable number of significant figures consistent with the data in the question was often not followed. To gain credit here, answers needed to be given to 2 or 3 significant figures.

(iii) Although many candidates made the correct choice of resistance for the unknown resistor, few were able to give an adequate explanation as to why they had chosen that value.

(e) Stronger candidates were able to suggest why plotting a graph gives a more accurate value of resistance than by just taking a single pair of values to calculate resistance. The answer usually given by these candidates was that an anomalous value can be easily identified and ignored.

Question 4

Most candidates chose suitable apparatus to use from the list of apparatus supplied in the question. Occasionally such phrases as "measure the temperature of the water" or "time the water cooling" were given without candidates specifying that they would need a thermometer and a stopwatch.

Several different methods were used by candidates in their investigations. The two main methods were to measure the temperature decrease of the hot water cooling for a fixed time or to measure the time for the hot water to cool for a specified temperature decrease.

Few candidates gained more than partial credit for listing the control variables in this investigation, namely that the volume of the hot water or the temperature decrease/time of cooling of the hot water should remain constant.

The majority of candidates gained credit for the table by drawing an appropriate table of results and giving relevant headings with units. Only two columns labelled, (starting) temperature or temperature decrease and time were required. Frequently, extra columns with reference to temperature were included. These were ignored.

Most candidates did not explain satisfactorily how they would process and use their results to reach a conclusion. The most common correct answer was that the readings should be compared to find out which starting temperature produced the greatest temperature decrease or took the least time to cool. Some stronger candidates suggested plotting a graph of temperature against time and using the gradient of the cooling curve to compare the rate of cooling at different temperatures. Only a minority of candidates took note of the phrase 'rate of cooling' in the question and showed evidence of calculating a rate in their answers.

PHYSICAL SCIENCE

Paper 0652/52
Practical Test

Key messages

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General comments

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

This year, only a minority of candidates entering this paper were able to demonstrate a good ability and understanding across the whole of the range of practical skills being tested. All parts of both practical tests were attempted and there was no evidence of candidates being short of time.

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The instruction to indicate on the graph the values chosen to calculate the gradient, was frequently not followed.

(ii) The value of R_X was usually calculated correctly by substitution into the given equation. The instruction to give the answer to a suitable number of significant figures consistent with the data in the question was often not followed. To gain credit here, answers needed to be given to 2 or 3 significant figures.

(iii) Although many candidates made the correct choice of resistance for the unknown resistor, few were able to give an adequate explanation as to why they had chosen that value.

(e) Stronger candidates were able to suggest why plotting a graph gives a more accurate value of resistance than by just taking a single pair of values to calculate resistance. The answer usually given by these candidates was that an anomalous value can be easily identified and ignored.

Question 4

Most candidates chose suitable apparatus to use from the list of apparatus supplied in the question. Occasionally such phrases as "measure the temperature of the water" or "time the water cooling" were given without candidates specifying that they would need a thermometer and a stopwatch.

Several different methods were used by candidates in their investigations. The two main methods were to measure the temperature decrease of the hot water cooling for a fixed time or to measure the time for the hot water to cool for a specified temperature decrease.

Few candidates gained more than partial credit for listing the control variables in this investigation, namely that the volume of the hot water or the temperature decrease/time of cooling of the hot water should remain constant.

The majority of candidates gained credit for the table by drawing an appropriate table of results and giving relevant headings with units. Only two columns labelled, (starting) temperature or temperature decrease and time were required. Frequently, extra columns with reference to temperature were included. These were ignored.

Most candidates did not explain satisfactorily how they would process and use their results to reach a conclusion. The most common correct answer was that the readings should be compared to find out which starting temperature produced the greatest temperature decrease or took the least time to cool. Some stronger candidates suggested plotting a graph of temperature against time and using the gradient of the cooling curve to compare the rate of cooling at different temperatures. Only a minority of candidates took note of the phrase 'rate of cooling' in the question and showed evidence of calculating a rate in their answers.

PHYSICAL SCIENCE

Paper 0652/61
Alternative to Practical

Key messages

Candidates need to address specific experimental contexts when suggesting methods to improve accuracy or reduce errors, and not rely on generic answers which would apply to all experimental methods e.g. repeating and averaging.

Knowledge of qualitative analysis tests and results, and the interpretation of these results was sometimes a weakness. Centres should ensure they undertake much more practical work where possible to aid memory of both procedure and results.

Candidates need to pay more attention to degree of accuracy and of approximation in their answers. There was some confusion over which figures are significant, particularly following a decimal point.

Candidates showed good planning skills and addressed the bullet points concisely, but tables needed to be actually drawn, not simply referred to in text, and conclusions needed inclusion and more careful consideration.

Regarding graphical representation of data, candidates should be reminded to include labelling of axes, to use over half the paper for axes scales and gradient measurement, and to ensure that the inclusion of a labelled origin does not conflict with a generally linear scale elsewhere.

General comments

The paper was accessible to the vast majority of candidates, and there was no evidence of any timing issues. There were few questions left unanswered apart from inorganic qualitative analysis, including the planning exercise.

Candidates should be advised to read questions carefully and then answer with practical procedure in mind so that their suggested improvements are based on practical rather than theoretical arguments.

It appeared that most areas of the specification had been addressed in most centres, but teachers are advised to encourage practical work whenever possible rather than relying on demonstrations.

Comments on specific questions

Question 1

Candidates were asked to perform guided calculations to determine the number of moles of water per mole of hydrated sodium carbonate, to give a detailed explanation about how repetition and averaging can improve accuracy, and to suggest improvements to the experimental approach which would also improve accuracy.

(a) Most candidates entered their correctly rounded masses in the correct places in the table, but a significant number did not round as instructed.

(b) Most candidates realised what was needed and subtracted the correct figures. Others did not understand the experiment and were unable to identify the relevant figures.

There were some good answers here to all parts but some candidates did not give their answers to two significant figures based on the degree of accuracy in the question. It was clear that some candidates were unclear about the lack of significance of for example, the two zeros in 0.04.

(b)(v) Most candidates performed the division as instructed but failed to notice that *x* had to be a whole number. Consequently many answers lacked the rounding to the nearest whole number.

(c) (i) Candidates found this question challenging. A detailed explanation was required as to why repeating and averaging increases accuracy but rarely given. It was expected that answers would focus on identifying (and disregarding) anomalies or explain that averaging reduces the effects of (random) error. Answers indicating the total elimination of errors and others referring to improved reliability did not earn credit.

(ii) This experiment seemed unfamiliar to several candidates and there were some very poor answers for suggested improvements. Repetition, clean apparatus and lab coats were common generic answers which were not credited. The correct answers, which showed an understanding of accurate mass measurement or the need for complete removal of water, were rare.

Question 2

Candidates were asked to predict observations and to make deductions from given results for a variety of common anions and cations, and to describe how to carry out a flame test.

(a) Only stronger candidates realised that only one test was positive for chloride ions and that observations recorded elsewhere needed to reflect no reaction. 'Colourless solution' was the best answer but 'no precipitate' was also accepted as was 'no reaction'.

(b) Answers very rarely identified this as an acid and lithium was a quite common error.

(c) Only the strongest candidates referred to a wire or splint, having been dipped in the solution under test, presented to a Bunsen flame. Many referred to a powder or solid or used a rod or stick of unspecified material or set fire to the solution with a lighted splint. The cleaning usually described was often not sufficient to avoid contamination. The use of an acid, hopefully hydrochloric, was expected for the wire, or the use of a different splint. These were rarely mentioned.

(d) Most candidates made some attempt to describe the evidence provided by the flame tests but did not refer to the universal indicator test results, from which they were expected to conclude that both were alkaline.

(e) A few candidates realised that a blue colour was observed but did not mention the precipitate for solution **B**. The sequence where first a deep blue solution appears, turning to a pale blue precipitate, i.e. the reverse of the usual test sequence, was challenging for all candidates.

(f) The test result for ammonium ions was better known but most candidates did not heat the solution, even if sodium hydroxide was mentioned.

Question 3

Candidates were required to complete a circuit, read an ammeter, plot a graph of current against voltage and determine the resistance of an unknown resistor X from the reciprocal of the gradient of their graph.

(a) The correct symbol for a voltmeter was usually supplied but not always in parallel with the resistor and sometimes even in place of it.

(b) Scales needed to be more carefully read. A few candidates were 0.01 out either way. Other candidates read even less carefully. Nearly all candidates gave a two significant figure answer.

(c) (i) Many candidates labelled the vertical axis current I rather than current / A, while a few reversed the axes. Most candidates used sensible scales, but quite a few did not use over half of the graph paper. The plotting was generally good.

(ii) This was usually done well but some candidates forced their line through the origin.

(d) (i) Few candidates followed the instruction to show working on the graph when calculating gradients, but most fell within tolerance. Some candidates inverted their calculation – *x* over *y* rather than the correct *y* over *x*.

(ii) Most candidates found the reciprocal of their gradient and expressed it to a suitable number of significant figures.

(iii) For almost all candidates, the calculated gradient was significantly higher than the two stated values. No credit was given for vague answers such as "not equal to the stated values" or "not close to them" in these cases. Candidates are expected to understand the significance of experimental error (without necessarily stating that their value was over 10 per cent out of the range of both stated values). Answers stating that the candidate's answer for R_x was too different or very different from the given values of the resistors were acceptable.

(e) Graphical representation allows anomalies to be identified, corrects for error or allows an average to be obtained, so improving accuracy. Most candidates did not go far enough, simply referring to a line of best fit possibility, more values being under consideration or more reliability.

Question 4

Candidates were expected to design an experiment to find out if the starting temperature of water affected its rate of cooling, given an apparatus list.

Most candidates answered this reasonably well and there were few blank answers. However, with the exception of the strongest candidates, most did not recognise that one variable, either cooling time or temperature change, must be fixed to enable a fair comparison.

Credit was available for the use of given apparatus in context, for different start temperatures which were occasionally incorrectly created by boiling the kettle for varying times, for measurement of temperature drop or time intervals depending on the approach taken, for controlled variables including volume of water and time, column headings in a table and a conclusion.

Quite a few candidates answered well and some only lacked a table or a conclusion. Weaker candidates often gained credit for the correct use of apparatus and nearly all knew the amount of water had to be controlled from different starting temperatures.

A table with correct column headings including units needed to be drawn, not just referred to in text, and there was credit for candidates who showed an understanding of how to calculate rate, who averaged repeated readings, or drew a graph and compared slopes, by way of conclusion.

PHYSICAL SCIENCE

Paper 0652/62
Alternative to Practical

Key messages

Candidates need to address specific experimental contexts when suggesting methods to improve accuracy or reduce errors, and not rely on generic answers which would apply to all experimental methods e.g. repeating and averaging.

Knowledge of qualitative analysis tests and results, and the interpretation of these results was sometimes a weakness. Centres should ensure they undertake much more practical work where possible to aid memory of both procedure and results.

Candidates need to pay more attention to degree of accuracy and of approximation in their answers. There was some confusion over which figures are significant, particularly following a decimal point.

Candidates showed good planning skills and addressed the bullet points concisely, but tables needed to be actually drawn, not simply referred to in text, and conclusions needed inclusion and more careful consideration.

Regarding graphical representation of data, candidates should be reminded to include labelling of axes, to use over half the paper for axes scales and gradient measurement, and to ensure that the inclusion of a labelled origin does not conflict with a generally linear scale elsewhere.

General comments

The paper was accessible to the vast majority of candidates, and there was no evidence of any timing issues. There were few questions left unanswered apart from inorganic qualitative analysis, including the planning exercise.

Candidates should be advised to read questions carefully and then answer with practical procedure in mind so that their suggested improvements are based on practical rather than theoretical arguments.

It appeared that most areas of the specification had been addressed in most centres, but teachers are advised to encourage practical work whenever possible rather than relying on demonstrations.

Comments on specific questions

Question 1

Candidates were asked to perform guided calculations to determine the number of moles of water per mole of hydrated sodium carbonate, to give a detailed explanation about how repetition and averaging can improve accuracy, and to suggest improvements to the experimental approach which would also improve accuracy.

(a) Most candidates entered their correctly rounded masses in the correct places in the table, but a significant number did not round as instructed.

(b) Most candidates realised what was needed and subtracted the correct figures. Others did not understand the experiment and were unable to identify the relevant figures.

There were some good answers here to all parts but some candidates did not give their answers to two significant figures based on the degree of accuracy in the question. It was clear that some candidates were unclear about the lack of significance of for example, the two zeros in 0.04.

(b)(v) Most candidates performed the division as instructed but failed to notice that *x* had to be a whole number. Consequently many answers lacked the rounding to the nearest whole number.

(c) (i) Candidates found this question challenging. A detailed explanation was required as to why repeating and averaging increases accuracy but rarely given. It was expected that answers would focus on identifying (and disregarding) anomalies or explain that averaging reduces the effects of (random) error. Answers indicating the total elimination of errors and others referring to improved reliability did not earn credit.

(ii) This experiment seemed unfamiliar to several candidates and there were some very poor answers for suggested improvements. Repetition, clean apparatus and lab coats were common generic answers which were not credited. The correct answers, which showed an understanding of accurate mass measurement or the need for complete removal of water, were rare.

Question 2

Candidates were asked to predict observations and to make deductions from given results for a variety of common anions and cations, and to describe how to carry out a flame test.

(a) Only stronger candidates realised that only one test was positive for chloride ions and that observations recorded elsewhere needed to reflect no reaction. 'Colourless solution' was the best answer but 'no precipitate' was also accepted as was 'no reaction'.

(b) Answers very rarely identified this as an acid and lithium was a quite common error.

(c) Only the strongest candidates referred to a wire or splint, having been dipped in the solution under test, presented to a Bunsen flame. Many referred to a powder or solid or used a rod or stick of unspecified material or set fire to the solution with a lighted splint. The cleaning usually described was often not sufficient to avoid contamination. The use of an acid, hopefully hydrochloric, was expected for the wire, or the use of a different splint. These were rarely mentioned.

(d) Most candidates made some attempt to describe the evidence provided by the flame tests but did not refer to the universal indicator test results, from which they were expected to conclude that both were alkaline.

(e) A few candidates realised that a blue colour was observed but did not mention the precipitate for solution **B**. The sequence where first a deep blue solution appears, turning to a pale blue precipitate, i.e. the reverse of the usual test sequence, was challenging for all candidates.

(f) The test result for ammonium ions was better known but most candidates did not heat the solution, even if sodium hydroxide was mentioned.

Question 3

Candidates were required to complete a circuit, read an ammeter, plot a graph of current against voltage and determine the resistance of an unknown resistor X from the reciprocal of the gradient of their graph.

(a) The correct symbol for a voltmeter was usually supplied but not always in parallel with the resistor and sometimes even in place of it.

(b) Scales needed to be more carefully read. A few candidates were 0.01 out either way. Other candidates read even less carefully. Nearly all candidates gave a two significant figure answer.

(c) (i) Many candidates labelled the vertical axis current I rather than current / A, while a few reversed the axes. Most candidates used sensible scales, but quite a few did not use over half of the graph paper. The plotting was generally good.

(ii) This was usually done well but some candidates forced their line through the origin.

(d) (i) Few candidates followed the instruction to show working on the graph when calculating gradients, but most fell within tolerance. Some candidates inverted their calculation – *x* over *y* rather than the correct *y* over *x*.

(ii) Most candidates found the reciprocal of their gradient and expressed it to a suitable number of significant figures.

(iii) For almost all candidates, the calculated gradient was significantly higher than the two stated values. No credit was given for vague answers such as "not equal to the stated values" or "not close to them" in these cases. Candidates are expected to understand the significance of experimental error (without necessarily stating that their value was over 10 per cent out of the range of both stated values). Answers stating that the candidate's answer for R_x was <u>too</u> different or <u>very</u> different from the given values of the resistors were acceptable.

(e) Graphical representation allows anomalies to be identified, corrects for error or allows an average to be obtained, so improving accuracy. Most candidates did not go far enough, simply referring to a line of best fit possibility, more values being under consideration or more reliability.

Question 4

Candidates were expected to design an experiment to find out if the starting temperature of water affected its rate of cooling, given an apparatus list.

Most candidates answered this reasonably well and there were few blank answers. However, with the exception of the strongest candidates, most did not recognise that one variable, either cooling time or temperature change, must be fixed to enable a fair comparison.

Credit was available for the use of given apparatus in context, for different start temperatures which were occasionally incorrectly created by boiling the kettle for varying times, for measurement of temperature drop or time intervals depending on the approach taken, for controlled variables including volume of water and time, column headings in a table and a conclusion.

Quite a few candidates answered well and some only lacked a table or a conclusion. Weaker candidates often gained credit for the correct use of apparatus and nearly all knew the amount of water had to be controlled from different starting temperatures.

A table with correct column headings including units needed to be drawn, not just referred to in text, and there was credit for candidates who showed an understanding of how to calculate rate, who averaged repeated readings, or drew a graph and compared slopes, by way of conclusion.