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CHEMISTRY

Paper 0620/11
Multiple Choice (Core) 11

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

General comments

Candidates found **Questions 3**, **5** and **26** to have the least demand.

Candidates found **Questions 9**, **15**, **17**, **20**, **27**, **29** and **37** most demanding.

Overall, candidates found this to be a challenging paper although this may reflect school closures and other factors associated with the COVID pandemic.

Candidates should take time to check all the statements in multiple completion questions.

Comments on specific questions

Question 2

Some candidates did not link all the units of the measurements to the measuring apparatus. A common incorrect choice was option **B**.

Question 6

Nearly all candidates recognised that these atoms were isotopes of the same element and that they would have the same number of electrons. Many candidates stopped there and did not read on to statement 4.

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Question 8

There was an equal split of candidates choosing the correct answer and option **C**, hydrogen.

Question 9

Candidates found this a demanding question. Candidates could determine the correct answer by counting the oxygen atoms on each side of the equation.

Question 11

Many candidates were unable to identify why aluminium is used in overhead power cables. Options **C** and **D** were commonly chosen.

Question 15

Candidates found this a demanding question. Candidates were more likely to choose option **A** than the correct answer, showing recall of the colour change in copper(II) sulfate but not the temperature change.

Question 16

Most candidates chose option **A**. The graph was correctly interpreted to show the increase in reaction rate, but candidates should be remined that catalysts do not change the amount of product produced.

Question 17

Many candidates chose option **B**. Candidates should be remined that neutralisation reactions produce water and a salt.

Question 20

Candidates found this a demanding question. There was evidence that many candidates were guessing. This would indicate that both anion and cation tests were poorly recalled.

Question 25

This question discriminated well. Candidates who performed less well overall were equally likely to choose any of the options showing poor recall of the general properties of noble gases and electron arrangements.

Question 27

All candidates found the significance of the extraction of a metal from its oxide using carbon difficult. Candidates should recall that it is the least reactive metals that are extracted using carbon, with more reactive metals requiring electrolysis. The most common answer was option **A**.

Question 29

Candidates found this a demanding recall question. Most candidates chose option **D**. All the reactions involved in iron extraction are a key part of the metals section of the syllabus.

Question 37

Option **A** was commonly chosen. Candidates should recall that ethanol can be mixed with water.

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Paper 0620/12
Multiple Choice (Core) 12

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

General comments

Candidates found **Questions 3**, **5**, **21**, **27** and **30** to have the least demand.

Candidates found **Questions 4**, **6**, **11**, **26**, **32**, **38** and **39** most demanding.

Overall candidates found this to be a challenging paper although this may reflect school closures and other factors associated with the COVID pandemic. For many questions, the weaker performing candidates appeared to be guessing.

Candidates should take time to check all the statements in multiple completion questions.

Comments on specific questions

Question 2

Better performing candidates had no difficulties with this question. Other candidates did not link all the units of the measurements to the measuring apparatus. A common incorrect response was option **B.**

Question 4

All candidates found this a demanding question. The distribution of choices suggests guessing. Candidates should recall that different elements have different numbers of protons, and that the nucleon number is the sum of proton and neutron numbers.

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Question 6

This question was the least well answered question on this paper. The correct option was the least chosen. Candidates should recall that atoms have equal numbers of protons and neutrons whereas ions are formed when electrons are gained or lost from atoms.

Question 11

Option **A** was the most commonly chosen option for better performing candidates and option **C** for those that performed less well overall. Candidates should recall that thermal decomposition of calcium carbonate (and hydrocarbons) does not require oxygen.

Question 14

This question discriminated between candidates well. Nearly all of the candidates who performed well overall answered this question correctly; others appeared to be guessing.

Question 20

This question discriminated well. Candidates who performed less well overall tended to choose option **C**, suggesting some confusion either about the meaning of monoatomic or the diatomic nature of nitrogen.

Question 23

Many candidates chose option **A**.

Question 26

Candidates should recall that combustion reactions are exothermic and in the blast furnace it is carbon that is burned. Few candidates were able to identify this reaction, with half of all candidates choosing option **D**.

Question 31

This question discriminated well. Candidates who performed less well overall chose any of the options in preference to the correct answer, with option **B** being the most commonly chosen. Candidates should recall that essential elements for plant growth are found in NPK fertilisers which correspond to the element symbols.

Question 32

Candidates found this a difficult question. Most candidates chose option **B**, suggesting they were not clear that an *unsaturated* compound contains one or more multiple carbon-carbon bonds such as C=C.

Question 35

Candidates who performed less well overall were more likely to choose option **A**.

Question 38

Candidates found this a demanding question. Option **A** was more commonly chosen by the better performing candidates; others chose option **C**. Both options would explain one of the observations but not both. To produce both water and carbon dioxide a fuel containing carbon and hydrogen would be needed.

Question 39

There was evidence of a significant amount of guessing to this question. There was a slight tendency for candidates to choose an option containing statement 3. Candidates should be reminded that neutralisation reactions produce water rather than hydrogen.

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Paper 0620/13
Multiple Choice (Core) 13

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

General comments

The number of candidates for this paper was relatively low.

Candidates found **Questions 5**, **26** and **40** to have the least demand.

Candidates found **Questions 8**, **9**, **10**, **20**, **31**, **36** and **38** most demanding.

Overall, candidates found this to be a challenging paper although this may reflect school closures and other factors associated with the COVID pandemic.

Candidates should take time to check all the statements in multiple completion questions.

Comments on specific questions

Question 2

Some candidates did not link all the units of the measurements to the measuring apparatus. Option **B** was a common incorrect choice.

Question 7

Candidates found the recall of properties of ionic compounds difficult. Option **D** was chosen by most candidates, showing some confusion about the solubility and conduction of ionic compounds.

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Question 8

Candidates found this the most demanding question on the paper. Option **C** was chosen by the majority of candidates. Candidates could sketch a dot-and-cross diagram to help work out an answer to this question.

Question 9

Candidates found this a demanding question. Option **D** was commonly chosen. For this type of question, candidates need to work through each option in turn.

Question 10

All of the distractors were equally chosen by many candidates who appeared to be guessing.

Question 13

Equal numbers of candidates chose options **A**, **B** and **C**. Almost none chose option **D**, suggesting that candidates either knew hydrogen was produced or that it was a redox reaction.

Question 15

Option **C** was chosen by many candidates who perhaps confused the terms anhydrous and hydrated.

Question 20

All candidates found this a demanding question. Option **A** was the most common incorrect answer. Candidates should be familiar with the formation and separation of soluble salts using insoluble bases.

Question 27

Candidates found this question challenging. Option **B** was a commonly chosen incorrect option. Candidates should recognise that metal reactivity can be determined by both the reactions they take part in and those they do not. In this case, only the less reactive metals can be extracted using carbon.

Question 28

The uses of aluminium and stainless steel were not well recalled. Most candidates chose option **B** which reversed typical uses for each metal.

Question 31

Candidates should recall that fertilisers are often referred to as NPK fertilisers in this syllabus. Most candidates chose option **C**, which was the only option to not include phosphorus.

Question 36

Candidates found this a challenging question. All the distractors were more commonly chosen than the correct answer Most candidates chose option **A**.

Question 38

Option **C** was chosen by many candidates. Candidates should recall that fermentation requires living organisms so the temperature can be neither too low nor too high for their survival; the range 25 – 40°C is most suitable for this.

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Question 39

This question tested understanding of chemical tests and the meaning of the terms saturated and unsaturated in organic chemistry. Both caused candidates some difficulty. Options **A** and **B** were commonly chosen.

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Paper 0620/21
Multiple Choice (Extended) 21

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

General comments

Candidates found **Questions 2**, **20**, **22**, **25**, **26**, and **29** to have the least demand.

Candidates found **Questions 14**, **27**, most demanding.

Overall, candidates found the paper was relatively accessible.

Comments on specific questions

Question 1

Some candidates appeared to be guessing, with an even distribution of each option chosen.

Question 5

Nearly all the better performing candidates answered this correctly. Others tended to choose option **B**. It is a common error to assume that all electrical conduction is through mobile electrons.

Question 8

Overall, this question was well answered but a significant number of candidates who performed less well chose option **C**.

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Question 14

This question was not well answered. Most candidates chose option **C**, suggesting that while the test for chloride ions was well recalled, the reduction and corresponding colour change in light was not.

Question 17

This question discriminated well. Nearly all the candidates who performed well overall answered this correctly. Other candidates appeared to be guessing, although there was a slight preference for option **A** showing some confusion between the strength of the acid and the pH of the solution.

Question 24

Option **B** was chosen by some candidates, with candidates finding the distinction between alloys and galvanised metals difficult.

Question 27

Although few candidates chose option **D**, the other distractors were frequently chosen, particularly option **A**. Candidates should recall that it is the least reactive metals that can be extracted from their oxide using carbon.

Question 31

This question discriminated well. Nearly all the candidates who performed well overall answered this correctly. Others appeared to be guessing, with all options being equally chosen. Candidates should recall that in this syllabus fertilisers are known as NPK fertilisers, reflecting the elements they contain.

Question 33

All the distractors were chosen by the candidates who performed less well overall. This suggests that the properties of sulfur dioxide were not well known because none of the statements were clearly recognised as correct.

Question 35

Weaker candidates appeared to be guessing on this question.

Question 37

Few candidates chose options **C** and **D** but found it difficult to distinguish between options **A** and **B**. Candidates could identify the correct answer by considering the observation that ethanol and water readily mix in the fermentation of glucose.

Question 39

Most candidates answered this correctly. The weakest candidates appeared to be guessing, with an even distribution of options chosen.

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Paper 0620/22
Multiple Choice (Extended) 22

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

General comments

Candidates found **Questions 2**, **3**, **5**, **6**, **9**, **14**, **23** and **27** to have the least demand.

Candidates found **Questions 17** and **39** most demanding.

Overall, candidates found the paper was relatively accessible.

Comments on specific questions

Question 1

Option **D** was the most commonly chosen incorrect answer, with candidates assuming that the common gases in the air would diffuse equally.

Question 7

This question was answered correctly by most candidates. A minority thought sulfuric acid and hydrochloric acid are liquid rather than aqueous, choosing options **B** or **D**.

Question 10

Some candidates chose option **C**, not recalling the formation of hydrogen in the electrolysis of aqueous sodium chloride.

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Question 13

Very few candidates chose options **C** or **D**. Many of the candidates who performed less well overall chose option **A**, showing confused understanding of activation energy and rate of reaction.

Question 16

Some candidates confused the activation energy with the overall energy change of reaction, choosing option **A.**

Question 17

Candidates found this the most demanding question on the paper. Option **C** was the most common answer. Although information was given in the question, candidates should recall the 2 : 1 ratio of hydrogen to oxygen in the reaction.

Question 20

Some candidates choose option **C**, which is the exact reverse of the correct answer.

Question 22

Candidates who performed less well overall were more likely to choose any of the incorrect options. Option **C** was often chosen by these candidates, confusing the liberation of ammonia from ammonium salts using a strong alkali.

Question 38

Although a small majority answered this correctly, option **C** was a common incorrect answer. Candidates should recall that displayed structures show the bonding but not the shape of a molecule. In this case, structures 2 and 3 represent the same molecule.

Question 39

Option **C** was the most chosen incorrect answer. Candidates should recognise that alkanes react with chlorine in a substitution reaction where hydrogen atoms are replaced by chlorine atoms. The reaction can continue, substituting all the hydrogen atoms in an alkane with chlorine. HCl is produced as a by-product each time.

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Paper 0620/23
Multiple Choice (Extended) 23

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

General comments

Candidates found **Questions 3** and **26** to have the least demand.

Candidates found **Questions 11**, **20** and **39** most demanding.

Overall, candidates found this paper relatively challenging. Questions involving observations in practical chemistry such as **Questions 15** and **20** were not well answered.

Comments on specific questions

Question 2

Most candidates recognised the need to use a stop-clock in this experiment. Some candidates chose option **B**, which is an incomplete answer. Candidates should take care to consider all the options.

Question 5

Option **A** was a common incorrect answer, which confused the meanings of the mass number and the atomic number.

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Question 6

Some candidates chose option **C**, which contains correct information but not an explanation.

Question 8

Option **C** was often chosen. Candidates adding an unnecessary 2:1 ratio in their calculation.

Question 11

Candidates found this one of the most demanding questions on the paper and many chose option **A**. Ethanol is a renewable energy source formed by fermentation.

Question 15

Most candidates chose option **A**, showing recall of the colour change but not the energy change when water is added to anhydrous copper(II) sulfate.

Question 20

Candidates found this question on ion tests to be one of the most demanding questions on the paper. Although there was a slight preference for the correct answer, overall, it appeared that most candidates were guessing.

Question 22

Many candidates chose option **B**.

Question 27

All the other options were chosen in preference. Option **D** was a common answer where candidates recognised a gas produced in the extraction of zinc.

Question 31

Some candidates were more likely to choose any of the incorrect options, particularly option **C**. Candidates should recall that in this syllabus, fertilisers are known as NPK fertilisers, reflecting the elements they contain.

Question 39

Candidates found this to be one of the more demanding questions on the paper. Some were able to identify the correct M_r but did not use the moles of the limiting reactant in their answer. Other candidates were more likely to choose any of the incorrect options.

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Paper 0620/31
Theory (Core) 31

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes.
- Many candidates need more practice in analysing the stem of a question.
- Interpretation of data from tables, completion of chemical equations and simple calculations were generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Few of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. Others need more practice in naming chemicals and learning specific chemical reactions. For example in **Question 2(a)(ii)**, many candidates could not name ammonium chloride correctly and in **Question 2(d)(iii)**, many candidates did not know the products of the reaction of a carbonate with an acid. Similarly in **Question 4(b)**, many candidates did not know the products of the reaction of a metal oxide with an acid. In **Question 5(b)**, many candidates did not appear to know the difference between the separation, arrangement and motion of the particles or wrote vague statements about the bulk properties of liquids and gases. Others wrote about separation methods such as distillation rather than focussing on the kinetic particle theory. In **Questions 5(d)(i)** and **5(d)(ii)**, a majority of the candidates wrote vague answers relating to a variety of atmospheric pollutants rather than focussing on lead. In **Question 6(c)**, many candidates need to learn the syllabus specific statements relating to the names and uses of petroleum fractions. Many vague answers were seen. In **Question 6(d)(i) Question**, attempts to explain the term cracking were often hampered by vague statements about ‘compounds’, ‘elements’ and ‘substances’ rather than focussing on hydrocarbons of different chain length. Others muddled the terms elements and compounds at various points throughout the paper. Some candidates need more practice in labelling diagrams and drawing graphs. For example in **Question 7(c)(i)**, many candidates did not draw a label line to the anode with sufficient precision and/or left gaps in the drawing of the external circuit in the electrolysis apparatus. In **Question 8(b)**, many candidates drew graph lines inaccurately and often as a straight line rather than a curve.

Many candidates need more practise in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 1(a)(iii)**, many candidates did not heed the word ‘element’ and gave the names of compounds. In **Question 1(b)**, many muddled relative charge with relative mass. In **Question 2(a)(i)**, some candidates did not use the information in the table as requested and hence chose a positive ion instead of a negative ion. In **Question 5(c)**, many did not refer to the equation and just gave a definition of reduction. In **Question 7(c)(ii)**, many candidates did not read the question properly and named the anode and cathode rather than the names of the products formed at the electrodes. In the same question, a considerable number of candidates did not read the question properly which stated that zinc chloride is the electrolyte. These candidates continued from **Question 7(b)**, and gave phosphorus as the anode product.

Some candidates would benefit from further revision of specific topic areas such organic chemistry (**Questions 2(d)(i)** and **6**), electronic structure (**Question 5(e)(iv)**) and electrolysis (**Question 7(c)**).

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Some candidates need to revise qualitative tests for specific ions and molecules. For example, the answers to the questions about the test for sulfate ions (**Question 2(b)**) and the test for unsaturation using aqueous bromine (**Question 6(a)(i)**) were not well known.

Many candidates were able to extract information from tables, balance symbol equations and undertake simple chemical calculations. Others need more practice in these skills.

Comments on specific questions

Question 1

Many candidates identified at least three of the substances correctly in **(a)**. In **(b)**, some candidates were able to deduce the correct charge on the neutron and electron. Others muddled the charge with the mass.

(a) (i) The majority of candidates recognised that calcium oxide is formed from the decomposition of calcium carbonate. The commonest error was to suggest sulfur dioxide.

(ii) Some candidates suggested copper ions. The commonest incorrect answers were potassium or sodium ions. A significant number of candidates gave the names of organic compounds.

(iii) This was the least well answered of **(a)**. Many candidates did not heed the word element and gave incorrect answers such as 'methane' or 'C_2H_6'. Others suggested that helium or nitrogen could be used as a fuel.

(iv) Many candidates realised that C_2H_4 is used to produce poly(ethene). The commonest incorrect answers were 'CH_4' or 'C_2H_6'.

(v) Some candidates recognised the chloride ion. The commonest incorrect answer was to suggest a positive ion such as Na^+ or K^+.

(b) Many candidates performed well. Others muddled the charge with the mass of the neutron and electron. The commonest incorrect answers were ±1 or +1 for the charge on the neutron and +1 or 1/2 000 for the charge on the electron.

(c) The commonest errors were to tick the first box (nitrogen molecules are monoatomic) or the 4th box (all nitrogen atoms have 14 neutrons).

Question 2

This was one of the least well done questions on the paper. Some candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(c)**. In **(a)(ii)**, many did not use the information in the table and gave the incorrect name for ammonium chloride. Few knew the test for sulfate ions in **(b)** and in **(d)(i)**, only the best responses drew the correct structure of the carboxylic acid functional group. In **(d)(ii)**, many candidates gave vague answers or gave the incorrect gases.

(a) (i) Many candidates selected the chloride ion as the negative ion having the lowest mass. The commonest error was to suggest zinc through not reading the question carefully enough and selecting the positive ion rather than the negative ion.

(ii) A minority of the candidates gave the correct name: ammonium chloride. The commonest errors were ammonia chloride, ammonium chlorine, nitrogen chloride and ammonium and chloride. Many confused the ammonium ion with the nitrate ion. A few gave formulae instead of the name.

(iii) Some candidates did the calculation correctly using simple proportion. A few tried to do mole calculations. Candidates should realise that there is no requirement for moles calculations on the core paper. The commonest error was to be a factor of 10 or 1000 out i.e. 61 or 6100.

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(b) This was one of the least well answered parts of this question. Some candidates knew that a white precipitate was formed. Common errors were to suggest adding sodium hydroxide or silver nitrate or nitric acid alone. Other candidates suggested a flame test or testing with litmus paper. A significant minority suggested adding potassium manganate(VII) – a confusion with the test for sulfites/sulfur dioxide. A significant proportion of the candidates did not respond to this question.

(c) Many candidates wrote the formula correctly. The commonest errors were to add an extra oxygen atom, to write the formula without subscripts (C9H8O) or to add + signs or commas between the elements e.g. C_9, H_8, O.

(d) (i) This was the least well answered part of this question. Some candidates included the alkyl group or hydrogen. Others did not show the O–H bond or missed out the double bond between the C and the O. Many candidates gave structures related to aldehydes or alcohols rather than carboxylic acids or drew divalent hydrogen atoms or pentavalent carbon atoms. A significant proportion of the candidates did not respond to this question.

(ii) Some candidates realised that carbon dioxide and water were formed. The commonest error was to suggest hydrogen instead of water. Other candidates gave vague answers unrelated to gases e.g. 'salt' or 'sodium oxide'. A few candidates wrote formulae instead of the names of the products.

Question 3

This was one of the best answered questions on the paper. Many candidates performed well in **(a)**, **(b)**, **(c)(i)** and **(d)(i)**. In **(c)(ii)**, few candidates gave a full enough explanation in terms of the relative reactivity of chlorine and iodine. In **(d)(ii)**, only the better performing candidates realised that they needed to refer to 105 °C as well as the melting point.

(a) The commonest error was to suggest 37 neutrons.

(b) Some candidates wrote answers which were too vague e.g. 'cleaning the water', 'purifying the water' or 'removing impurities'. A significant number of candidates referred to the bleaching action of chlorine rather than the fact that it kills bacteria.

(c) (i) Most candidates were able to balance the equation. The commonest error was '1 KCl'.

(ii) A minority of the candidates compared the reactivity of chlorine and iodine. The commonest errors were to compare the reactivity of iodine with chloride, to state that 'iodine is less reactive than potassium' or 'iodine is less reactive than potassium chloride'.

(d) (i) Most candidates were able to predict both values. The commonest error was to give a positive value or a value that was not negative enough for the boiling point of fluorine.

(ii) A minority of the candidates realised that they needed to refer to the 105 °C as well as the melting point. Many gave vague answers such as 'its not reached the melting point' or 'its before the melting point'.

Question 4

This question was the least well answered in the paper. Some candidates were able to answer **(a)**, **(b)** and **(d)(i)** well. Most candidates gave vague answers in **(c)** (use of lime) and **(d)(ii)** (explanation of an energy level diagram).

(a) A minority of candidates knew the colour of methyl orange in acidic and alkaline solution. The commonest errors were 'orange' in acidic solution and 'blue', 'orange' or 'colourless' in alkaline solution.

(b) Some candidates knew the products formed when an oxide reacts with an acid. Others seemed to guess the answers and suggested 'calcium hydroxide' or 'calcium carbonate' instead of the salt, calcium chloride. Many candidates suggest 'hydrogen' as the co-product rather than water. Others suggested that 'oxygen' was formed.

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(c) Few candidates gave a suitable use for calcium oxide. The commonest errors were 'cooking', 'making limestone', 'making statues' or 'fruit'. Some candidates wrote about 'neutralising soil'. This was too vague because it omitted the essential word 'acidic'.

(d) (i) The best answers included the words 'heat' or 'thermal energy'. Many candidates did not gain credit because they wrote vague statements about 'energy being produced' without specifying thermal energy.

(ii) The best answers referred to the relative energy levels of the reactants and products. Many did not gain credit because they did not interpret the diagram with sufficient exactitude. Examples of answers which were too vague included 'reactants higher than the products' (no mention of energy), 'products lose energy' (incorrect) and 'reaction loses energy' (no mention of reactants or products).

Question 5

Many candidates were able to name the changes of state in **(a)** and answer the questions about diamond in **(e)** correctly. In **(b)**, many candidates muddled the separation and motion of the particles with their arrangement or wrote about motion when they were meant to be writing about separation. In **(c)**, many candidates did not refer to the equation as requested, whilst in **(d)**, few candidates gave a correct source or adverse effect of lead in the air.

(a) Most candidates gave the correct terms for the changes of state. The commonest error for freezing were 'cooling' or 'solidifying'. The latter was not allowed because the word 'solid' had been provided in the question. The commonest error for boiling was 'freezing'.

(b) Some candidates wrote correct comments in the wrong sections or muddled separation and motion with the arrangement of particles. A considerable number of candidates wrote about separation techniques e.g. 'distillation' or 'filtration' rather than the distance between the particles. Candidates should be advised that as soon as they see the mention of the words 'kinetic particle model' in a question, they know that 'separation' does not refer to experimental methodology. Common errors included: 'small gaps' or 'loosely packed' (for liquid separation), 'separated' or 'gaps' (for gas separation), comments on speed or 'vibration only' (for liquid motion). Most candidates made a suitable comment about the motion of the particles in a gas. Other candidates described the bulk properties of liquids and gases e.g. 'takes the shape of its container'.

(c) Many candidates just described the reaction in words. Others gave a definition of reduction without referring to the equation or suggested that lead (on the right of the equation) lost oxygen instead of lead oxide lost oxygen.

(d) (i) Very few candidates gave a suitable source of lead in the air. Many gave vague answers such as 'burning fossil fuels' or 'incomplete combustion'. Others gave general descriptions such as 'factories', 'chimneys' or 'industry'.

(ii) A minority of the candidates gave answers relating to adverse effects on the brain or nervous system. Most candidates suggested effects on breathing or lung damage. Others suggested problems more specific to carbon monoxide or sulfur dioxide than to lead. A significant number of candidates suggested that lead either causes cancer or gave vague answers such as 'affects the nerves' without specifying that the affect is negative.

(e) (i) Most candidates realised that diamond is a giant structure. The commonest error was to choose 'ionic'.

(ii) Some candidates correctly identified the bonding in diamond as being covalent. The commonest errors were to suggest 'ionic' or 'metallic'.

(iii) Most candidates gave a correct use for diamond, 'jewellery' or 'drilling', being the commonest correct answers. The commonest incorrect answers were 'cutlery' or 'digging'.

(iv) A minority of the candidates gave the correct electronic structure of carbon. Many candidates appeared not to understand the term electronic structure. The commonest errors were 2.8.2 (using mass number), 6 (number of protons) or ^{12}C.

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Question 6

This was one of the least well answered questions on the paper. Many candidates identified the structures in **(a)(ii)**, **(a)(iii)** and **(a)(iv)** and could name the method used to separate petroleum fractions in **(b)**. Few candidates identified the compound that decolourises aqueous bromine in **(a)(i)** or gave suitable uses for the fractions in **(c)**. In **(d)(i)**, a minority of the candidates gave a suitable definition of the term cracking. In **(d)(ii)**, some candidates realised that a high temperature is required for cracking, but fewer gave another suitable condition.

(a) (i) Many candidates misunderstood the question and chose the product of the reaction of an alkene with bromine rather than the alkene itself.

(ii) Most candidates identified the alcohol. There were no consistent errors.

(iii) Many candidates identified the unsaturated compound. There were no consistent errors.

(iv) Many candidates identified **E** as being in the same homologous series as ethane. The commonest error was to suggest **F** (dibromoethane).

(b) Many candidates realised that petroleum fractions are separated by fractional distillation. The commonest errors were 'cracking', 'filtration' or 'fractionating column'.

(c) Many candidates gave answers which were too vague or appeared to select the use of fractions other than those requested. Candidates would be advised to learn the examples in the syllabus. The commonest errors were: 'fuel for home' or 'fuel for aircraft' (for refinery gas); 'fuel' or 'cars' (unqualified) or 'fuel for aircraft' (for gasoline) and 'naphtha', 'kerosene' or 'bitumen' (for the name of the fraction containing waxes and polishes).

(d) (i) Few candidates were able to state the meaning of the term cracking satisfactorily. The best answers focused on long chain hydrocarbons being broken down to smaller hydrocarbons such as alkanes and alkenes. Many gave vague answers such as 'breaking down compounds', 'breaking down chains', 'separating hydrocarbons' or 'breaking down polymers to monomers'. Others did not specify the length of the hydrocarbon chains or did not state the products of the breakdown. A few suggested 'breakdown of elements'.

(ii) Many candidates realised that 'heat' or 'high temperature' was needed for cracking. Few gave a suitable second condition. Many suggested high pressure instead of a catalyst. A significant proportion of the candidates did not respond to this question.

Question 7

This was the best answered question on the paper. Many candidates performed well in **(a)**. Parts **(b)**, **(d)** and **(e)** were generally well answered. In **(c)(i)**, many candidates did not label the anode accurately. Candidates should be reminded that the label line should go to the anode itself and not the electrolyte or the wires attached to the anode. In **(c)(ii)**, many candidates gave the names of the electrodes (anode and cathode) instead of the products at the electrodes.

(a) The best answers included malleability, lustre and conductivity. Candidates should be reminded that electrical conduction and heat conduction are considered too similar to be awarded separate credit. Similarly, high melting point and high boiling point are also too similar to be awarded separate credit.

(b) Most candidates balanced the equation correctly. The commonest error was to reverse the stoichiometry (2Zn and 3P).

(c) (i) Many candidates completed the circuit correctly. Others did not place a power source in the circuit or attached the wires to the sides of the beaker instead of to the electrodes. A considerable number of the candidates left gaps in the circuit, often not attaching the wires to the electrodes. Many candidates did not label the anode accurately. Candidates should be reminded that the label line should go to the anode itself and not the electrolyte or the wires attached to the anode. A significant minority of the candidates labelled the cathode or the electrolyte as the anode. A significant proportion of the candidates did not respond to this question.

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(ii) The best answers gave the names of the elements, chlorine and zinc, as the positive and negative electrode products. Others suggested chloride is formed at the anode. A significant minority of the candidates suggested phosphorus forming at the anode, presumably because they did not read the question properly and were still thinking about the zinc phosphide in **(b)**.

(d) (i) Most candidates knew the symbol for a reversible reaction. The commonest errors were 'reverse reaction' or 'equals'.

(ii) Most candidates chose the correct pH value. The commonest error was to suggest pH 9.

(e) Many candidates completed the calculation correctly. The commonest error was to suggest 138 by using the atomic number 6 for carbon, even though the relative atomic mass had been given in the table. Others forgot to add the 65 from the zinc or miscounted the number of carbon and/or hydrogen atoms.

Question 8

Many candidates deduced the mass of the reaction mixture correctly in **(a)** and described the effect of a catalyst and lowered concentration of hydrochloric acid in **(c)**. Most candidates were able to do the calculation in **(d)**. In **(b)**, many candidates needed to improve their skills in interpreting data and in drawing graph lines.

(a) Most candidates deduced the mass of the reaction mixture at 30 s correctly. The commonest errors were 180.4, 180.41 or 180.44.

(b) Many candidates needed to improve their skills in drawing line graphs with sufficient care. Many candidates drew lines following the original line for too long or started the line vertically on the *y*-axis for too long. Others drew straight lines rather than a curve or did not make it clear that the final mass remains the same as the original line. Other common errors included transposing the curve higher or lower than the original, moving the final mass to the bottom of the grid or giving a slower initial rate.

(c) The best answers referred to a faster rate in the presence of a catalyst and a slower rate when the concentration of the hydrochloric acid is lowered. A significant number of candidates gave answers associated with time rather than rate. Others gave answers which were absolute rather than comparative e.g. 'the reaction is fast with a catalyst'. This is not acceptable because the reaction could be fast without the catalyst.

(d) Most candidates calculated the volume of carbon dioxide correctly, using simple proportion. Some candidates were a factor of 10 out with their calculation e.g. 9.5 or 950 cm^3. A common incorrect answer was 15.2, derived from $(38 \times 0.2) \div 0.5$.

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CHEMISTRY

Paper 0620/32
Theory (Core) 32

Key messages

- Questions where the candidate had to match the formula of an atom or ion to a statement were answered well. It was clear that candidates had been practising lots of these types of questions.
- Questions requiring simple answers to calculations were usually answered well, as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound as in **Question 7(d)**.
- Questions on the more detailed aspects of the kinetic particle theory were answered well by some candidates but others still need to answer these in more detail using the correct terms. There was also a tendency for candidates to get 'arrangement, separation and movement' mixed up. Some candidates got the word 'separation' mixed up with separation techniques using mixtures.
- Questions involving extended writing need to contain the same number of relevant points as the number of marks available. This also should be applied to any other question that has more than one mark available.
- It is very important that candidates read the question carefully to understand what exactly is being asked. Practice of reading and interpreting data-based questions should also be prioritised.
- Candidates performed poorly when answering questions on chemical tests, showing large gaps in the knowledge of many candidates. This is a part of the syllabus that needs to be practiced more often. Candidates struggled with 'Describe a test for chloride ions' **Question 2(b)**.
- Organic questions were answered reasonably well and some candidates could draw structures of organic compounds. The structure of ethanol in **Question 2(d)(i)** was drawn well. However, the longer question on fractional distillation was not answered as well (**Question 6(b)**), which showed more practice needs to be done on these types of questions.
- Candidates struggled with stating the use of substances, especially **Question 6(c)** which was to show the name and uses of petroleum fractions. More work on the recall of specific uses of substances detailed in the syllabus should be done with candidates recalling at least one use for each of the substance detailed.
- Candidates answered the graph question well (**Question 8**). They were able to read off the graph the value that was needed and also draw the line for the different condition.

General comments.

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Good answers were shown throughout the paper to a number of different questions. However, most candidates found parts of every question challenging with the longer questions being poorly answered. Nearly all candidates were entered at the appropriate level. There were a few candidates who performed very poorly and left many questions blank. It was evident that many candidates are now using past paper practice as part of their revision program, but more revision is needed on some aspects of the syllabus.

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Misinterpretation of the rubric happened in some cases. The most common misinterpretation or simply not reading of the rubric was in the question that asked, ‘use the kinetic particle model to describe the differences between solid aluminium and liquid aluminium in terms of the arrangement and the separation of the particles’. Some candidates described separation of particles in a gas instead. However, not reading the question properly was a key factor of some making mistakes in their answers. Many candidates thought that the ‘separation’ part of the question was to do with the separation of mixtures and put down ‘fractional distillation’; ‘filtration’ or describing the particles ‘being too far away from each other’ whereas many other candidates talked about the ‘movement’ of particles instead of the ‘separation’ and gained no credit.

Another misinterpretation question was in **Question 1(b)** which asked candidates to ‘complete the table to show the relative masses of a proton, a neutron and an electron’. Lots of candidates thought that this meant the ‘relative charge’ and gave the charges of a neutron and an electron instead. The other misinterpretation was in **Question 7(a)(ii)**, where candidates incorrectly thought that the difference in reactivity was a physical property.

The balancing of equations showed that candidates had practiced these as part of their revision from past papers. Definitions from across the syllabus were poorly done and candidates need to concentrate on them both when being taught for the first time and during the revision period.

The vast majority of candidates were able to ‘deduce the number of electrons, neutrons and protons in one atom of the isotope of potassium shown’ as in **Question 3(a)**. Good responses were seen for ‘predict the physical state’ of an element at a certain temperature, where most candidates could give the state and a good reason, which showed much practice and revision of past paper questions. Data handling type questions could have been answered better. Candidates were not being precise enough when answering questions. Candidates were able to draw the structure of ethanol in **Question 2(d)(i)**. This showed that candidates had been doing lots of practice in the drawing of molecules listed in this part of the specification.

Candidates needed to be more explicit when talking about certain concepts and should not use the words ‘it’ and ‘they’ to answer questions. The standard of English was reasonably good. Some candidates wrote their answers as short phases or bullet points. Candidates are less likely to write vague statements or contradict themselves if this is done.

<u>Comment on specific questions</u>

Question 1

Candidates tackled this question reasonably well. Some struggled with **(b)** and **(c)**. Candidates struggled with the relative masses of subatomic particles.

(a) (i) Most candidates could answer this question and knew that carbon dioxide is a product of respiration.

(ii) Candidates did struggle with this part, some giving the sodium ion instead of the potassium ion. More revision practice is needed for this part of the syllabus.

(iii) Most candidates could give oxygen as the correct answer here for the composition of clean, dry air.

(iv) Candidates did not know that uranium was the radioactive isotope used as a source of energy.

(v) This was answered well and most candidates knew that the bromide ion was the ion formed when an atom gains an electron.

(b) Candidates found this challenging and confused relative mass and charge of the subatomic particles – neutron and electron. More revision was needed as many could not remember the mass of an electron. Lots of candidates thought the mass of an electron was –1 and the neutron was zero.

(c) Candidates performed poorly on this question and many did not gain any credit. Many struggled with the statement of ‘carbon dioxide is an acidic oxide’.

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Question 2

Some parts of this question were answered well. For example, **(a)(i)** and **(iii)** and **(c)**. Candidates struggled with the chemical test in **(b)** and the 'use of ethanol' in **(d)(iii)**.

(a) (i) Most candidates could answer this question well and had obviously practiced from previous past papers.

(ii) Some candidates could name this compound; others struggled and called it 'magnesium sulfoxide' which is incorrect. More practice of this type of question would help the candidates.

(iii) This mathematical question was answered well and showed that candidates had practiced this type of question.

(b) Candidates struggled with recalling the chemical tests that are in the syllabus. This question was very poorly answered with many candidates giving the wrong test, getting mixed up between tests or not putting down a chemical test at all. A few candidates got the correct test but then went on to put the incorrect observations. Many had not learnt the chemical tests well enough. More practice and learning of the chemical tests is needed by candidates.

(c) Most candidates could write down the correct formula from the structure of glycerol. However, some candidates used superscripts and therefore did not gain credit.

(d) (i) Candidates did very well on this question. They remembered to draw the bond between the oxygen and hydrogen in the alcohol functional group, which showed much practice and revision.

(ii) Not many candidates could answer this question completely. Some candidates could state 'carbon dioxide' but not many could state 'water'. More practice is needed in remembering the two products formed when ethanol undergoes complete combustion.

(iii) This was the first 'use of a substance' question. It was answered much better than the other 'uses' questions on this paper. However, some candidates could not remember the 'use of ethanol' and just put 'for burning' or as an 'alcohol'. Uses of substances named in the syllabus should be practiced when revising.

Question 3

Candidates coped well with this question, especially **(a)** and **(b)**. However, candidates struggled with **(d)(i)** and **(e)**, showing that the content in the Group VII part of the syllabus needs to be practiced and learned more.

(a) Candidates did very well on this question – probably the best answered question on the whole paper. They knew how to work out the 'electrons, neutrons and protons in one isotope of potassium'. Candidates had obviously been practicing this as part of their revision for this paper.

(b) The balancing of equations was answered very well, showing that candidates had done much practice and perfected their technique for answering this type of question.

(c) (i) Most candidates could answer this data handing question and had obviously practiced this style of question from previous papers. They realised the trend in the melting points of Group I elements and could slot in an appropriate melting point for sodium and a relative hardness for potassium. They were able to keep in the required range for the data.

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(ii) Many candidates did very well on this question. They could easily work out the physical state of potassium at the temperature given and gave the relevant correct answer. Candidates who performed poorly overall on this paper struggled with this. Most could say the state but not give the correct reason.

(d) (i) This question was the one that candidates struggled with the most on this paper. Candidates need to make sure they name elements and compounds and not just use the words 'it' and 'they'. This is a displacement reaction and candidates needed to answer it in detail in order to achieve credit. More revision of these types of question is needed.

(ii) Not many candidates knew that the 'colour of aqueous iodine' is brown. One definite colour is needed and not different shades like 'orange – brown'.

(e) This was not a well answered question, with only candidates who performed well on this paper achieving credit. Not all candidates had revised this definition.

(f) Candidates struggled to 'choose the word which best describes a substance that evaporates easily' and many went for 'flammable' instead of the correct response of 'volatile'. More revision of this definition is needed.

Question 4

Candidates found this question particularly hard compared to other questions on the paper. Part **(b)** was answered well, whereas candidates struggled with the other parts especially **(c)** and **(e)**. Part **(e)** was again another 'use of a substance' question.

(a) Candidates struggled with naming this type of chemical reaction and only the candidates who did particularly well on this paper gained credit.

(b) This question was answered well by most candidates. Most could say that litmus was red in acidic solution and blue in alkaline solution. However, it is not a good idea to use combinations of colours in these types of answers. For example, 'orange – pink' or 'blue – green'.

(c) Candidates struggled with this question and could not write the word equation correctly. More practice is needed here. Wrong answers like 'calcium nitroxide' were seen many times. Few candidates could name the second compound, 'water'. The reactions of acids need more revision.

(d) (i) Candidates struggled with this question and got mixed up with the terms 'exothermic' and 'endothermic' and what they mean. This question stated that 'the temperature of the reaction mixture increases' – however, lots of candidates incorrectly thought that this meant that it was an 'endothermic' reaction.

(ii) A few candidates mixed up the reactant and product labels. Candidates need to be reminded that the labels must be on or just under the line otherwise they will not gain credit.

(e) This was another 'use of a substance' question – this time for slaked lime. The candidates struggled with this type of question and not many correct answers were seen. Candidates need to make sure that they recall at least one use of all the substances named in this syllabus.

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Question 5

Candidates found this question hard, especially the kinetic particle model part in **(b)**. Some candidates also found the electronic configuration in **(f)** challenging and more practice should be done on this concept. Parts **(a)** and **(c)(i)(ii)** were answered much better by candidates.

(a) Most candidates could easily recall the correct changes of state.

(b) Candidates struggled with the 'kinetic particle model' question. Some candidates got mixed up with the words 'arrangement' and 'separation' and more practice is needed here using those words. Some candidates put their answer for 'separation' into the 'arrangement' part and gained no credit. Other candidates used answers that would be correct for 'movement' instead of what was actually required in the question. More correct reading of the question was needed here. There were some candidates who thought that 'separation' meant the 'separation of a mixture' and answered the question using words like 'fractional distillation' and 'filtration'. More practice is needed in answering 'kinetic particle model' type questions.

(c) (i) Most candidates could answer this question. However, in some cases candidates could not remember the correct spelling and used incorrect terms like 'bauxide'. Some candidates got mixed up with the ores and answered with 'hematite' which is the incorrect ore – this being the main ore of iron.

(ii) Candidates did reasonably well on this part and candidates could state that 'aluminium is too reactive' or 'aluminium is more reactive than carbon'. There were few wrong answers seen here. However, candidates should not use the words 'it' or 'they' – they should name the element they are talking about.

(d) There has been a significant improvement from candidates when answering this type of question in recent years, which has shown a definite benefit from practising these question types. Many candidates got this question correct and could say that 'oxygen is removed from iron oxide' or 'iron oxide loses oxygen'.

(e) Candidates struggled with this 'use' question. Some candidates did not know another use of aluminium and so just put down 'electric cables' again – this was already mentioned in the question stem so could not be used again.

(f) Some candidates found this part challenging and put down '13' instead of the 'electronic configuration of aluminium'. More practice needs to be done on this part of the syllabus when revising.

Question 6

Candidates struggled with the longer **(b)** on this question and also **(c)**, where they struggled with a 'use of a substance' question. Many candidates knew how to recognise 'two compounds in the same homologous series' and 'a compound that is a carboxylic acid' as in **(a)(i)** and **(ii)**.

(a) (i) Most candidates could recognise 'two compounds in the same homologous series' from those given on the paper.

(ii) Candidates could also pick out 'a monomer used to make poly(ethene)'. They did well on this question.

(iii) Candidates did very well on this question and could easily pick out the 'compound that is a carboxylic acid' from the structures of the organic compounds that were given on the paper.

(b) Candidates struggled with this longer question. Most could 'name the process used to separate the fractions' but they struggled to explain how this process separates the different fractions. The answering of longer questions needs practicing when revising.

(c) Candidates struggled with the uses of petroleum fractions. Lots of candidates could not remember the name of the fraction used for 'making roads' and many others did not know the uses of 'naphtha' and 'diesel oil'.

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Question 7

Candidates did reasonably well on this question especially on **(a)(i)**, **(b)** and **(d)**. Candidates had mastered the methods of balancing equations. They also did very well on the calculation of the relative molecular mass. Candidates struggled with the labelling of the electrolytic cell.

(a) (i) Most candidates did well on this question and could recall the 'two physical properties of all metals'. Candidates should not give both 'conduct electricity' and 'conduct heat' for a physical property and conductivity is considered the same property.

(ii) Most candidates knew one physical property of Group I metals that is different from most other metals and were able to state how it is different.

(b) This question was very well answered by most of the candidates showing that they had mastered the methods for balancing equations and had practised them as part of their revision.

(c) (i) Candidates struggled with labelling the electrolytic cell, with the cathode often being incorrect. More could label the 'electrolyte'. Candidates must make sure that they use arrows to pinpoint exactly where they mean for each label and not just write the word beside where they think it is, without an arrow or clear label line it is hard to see which part they are referring to.

(ii) Most candidates could name the products formed at each electrode and this showed clear revision and practice. A few candidates got the products the wrong way around.

(d) This was a very well answered question by the majority of the candidates.

Question 8

This was a reasonably well answered question by most candidates. Parts **(a)** and **(d)** were answered well by most candidates. However, some candidates struggled with **(b)** and **(e)**.

(a) This question was very well answered and most candidates were able to use the graph to 'deduce the volume of carbon dioxide gas at 35 s'. Candidates do need to make sure that they draw the lines on the graph to make sure it is easy to read off the required volume. It was obvious that many candidates had practiced this question in their revision.

(b) Most candidates struggled with this graph question and found it challenging to draw the correct line on the graph. Many candidates thought that the line did not finish at the same volume and drew a line that ended above the horizontal line of the original graph. Candidates needed to also make sure that the line starts at the origin and not just near it. This was a very well answered question.

(c) Many candidates stated that the 'rate increases' for both parts. However, there were a small number of candidates who incorrectly made a reference to time in their answers.

(d) This was a very well answered question. Most candidates could calculate the mass of calcium carbonate needed to produce 100 cm^3 of carbon dioxide gas.

(e) Most candidates did not know one use of calcium carbonate.

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CHEMISTRY

Paper 0620/33
Theory (Core) 33

Key messages

- Candidates would benefit by improving their knowledge of chemical terms, specific chemical reactions and qualitative tests.
- Candidates need more practice in writing with precision.
- Candidates would benefit by more practice in interpreting the stem of a question.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Most candidates showed some knowledge of core chemistry. All the candidates were entered at the appropriate level. Many of the candidates did not respond to five or more parts of the questions in this paper.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. Others need more practice in naming chemicals and learning specific chemical reactions and chemical properties. For example in **Question 2(a)(ii)**, many candidates could not name ammonium carbonate correctly and in **Question 2(d)(ii)**, many candidates did not know the products of incomplete combustion. In **Question 3(b)(i)**, few candidates knew the colour of chlorine gas and in **Question 3(b)(ii)**, only a minority of the candidates could explain the term 'diatomic'. In **Question 3(c)(iii)**, only the better performing candidates were able to explain how the physical properties of the Group I metals differed from those of the transition elements. Many candidates did not know the products of the reaction of an acid with a carbonate (**Question 4(b)**). Uses of particular chemicals were not well known e.g. use of calcium carbonate in **Question 4(c)(i)**. In **Question 5(b)**, some candidates did not appear to know the difference between the separation, arrangement and motion of the particles. In **Question 5(c)**, a majority of the candidates did not appear to understand the term 'electronic structure'. In **Question 6(b)**, few knew about the hydration of ethene.

Many candidates need more practice in writing their answers with greater precision. For example, in **Question 3(b)(iv)**, many candidates wrote vague statements about the properties of ionic compounds, many of which did not refer to physical properties. In **Question 3(c)(ii)**, many candidates did not gain credit because they wrote vague answers such as 'it's reached the boiling point' or 'it's after the melting point'. In **Question 4(c)(ii)**, many did not refer to heat or thermal energy in their answers whilst in **Question 5(c)(ii)**, many wrote vague statements about 'the effect of sulfur dioxide on buildings'. The commonest error was to suggest 'acid rain'. This indicates that many candidates confused the meaning of the word 'use' with the word 'effect'. In **Question 6(c)**, many candidates need to learn the syllabus specific statements relating to the names and uses of petroleum fractions; many vague answers were seen. Some candidates need more practice in labelling diagrams and drawing graphs. For example in **Question 7(b)(i)**, many candidates did not draw a label line to the anode with sufficient precision. In **Question 8(b)**, many candidates drew graph lines inaccurately and often as a straight line rather than a curve.

Many candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 1(a)(iii)**, many candidates did not heed the word 'element' and gave the names of compounds. In **Question 1(b)**, many muddled relative charge with relative mass. In **Question 2(a)(i)**, some candidates did not use the information in the table as requested and hence chose a positive ion instead of a negative ion. In **Question 5(b)**, some candidates did not appear to know the difference between the separation, arrangement and motion of the particles or wrote vague statements about the bulk properties of solids and gases. Others wrote about separation methods such as distillation rather

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than focussing on the kinetic particle theory. In **Question 7(b)(ii)**, many candidates did not read the question properly and named the anode and cathode rather than the names of the products formed at the electrodes. **In Question 7(b)(iii)**, many candidates did not read the stem of the question properly and answered in terms of electrical conduction. In **Question 8(d)**, many did not refer to the sodium chlorate and just gave a definition of reduction.

Some candidates would benefit from further revision of specific topic areas such as organic chemistry (**Questions 2(c)**, **2(d)** and **6**) and electrolysis (**Question 7(b)**).

Some candidates need to revise qualitative tests for specific ions and molecules. For example, the answers to the questions about the test for zinc ions (**Question 2(b)**) and the test for unsaturation using aqueous bromine (**Question 6(a)(iv)**) were not well known.

Many candidates were able to extract information from tables, balance symbol equations and undertake simple chemical calculations; others need more practice in these skills.

Comments on specific questions

Question 1

Many candidates identified at least two of the substances correctly in **(a)**. In **(b)**, some candidates were able to deduce the correct charge on the proton and electron. Others muddled the charge with the mass of these particles.

(a) (i) A minority of the candidates recognised that helium is a monoatomic gas. The commonest incorrect answer was H_2.

(ii) A minority of the candidates recognised that lithium ions give a red colour in the flame test. The commonest incorrect ion suggested was sodium. A majority of the candidates gave the names of non-ionic substances such as He or Fe_2O_3.

(iii) This was the least well answered of **(a)**. Many candidates did not heed the word element and gave incorrect answers such as Fe_2O_3, Al_2O_3 or Li^+. Others suggested that helium or nitrogen could be used as a fuel.

(iv) A majority of the candidates recognised that CO_2 is responsible for climate change. The commonest error was to suggest O^{2-}.

(v) Some candidates recognised the O^{2-} ion. The commonest incorrect answer was to suggest the K^+ ion. A significant number of candidates suggested non-ionic compounds such as Fe_2O_3 or C_2H_5OH.

(b) Some candidates muddled the charge with the mass of the proton and electron. The commonest incorrect answers were 1 (no sign for the charge) or –1 for the charge on the proton and +1 or 1/2 000 for the charge on the electron. A significant number of candidates muddled the charge with the mass of these particles.

(c) The commonest errors were to tick the second box (nitrogen and hydrogen are liquid at room temperature) or the third box (atoms of nitrogen and hydrogen are chemically combined).

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(c)**. In **(a)(ii)**, most candidates did not name ammonium carbonate correctly. Few knew the observations when aqueous ammonia was added to zinc ions in **(b)** and in **(d)(ii)**, many candidates gave incorrect gases.

(a) (i) Many candidates selected the phosphate ion as the negative ion having the highest mass. The commonest error was to suggest sodium through not reading the question carefully enough and selecting the positive ion rather than the negative ion.

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(ii) Few candidates gave the correct name: ammonium carbonate. The commonest errors were 'ammonia carbonate', 'ammonium carbon dioxide' or 'nitrate hydroxide'. Many confused the ammonium ion with the nitrate ion. A few gave a formulae (which was often incorrect) instead of the name. A significant proportion of the candidates did not respond to this question.

(iii) Some candidates did the calculation correctly using simple proportion. A few tried to do mole calculations. Candidates should realise that there is no requirement for moles calculations on the core paper. The commonest error was to be a factor of ten or 1000 out i.e. 5.5 or 5500.

(b) This was one of the least well answered parts of this question. Some candidates knew that a white precipitate was formed but few wrote about the precipitate dissolving in excess ammonia. Common errors were to suggest 'fizzing', 'bubbles', 'change in colour' or 'temperature changes'. A significant proportion of the candidates did not respond to this question.

(c) Many candidates wrote the formula correctly. The commonest errors were to miss out an oxygen atom (giving C_3H_8O); to write the formula without subscripts (C3H8O2) or to add + signs or commas between the elements e.g. C_3, H_8, O_2.

(d) (i) Some candidates correctly selected the words 'group' and 'similar'. Others either wrote words which were not on the list e.g. 'same' instead of 'similar' or selected 'formula' instead of 'group' for the first sentence.

(ii) Some candidates realised that carbon monoxide, carbon or water were formed. The commonest error was to suggest nitrogen or hydrogen instead of water. Other candidates gave vague answers unrelated to gases e.g. 'calcium carbonate'. A few candidates wrote formulae instead of the names of the products. A significant proportion of the candidates did not respond to this question.

Question 3

Many candidates performed well in **(a)**, **(b)(iii)** and **(c)(i)**. In **(a)(ii)**, some gave answers which were too vague. Few candidates knew the properties of ionic compounds in **(b)(iv)** or how the physical properties of Group I metals are different from those of transition elements (**(c)(iii)**). In **(d)**, few candidates gave a full explanation in terms of the relative reactivity of chlorine and iodine.

(a) The commonest errors were to suggest 23 electrons, 23 protons and/or 11 neutrons.

(b) (i) A minority of the candidates knew the colour of chlorine gas. The commonest incorrect answer was 'yellow'. Others suggested 'transparent' or 'clear', perhaps thinking of a dilute solution of aqueous chlorine rather than the gas. A significant proportion of the candidates did not respond to this question.

(ii) Few candidates knew the meaning of diatomic. Many wrote vague answers relating to 'double bonded', or 'double'. Others suggested that 'the atoms were the same'.

(iii) Some candidates were able to balance the equation. The commonest error was to write chlorine as $2Cl$ rather than Cl_2.

(iv) The best answers focused on high melting points. Most candidates wrote vague answers relating to charge or reactivity or gave properties such as 'solid' or 'conducts', without further qualification. A significant proportion of the candidates did not respond to this question.

(c) (i) Most candidates were able to predict both values. The commonest error was to give a value of greater than 98 °C for the melting point of potassium or a value less than 0.157 nm for the atomic radius of sodium. A significant proportion of the candidates did not respond to this question.

(ii) The best answers were given by candidates who realised that they needed to refer to the 700 °C as well as the boiling point. Many gave vague answers such as 'it's reached the boiling point' or 'it's after the melting point'.

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(iii) Few candidates knew how the physical properties of Group I metals differ from those of transition elements. Many gave answers in terms of reactivity and others gave the trend in the properties down the group. Other common errors were to suggest 'the structures are different' or 'the melting points are different'. A significant proportion of the candidates did not respond to this question.

(d) The best answers concentrated on the chlorine replacing the iodine in the sodium iodide. Many candidates did not refer to the sodium iodide and gave vague statements such as 'the chlorine bonds with the sodium' or 'it is more reactive'. The latter answer was not acceptable because it just repeats the stem of the question.

Question 4

This question was the least well answered in the paper. Some candidates were able to answer **(b)**, **(c)(ii)** and **(c)(iv)** well. Most candidates gave vague answers in **(c)(i)** (use of calcium carbonate), **(c)(ii)** (explanation of the term endothermic) and **(c)(iii)** (explanation of an energy level diagram).

(a) A minority of candidates knew the colour of methyl orange in acidic and alkaline solution. The commonest errors were 'orange' in alkaline solution and 'transparent', 'clear' or 'yellow' in acidic solution.

(b) A minority of the candidates knew the products formed when a carbonate reacts with an acid. Others seemed to guess the answers and suggested 'calcium hydroxide' or 'hydrochloric carbonate' instead of the salt, calcium chloride. Many candidates suggested 'hydrogen' as the co-product rather than carbon dioxide. A significant proportion of the candidates did not respond to this question.

(c) (i) Few candidates gave a suitable use for calcium carbonate. The commonest errors were 'food production', 'bleach' and' cleaning products'. Some candidates wrote about 'neutralising soil'. This omitted the essential word 'acidic'. A significant proportion of the candidates did not respond to this question.

(ii) The best answers included the words 'heat' or thermal energy'. Many candidates did not gain credit because they wrote vague statements about 'energy being taken in' without specifying thermal energy. Other answers were too vague e.g. 'takes in the warm'.

(iii) The best answers referred to the relative energy levels of the reactants and products. Many did not gain credit because they did not interpret the diagram with sufficient exactitude. Examples of answers which were too vague included 'products higher than the reactants' (no mention of energy); 'products gain energy' (incorrect) and 'reaction gains energy' (no mention of reactants or products).

(iv) Many candidates calculated the volume of carbon dioxide correctly, using simple proportion. Common errors were to multiply 0.5 by 0.1 or to give the answer 240 cm^3 (factor of 10 difference).

Question 5

Some candidates were able to name the changes of state in **(a)** and many recognised the symbol for a reversible reaction in **(d)(i)** and chose the correct pH for an acid in **(e)(i)**. In **(b)**, many candidates muddled the arrangement and motion of the particles with their distance of separation or wrote about motion when they were meant to be writing about arrangement. In **(c)**, many candidates needed more practice in determining electronic structures. In **(e)(ii)**, (effect of acid rain on buildings), more candidates needed practice in writing answers with greater precision.

(a) Some candidates gave the correct terms for the changes of state. The commonest error for the change of state from gas to liquid was 'boiling' and the commonest error for the change of state from solid sulfur to gaseous sulfur was 'burning'. Many candidates did not read the question properly and tried to answer in terms of the kinetic particle theory e.g. 'the particles get closer' or 'the particles separate'.

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(b) Some candidates wrote correct comments in the wrong sections or muddled arrangement and motion with the separation of particles. In many cases, it was not clear the solid or gas was being discussed. Most candidates gained credit for a suitable comment about the motion of the particle in a gas. Others wrote statements that were not precise enough e.g. 'moving away from each other' or 'slower movement in a solid compared to a gas'. Other candidates described the bulk properties of solids and gases e.g. 'spreads everywhere'. A significant proportion of the candidates did not respond to this question.

(c) A minority of the candidates gave the correct electronic structure of sulfur. Many candidates appeared not to understand the term 'electronic structure'. The commonest errors were 2.6; 2.8.4; 16 (number of protons) or ^{16}S. A significant proportion of the candidates did not respond to this question.

(d) (i) Most candidates knew the symbol for a reversible reaction. The commonest errors were 'reverse reaction' or 'equals'.

(ii) Very few candidates gave a suitable use of sulfur dioxide. The commonest error was to suggest 'acid rain'. This indicates that many candidates confused the meaning of the word 'use' with the word 'effect'. Others suggested 'making sulfur'. A significant proportion of the candidates did not respond to this question.

(e) (i) A majority of the candidates recognised that pH 4 is acidic. The commonest error was to choose pH 7.

(ii) Many candidates gave vague answers when describing the effect of acid rain on buildings. Common incorrect examples included 'decays'; 'chemical effect'; removes paint'; 'rusts it' or 'deteriorates the building'.

Question 6

This was one of the least well answered questions on the paper. Some candidates identified the structures in **(a)(i)**, **(a)(ii)** and **(a)(iv)**. Fewer identified the relatively unreactive compound in **(a)(iii)**. Many candidates needed to revise the synthesis of alcohol from ethene and the conditions required (**(b)**. In **(c)**, many candidates gave answers which were too vague or appeared to select the use of fractions other than those requested.

(a) (i) Some candidates realised that the COOH group in carboxylic acids is acidic. Others seemed to guess since there was a wide range of incorrect answers.

(ii) Many candidates correctly identified **C** as being a saturated hydrocarbon. The commonest incorrect answer was **D** (propene).

(iii) A minority of the candidates recognised that alkanes are relatively unreactive. The commonest incorrect errors were **D** (propene) or **B** (carboxylic acid).

(iv) Some candidates realised that **D** decolourises aqueous bromine. The commonest error was to suggest **E** (ethanol).

(b) The better performing candidates gave the correct formula, C_2H_4, and gave a suitable condition, usually high temperature. Others appeared to guess the formula; the commonest errors being C_2H_6 or C_3H_9. Few knew the name of the other reactant (steam). The wide variety of incorrect answers (e.g. 'fuel oil', 'yeast', 'oxygen') suggested that many were guessing. Some candidates gave one correct condition, usually 'heat' or 'high temperature'. Fewer chose 'catalyst' or 'high pressure'. A significant proportion of the candidates did not respond to this question.

(c) Most candidates gave answers which were too vague or appeared to select the use of fractions other than those requested. Candidates would be advised to learn the examples in the syllabus. The commonest errors were: 'gasoline' (for making chemicals); 'burning' (for kerosene) and 'to power things', or 'starting cars' (for fuel oil). Many candidates did not include the essential word 'fuel' when answering the last two lines of the table. A significant proportion of the candidates did not respond to this question.

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Question 7

This was the best answered question on the paper. Many candidates balanced the equation correctly in **(a)** and labelled either the anode or electrolyte correctly in **(b)**. Some candidates did not label the anode accurately. Candidates should be reminded that the label line should go to the anode itself and not the electrolyte or the wires attached to the anode. In **(c)**, (calculation of relative molecular mass) was generally well answered. In **(c)(ii)**, many candidates gave the names of the electrodes (anode and cathode) instead of the products at the electrodes. In **(c)(iii)**, many candidates did not read the question carefully enough and suggested ‘conducts electricity’, which was in the stem of the question.

(a) Many candidates balanced the equation correctly. The commonest errors were to write 2(Li) or 3(Li_3N).

(b) (i) Some candidates did not label the anode accurately enough. Candidates should be reminded that the label line should go to the anode itself and not the electrolyte or the wires attached to the anode. A significant minority of the candidates labelled the cathode or the electrolyte as the anode. Others labelled the beaker as the electrolyte. A significant proportion of the candidates did not respond to this question.

(ii) The best answers gave the names of the elements, bromine and lithium as the positive and negative electrode products. Others suggested bromide is formed at the anode. A significant minority of the candidates suggested ‘lithium bromide’ or ‘carbon’ at either electrode. Others did not appear to understand the term ‘products’ in the stem of the question and suggested ‘anode’ and ‘cathode’. A significant proportion of the candidates did not respond to this question.

(iii) Many candidates did not read the question carefully enough and suggested ‘conducts electricity’, which was in the stem of the question. Others gave incorrect answers such as ‘conducts heat’ or ‘it is reactive’. A significant proportion of the candidates did not respond to this question.

(c) Many candidates completed the calculation correctly. A common error was to use the atomic number for oxygen, even though the relative atomic mass had been given in the table. Others forgot to add 36 from the carbon or miscounted the number of oxygen and/or lithium atoms as 8 and 3 respectively.

Question 8

Many candidates deduced the time taken to collect 35 cm^3 of gas correctly in **(a)**. Some described the effect of a higher temperature or lowered concentration of hydrogen peroxide in **(c)** but few gave the correct answer for both. In **(b)**, many candidates needed to improve their skills in interpreting data and in drawing graph lines. In **(d)**, most candidates wrote vague answers and did not refer to the equation as instructed.

(a) Many candidates deduced the time taken to collect 35 cm^3 of gas correctly. The commonest errors were 26 s, 19 s or 20 s.

(b) Many candidates needed to improve their skills in drawing line graphs with sufficient care. Many candidates drew lines following the original line for too long or started the line vertically on the *y*-axis for too long. Others drew straight lines rather than a curve or did not make it clear that the final volume remains the same as the original line. Other common errors included transposing the curve higher or lower than the original or giving a slower initial rate. A significant proportion of the candidates did not respond to this question.

(c) The best answers referred to a faster rate at a higher temperature and a slower rate when the concentration of the hydrogen peroxide is decreased. A significant number of candidates gave answers associated with time rather than rate. Others gave answers which were absolute rather than comparative e.g. ‘the reaction is fast with a high temperature’. This is not acceptable because the reaction could still be fast at a lower temperature. A significant proportion of the candidates did not respond to this question.

(d) The best answers referred to the removal of oxygen from the sodium chlorate. Many candidates did not gain credit because they did not refer to the equation and just gave a definition of reduction or paraphrased the equation e.g. ‘when hydrogen peroxide reacts with sodium chlorate, oxygen is formed with the sodium chloride’.

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Paper 0620/41
Theory (Extended) 41

Key messages

- Candidates should be aware that the word 'free' is not equivalent to mobile and candidates should refrain from using it. This year, it was used excessively and did not receive credit.
- When candidates are asked to name a substance, a name is all that is credited. Equations and formulae were often seen instead of names.
- When writing formulae:
  - Lower case letters must be smaller than upper case letters e.g. the symbol for zinc is written Zn as opposed to zN or ZN, whereas the formula of sulfur dioxide is written SO_2 as opposed to So_2.
  - Subscripts must be written below the line e.g. SO_3 as opposed to SO3. This applies to writing general formulae e.g. $C_nH_{2n+1}COOH$ as opposed to CnH2n + 1COOH

Comments on specific questions

Question 1

(a) Glucose and oxygen were common wrong answers. This suggested there was confusion between products and reactants.

(b) This was answered very well. Iron(III) oxide was seen occasionally.

(c) This was answered well. Glucose was seen occasionally.

(d) This was answered well. Oxygen was seen occasionally.

(e) Candidates found this to be challenging. Iron(III) oxide, limestone and carbon dioxide were seen often, presumably because of their connection to the blast furnace. Many answers were solids despite the question asking for gases.

(f) This was answered very well. Nitrogen was occasionally seen, presumably because of the connection between plants and greenhouses. Many answers were solids despite the question asking for gases.

(g) This was answered extremely well. Oxygen was seen very occasionally. Many answers were solids despite the question asking for gases.

(h) This was answered quite well. Some candidates thought they had to choose a substance containing carbon. Thus, they chose carbon dioxide, glucose, limestone or ethanol.

Question 2

(a) (i) This was answered very well. 1/1840 was occasionally seen as the relative mass of the neutron and/or proton.

(ii) This was answered extremely well. There were no common errors.

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(iii) This was answered quite well. Statements that magnesium has 2 electrons in its outer shell or that magnesium is in Group II needed to go further and refer to loss of two electrons.

(b) The answers were sometimes names as opposed to formulae. This applied to neon in particular. Species other than positive ions, negative ions and atoms were often seen. Magnesium ions with a variety of charges e.g. Mg^{2+} and Mg^{2-} were often seen.

Question 3

(a) (i) Candidates found this challenging. Many candidates thought that the question was about bonding between sodium and another element.

A common error was to confuse metallic bonding with ionic bonding. Chloride ions were often mentioned instead of, or as well as, a sea of electrons. It was common to see that attraction between particles was missing. Atoms, molecules and intermolecular forces were seen often.

Diagrams showing unidentified positively charged particles and negatively charged particles were common.

Protons were seen as an alternative to positive ions.

(ii) Those who mentioned electrons often omitted to refer to movement of electrons. 'Free' was seen often in place of 'mobile'; this did not gain credit. Electrons were often described as 'carrying charge'. This also gained no credit. Better performing candidates referred to moving electrons.

(b) (i) This was answered well. Covalent was the most common incorrect answer.

(ii) Candidates found this very challenging. Electrons were commonly mentioned as well as, or instead of, ions. 'Free' was seen often and received no credit. Ions were often described as 'carrying charge'. This also gained no credit. Better performing candidates referred to moving ions.

(c) (i) 'Measuring cylinder' was a common incorrect answer. The piece of apparatus was required to measure to 1 decimal place as shown by the volume of $25.0\,cm^3$ in the question

(ii) Candidates found this very challenging. The starting colour was rarely stated as yellow. Orange was the most common starting colour.

(iii) Candidates found this very challenging. Words and phrases such as 'similar', 'almost the same', 'close' were unacceptable as these are too vague. 'Taking the average' was a very common incorrect answer. 'When there are no anomalous results' was also a frequent answer. Better responses stated a specific statement concerning what a non-anomalous result meant.

(iv) Many candidates found this calculation very straight forward. There were no common errors. A small number used 24, suggesting confusion with gaseous volumes.

Question 4

(a) (i) This was answered very well. The formulae for sulfur and oxygen were occasionally seen as S_2 and O respectively.

(ii) The oxidation state of vanadium in vanadium(V) oxide was often either missing or incorrect.

Units are essential when quoting temperature and pressure. Units of pressure were occasionally seen as atmospheric pressure as opposed to atmospheres. A pressure of 200 atmospheres showed confusion with the Haber process.

The formula for oxygen was occasionally seen as O. If the formulae were all correct, the equation was sometimes unbalanced.

(iii) This was answered very well. The formula of sulfuric acid was the most common error.

(iv) This was answered quite well. Oxygen and sulfuric acid were the most common errors.

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(b) (i) This was answered very well. There were no common errors. A small number showed non-bonding electrons on the hydrogen atoms.

(ii) The S was often preceded by a 2 instead of a 3. Presumably this was because candidates omitted to count the S in SO_2.

Question 5

(a) Candidates found this question challenging. Some suggested that reversible reaction is a characteristic of an equilibrium.

Common errors seen included:

- forward reaction = reverse reaction (without rate)
- rates of reaction are constant (as opposed to equal)
- concentrations of reactants and products are the same (as opposed to constant).

(b) Candidates found it difficult to express their answers coherently. Many answers did not focus on rate and yield despite the comment at the beginning of the question. Several responses commented on enzymes being denatured at higher temperatures.

(c) This was answered reasonably well. Some candidates used different words to *increases, decreases* or *no change* despite what they were told in the question.

(d) This was answered quite well**.** Some candidates chose aluminium because they thought it was a transition element or that a protective oxide layer was advantageous. Those who chose potassium often referred to its high reactivity as a reason.

(e) This was answered reasonably well. $C_nH_{2n+1}O_2$, $C_nH_{2n}COOH$, $C_nH_{2n-1}OOH$ and COOH were common wrong answers. Some candidates added a '+' in the formula e.g. $C_nH_{2n}+O_2$.

(f) This was answered quite well. The missing O–H bond was the most common error. A small number of candidates drew an alcohol. A four-carbon compound was seen very occasionally.

(g) (i) Candidates found naming the ester from its structure very challenging. A large number of answers were unrecognisable as esters. Propyl ethanoate and ethyl propanoate were common wrong names.

(ii) Candidates found this slightly easier than **(i)**.

(h) There were many extremely good answers which showed all the working very clearly. Credit was lost by over approximations. Those who calculated the number of moles of atoms as 4.05 : 8.11 : 2.70 sometimes wrongly approximated these values to 4 : 8 : 3.

Those who correctly divided all the moles of atoms by the smallest one and achieved the values of 1.5 : 3 : 1 often went on to approximate 1.5 to either 1 or 2 instead of multiplying all the values by 2 and arriving at 3 : 6 : 2, which gave the correct formula of $C_3H_6O_2$.

Some divided all the percentages by the smallest one (8.11).

(i) This was answered quite well. Answers other than formulae (e.g. 2) were often seen. Candidates who got as far as realising that $88 \div 44 = 2$ went no further.

Question 6

(a) (i) This was answered quite well, although 'blende' was often spelt incorrectly. Bauxite and hematite were seen occasionally.

(ii) Candidates performed poorly on this question. Either air or the requirement to heat strongly or roast were often missing. Oxygen was regularly seen instead of air.

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(iii) Candidates performed well on this question. Oxygen, zinc sulfide and potassium manganate(VII) were seen occasionally.

(iv) Candidates found this very challenging. 'Explain' meant that more than a description such as, 'the furnace was at a high temperature' or 'zinc boils' was required.

Many answers were vague and non-specific. Better performing candidates referred to the temperature of the furnace being higher than the boiling point of zinc. Many thought that a gas such as carbon dioxide was produced as a result of a chemical reaction.

(v) This was answered very well. Sublimation was the most common incorrect answer.

(b) (i) Candidates found this very challenging. Many answers referred to solids remaining rather than the absence of effervescence.

(ii) Many candidates chose zinc nitrate instead of choosing a metal or a base.

(iii) A majority of candidates correctly referred to increased surface area of the zinc carbonate. Many then went on to add that particles gained energy or moved faster.

There was limited reference to collisions. Those who mentioned collisions often said there would be 'more collisions' as opposed to 'more frequency of collisions'. Some suggested that an increased surface area gave particles more energy or led to particles moving faster.

(iv) Candidates rarely referred to the formation of crystals. Many attempted to explain the meaning of a saturated solution.

(v) A formula was required. Many formulae were of non-existent substances. Some gave an equation instead of a formula.

Question 7

(a) (i) The correct order was often reversed. Potassium was sometimes chosen as the most reactive, presumably because it is the most reactive candidates have seen.

(ii) Caesium oxide was the most common incorrect answer. A name was required; some gave an equation or a formula.

(b) A correct answer had to refer to Group I or transition elements, both of which were occasionally absent.

(c) The majority of candidates answered this correctly. 'Gas' was the most common incorrect answer.

(d) (i) Very few candidates knew the colour of potassium bromide solution. The correct colours were very often reversed. The final colour was often green with another colour e.g. yellow-green.

(ii) Bromine or bromide were the most common answers to species oxidised. The explanation was known by more candidates than those who knew which species was oxidised.

(e) This was answered well. A number of candidates multiplied the correct value of energy required to break the bonds by 2 giving a value of 864. Some gave 4 rather than –4 as the answer.

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Paper 0620/42
Theory (Extended) 42

Key messages

- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, candidates should be encouraged to make sensible guesses rather than leaving an answer blank.
- Candidates should not provide fractions as answers to calculations.
- When determining the M_r of a substance, candidates should clearly state that the number they have determined is in fact the M_r, rather than a random number.
- Candidates need to consider the valences of the atoms drawn; divalent hydrogen atoms and pentavalent carbon atoms were commonly seen in the structures drawn.

General comments

Candidates appeared to have sufficient time for all questions to be answered.

Comments on specific questions

Question 1

This question required choices from the eight Period 3 elements given in the question.

(a)(b)(c) Most candidates performed well overall.

(d)(f) These parts proved to be the hardest, with around two-thirds of the candidates getting these questions correct.

(g) Many candidates correctly selected aluminium.

(h) Candidates found this challenging.

Question 2

(a) (i) This proved a difficult question. Only the best responses placed H_2 as a product and consequently balanced the equation.

(ii) Only about half the candidates knew calcium oxide would react with water to form calcium hydroxide. ‘Calcium carbonate’ was a frequently seen error.

(b) (i) Nearly all candidates gave a pH within the acceptable range. It should be noted that an answer such as pH $\geqslant$ 7 would not get credit for two reasons: the pH could not equal 7 and the pH of a strong alkali, e.g. a pH of 14, fits this expression.

(ii) Over half the candidates knew the formula of the hydroxide ion.

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(c) (i) Carbon dioxide was well known as the gas limewater is used to test for.

(ii) There was a significant minority of candidates that linked 'saturated' solely to organic compounds, but many did not gain any credit. Candidates needed to state that saturation is temperature specific.

The terminology of solute, solvent and dissolve was often confused by weaker performing candidates.

(iii) This proved to be the most difficult question on the paper, with few getting full credit. Better responses had the idea of adding excess solid calcium hydroxide to water but often omitted the filtration stage.

Using excess water rather than calcium hydroxide was a common error amongst weaker responses.

(iv) Candidates generally adopted the correct approach and elected to use sodium hydroxide, or (aqueous) ammonia and performed well, with only a few omitting to add the sodium hydroxide in excess. A correct flame test description was also given by a few and this was credited.

(d) (i) Frequently seen incorrect responses included 'pipette' and 'measuring cylinder'. Many candidates struggled with the spelling of 'burette'.

(ii) This question was usually well answered, but a variety of other reaction types were also seen.

(iii) A large number of candidates gave the name of a specific indicator such as 'methyl orange', rather than the term 'indicator' as the type of substance in the question. Credit was awarded if they opted to use the term 'methyl orange indicator'. Weaker responses gave indicators unsuitable for titration such 'Universal Indicator' or 'pH indicator'.

(iv) Many candidates performed well on parts of the calculations. Candidates should be reminded that fractions as answers to calculations should not be given. Candidates should also be reminded that leaving the M_r calculation as a sum should also be avoided.

Question 3

(a) (i) The majority of candidates incorrectly referred to 'elements' rather than 'atoms of an element' having the same number of protons.

(ii)(iii) Most candidates had a good appreciation of the nucleon number, and numbers of protons, neutrons and electrons involved in the various atoms and ions.

(b) (i) Candidates were more likely to know the colour of copper(II) sulfate than that of cobalt(II) chloride. Many candidates gave colour changes from the anhydrous to hydrated form.

(ii) The most popular correct responses were 'catalytic ability' and 'variable oxidation state'. Some candidates gave general chemical properties common to all metals such as formation of basic oxides or positive ions. It was very common to see only physical properties given.

(c) (i) Many candidates did not link to 'movement' of the electrons. Common answer such as 'delocalised electrons' or 'free electrons' were not creditworthy. Weaker responses focused on the 'movement of ions'.

(ii) Malleable/malleability was generally well known. It was not uncommon to see ductile/ductility.

(d) Many could not distinguish between physical and chemical properties or repeated the properties given in the stem of the question in **(b)(ii)** and **(d)**.

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Question 4

(a) The statement that fluorine is a gas was commonly seen and any colour lighter than that of chlorine was credited. Many candidates only gave the state or the colour but not both.

(b) The majority got as far as the empirical formula in their calculations. Some candidates struggled to achieve any credit.

(c) Many excellent answers were seen. The most frequent error was the omission of the non-bonding electrons on the chlorine atoms.

Most candidates paired non-bonding electrons. This is good practice as it is easier for candidates to check that atoms have a full outer shell. Candidates who opted to draw individual electrons often did not allocate the full eight electrons to fluorine atoms.

(d) Some candidates were only able to give correct charges. Many candidates drew only an empty shell for lithium. It was also common to see the use of dots for the lithium ion, despite the chloride ion having dots already drawn. Candidates who performed less well did not attempt to draw the outer shell for the chloride ion or, if they did, only used dots to fill it. This demonstrated a lack of understanding of the concept of electron transfer from lithium.

(e) The best responses explained:

- lithium chloride has attraction between ions
- nitrogen chloride has attraction between molecules
- the attraction between ions is stronger than the attraction between molecules.

Many candidates stated 'LiC*l* has attraction between ions and NCl_3 has attraction between molecules and the intermolecular forces in LiC*l* is weaker than the intermolecular forces in NCl_3'. This explanation would mean that lithium chloride is molecular which is incorrect and contradicts the idea that lithium chloride has attraction between ions.

Question 5

(a) 'Fermentation' was very well known.

(b) Most candidates identified combustion as the name of the reaction, but the equation eluded many.

(c) (i) Most candidates correctly identified ethene as alkene **A**.

(ii) Most candidates correctly identified the type of reaction as hydration. Addition was also credited.

(iii) Many candidates thought that the reagent needed to convert ethene to ethanol is 'water' rather than 'steam'. The conditions were well known.

(d) (i) As in **(c)(iii)**, many candidates omitted to include hydrogen as the reagent, but most were able to state the correct conditions.

(ii) The general formula of alkanes was well known, but candidates needed to be careful in the use of subscript. C_nH_{2n}+2 was not creditworthy.

(e) (i) Candidates did not perform well in this question. Many made errors in the oxidation number of manganese (or omitted it) in the name.

(ii) The name of the homologous series of **C** was well known.

(iii) The structure was well known but many candidates did not show all the bonds, particularly the O–H bond in the functional group.

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Question 6

(a) (i) The majority of candidates recognised that three ester linkages would produce three molecules of water.

(ii) Many candidates did not appreciate that monomers do not have continuation bonds and are discrete molecules.

Other frequently seen errors included connecting the O–H bonds to the box via the hydrogen atom, thus creating divalent hydrogen atoms or transposing correctly drawn groups to the wrong box.

(iii) Many candidates did not read the question and gave specific examples rather than the term 'polyester'.

(b) Many candidates did not recognise that a single monomer was used to create the polymer and 'three' was a common error, as was 'zero'.

(c) (i) Candidates who performed less well did not realise that this was addition polymerisation and that the monomer required a C=C double bond. Common errors included otherwise correct structures of but-2-ene but with continuation bonds resulting in pentavalent carbon atoms.

Better performing candidates including the position of the double bond in the name but-2-ene.

(ii) Many candidates misread the remit of the question and opted for 'addition polymerisation' or 'polymerisation' rather than the method of monomer formation.

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Paper 0620/43
Theory (Extended) 43

Key messages

- Candidates must read questions carefully to ensure that the answer they give addresses what has been asked. Typical examples of where candidates did not address the question were responses seen in **Question 5(e)**, where an explanation of why rate decreases was asked for but explanations for increasing rate were given, and **Question 6(a)(i)** where physical properties rather than chemical properties were given.

- Candidates should understand what the word 'observation' means and how to answer questions that ask for observations. They should describe:
  - colour changes
  - solids dissolving or disappearing
  - effervescence or bubbling when a gas is evolved
  - the formation of precipitates (with their colours), although this only applies if two solutions are mixed
  - heat changes
  - smells and colours of gases.

  It is unnecessary to describe a test for a gas unless the question specifically asks for one.

- Candidates who performed less well had not learnt the definitions and statements within the syllabus. This was seen in **Question 3(e)(i)**, where the meaning of the term 'base' was required; **Question 4(a)**, where the meaning of the term catalyst was required and **Question 6(c)(ii)** where the name given to the type of reaction where electrons are transferred was required.

General comments

- When drawing diagrams to support a written response, candidates should check that they are labelled clearly and do not contradict their written text.
- When drawing organic structures, candidates should be aware that structures will require all bonds to be drawn and thus the valency of the atoms used needs to be correct. Trivalent and pentavalent carbons were often seen and the bond between oxygen and hydrogen in the alcohol functional group was often omitted.
- Very few candidates felt the need to write on extra pages. If extra pages are used, the questions must be clearly numbered.

Comments on specific questions

Question 1

Candidates found it challenging to identify the correct substance from the list. It was common for details given in the question to be ignored or for candidates to confuse reactants with products.

(a) Glucose and oxygen were common incorrect responses.

(b) The main constituent of hematite was not well known; limestone or aluminium oxide were commonly seen.

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(c) Chlorine was a common incorrect response, possibly due to candidates confusing anhydrous copper(II) sulfate with cobalt(II) chloride.

(d) This was generally well known, although candidates ignoring the requirement for the toxic gas to be colourless gave chlorine as an incorrect answer.

(e) Carbon dioxide and oxygen were frequently suggested due to confusion between fermentation and respiration and also between the terms reactants and products.

(f) A reducing agent in the extraction of iron was not well known, with many candidates selecting other substances associated with the extraction of iron. For example, limestone, iron(III) oxide and carbon dioxide were commonly seen.

(g) This question was well answered.

(h) This was generally well known, although nitrogen was a common incorrect response.

Question 2

(a) (i) This was well done in general. Common errors included omitting electrons entirely; stating that electron numbers were different or contradictory statements on electrons in both parts of the response. Some candidates did not follow the question remit to use a particulate approach. Weaker responses were based solely on statements regarding atomic number and mass number.

(ii) Candidates who performed less well often gave vague statements in an attempt to explain the lack of overall charge. For example, 'they had not lost or gained electrons'; 'they are atoms'; 'they are not ions'; 'protons and electrons cancel out'; 'charges cancel'; or 'neutrons have no charge'.

(iii) Many candidates believed that proton number determines the chemical properties of an element. Indistinct responses stated they were 'the same element' or 'both are sulfur' were also common.

(b) (i) This question required the number of electrons to be stated in comparison to the number of protons. Many responses were often too vague with candidates stating that the 'sulfur had gained electrons' with the number unspecified or 'sulfur now has a full outer shell'. Also, the ideas that 'sulfur needed two more electrons' rather than having actually gained them, or 'sulfur had six electrons in the outer shell and now has eight' were common. Candidates should be encouraged to write about the atom gaining electrons rather than the sulfide ion doing so as this is not strictly correct.

(ii) The majority of candidates found this question challenging even though the electronic structure of the sulfide ion was stated in the question stem. Better performing candidates were able to apply their understanding of ion formation from atoms correctly. Ions were sometimes given in reversed order demonstrating a lack of understanding of the terms anion and cation.

Question 3

(a) (i) This was a well answered question.

(ii) Most candidates knew that weak attractive forces gave low melting points, but few candidates went on to state that the particles these forces occurred between were molecules.

(iii) To explain why nitrogen does not conduct electricity, many candidates stated that there was a lack of free or delocalised electrons rather than correctly focusing on the inability of the electrons to move. Some made poorly expressed references to nitrogen having ions that were not free to move, suggesting nitrogen is ionic in structure, rather than stating clearly that it lacks ions at all. Weaker responses referred to nitrogen being a gas or a non-metal.

(b) Some very good answers were seen and it was not uncommon for full credit to be awarded. The essential conditions for the Haber process were generally well known, although occasionally units were missing. A significant proportion of candidates did not gain credit for the chemical equation and it commonly featured nitrogen as being monatomic or was unbalanced. The catalyst was also omitted completely in some cases.

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(c) This question was answered well.

(d) This was answered well with candidates demonstrating a good understanding of covalent bonding. Common errors included a double covalent bond between the nitrogen atoms or the omission of the non-bonding electrons on the nitrogen atoms.

(e) (i) The definition of a base as a 'proton donor' was not well known. The majority of candidates gave statements about pH, neutralisation or formation of hydroxide ions in solution. Candidates should be encouraged to learn the definitions in the syllabus.

(ii) Those candidates who were successful in **(i)** were generally more able to apply their knowledge and combine it with the example given in the question to write a fully correct equation. N_2H_6O was often seen as a lone product in an incorrect equation.

Question 4

(a) Many candidates knew that catalysts increase the rate of reaction. The most common error was to state 'catalysts do not take part in the reaction'. If catalysts did not take part in some way, then they would not change the rate of reaction; the key thing is that they are unchanged at the end of the reaction.

(b) The effects on the rate of the forward reaction were answered with a greater degree of success than the effects on the yield of ethanol. Candidates should ensure that they follow the rubric of the question and do not attempt to use alternative words and phrases in the table.

(c) (i) The general formula of alcohols was often not accurately represented. It was common for subscripts to be used incorrectly or for the inclusion of a '+' before the OH.

(ii) The majority of correct answers focused on similar chemical properties or the same functional group within a homologous series. Those candidates choosing physical properties were often unable to offer credit-worthy responses due to not mentioning trends or gradual changes. These candidates were more likely to state 'similar physical properties' or 'similar trends in physical properties'. Better performing candidates were aware that the words 'same' and 'similar' have different meanings.

(iii) Candidates were required to show every atom and every bond in their diagram. Many opted to omit the bond between the oxygen and hydrogen in the alcohol functional group.

Common incorrect responses included drawing the structure of propan-1-ol or drawing structures with an incorrect valency on either hydrogen or oxygen or both.

The naming of propan-2-ol was often correct even if an incorrect structure had been drawn.

(d) (i) The most common incorrect responses were ethyl propanoate and hexanoic acid. Some candidates did not give the correct 'anoate' ending to their otherwise correct ester name. Attempts at ester names that were hybrids ending in 'acid' were very commonly seen.

(ii) Many candidates who could not correctly name the ester in the previous response were nevertheless able to give the correct alcohol and acid here. Also, many of those giving 'ethyl propanoate' in **(i)** were able to gain credit for 'propanoic acid' as an error carried forward. Some candidates transposed the prefixes from their named ester in **(i)** but seldom gained any credit due to not identifying the position of the OH group as being on the first carbon in an alcohol of three or more carbons in length.

(e) Most candidates made some progress on this demanding empirical formula calculation, with only a minority of candidates not knowing where to start with this calculation. One of the most common errors involved rounding following the division of the percentage composition figures by the A_r of each element and the subsequent division of the numbers obtained to give a ratio to 1 of 2.5:5:1. This ratio was often then incorrectly rounded resulting in C_3H_5O or C_2H_5O rather than being multiplied by two to obtain the correct empirical formula.

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(f) Candidates who performed less well did not understand the meaning of the term 'molecular formula' and therefore made no attempt to answer this question. A numerical answer was sometimes seen rather than a molecular formula due to candidates not multiplying the empirical formula by a factor of two.

Question 5

(a) Marking points were much more likely to be achieved from candidate text rather than from diagrams which, if given, were often poorly drawn and insufficiently labelled. Many diagrams did not contribute anything creditworthy or were contradictory to the written element. A description of a 'sea of electrons' or 'delocalised electrons' was often correctly stated. Common errors included protons and nuclei rather than positive ions; negative ions (sometimes in a 'sea') rather than electrons and omitting the attraction between oppositely charged particles. Many candidates described ionic rather than metallic bonding or drew dot-and-cross diagrams of anions and cations. It was not uncommon for descriptions of alloys to be given or for the physical properties of metals to be described rather than candidates following the question remit.

(b) Candidates found this challenging. Some candidates transposed the copper and spoon electrode positions. Graphite electrodes in combination with electrolytes given as water or insoluble copper compounds were common incorrect answers.

(c) Most candidates attempted to show full working; this is good examination practice and meant some candidates could be awarded credit as error carried forward. The most frequent errors seen were the use of the M_r of sulfuric acid to calculate moles or ignoring the requirement to convert the volume units from cm^3 to dm^3.

(d) Many weaker responses simply repeated the wording from step 1 of the question information rather than giving an observation that indicated how they knew that the solid was in excess. Other commonly seen errors were that copper(II) oxide stops reacting; bubbling stops; a precipitate is seen; or copper(II) sulfate builds up in the solution.

(e) It was very common for candidates to ignore the question remit and instead choose to describe the more familiar scenario of how a temperature increase affects the rate of reaction. A very brief temperature decrease effect was sometimes given at the end of the response.

For those that fully described the effect of a temperature decrease, most stated that particles have less energy. However, many wrote 'there are fewer collisions' rather than stating that the *frequency* of collisions decreases. It was rare to see the statement that a *smaller proportion* (or lower percentage) of collisions have enough energy to produce a reaction. Fewer collisions having enough energy to produce a reaction is insufficient.

(f) The expected answers of copper(II) carbonate or copper(II) hydroxide were the most commonly seen. Credit was also given for copper(II) sulfide or copper(II) sulfite as these too will form the sulfate when reacted with sulfuric acid.

(g) This was a well answered question.

(h) Many candidates attempted to use the correct terminology of solute, solvent and dissolve but often confused the terms, for example 'solvent dissolving in solute' was regularly seen. It was common to see answers given in reference to saturation of organic compounds, rather than saturated solutions.

(i) Candidates found this very difficult and only a few candidates had the correct idea of water being needed to form the crystals. Statements were often vague or incomplete such as 'crystals would not form' or 'water is needed'. Many candidates simply repeated a phrase from the method given in the question about a saturated solution being formed, or 'to form a saturated solution you need water'.

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Question 6

(a) (i) Some candidates did not understand the difference between physical and chemical properties. When different types of substances are being compared it is also important that candidates identify the substance they are describing. The use of non-specific terms such as 'it' or 'they' should be avoided.

(ii) Candidates found this very difficult. Many answers did not give accurate observations, although 'bubbling' was often credited. The equation was rarely correct with potassium oxide a common incorrect product. Many candidates did not attempt to add state symbols to their equation. For those that did include state symbols, water was often given as aqueous.

(b) The use of non-specific terms such as 'it' or 'they' should be avoided when comparing two different types of substances. Although most candidates were able to discuss physical properties, it was common to see generic physical properties such as ductility and malleability stated rather than a comparison being made between both groups of metals.

(c) (i) A wide variety of incorrect colours were suggested. The majority of candidates did not know that potassium iodide was colourless.

(ii) This was a well answered question.

(iii) Candidates should be reminded that either a fully correct name or a correct formula is required when identifying a substance. 'Br', iodine and potassium iodide were common incorrect answers for the oxidising agent. The majority of candidates gave an explanation linked to the action of the oxidising agent on the iodide ion, for example 'it oxidises the iodide', rather than stating how the oxidising agent achieves this by gaining electrons.

(d) The displacement reaction between chlorine and the halides was generally well answered, whereas many candidates were not able to determine the outcome of the reactions with bromine or iodine. Candidates should be reminded that if they wish to make corrections to their answers these should be done clearly. Occasionally, it was not clear whether a tick or a cross was the intended answer.

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Paper 0620/51
Practical Test 51

Key messages

- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice.
- Plotted points on a grid should be clearly visible e.g. crosses. Smooth line graphs should be curves with no straight-line sections drawn with a ruler.
- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not. Smells, such as the 'pungent smell of ammonia' and 'the bleach or swimming pool smell of chlorine', are acceptable as observations.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.
- Lists of answers with correct and incorrect responses are marked according to the list principle and are penalised if contradictory. For example, if the correct answer is precipitate dissolves/is soluble and a candidate writes 'precipitate dissolves and a white solid forms', no credit can be awarded.
- In the planning question, **Question 3**, there is no need to write a list of apparatus at the start of the answer. Any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

General comments

The majority of candidates successfully attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all.

Candidates found **Question 3** demanding.

Comments on specific questions

Question 1

(a) Almost all candidates recorded both thermometer readings correctly and all eight volumes of hydrogen.

(b) Better performing candidates recorded the final and initial temperatures and the final temperature being lower than in Experiment 1.

Good responses showed the volume of gas increasing in both experiments and the volume of gas at 40 s being lower in Experiment 2 than in Experiment 1. The maximum volume of gas collected sometimes occurred before 160 s. It was expected that all boxes of the table were completed with a volume.

(c) Many excellent graphs were seen where all the instructions were followed. Common errors included not labelling the graph lines as instructed (when there are two lines on a graph, they should always be labelled so that it is evident which line is which), joining the data points with straight line sections or incorrect plotting of points.

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(d) The majority of candidates performed well. A number of candidates read from the graph at the wrong time (normally at 70 s rather than at 50 s) or missed the units off from their answer; all physical quantities should have units with them. A small number of candidates, having correctly read from their graph, performed an additional unnecessary calculation and gave an incorrect final answer.

(e) Most candidates correctly stated which acid was the most concentrated; others avoided using the word 'concentration' in their answer. Terms such as 'better' or 'more reactive' are not synonyms for 'more concentrated'. The explanation required some reference to a higher rate of reaction or steeper graph line. If candidates chose to answer in terms of the volume of gas made, then they needed to include a reference to time as well.

(f) (i) The majority of candidates correctly stated that the temperature increased.

(ii) Stronger responses stated that the volume of the gas at the end of the reaction would be unchanged. The gas will be cooled when bubbling through water while it is being collected and while it is stored in the measuring cylinder. The very best answers stated that the gas volume would be unchanged because the number of moles of reactants have not changed.

(iii) Many candidates correctly stated that a water bath or ice bath could be used around the conical flask to minimise the temperature increase of the acid. A common error was to state the flask should be insulated. This would actually make the temperature increase more as it would prevent loss of heat energy from the flask to the surroundings.

(g) Most candidates correctly identified the issue with possible gas loss/escape.

(h) This proved to be a challenging question. Many candidates had the erroneous belief that taking more readings would make the readings more accurate. There is no change to the accuracy of each reading. In the experiment, the gas is made quickly (particularly in Experiment 1) and so there is a rapid change in the volume of gas collected. This can make drawing a graph line difficult as there is a large distance between the data points. Taking more frequent readings will make the points closer together and so improve the graph line.

Question 2

(a) An insoluble green precipitate was the expected observation. A common error was to refer to this as blue or brown.

(b) The gas produced should have been tested and candidates should have given the details of the positive test and its result. Most candidates were able to correctly state the gas produced was ammonia and describe the smell of the gas, despite not having given a test for ammonia earlier.

(c) Many candidates realised this was the test for halide ions and that the compound being tested was not a halide and so there would be no reaction. The most common incorrect answer was to state that a white or cream precipitate formed. Candidates often find negative tests more challenging than positive tests; these are useful as they tell us what a compound is not.

(d) This was well answered with most candidates stating a white precipitate formed.

(e) Careless errors were apparent. Ions were identified as ammonia or iron instead of ammonium and iron(II).

(f) Most candidates were able to state an appropriate pH for a weak acid.

(g) Most candidates gave a correct observation of 'bubbles/fizzing' and 'limewater turning milky'. Many missed the dissolving of the solid/formation of a colourless solution.

(h) This proved to be very demanding for candidates. A common error was to state that the compound was a carbonate or contained sodium ions – these were the ions in the test reagent used in **test 2**. The strongest answers stated, either from **test 1** or **test 2**, that solution **F** must be an acid and so contained hydrogen ions.

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Question 3

Some excellent and fully correct answers were seen to the quantitative planning question.

Candidates are advised that 'amount' is not an acceptable term for mass or volume.

The expected answer involved including the steps:

- removal of the insoluble mud
- removal of all the water from the mud-free solution
- determining the mass of the solid left after the water had been removed.

Common errors included not measuring the volume of the river water at the start; not removing all the water (often heating to crystallisation point and then crystallising from the saturated solution – this will not obtain all the dissolved substances); performing overly complicated calculations which sometimes involved the volume of the solid obtained or moles.

A minority of candidates did not attempt the question.

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CHEMISTRY

Paper 0620/52
Practical Test 52

Key messages

- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge for advice.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- Where, in a quantitative task, a reagent is added dropwise (or gradually) and then in excess, candidates should give observations for the dropwise addition and then for the addition in excess. They should make it clear which observation is for dropwise addition and which for addition in excess.
- In qualitative analysis, the reagents should be mixed after they have been put into the test-tube or boiling tube. There should not be different layers unless the instructions include leaving the tube to stand.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances of the last two years. This was more noticeable on the qualitative task (**Question 2**) than the quantitative task (**Question 1**).

In **Question 1**, most centres obtained results that were in line with those expected given the concentrations of the solutions specified in the Confidential Instructions. A small minority of centres clearly used solutions of the incorrect concentrations. While this will not penalise candidates as the Supervisors' results (which centres must send in along with the candidates' answer scripts) are used to resolve any issues, it may make answering some questions more difficult for candidates.

Comments on specific questions

Question 1

(a)(b) The majority of candidates recorded three burette readings in the correct places in each table. The initial burette reading should be the smallest of the burette readings; an initial reading of 50.0 cm^3 is not acceptable; it is expected that burettes are graduated with 0.0 cm^3 at the top. Most candidates calculated correctly the two titres. A minority did not appreciate that the bottom titre in each table was for the total volume of acid and not the volume since the previous colour change. Most candidates were able to gain credit for comparison of titres to the Supervisor result provided.

(c) Most candidates gave the colour change correctly. It should be noted that the end point colour for methyl orange is orange, as that is the mid point between the alkaline colour (yellow) and the acidic colour (red). Pink or red were accepted as the final colour but if the indicator has turned red it does mean the end-point has been overshot.

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(d) The best responses made a correct qualitative comparison, such as 'bigger' or 'smaller' and a quantitative comparison, such as 'twice the volume'. A small number of candidates did not compare the volumes for the colour changes in Experiment 1 but compared Experiment 1 with Experiment 2.

(e) As with **(d)**, a quantitative comparison was required to gain full credit. In this case, an explanation was required. Ideally candidates should have compared the volumes of dilute hydrochloric acid required and from that conclude which solution, **K** or **L**, was the more concentrated.

(f) (i) The majority of candidates gained full credit. Some candidates omitted the units for the volume. Candidates are expected to know that all physical quantities should be accompanied by the units for that quantity.

(ii) Better responses knew that the maximum capacity of a burette is 50 cm^3 and so with a larger volume of solution **L**, the acid would not all fit in the burette. Other answers focused erroneously on problems such as large volumes being difficult to swirl or difficult to see the colour change.

(g) Most candidates were able to correctly state that pipettes give more accurate volumes than measuring cylinders. Although there seemed to be some confusion as to the type of pipette, as some candidates said you could add drop by drop using a pipette. With the changes to the specification, from 2023 onwards a pipette used to measure a specific volume will be referred to as 'volumetric pipette' to avoid similar confusions.

(h) Most candidates realised that swirling ensured that the contents of the flask were mixed so that the acid was distributed evenly throughout the flask, and it could all react.

(i) (i) This was well answered, although a small minority claimed that rinsing the flask would clean the burette or focused on dust particles rather than left over reactants or products from the previous experiment.

(ii) Stronger responses realised that rinsing with solution **L** would leave a residue in the flask that would introduce additional solution **L** beyond the measured 25 cm^3.

Question 2

(a) The majority of candidates were able to report an appropriate pH value. It should be noted that a statement of acidic or alkaline is not a suitable alternative to a pH value. It should also be noted that if candidates give a range of pH values, then all numbers within that range must be acceptable pH values. It is much better for candidates to just state one pH value, preferably in the middle of the range they would have given.

(b) Candidates were expected to give an observation for addition of the reagent dropwise and then in excess. Most candidates correctly noted the formation of a brown or red-brown precipitate which then remained in excess. Some erroneous observations such as fizzing or redissolving or precipitates were seen.

(c) (i) Where candidates are asked to test any gas produced, they should give details of the positive test and the result they obtained. Better performing candidates were guided by the mark allocation of two which indicated to candidates that there was something else required in addition to the test and result. Many candidates performed well but a significant number only gave one acceptable observation (such as fizzing) and did not describe a positive test and result.

(ii) Many candidates were able to correctly identify the gas, often without an appropriate test for the gas having been reported.

(d) While the majority of candidates correctly noted that there was no reaction or that the solution became paler (due to dilution), a few managed to get the impossible result of a white precipitate, possibly because that is what they expect to see in a positive sulfate test. Negative tests are useful as they tell us what something is not.

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(e) (i) While some fully correct answers were seen, this question proved very demanding, possibly because some candidates did not follow the instructions carefully. The test-tube should have been shaken and then left to stand for five minutes. At the end of the five minutes the zinc should have sunk to the bottom and the colour of the solution remaining should have been evident (as colourless or pale green).

(ii) While some fully correct answers were seen, this question proved demanding and for the same reason as **(i)**, the first part of the instruction was to decant the solution. After this, there should not have been an appreciable amount of solid in the test-tube being used. Addition of aqueous ammonia would have caused the formation of a green precipitate that remained when aqueous ammonia was added in excess. Some observations suggested that there was a large amount of zinc remaining in the solutions used.

(f) (i) Iodide ions should react with iron(III) ions to form iodine, which gives a brown colour to the solution. Many candidates gave appropriate observations. Some observations suggested that candidates had mixed up the reagents with which they were provided and obtained unexpected results.

(ii) The addition of thiosulfate ions to aqueous iodine will convert the coloured iodine back to colourless iodide ions, and the brown colour should disappear. Many candidates noted the fading of the brown colour or the formation of colourless or yellow solutions. Some observations suggested incorrect reagents had been used. Many unnecessary observations of what happened in the stop-bath were seen. The stop-bath is required as a safety precaution to prevent the formation of excessive sulfur dioxide from the reaction between thiosulfate ions and the hydrogen ions from the iron(III) salt solution. The instructions told candidates to pour the solution into the stop-bath after they had made their observation.

(g) Most candidates correctly identified the nitrate and iron(III) ions. The hydrogen ion was suggested by some candidates who were able to link the pH recorded in **(a)** with the fact the solution must be acidic and so contain hydrogen ions. A common error was to state the solution contained sulfate ions, presumably because a sulfate ion test had been carried out.

Question 3

Many excellent answers to this planning question were seen.

The expected procedure was to dissolve the caffeine in hot water, filter insoluble materials out of the mixture and then cool the filtrate so that the caffeine would crystallise. It was evident that some candidates did not realise that not all parts of a coffee bean were soluble in water. As this is not an error in chemical understanding, full credit was still available to candidates who made this incorrect assumption.

Many candidates added an extra unnecessary stage that involved dissolving the soluble parts in cold water, filtering and then dissolving the caffeine in hot water and filtering to remove insoluble parts of the beans. The same result can be obtained by dissolving in hot water and filtering.

It should be noted that large lumps (such as coffee beans) should be broken down into small particles prior to dissolving and that dissolving is much more efficient if the solvent is stirred.

This was not a quantitative task and there was no requirement to work out masses or percentages. There was no need for candidates to measure the water volumes or to find the mass of the caffeine.

A few candidates did not understand what was required and tried to compare the solubility of coffee beans in hot and cold water.

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CHEMISTRY

Paper 0620/53
Practical Test 53

Key messages

- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge for advice.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- Where, in a quantitative task, a reagent is added dropwise (or gradually) and then in excess, candidates should give observations for the dropwise addition and then for the addition in excess. They should make it clear which observation is for dropwise addition and which for addition in excess.
- In qualitative analysis, the reagents are mixed after they have been put into the test-tube or boiling tube. There should not be different layers unless the instructions include leaving the tube to stand.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances of the last two years. This was more noticeable on the qualitative task (**Question 2**) than the quantitative task (**Question 1**).

In **Question 1**, most centres obtained results that were in line with those expected given the concentrations of the solutions specified in the Confidential Instructions.

Comments on specific questions

Question 1

(a) The vast majority of candidates completed successfully the three tables for the titration results. The initial burette reading should be the smallest of the burette readings; an initial reading of 50.0 cm^3 is not acceptable. It is expected that burettes are graduated with 0.0 cm^3 at the top. It is also expected that all burette readings and calculated titres will be recorded to one decimal place.

(b) The expected ratio was 1 : 1. However, any simplest whole number ratio that was correct for the titres in Experiment 2 and Experiment 3 was accepted.

(c) Better performing candidates successfully completed the calculation using either their titres or the previously determined ratio. Most candidates remembered that physical quantities require units.

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(d) The best responses made a correct qualitative comparison, such as 'more concentrated' and a quantitative comparison, such as 'twice as concentrated'. An explanation was also required, this should have been based on the volume of **Q** and **R** used in the two titrations.

Only the better performing candidates included a quantitative comparison.

(e) Candidates who performed well realised that heating will not change the number of moles of each reactant and so will not change the titre. The most common error was to state that the higher temperature means the reaction will be faster (which is true, but irrelevant in a titration) and so less dilute hydrochloric acid will be added because the titration is completed in less time.

(f) Most candidates were able to correctly state that pipettes give more accurate volumes than measuring cylinders. Although there seemed to be some confusion as to the type of pipette, as some candidates said you could add drop by drop using a pipette. With the changes to the specification, from 2023 onwards a pipette used to measure a specific volume will be referred to as 'volumetric pipette' to avoid similar confusions.

(g) The reason for the use of a white tile in titrations was not well known, possibly due to a reduced amount of practical work that some centres have been able to carry out over the last two years. The best responses stated it enabled the colour change to be seen more clearly. Common errors were to state 'the tile protected the bench', or 'lifted the flask up higher'.

(h) (i) Most candidates realised that acid **Q** was removed from the burette by washing with water. Some candidates identified other impurities. These answers did not receive credit as the burette had just been using with acid **Q** and so should contain no other impurities.

(ii) This was well answered, with many candidates identifying water as the substance removed.

(iii) This was well answered, with most candidates correctly stating that the same acid is being used and so rinsing is not needed.

(i) This proved to be demanding and this may reflect the reduced practical experience of candidates over the past two years. The most common incorrect answers were based on checking the tap worked. Only better performing candidates realised that the area below the tap will be full of air and this needs to be removed before the titration begins.

Question 2

(a) Substance **S** was anhydrous copper(II) sulfate. The Confidential Instructions stated that this should be provided in a stoppered boiling tube; the purpose of this was to prevent absorption of water vapour from the air. The expected starting colour was white or grey with pale blue being allowed in case samples had absorbed a small amount of water vapour. Candidates gave a variety of start colours, even within the same centre, suggesting some candidates had anhydrous copper(II) sulfate while others had samples that had absorbed a significant amount of water. To allow for this answers were credited if they showed the substance becoming more blue or a darker blue on addition of water.

(b) To answer this question candidates needed to use the pH indicator paper and chart provided. Most candidates gave a pH within the accepted range. Some candidates reported an alkaline pH value, suggesting that they may have tested the wrong solution. It should be noted that if a pH is asked for, the term 'acid' is not sufficient as a numerical value is required.

(c) Most candidates were able to observe bubbling and the formation of a dark or black solid. Only a very small minority noticed that the colour of the solution fades. However, only two of the possible observations were required to gain full credit.

(d) (i) Iodide ions should react with copper(II) ions to form iodine, which gives a brown colour to the solution, and solid copper(I) iodide. Many candidates gave appropriate observations. Some observations suggested that candidates had mixed up the reagents with which they were provided and obtained unexpected results.

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(ii) The addition of thiosulfate ions to aqueous iodine will convert the coloured iodine back to colourless iodide ions and the brown colour should disappear. This should leave the white solid copper(I) iodide visible. Many candidates reported seeing a white or cream coloured solid. Some observations suggested incorrect reagents had been used.

(e) As this reaction produced a white precipitate in a blue solution it was a difficult observation. Candidates should be familiar with observing precipitate colours where they may be masked by the colour of the solution. Leaving the precipitate to settle or observing the precipitate held at the top of the solution by surface tension can help.

(f) Many candidates correctly reported that there was no change or that the blue solution became paler (due to dilution). Some candidates erroneously stated a precipitate formed, presumably because that is the positive result for a halide ion test. Solid **S** was not a halide and so no precipitate would have formed.

(g) As the reagent was added dropwise and then in excess, observations for dropwise addition of the aqueous ammonia and then addition in excess should have been reported. Some candidates reported the formation of different layers. This indicates they had not mixed the content of the test-tube by gentle side to side shaking. The best responses reported the formation of a blue precipitate which dissolved to give a deep blue solution. Some answers suggested that the mixture went directly to a deep blue solution, suggesting that the dropwise addition had been omitted and that an excess had been poured in at the start.

(h) Many candidates correctly identified solid **S** as copper(II) sulfate. Only a minority of those were able to also state that it was anhydrous.

Question 3

Some excellent answers to this planning question were seen.

The expected procedure was to mix known volumes of **A**, **B** and starch solution; time until the mixture went blue black and then repeat the experiment at other temperatures.

Common errors were to omit naming the item of apparatus used to measure the known volumes of **A** and **B** and not mixing or stirring **A** and **B** together (so that a homogeneous mixture is obtained in the container used for the reaction). Many candidates combined the reagents and then heated them, not realising that they would be reacting while the temperature was changing and so they would not know the temperature at which the reaction took place. The very best answers gave details of warming the reagents individually before combining them.

A few candidates did not understand what was required and described reactions in which they added starch or iodine individually to **A** and to **B** and did not allow **A** to react with **B**.

Better performing candidates are likely to have completed some of the quantitative tasks from past papers as part of their preparation for the examination. The past papers and Confidential Instructions are available on-line.

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CHEMISTRY

Paper 0620/61
Alternative to Practical 61

Key messages

- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice.
- Plotted points on a grid should be clearly visible e.g. crosses. Smooth line graphs should be curves with no straight-line sections drawn with a ruler.
- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not. Smells, such as the 'pungent smell of ammonia' and 'the bleach or swimming pool smell of chlorine', are acceptable as observations.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.
- Lists of answers with correct and incorrect responses are marked according to the list principle and are penalised if contradictory. For example, if the correct answer is precipitate dissolves/is soluble and a candidate writes 'precipitate dissolves and a white solid forms', no credit can be awarded.
- In the planning question, **Question 4**, there is no need to write a list of apparatus at the start of the answer. Any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

General comments

The majority of candidates successfully attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all.

The majority of candidates were able to complete tables of results from readings on diagrams in **Question 2**.

Candidates found **Question 4** demanding.

Comments on specific questions

Question 1

(a) Some candidates were either unfamiliar with these common items of laboratory apparatus or did not look carefully at what was being labelled. Most candidates were able to identify the funnel and the boiling/test-tube. Vague answers such as 'tube' were not accepted.

(b) Most candidates appreciated the need to cool the gases produced by combustion to condense the water vapour. Answers based on keeping the water cold to avoid evaporation were not credited.

(c) Both the chemical test for the presence of water and the physical test for the purity of water were accepted. Candidates were expected to give the test and outcome of that test. A few candidates mixed up the colour changes shown by anhydrous copper(II) sulfate and anhydrous cobalt(II) chloride.

(d) Almost all candidates correctly identified the solution as limewater. A small minority suggested it was a solution of calcium carbonate, which is the insoluble product made in this test.

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(e) This question proved demanding. Many candidates suggest the candle must contain oxygen, presumably because the products were both oxides, forgetting that the oxygen used in combustion comes from the air.

(f) Many candidates gave fully correct or partially correct answers to this question. The name of the test reagent required the correct oxidation state and this was sometimes missing, incorrect or written after potassium rather than after manganate.

Question 2

(a) Almost all candidates gave both thermometer readings correctly and many got all eight measuring cylinder readings correct. The fact the measuring cylinder diagrams were shown inverted (as would be the case if candidates were doing the practical) did cause difficulties for some; it was clear that some enterprising candidates had turned the examination paper upside down to read the diagrams, written their answers on the diagrams and then turned the examination paper back the right way up and written the volumes in the answer spaces. This is a good way to make the readings easier.

(b) Good response gave accurate actual values and gave both readings to the nearest 0.5 °C (35.5 °C and 31.0 °C). Candidates are expected to be able to read thermometer scales to the nearest half division. Similar issues were noted to those seen in **(a)**.

(c) Many excellent graphs were seen where all the instructions were followed. Common errors included not labelling the graph lines as instructed (when there are two lines on a graph, they should always be labelled so that it is evident which line is which); joining the data points with straight-line sections or incorrectly plotted points. If a point looks like it is not on the best fit line, candidates are advised to check it has been plotted correctly.

(d) The majority of candidates performed well. A number of candidates read from the graph at the wrong time (normally at 70 s rather than at 50 s) or missed the units off from their answer; all physical quantities should have units with them. A small number of candidates, having correctly read from their graph, performed an additional unnecessary calculation and gave an incorrect final answer.

(e) Most candidates correctly stated which acid was the most concentrated; others avoided using the word ‘concentration’ in their answer. Terms such as ‘better’ or ‘more reactive’ are not synonyms for ‘more concentrated’. The explanation required some reference to a higher rate of reaction or steeper graph line. If candidates chose to answer in terms of the volume of gas made, then they needed to include a reference to time as well.

(f) (i) The majority of candidates correctly stated that the temperature increased.

(ii) Stronger responses stated that the volume of the gas at the end of the reaction would be unchanged. The gas will be cooled when bubbling through water while it is being collected and while it is stored in the measuring cylinder. The very best answers stated that the gas volume would be unchanged because the number of moles of reactants have not changed.

(iii) Many candidates correctly stated that a water bath or ice bath could be used around the conical flask to minimise the temperature increase of the acid. A common error was to state the flask should be insulated. This would actually make the temperature increase more as it would prevent loss of heat energy from the flask to the surroundings.

(g) Most candidates correctly identified the issue with possible gas loss/escape.

(h) This proved to be a challenging question. Many candidates had the erroneous belief that taking more readings would make the readings more accurate. There is no change to the accuracy of each reading. In the experiment, the gas is made quickly (particularly in Experiment 1) and so there is a rapid change in the volume of gas collected. This can make drawing a graph line difficult as there is a large distance between the data points. Taking more frequent readings will make the points closer together and so improve the graph line.

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Question 3

(a) Where a question states that the gas produced was tested, in the observations section of the answer space, candidates should give the details of the positive test and its result. Almost all candidates were able to correctly state the gas produced was ammonia despite not having given a test for ammonia earlier.

(b) Many candidates realised this was the test for halide ions and that the compound being tested was not a halide and so there would be no reaction. The most common incorrect answer was to state that a white or cream precipitate formed. Candidates often find negative tests more challenging than positive tests; these are useful as they tell us what a compound is not.

(c) This was well answered with most candidates stating a white precipitate would form.

(d) Most candidates were able to state an appropriate pH for a weak acid.

(e) This proved to be very demanding for candidates. A common error was to state that the compound was a carbonate or contained sodium ions – these were the ions in the test reagent used in **test 2**. The strongest answers stated, either from **test 1** or **test 2**, that solution **F** must be an acid and so contained hydrogen ions.

Question 4

Some excellent and fully correct answers were seen to the quantitative planning question.

Candidates are advised that ‘amount’ is not an acceptable term for mass or volume.

The expected answer involved including the steps:
- removal of the insoluble mud
- removal of all the water from the mud-free solution
- determining the mass of the solid left after the water had been removed.

Common errors included not measuring the volume of the river water at the start; not removing all the water (often heating to crystallisation point and then crystallising from the saturated solution – this will not obtain all the dissolved substances); performing overly complicated calculations which sometimes involved the volume of the solid obtained or moles.

A minority of candidates did not attempt the question.

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CHEMISTRY

Paper 0620/62
Alternative to Practical 62

Key messages

- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

The majority of candidates successfully attempted all the questions and the full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few blank spaces.

Some responses might suggest that candidates have limited practical experience.

The vast majority of candidates were able to complete tables of results from burettes on diagrams in **Question 2**. Some problems were caused by the fact that the scale read downwards. This suggested that these candidates were not familiar with burettes.

Question 4 was a planning task based on the extraction of a pure sample of caffeine from coffee beans. Nearly all candidates used a valid method, even if a few details were missing or confused.

Comments on specific questions

Question 1

(a) The two pieces of apparatus were well known; a boiling tube and a measuring cylinder. Some confused the measuring cylinder with a gas jar or gas syringe.

(b) Most candidates realised that the colourless liquid was water.

(c) The arrow representing heating was generally drawn in the correct place, aimed at the sodium hydrogencarbonate. A few had their arrow aimed at the water in the boiling tube or under the trough.

(d) The idea that there would be no more bubbles when the reaction had finished was a popular answer. A few candidates said 'there would be no more gas formed'; this is not an observation.

(e) This was challenging. A number of candidates knew that water would enter the delivery tube and boiling tube due to low pressure; many used the term suck-back. Fewer went on to explain that this would cause the boiling tube to shatter. A common misconception was the gas produced would be drawn back and so the volume of gas collected would be incorrect.

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Question 2

(a) Nearly all candidates recorded the burette readings correctly. The inverted scale did cause problems for some. Readings should be recorded in a consistent manner in terms of decimal places, for example 12.0. The subtractions were also largely correct. A minority missed the word 'total' in the last box.

(b) Most candidates were able to complete the table correctly.

(c) The colour change was generally well known; some gave the colour change the wrong way round.

(d) Many candidates gained credit for a qualitative comparison (more, less) and also for a quantitative comparison (twice as much, half as much).

(e) Good responses included a quantitative explanation that compared the volumes of dilute hydrochloric acid required and from this, concluded which solution, **K** or **L**, was the more concentrated.

(f) (i) This was generally well answered; units were frequently missing.

(ii) This was a challenging question, where the expected answer was that the required volume was more than would fit into the burette.

(g) Nearly everyone knew that a pipette would be more accurate.

(h) Most knew that swirling was to mix the solutions or to ensure that all the solutions reacted.

(i) (i) Nearly all candidates knew why the conical flask was rinsed with water.

(ii) Candidates found this explanation challenging. Very good responses included the idea that rinsing the conical flask with solution **L** would leave some of the solution in the flask, thus increasing its volume in the titration, leading to too high a volume of hydrochloric acid in the titration.

Question 3

(a) Performance here was dependent on how well candidates had learned the qualitative tests for ions. Most candidates knew that iron(III) nitrate would give a red-brown precipitate which is insoluble in excess.

(b) Candidates found this a difficult question. Many candidates realised that the gas was ammonia; fewer knew the test for ammonia. Where candidates are asked to test any gas produced, they should give details of the positive test and the result they obtained.

(c) Candidates find negative tests challenging and this was no exception. Many candidates gave a positive result for sulfate ions.

(d) A number of correct answers for the test for sulfur dioxide were seen.

(e) More candidates identified the lithium ion than the sulfite ion. Common errors included sulfate or sulfide. Many gave the correct formulae, Li_2SO_3. However, an incorrect formula is contradictory to the correct name.

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Question 4

Many excellent answers to this planning question were seen.

The expected procedure was to dissolve the caffeine in hot water, filter insoluble materials out of the mixture and then cool the filtrate so that the caffeine would crystallise. It was evident that some candidates did not realise that not all parts of a coffee bean were soluble in water.

Many candidates unnecessarily added an extra stage that involved dissolving the soluble parts in cold water, filtering and then dissolving the caffeine in hot water and filtering to remove insoluble parts of the beans. The same result can be obtained by dissolving in hot water and filtering.

It should be noted that large lumps (such as coffee beans) should be broken down into small particles prior to dissolving and that dissolving is much more efficient if the solvent is stirred.

This was not a quantitative task and there was no requirement to work out masses or percentages. Hence, there was no need for candidates to measure the water volumes, nor to find the mass of the caffeine.

A few candidates did not understand what was required and tried to compare the solubility of coffee beans in hot and cold water.

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CHEMISTRY

Paper 0620/63
Alternative to Practical 63

Key messages

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- Where, in a quantitative task, it is stated that a reagent is added dropwise (or gradually) and then in excess, candidates should give observations for the dropwise addition and then for the addition in excess; making it clear which observation is for dropwise addition and which for addition in excess.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.

General comments

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances of the last two years.

In the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start or the aims of the experiment. Credit can only be awarded if it is stated what the apparatus is used for; credit is not awarded for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The majority of candidates were able to correctly name the gas syringe.

(b) The vast majority of candidates could name the Bunsen burner as the apparatus required for heating strongly. Other items, such as a blow-torch were not accepted as they are not normal laboratory equipment.

(c) This question proved demanding. Common incorrect answers included stating that copper did not react with air or that it did not get hot enough. In the stem to **Question 1**, candidates were told the heating was started at point **X** and gradually moved along the tube. The best responses stated that this would gradually use up the oxygen in the apparatus and by the time the heating reached **Y**, there would be no oxygen left.

(d) (i) Most candidates correctly calculated the total volume of air at the start of the experiment.

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(ii) Candidates found this question the most demanding part of **Question 1**. Candidates needed to work out the total volume of gas at the end of the experiment, and then work out the change in volume as compared to the start of the experiment. That change is the volume of oxygen that has reacted. This then needed to be converted to a percentage of the initial air volume. While many fully correct answers were seen, the most common errors involved calculating the percentage of the air that was left (so the percentage that was not oxygen) rather than the percentage that had been used up.

Question 2

(a) Candidates performed well here, with most candidates able to read burette scales and calculate the volumes added. Some candidates did not give all burette readings to a consistent number of decimal places. Many candidates recorded the initial reading in Experiment 3 as 7 rather than 7.0. Some candidates gave readings to a consistent number of significant figures and so, for example, recorded the numbers such as 8.50 and 43.7; this is incorrect as if a burette can be read to one scale division on one part of the scale it will not be possible to read it to better than one scale division elsewhere on the scale.

(b) Most candidates correctly stated the ratio was 1 : 1.

(c) Most candidates correctly gave a volume that was the same as the volume of acid required in Experiment 1. Most candidates remembered that physical quantities require units, although some omitted the units.

(d) The best responses made a correct qualitative comparison, such as 'more concentrated' and quantitative comparison, such as 'twice as concentrated'. An explanation was also required; this should have been based on the volume of **Q** and **R** used in the two titrations.

Only the very best responses included a quantitative comparison.

(e) Better performing candidates realised that heating will not change the number of moles of each reactant and so will not change the titre. The most common error was to state that the higher temperature means the reaction will be faster (this is true, but irrelevant in a titration) and so less dilute hydrochloric acid will be added because the titration is completed in less time.

(f) Most candidates were able to correctly state that pipettes give more accurate volumes than measuring cylinders. Although there seemed to be some confusion as to the type of pipette, as some candidates said you could add drop by drop using a pipette. With the changes to the specification, from 2023 onwards a pipette used to measure a specific volume will be referred to as 'volumetric pipette' to avoid similar confusions.

(g) The reason for the use of a white tile in titrations was not well known, possibly due to a reduced amount of practical work that some centres have been able to carry out over the last two years. Better performing candidates stated it enabled the colour change to be seen more clearly. Common errors were to state 'the tile protected the bench', or 'lifted the flask up higher'.

(h) (i) Most candidates realised that acid **Q** was removed from the burette by washing with water. Some candidates identified other impurities; these answers did not receive credit as the burette had just been used with acid **Q** and so should contain no other impurities.

(ii) This was well answered, with many candidates identifying water as the substance removed.

(iii) This part was well answered, with most candidates correctly stating that the same acid is being used and so rinsing is not needed.

(i) This proved to be demanding and this may reflect the reduced practical experience of candidates over the past two years. The most common incorrect answers were based on 'checking the tap works'. Only the best responses realised that the area below the tap will be full of air and this needs to be removed before the titration begins.

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Question 3

(a) The majority of candidates were able to give an acceptable flame colour of either 'blue-green' or 'green'. The colour 'blue' alone was not accepted for the copper ion flame test. It was evident that some candidates were not familiar with flame tests and gave answers suggesting that they confused gas tests with using a lighted or glowing splint.

(b) The colour change when water is added to anhydrous copper(II) sulfate was well known.

(c) Most candidates were able to give a correct observation for a positive sulfate ion test.

(d) Many candidates performed well and gave the observations for the addition of aqueous ammonia to aqueous copper(II) sulfate. The question stated that the ammonia was added dropwise and then in excess; candidates needed to structure their answers so the observation for dropwise addition was clearly stated and then the observation for addition in excess. Some candidates gave contradictory answers such as stating that 'on addition of excess aqueous ammonia the blue precipitate dissolved to give a dark blue precipitate'. If the initial blue precipitate dissolved, it can no longer be a precipitate; it should have been a dark blue solution that was formed. Answers such as this were not awarded the credit available for stating the precipitate dissolved.

(e) The test for sulfur dioxide was not well known and only the better performing candidates gained credit for identifying this gas.

(f) The best responses successfully identified all three ions, with some answers showing excellent reasoning as the identity of each ion tested for had been written alongside the appropriate tests. A common error was to confuse the test which showed that zinc ions were present with a test for aluminium ions.

Question 4

Some excellent answers to this planning question were seen.

The expected procedure was to mix known volumes of **A**, **B** and starch solution; time until the mixture went blue-black and then repeat the experiment at other temperatures.

Common errors were to omit naming the item of apparatus used to measure the known volumes of **A** and **B**, not mixing or stirring **A** and **B** together (so that a homogeneous mixture is obtained in the container used for the reaction). Many candidates combined the reagents and then heated them, not realising that they would be reacting while the temperature was changing and so you would not know the temperature at which the reaction took place. The very best answers gave details of warming the reagents individually before combining them.

A few candidates did not understand what was required and described reactions in which they added starch or iodine individually to **A** and to **B** and did not allow **A** to react with **B**.

Better performing candidates are likely to have carried out some of the quantitative tasks from past papers as part of their preparation for the examination. The past papers and Confidential Instructions are available online.

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