CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

This cohort was relatively small.

Candidates found **Questions 10** and **40** to have least demand. **Questions 1**, **6** and **15** were also answered correctly by most candidates. **Questions 2**, **11**, **12**, **19**, **22**, **24**, **25** and **37** were found to be of high demand. No candidates in this small cohort were able to answer **Questions 4**, **13**, **20**, **34** or **38** correctly.

Questions on organic chemistry were least well answered.

Comments on specific questions

Question 2

All candidates recognised that particles move more quickly when heated. Most candidates did not recognise that an increased pressure would not change the particle speed.

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Question 4

Candidates were not able to identify the solvent front. Some identified the solvent, option **C**, or the labelled spot on the chromatogram, option **B**.

Question 11

Most candidates incorrectly chose option **A**, which would not balance the oxygen molecules.

Question 12

Most candidates incorrectly related the relative masses to the proton, option **B**.

Question 13

Candidates found this question challenging. Both the difference in electrode products of molten and aqueous sodium chloride and the difference in concentration of aqueous solution were tested. Most candidates recalled one of the electrode products but not both.

Question 19

Most candidates incorrectly thought a higher concentration, option **A**, would give the shallower curve for experiment 2.

Question 20

The majority of candidates confused the two colours of cobalt(II) chloride and thought the colour would remain blue. Most also assumed that the heating of hydrated cobalt(II) chloride was an exothermic rather than an endothermic process and so predicted a temperature fall.

Question 22

Option **A** was the most popular incorrect choice, followed by option **B**. Few candidates recalled the reaction of carbonates with acids to form salts.

Question 24

Candidates recognised the need to remove the water and many chose options **A** and **B**. A key word in the question was 'excess', which should have suggested to candidates that the leftover unreacted solid should be removed first.

Question 25

Most candidates incorrectly chose option **D**, zinc as an ion, which forms a green precipitate.

Question 34

Option **B** was a popular incorrect choice. The majority of candidates recalled the treatment of soils using lime or limestone but did not recognise that it is acidic rather than alkaline soils that would be treated.

Question 38

Most candidates recognised that yeast is used in fermentation but not that it is the glucose that is fermented to form ethanol. Option **A** was the most popular response.

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Paper 0620/12
Multiple Choice (Core)

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

General comments

Questions 3, **7**, **10**, **15**, **17**, **19** and **32** had the lowest demand.

Questions 8, **20**, **29**, **36**, **38** and **40** were found to be more challenging. Overall the questions on organic chemistry were least well answered.

Comments on specific questions

Question 2

Most candidates were able to correctly reject option **D**, but all other options were popular responses. Candidates should recall that a substance will be a liquid at a temperature between the melting and boiling points.

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Question 4

All the options were chosen in a ratio that suggests many were guessing the position of the solvent front.

Question 8

Options **A** and **B** were the most common incorrect answers selected. In option **A**, candidates assumed that the number of hydrogen atoms was equal to the number of bonding electrons and for option **B**, candidates counted the correct number of bonds but did not recall that each bond would contain two electrons.

Question 12

Although most candidates gave the correct option, **C**, option **B** was also chosen frequently suggesting that many candidates were unclear which particle was chosen as the comparison for relative masses.

Question 13

The majority of candidates incorrectly chose option **A** or option **B**. The question tells candidates that the initial solution was neutral so the initial colour should be green not blue.

Question 20

Most candidates identified the correct colour change but thought that the addition of water would cause the temperature to fall.

Question 21

Properties of acids and bases were not commonly known. Although option **A**, the correct answer, was the most common option chosen, the distribution of options chosen suggested many candidates were guessing.

Question 29

Option **C** was a popular incorrect choice. The majority of candidates incorrectly chose a solid ionic substance as an electrical conductor, not recognising that the alloy would be a solid conductor.

Question 36

Option **C**, the key, was the least popular answer. Candidates did not recognise that three fractions had been chosen and the boiling point was not listed in descending order.

Question 38

Most candidates thought that yeast is fermented rather than glucose. Only a minority were able to identify water as steam as a product of combustion of ethanol.

Question 40

Most candidates were able to recall the reaction of acids with $CaCO_3$ and their effect on methyl red but did not recognise CuO as a basic oxide, which would also react. The incorrect option **D** was the most popular answer.

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Paper 0620/13
Multiple Choice (Core)

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

General comments

Questions 2, **8**, **10**, **33** and **40** had the lowest demand.

Questions 4, **14**, **18**, **25**, **36** and **38** were found to be more challenging. Questions which required applying syllabus content from data such as **Questions 29**, **36** or **38** were least well answered. Candidates are advised to spend more time interpreting the data provided.

Comments on specific questions

Question 4

Most candidates were unable to identify the solvent front on the chromatogram. All the options were popular suggesting many were guessing.

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Question 11

Although the correct answer was most commonly chosen, a large proportion of candidates incorrectly thought relative masses were compared to either a proton or a neutron.

Question 13

In this question, many candidates confused endothermic and exothermic or did not recognise the combustion reaction as exothermic.

Question 14

Candidates are not required to describe nuclear processes but should know that the use of uranium-235 to produce energy is not combustion. The incorrect option **A** was the most common response.

Question 18

The majority of candidates correctly identified that the cobalt(II) chloride would become pink. Most also incorrectly assumed that the heating of hydrated cobalt(II) chloride was an exothermic rather than an endothermic process and so predicted a temperature fall, which was option **A**.

Question 21

The majority of candidates answered this correctly. A significant minority chose option **C**, which would give a pH change in the opposite direction.

Question 24

Candidates recognised the need to remove the water and so many incorrectly chose option **A** as the next stage in the preparation. A key word in the question was 'excess', which should have suggested to candidates that the leftover unreacted solid should be removed first.

Question 25

Most candidates were able to recall the trend in colour as Group VII is descended. The trend in density was not well recalled and option **B** was the most common answer.

Question 29

Although fewer candidates chose option **A**, all the other options were commonly chosen suggesting that guessing was common or candidates were confusing the reactions of metals and their oxides.

Question 32

Most candidates correctly recalled the toxic nature of oxides of nitrogen but did not recall the typical acidic nature of non-metal oxides. Option **B** was most commonly chosen.

Question 36

Candidates did not recognise that three fractions had been chosen but not presented in order of boiling point or number of carbon atoms. Most assumed that the boiling points were listed in descending order and chose option **A**.

Question 38

Option **A** was the most common incorrect answer. Although yeast is used, it is the glucose that is fermented. Many candidates chose option **A** or **D**.

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Paper 0620/21
Multiple Choice (Extended)

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

General comments

Questions 2, **5**, **7**, **10**, **11**, **19**, **27** and **30** had the lowest demand. **Questions 8**, **33** and **35** were found to be more challenging.

Comments on specific questions

Question 3

Most candidates correctly identified the pipette; others chose option **A**.

Question 4

The parts of a chromatogram were not well recalled. Some candidates chose the base line, option **D**, or the solvent, option **C**, instead.

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Question 8

Most candidates recalled the covalent nature of SiO_2 but went on to choose option **C**, simple covalent.

Question 9

Candidates were able to match the formation of an ion with the correct electron movement. Some incorrectly chose option **B** to produce a rubidium anion.

Question 16

Most candidates identified ^{235}U, option **D**. Some candidates were as likely to choose hydrogen, option **B**.

Question 17

Option **D** was a popular choice for some candidates, suggesting a simple subtraction of the bottom two numerical values from the top two.

Question 18

Some candidates tended to incorrectly give option **B** or option **C** to this question.

Question 20

Some candidates thought all the statements were correct and gave option **A**.

Question 21

Most candidates correctly identified that the reducing agent will be oxidised in the reaction. A common error was to double the oxidation state of the bromide ion because there are two ions in the equation.

Question 24

Candidates recognised the need to remove the water and so many incorrectly chose option **A** as the next stage in the preparation. A key word in the question was ‘excess’, which should have suggested to candidates that the leftover unreacted solid should be removed first.

Question 26

Most candidates selected the correct response, but a significant minority chose hydrogen, option **B**.

Question 33

Candidates must make sure they read questions about neutralising carefully. In this question, the industrial waste was described as acidic. The substance that will neutralise it must therefore be basic. Most candidates gave option **A** or **C**, incorrectly saying that sulfur dioxide is basic.

Question 35

Structural isomerism was not well known by candidates. Most gave option **B**, which was not an isomer.

Question 38

Some candidates gave option **A** or **D** rather than the correct response. For both responses, candidates thought that it is yeast that is fermented rather than glucose and for option **A**, that oxygen is a product rather than a reactant in combustion.

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Paper 0620/22
Multiple Choice (Extended)

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

General comments

Questions 2, **10**, **17**, **19**, **27** and **35** had the lowest demand. **Questions 15**, **29**, **36**, **37** and **39** were found to be more challenging. Questions on organic chemistry were least well answered.

Comments on specific questions

Question 1

This question was well answered by many candidates. Some candidates showed little understanding and responses suggested a high degree of guessing.

Question 5

Although most candidates correctly chose option **A**, some candidates gave option **D**, thinking distillation relies on a difference in solubility**.**

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Question 7

Some candidates were more likely to choose option **D** than any other response, suggesting a poor recall of bonding in molecules listed in the syllabus.

Question 13

Most candidates made an attempt at this calculation. Some candidates tended to choose option **B** more frequently than the key, option **C**.

Question 14

Most candidates correctly identified the energy released being greater than the energy needed for the exothermic reaction. Some candidates gave option **C** thinking that bond breaking released energy.

Question 15

Candidates tended to complete the calculations well but did not pay enough attention to the units. Information on energy was given in both J and kJ and volume in both cm^3 and dm^3. As a result, many candidates were confused and gave option **C**.

Question 18

Few candidates gave option **C**, suggesting a good understanding of the effect of adding more reactants on the yield of ammonia. The effect of temperature on yield was less well understood BY some candidates who selected option **D**.

Question 21

Only a small majority of candidates identified the correct proton transfer in this reaction. Some candidates incorrectly thought this was a redox reaction and gave option **B**.

Question 22

Some candidates performed well on this question. However, there was evidence to suggest guessing by other candidates, as each option was chosen with equal popularity.

Question 26

Many candidates incorrectly gave option **C**, although a few gave option **A**. Only a minority were able to use typical properties of syllabus elements to identify this ‘new element’.

Question 29

Option **C** was a popular incorrect choice. The majority of candidates incorrectly chose a solid ionic substance as an electrical conductor, not recognising that the alloy would be a solid conductor.

Question 32

Most candidates correctly identified a test for zinc ions. Only a minority of candidates recognised the decomposition of a nitrate presented as a chemical test. Option **C** was a popular incorrect answer.

Question 36

Structural isomerism was not well known. The majority of candidates thought that all the structures were different isomers and chose option **A**.

Question 37

The addition reactions of alkenes were not well known. All possible responses were popular suggesting a significant degree of guessing.

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Question 38

Some candidates thought that it was the yeast that was converted to ethanol rather than the glucose or confused oxygen as a product rather than a reactant in combustion.

Question 39

The properties of nylon and *Terylene* were not well known. All responses were almost equally popular suggesting a significant degree of guessing.

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Paper 0620/23
Multiple Choice (Extended)

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

General comments

Questions 2, **8**, **29** and **30** had the lowest demand. **Questions 17**, **19** and **43** were found to be more challenging.

Comments on specific questions

Question 13

Most candidates identified the correct product at the anode. Some candidates confused the electrolysis of aqueous and of molten salts and incorrectly chose option **B.**

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Question 17

Option **B** was a popular incorrect choice. Candidates found the identification of a redox reaction challenging. Some candidates were also likely to give option **C**.

Question 18

Option **A** was a popular incorrect choice. Some candidates recalled glucose being involved in a photochemical reaction but did not read the statement clearly to interpret which reaction involving glucose was being described.

Question 19

Option **A** was a popular incorrect choice. This was found to be a very challenging question for all candidates. Most were able to recognise the effect of concentration on rate but did not consider the final volume of gas and therefore the moles of reactant used.

Question 25

The general properties of Group VII elements were not well known by some candidates who were almost as likely to give option **B** or option **D**.

Question 26

Option **B** was a popular incorrect choice. Most candidates were able to predict the trend in reactivity down Group II but not the density.

Question 28

Option **D** was a popular incorrect choice. The most common error was to reverse the order of reactivity of metal X and Y by misinterpreting the data given.

Question 32

Option **B** was a popular incorrect choice. Most candidates recalled the link between gas pressure and rate of reaction. Some candidates confused the effect of pressure on the position of equilibrium.

Question 36

Option **C** was a popular incorrect choice. Candidates found this a challenging question. The product of the reaction of bromine with an alkene was not well known.

Question 38

Some candidates were as likely to choose any of the options suggesting a degree of guessing.

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Paper 0620/31
Theory (Core)

Key messages

- Some candidates needed more practice in memorising definitions, the results of qualitative tests and standard chemical reactions.
- Some candidates needed more practice in answering questions with greater precision.
- Many candidates needed further practice in drawing organic formulae and in revising organic reactions.
- Interpretation of data from tables and graphs was generally well done.

General comments

Many candidates showed a basic knowledge of core chemistry. Many candidates did not respond to one or more parts of each question. The standard of English was generally good; some candidates needed more practice in writing with precision.

Some candidates needed practice in revising standard chemical reactions and chemical terms such as isotopes (**Question 1(b)(i)**) and thermal decomposition (**Question 4(c)(i)**). Others needed more practice in revising chemical tests, e.g. for Cr^{3+} ions (**Question 1(a)(v)**), for unsaturated compounds (**Question 5(b)(i)**), for hydrogen (**Question 7(c)(i)**) and for water (**Question 8(d)(ii)**). Many candidates also needed to revise the correct naming of reactants and products in standard chemical reactions such as acid with alkalis (**Question 4(b)(i)**). Some candidates needed more practice in analysing what a question is asking and in following the instructions precisely. For example, in **Question 4(c)(iii)** some candidates did not refer to the instruction to use the information from the diagram and just defined an exothermic reaction.

Most candidates needed further practice in writing precise answers rather than providing vague or unqualified statements. For example, in **Questions 2(b)(i)** and **(ii)** (sources and effects of oxides of nitrogen in the air) many just wrote 'factories' or 'harmful'. In **Questions 3(a)** and **3(b)** (relating properties to uses), many candidates did not make the distinction between very hard and hard or very good ductility and poor ductility. In **Question 4(b)(iii)**, most candidates gave imprecise answers about determining the pH without using a pH meter. In **Question 4(b)(iv)** (use of slaked lime), many candidates gave vague answers such as 'increases the chances of growing'. In **Question 5(e)** (pollution problems with plastics), many candidates gave imprecise answers such as 'kills animals'. In **Question 7(b)(ii)** (why no more gas is produced in the reaction), candidates did not refer to the reaction being complete but wrote vague statements about the volume of gas. In **Question 8(c)(i)** (making crystals of copper(II) sulfate), many candidates omitted essential details and gave answers in a disordered fashion.

Many candidates needed more revision of organic chemistry, particularly in writing and interpreting organic structures (**Questions 4(a)(i)** and **4(a)(ii)**). Many candidates did not know details of the reaction of ethene with steam (**Questions 5(c)(i)** and **5(c)(ii)**). Others needed to revise details of polymerisation and polymers given in the core syllabus (**Questions 5(e)(i)** to **5(e)(iii)**).

Many candidates were able to extract information from graphs as well as from tables. Many candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion. Others needed to revise these areas.

Questions involving atomic structure were generally tackled well by many candidates, as was the completion of symbol equations.

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Comments on specific questions

Question 1

This was one of the least well answered questions on the paper. Some candidates identified two of the elements correctly in **(a)**, as well as completing the electronic structure in **(c)**. Fewer gave a convincing definition of the term *isotopes* in **(b)(i)** or deduced both the number of protons and neutrons in **(b)(ii)**. Some completed the electronic structure in **(c)** correctly. Others needed more practice in this.

(a) (i) The commonest incorrect answers were oxygen or hydrogen, both diatomic gases.

(ii) A variety of incorrect answers was seen including the solids aluminium and zinc and the gas chlorine.

(iii) Many candidates appeared to guess the answer. Incorrect answers included elements forming positive ions such as potassium or calcium.

(iv) Most candidates did not recognise that hematite is an ore of iron. Chromium was the commonest incorrect answer.

(v) A variety of incorrect answers was seen, e.g. aluminium, magnesium, potassium, none of which form coloured ions.

(b) (i) Few candidates were able to define the term *isotopes* with sufficient precision. The essential word 'atoms' was generally missing. Some candidates referred to 'elements' or 'amounts'. Others referred to 'different numbers of electrons'.

(ii) The commonest incorrect answer for the number of protons was 26 (mass number). The commonest incorrect answer for the number of neutrons was 12 (number of protons).

(c) A minority of the candidates gave the correct electronic structure of magnesium. The commonest errors were 6 or 8 electrons in the outer shell, or 4 electrons in the second shell.

Question 2

Most candidates were able to extract the information from the table in **(a)(i)** and **(a)(ii)**. Fewer were able to calculate the mass of sulfur dioxide in **(a)(iii)**. The sources and adverse effects of oxides of nitrogen dioxide in **(b)** were not well known. In **(b)(iii)**, some candidates were able to complete the equation correctly. Fewer were able to identify Brownian motion in **(c)**.

(a) (i) Most candidates were able to extract the information from the table. The commonest incorrect answer was sulfur dioxide.

(ii) Most candidates selected the correct answer 'carbon monoxide' from the table. Incorrect answers included sulfur dioxide or carbon dioxide.

(iii) Some candidates were able to use simple proportion to obtain the correct answer. Others needed more practice at this. The commonest errors were 0.25 (obtained by dividing 250 by 1000) or writing seemingly random numbers without showing any working.

(b) (i) The sources of oxides of nitrogen dioxide in the air was not well known. Candidates generally gave imprecise answers such as 'factories' or 'burning fossil fuels'.

(ii) The best answers mentioned irritation of the lungs. Most candidates gave imprecise answers such as 'harmful' or vague statements about the lungs.

(iii) A majority of the candidates balanced NO_2 correctly. Fewer wrote N_2 for nitrogen, the commonest errors being '2N'.

(c) The commonest errors were to suggest 'random movement', 'free movement' or 'diffusion'.

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Question 3

Some candidates performed well in **(a)** and **(b)**, giving answers which highlighted exactly why the substances were chosen either for the core of an overhead electricity cable or for the tip of a drill. Others tried to write about all the properties in the table in both **(a)** and **(b)**; a considerable number of candidates ended up by contradicting themselves. Many did not write with sufficient precision.

(a) A minority of the candidates identified **C** as being the best substance to be used for the core of an electricity cable. Some candidates wrote too much and included all the properties in the table. These candidates often wrote contradictory statements. Some did not write with precision and did not make the distinction between the very good strength of **C** and the strength of **B**. The commonest incorrect answers were to select **A** or **B**.

(b) A minority of the candidates identified **B** as being the best substance to be used for the tip of a drill. Some did not write with precision and did not make the distinction between the very hard of **B** and the hard of either **A** or **C**. The commonest incorrect answer was to select **A**.

Question 4

A majority of the candidates performed well in **(a)(iii)** (relative molecular mass calculation) and **(c)(ii)** (energy level diagram). Most needed more practice in interpreting organic structures (**(a)**) in completing standard word equations (**(b)(i)**) and in writing definitions of common chemical terms such as thermal decomposition (**(c)(i)**).

(a) (i) A minority of the candidates recognised the alcohol functional group. Others selected the carboxylic acid functional group or the C=O group within the COOH group. Some candidates drew a single circle around the C=O group as well as the O-H group.

(ii) A minority of the candidates were able to deduce the correct molecular formula for tartaric acid. The commonest error was to miscount the number of oxygen atoms, e.g. $C_4H_{16}O_5$ or $4_7H_6O_8$. Some candidates wrote the formula as 6H 6C 4C, which was not accepted.

(iii) A majority of the candidates were able to deduce the correct relative molecular mass of tartaric acid. Credit was given for those candidates who wrote the incorrect molecular formula in **(a)(ii)** but did the correct calculation using this formula. Some candidates did not use the correct atomic masses or made multiplication errors.

(b) (i) Few candidates gave calcium nitrate and water as the correct products. Others seemed to guess the products and it was not uncommon to see atoms which were not present in the reactants. The commonest example of this was 'sulfur dioxide'. Other errors included the inclusion of calcium, oxygen or hydroxide. The nitrate was sometimes incorrectly expressed as 'nitric hydroxide' or 'nitrogen acid'.

(ii) Some candidates realised that an alkaline pH is above pH 7. A minority of the candidates identified a diatomic molecule. The commonest incorrect answer was **B** (diamond). Other candidates suggested **C** (lithium chloride).

(iii) Many candidates did not appear to understand the question and wrote vague statements about colour changes. The best answers mentioned universal indicator or related the colour change to the pH. None of the candidates wrote about comparing the colour with a pH colour chart.

(iv) The best answers suggested that calcium hydroxide neutralises acidic soils. Most candidates wrote vague statements such as 'increases the chance of growing' or 'because the crops need nutrients like calcium'.

(c) (i) Some candidates gave good answers which included the idea of breaking down a compound and using heat to do this. Others mentioned heating but wrote 'decomposition' (which is in the stem of the question); these responses did not state its meaning. Errors included statements such as 'the temperature changes in a reaction' or 'cold temperatures are needed'.

(ii) A majority of the candidates wrote the words in the correct places on the energy level diagram. Some wrote 'reactants' in the middle of the arrow.

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(iii) A minority of the candidates gave a good explanation in terms of the reactants having more energy than the products. Others did not refer to the instruction to use the information from the diagram and just defined an endothermic reaction.

Question 5

The answers to most parts of this question showed that many candidates needed more practice in revising organic chemistry. A minority of the candidates drew the correct structure of ethene in **(a)**. In **(b)**, few knew the test for the C=C bond in alkenes using aqueous bromine. In **(c)**, a minority described the reaction of ethene with steam correctly. A majority of the candidates balanced the equation in **(d)** correctly and gave a correct use for nylon in **(e)(ii)**. Fewer were able to describe a pollution problem caused by non-biodegradable plastics with any degree of precision in **(e)(iii)**.

(a) A minority of the candidates were able to draw the structure of ethene. Most drew either incomplete structures containing one carbon atom or a saturated hydrocarbon.

(b) A minority of the candidates gave the correct colour change when ethene reacts with aqueous bromine. A wide variety of incorrect colours was seen. Incorrect colours suggested for aqueous bromine included green and pink. Incorrect colours suggested for the product(s) of the reaction included green, brown and blue.

(c) (i) Many candidates misinterpreted the stem of the question and gave names of processes such as evaporation or fermentation instead of the name of a compound. Those who did suggest names gave the names of the reactants rather than the name of the product. A significant proportion of the candidates did not respond to this question.

(ii) Few candidates identified the type of reaction when ethene reacts with steam. Polymerisation was the commonest incorrect answer.

(d) The majority of candidates were able to balance the equation. Incorrect answers included CH_4 and O_2 even though there was no oxygen in the reactants.

(e) (i) Some candidates recognised that monomers are small molecules, which combine to form polymers. Others wrote general answers such as ‘atoms’ or ‘particles’.

(ii) Some candidates stated a correct use for nylon. Others wrote vague answers such as ‘plastic fabrication’ or ‘plastic cover’.

(iii) Some candidates described a pollution problem caused by plastics. Most wrote statements were not precise enough to gain credit. Examples include ‘damages life’, ‘kills fishes’ or ‘take a long time to disappear’.

Question 6

In **(a)**, the majority of candidates gained credit for the diagram only. In **(b)**, many candidates muddled the term *arrangement* with the term *separation*. In **(c)**, the majority of candidates stated one of the physical properties of lead. In **(d)**, many did not refer to the lead oxide or tried to answer the question in terms of electron transfer.

(a) Some candidates identified one of the electrode products. Many gained credit for their diagram; others did not label their diagrams fully as requested. It is important that a power pack, if drawn as a rectangle, is labelled as it could be another piece of equipment. Some candidates did not show the surface of the electrolyte so that the electrodes were in the air. The labelling of the positive and negative electrodes (anode and cathode) was often not accurate enough. Candidates should be advised to draw a clear line linking the word to the body of the electrode. Other candidates put the labels next to the connecting wires rather than the electrodes; this was not credited.

(b) A majority of the candidates did not recognise the term *arrangement* in reference to particles. Many muddled arrangement with separation or wrote answers related to movement, e.g. ‘anticlockwise’. The best answers referred to random arrangement.

(c) The majority of candidates stated one of the physical properties of lead.

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(d) Some candidates overcomplicated their answers by writing about electrons. In order to gain credit via this route, responses would have to state that the lead in the lead oxide gains electrons. Candidates did not give the simplest answer relating to lead oxide losing oxygen. Others wrote vague statements about the products, which mimicked the equation given such as ‘it gets divided into 3Pb and 4CO’.

Question 7

Parts **(a)** and **(b)(i)** of this question about rates of reaction were generally well answered by the candidates. The explanation as to why no more hydrogen is produced in **(b)(ii)** was often vague. A minority of the candidates knew the test and a use for hydrogen in **(c)**.

(a) Some candidates identified particular transition elements as catalysts. Others gave the names of other metals or non-metals.

(b) (i) A majority of the candidates were able to deduce the correct volume of hydrogen. The commonest error was to suggest $65\,cm^3$ by misreading the $80\,cm^3$ on the graph as $70\,cm^3$.

(ii) Some candidates realised that the reaction had finished. Others wrote imprecise answers such as ‘it doesn’t have any more volume’ or ‘it reached its limit’.

(iii) Some candidates drew the line correctly. Others either drew the final volume levelling out below $96\,cm^3$ of hydrogen or drew the line so that the initial gradient was the same as that for the uncatalysed reaction. A significant proportion of the candidates did not respond to this question.

(iv) Some candidates realised that decreasing the concentration, decreases the rate of reaction. The commonest errors included reference to time taken for the reaction to be completed rather than referring to rate or reference to change in volume of hydrogen. Others realised that using large pieces of zinc decreases the rate of reaction. The commonest errors were reference to time taken for the reaction to be completed or reference to change in volume of hydrogen.

(c) (i) Few candidates knew the test for hydrogen. The answers were generally not precise enough, e.g. ‘flammability’, or ‘light the gas’. Other candidates muddled the test for hydrogen with the flame test for ions. A significant proportion of the candidates did not respond to this question.

(ii) A minority of the candidates gave a suitable use of hydrogen. Some gave vague answers such as ‘transport’ rather than ‘fuel’; others suggested ‘making acids’.

Question 8

A majority of the candidates gave good answers to **(a)**, **(b)** and **(d)(i)**. Others made a considerable number of errors or omissions when explaining how to prepare crystals of pure, dry copper(II) sulfate in **(c)(i)**. The colour change on adding water to anhydrous copper(II) sulfate in **(d)(ii)** was not well known.

(a) A majority of the candidates identified at least one correct statement about transition elements. The commonest error was to tick the fifth box, transition elements are found between Group IV and V.

(b) A majority of the candidates gave the correct order of reactivity. The commonest errors were to reverse either manganese and cobalt or manganese and magnesium.

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(c) (i) Some candidates mentioned filtering off the excess solid or heating to the point of crystallisation or drying with filter paper; most only mentioned one of these points. Many did not write with sufficient precision. Most candidates wrote vague statements such as 'heat until all the liquid goes away' or 'heat it and let it dry'. Others contradicted themselves or wrote their answers in a confusing sequence. The idea of washing the crystals with cold water or organic solvent was not well known. Some candidates suggested heating in an oven, which would dehydrate the crystals unless a low temperature had been specified. A significant proportion of the candidates did not respond to this question.

(ii) Few candidates realised that copper(II) sulfate is a salt. The commonest incorrect answer was polymer.

(d) (i) A majority of the candidates drew the reversible reaction sign correctly. Others drew a single forward arrow →.

(ii) A minority of the candidates gave the correct colour change when water is added to anhydrous copper(II) sulfate. Many candidates appeared to muddle the colour changes with those of anhydrous cobalt(II) chloride. Few candidates gave colours other than blue or red, although brown was also seen as the colour for either the anhydrous or hydrated salt.

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Paper 0620/32
Theory (Core)

Key messages

- It is important that candidates read the stem of the question carefully in order to understand what is exactly being asked.
- Some candidates needed more practice in answering questions involving standard chemical reactions including organic chemistry.
- Many candidates needed further practice in writing definitions and answers with precision.
- Interpretation of data from tables and graphs was generally well done, as were simple calculations.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Many candidates answered every part of each question, although others did not respond to one or more questions. The standard of English was generally good; some candidates needed more practice in writing with precision.

Some candidates needed more practice in reading and interpreting questions. In some questions, the rubric was misinterpreted or ignored by a significant number of candidates. For example, in **Question 1(a)(iv)** many selected carbon despite the question asking for the name of a metal and in **Question 1(a)(v)** many candidates ignored the word ion and suggested chlorine. In **Question 2(c)(iii)**, many candidates did not refer to the diagram. In **Question 6(a)**, most candidates gave specific names of the products of electrolysis rather than observations. Candidates should be encouraged to revise the meaning of specific command words. In **Question 6(c)**, many candidates wrote about chemical changes rather than physical changes. In **Question 7(b)(iv)**, most candidates referred to time rather than rate. In **Question 8(b)**, many candidates did not follow the instruction to tick two boxes.

Many candidates needed practice in revising standard chemical reactions such as the reaction of acids with bases (**Question 4(b)**) and metals with acids (**Question 8(a)(i)**). Others needed more practice in selecting relevant chemical tests, e.g. for unsaturation (**Question 5(e)**) and for water (**Question 8(e)(ii)**). Many candidates needed further revision of organic structures and reactions (**Questions 5(a), 5(e) and 5(f)**).

Some candidates had learnt chemical definitions well; others needed more practice in memorising these. For example, in **Question 1(b)** (definition of the term *element*) many omitted essential details or wrote about molecules. In **Question 5(d)** (definition of the term *hydrocarbon*), many omitted essential words such as ‘only’ or ‘compounds’. Many candidates needed further practice in writing specific answers rather than providing vague or unqualified statements. For example, in **Questions 3(a)** and **3(b)** (relating properties to uses), many candidates did not discriminate sufficiently between the various possibilities given in the table. In **Question 8(d)**, many omitted essential details and wrote their answers down in a disordered fashion.

Many candidates were able to extract information from graphs as well as from tables. Many candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion; others needed to revise these areas.

Questions involving atomic structure were generally tackled well by many candidates, as was the completion of symbol equations.

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Comments on specific questions

Question 1

This was one of the better answered questions on the paper. Most candidates identified at least two of the elements correctly in **(a)**. Many performed well in **(b)(ii)** and **(c)**. Fewer candidates gave a convincing definition of the term *element* in **(b)(i)**.

(a) (i) Many candidates identified argon as the inert gas. The commonest error was to suggest oxygen. The incorrect responses iodine or aluminium were occasionally given.

(ii) A minority of the candidates identified calcium. The commonest incorrect answer was chlorine. The incorrect responses carbon or oxygen were also frequently seen.

(iii) Many candidates realised that potassium forms an ion by loss of an electron. The commonest incorrect answers were the halogens (usually bromine or fluorine), which form ions by gaining an electron.

(iv) Few candidates identified the metal used as an inert electrode. The commonest incorrect answer was iron. Some candidates did not read the question carefully enough and chose potassium (a very reactive metal) or the non-metals iodine or carbon.

(v) A minority of the candidates recognised the test for iron(II) ions. The commonest incorrect answer was chlorine. Candidates chose this because it is green in colour but ignored the fact that chlorine is not ionic. Other common errors were to suggest either zinc or aluminium.

(b) (i) Few candidates gained credit for a suitable definition of an element. Many wrote vague statements such as ‘a group of atoms bonded together’ or ‘a substance having only one atom’. The best answers referred to there being ‘only one kind of atom present in the substance’ or that an element is ‘a substance which cannot be broken down further chemically’. In the latter definition, many candidates omitted ‘broken down chemically’, which was essential. Many candidates referred to molecules rather than atoms, forgetting that molecules can contain different kinds of atoms.

(ii) Many candidates deduced the correct number of protons and neutrons. The commonest incorrect answers for the number of protons were 35 (mass number) or 18 (number of neutrons). The commonest incorrect answers for the number of neutrons were 35 (mass number) or 17 (number of protons).

(c) Most candidates gave the correct electronic structure of chlorine. The commonest errors were eight electrons in the outer shell, two electrons in the outer shell or four electrons in the second shell.

Question 2

Most candidates were able to extract the information from the table in **(a)(i)** and **(a)(ii)**. Fewer were able to calculate the mass of carbon monoxide in **(a)(iii)**. A small minority of the candidates knew the sources, effects and uses of sulfur dioxide in **(b)**. In **(c)(i)** and **(c)(ii)**, many candidates were able to complete the equation and the energy level diagram correctly. Fewer were able to explain why the reaction is exothermic in **(c)(iii)**. Parts **(d)** (catalysis), **(e)** (pH of acid) and **(f)** (Brownian motion) were well answered by a majority of the candidates.

(a) (i) Most candidates were able to extract the information from the table. The commonest incorrect answer was ozone.

(ii) Nearly all the candidates selected the correct answer ‘particulates’ from the table. The commonest incorrect answer was carbon monoxide.

(iii) Some candidates were able to use simple proportion to obtain the correct answer. Others needed more practice at this. The commonest errors were 0.0125 (obtained by dividing 2.5 by 200), 0.2 (obtained by dividing 200 by 1000) or 12.5 ($2.5 \times 1000 \div 200$).

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(b) (i) Very few candidates were able to suggest a suitable source of sulfur dioxide. Many just referred to incomplete combustion or car engines. Others wrote vague statements about 'waste from factories', 'from crude oil' or 'from distillation'.

(ii) The best answers referred to erosion of limestone or corrosion of metals. Many candidates wrote about 'discolouring of paintwork' or extreme suggestions such as 'making the buildings fall down' or 'destroying buildings'.

(iii) This was the least well answered part of **Question 2**. Many candidates suggested 'making sulfuric acid', which was not accepted because sulfur dioxide is formed 'in situ' in the Contact process. Other incorrect suggestions included 'cleaning materials' or 'chemical tests'. These answers were too vague. A significant number of candidates did not respond to this question.

(c) (i) Most candidates balanced the equation successfully. The commonest errors were $3SO_2$ or $4SO_2$. A few candidates wrote symbols such as C or O on the dotted line instead of numbers.

(ii) Most candidates wrote either the words or the symbols in the correct places on the energy level diagram. Some wrote 'products' on the left and 'reactants' on the right. Another common error was to write products in the middle of the arrow.

(iii) Some candidates gave a good explanation in terms of the reactants having more energy than the products. Others did not refer to the instruction to use the information from the diagram and just defined an exothermic reaction.

(d) Most candidates gave a good explanation of the term *catalyst*. The commonest error was to write vague statements such as 'a substance which changes the rate of reaction'. A few candidates suggested that a catalyst 'neutralises a reaction'.

(e) Many candidates selected the correct pH value. The commonest error was to suggest pH 7. The second commonest error was to suggest pH 9.

(f) Many candidates selected the correct statement. Others chose the first statement (particles move from higher concentration) or the third statement (Brownian motion is example of diffusion) in about equal number.

Question 3

Some candidates performed well in both **(a)** and **(b)** giving answers which highlighted exactly why the substances were chosen for either an electricity cable or cutlery. Others tried to write about all the properties in the table and a considerable number of candidates ended up contradicting themselves. Many candidates did not write with sufficient precision.

(a) Many candidates identified **E** as being the best substance to be used for electricity cables. Some candidates wrote too much and included all the properties in the table. These candidates often wrote contradictory statements. Many candidates did not write with precision and did not make the distinction between the very good electrical conductivity and very good ductility of **H** and the good electrical conductivity and ductility of **E** and **F**.

(b) Few candidates identified **E** as being the best substance to be used for cutlery. Many candidates wrote too much and included all the properties in the table. Many did not make the distinction between the very good resistance to corrosion and the very good strength of **E** and the good resistance to corrosion and strength of **G** and **H**.

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Question 4

This was the best answered question on the paper with many candidates performed well in **(a)(ii)** (formula of organic compound), **(a)(iii)** (calculation of relative molecular mass), **(c)(i)** (naming calcium sulfate) and **(c)(ii)** (properties of ammonia). Fewer candidates were able to identify the carboxylic acid functional group in **(a)(i)** or to complete the equation in **(b)**.

(a) (i) Some candidates recognised the carboxylic acid functional group. Others selected the alcohol functional group or the C=O group within the COOH group. A minority of candidates selected the C=C double bond. A significant number of circled extra atoms. For example, many circled the C=C as well as the COOH group.

(ii) Many candidates were able to deduce the correct molecular formula for compound **J**. The commonest error was to miscount the number of carbon atoms, $C_8H_{10}O_3$ or $C_7H_{10}O_3$ being frequently seen. Another common error was to suggest that there are four H atoms rather than three. A minority of the candidates wrote the formula as $C_6 + H_{10} + O_3$, which was not accepted.

(iii) Many candidates were able to deduce the correct relative molecular mass of compound **J**. Credit was given for those candidates who wrote the incorrect molecular formula in **(a)(ii)**, but did the correct calculation using this formula. A considerable number of candidates did not use the correct atomic masses or made multiplication errors. This was usually observed with candidates who made counting errors in **(a)(ii)**. The commonest examples of this were $8 \times 2 = 16$ or $8 \times 16 = 96$. It was not uncommon to see eight oxygen atoms used even when **(a)(ii)** was correct.

(b) Some candidates gave calcium chloride and water as the correct products. Others seemed to guess the products and it was not uncommon to see atoms which were not present in the reactants. The commonest example of this was carbon dioxide. Common errors included the inclusion of chlorine, calcium hydroxide, calcium and hydrogen chloride.

(c) (i) A majority of the candidates named calcium sulfate correctly. A few muddled the sulfate with the sulfide or sulfite but a greater number of candidates did not recognise the group of sulfur and oxygen atoms and wrote answers such as calcium sulfur oxide or calcium sodium hydroxide. The latter was likely to have been through lack of learning of symbols (S = sodium rather than Na).

(ii) The commonest errors were to suggest solid or liquid for the state of ammonia or to suggest that the litmus paper turned pink, despite red being the initial colour stated in the question.

Question 5

The answers to most parts of this question showed that many candidates needed more practice in revising organic chemistry. Part **(b)** (balancing an equation) was generally well answered by a majority of the candidates. Most needed more practice in describing hydrocarbons (**(d)**), in recollecting the bromine water test (**(e)**) and in cracking (**(f)**).

(a) Some candidates drew the correct structure of ethane. Common errors included omission of two hydrogen atoms (usually seen as an ethene structure with the double bond converted to a single bond), ethene rather than ethane, ethanol or pentavalent carbon atoms.

(b) A majority of the candidates balanced the equation correctly. The commonest error was to suggest $2CO_2$. The water was sometimes unbalanced; $3H_2O$ or $6H_2O$ were errors which were frequently seen.

(c) (i) Very few candidates could state a process which puts methane into the atmosphere. The commonest errors were to suggest 'combustion', 'acid rain' or 'fossil fuels'. A significant number of candidates misread the question and gave a use rather than a process.

(ii) Few candidates could state a major use of methane. The commonest errors were to suggest 'greenhouse effect', 'petrol for a car' or 'fertilisers'.

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(d) The commonest error was to omit the important word 'only' (or no other elements). Many candidates did not mention that hydrocarbons are compounds. This is an important word to include since 'it contains hydrogen and carbon' could refer to a mixture of hydrogen and carbon. In fact, many candidates did refer to a hydrocarbon as being a mixture. This is a common error.

(e) Few candidates knew the bromine water test for unsaturation. A wide variety of incorrect test reagents were seen including sulfur dioxide, water and carbon dioxide. A significant number of candidates did not respond to this question.

(f) (i) Some candidates remembered that hydrogen is an element, which is the product of cracking. A majority of the candidates appeared to guess the answer. Many did not heed the term *element* in the question and gave the names of compounds such as propane, carbon dioxide or methane. A significant number of candidates gave 'bromine'. A significant number also did not respond to this question.

(ii) Some candidates recognised that a high temperature is required for cracking. Others just wrote 'temperature', which is too vague. Other errors frequently seen included 'pressure' or 'carbon'. A significant number of candidates did not respond to this question.

Question 6

This was one of the least well answered questions on the paper. In **(a)**, hardly any candidates gave observations. Most gave the names of the elements produced. In **(b)**, many candidates muddled the term *arrangement* with the term *separation*. In **(c)**, many candidates confused the physical properties of sodium and iron. In **(d)**, many candidates did not refer to the carbon monoxide or tried to answer the question in terms of electron transfer.

(a) Nearly all the candidates gained credit for their labelled diagram. In the first section of the question, nearly all gave the names of the elements produced rather than observations. Many candidates did not label their diagrams fully as requested. It is important that a power pack, if drawn as a rectangle, is labelled as it could be another piece of equipment. Some candidates labelled the rectangle with a 'V'. Many candidates did not show the surface of the electrolyte so that the electrodes were in the air. The labelling of the positive and negative electrodes (anode and cathode) was often not accurate enough. Candidates should be advised to draw a clear line linking the word to the body of the electrode. Many candidates positioned the labels next to the connecting wires rather than the electrodes.

(b) Many candidates did not recognise the term *arrangement* in reference to particles. Many muddled *arrangement* with *separation* and so wrote the same answer twice, sometimes in a slightly different way. Others suggested that the particles were 'a little way apart'.

(c) Some candidates selected two of the physical properties which differentiate Group I metals from transition elements. Others either gave chemical properties or chose physical properties, which were not relevant such as a suggested comparison of electrical conductivity or lustre. A considerable number of candidates muddled the properties of sodium and iron. For example, some suggested that sodium had a high melting point and was harder than iron.

(d) Some candidates overcomplicated their answers by writing about electrons. In order to get credit for this route, responses would have to state that the carbon in the carbon monoxide loses electrons. The best answers stated simply that 'carbon monoxide gains oxygen'. Many candidates focused on the iron oxide losing oxygen instead of the carbon monoxide gaining oxygen. Others wrote vague statements about the products such as 'the carbon dioxide has more oxygen than before' or that 'there are two O's in CO_2 and 1 in CO'.

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Question 7

Part **(b)** of this question about rates of reaction was generally well answered by candidates, apart from **(b)(i)** where any candidates confused volume of oxygen with rate of reaction. Others drew incorrect diagrams (sometimes unlabelled) for **(a)** or did not respond to this part. In **(c)**, only a minority of the candidates identified the element which was most likely to act as a catalyst. In **(d)**, the test for oxygen was fairly well known.

(a) Some candidates drew clearly labelled diagrams using a ruler. Others labelled parts of their diagram as a syringe even though it bore no resemblance to a gas syringe. Many candidates needed to improve their drawing of pieces of chemical apparatus. Those who drew a presumed measuring cylinder without graduations, or a label did not gain credit because the drawing could be confused with a gas jar. A significant number of candidates drew apparatus which included a measuring cylinder as well as a syringe, with the measuring cylinder often connected to the side or end of the syringe by a tube. A significant number of candidates did not respond to this question.

(b)(i) A minority of the candidates realised that the rate was related to the change in gradient of the graph with time. A majority of the candidates incorrectly equated rate with the increase in volume and therefore suggested that the rate increased until it stopped. A few candidates recognised that the rate decreased but started their answer with 'the rate increases at first' before mentioning that it decreases.

(ii) Most candidates deduced the correct time to collect 60 cm^3 of oxygen. The commonest error was 10.1 seconds due to thinking that each small square on the graph was 0.1 second.

(iii) Many candidates gained credit for drawing the line correctly. Others drew the line so that the final volume of oxygen was greater than 96 cm^3. A minority of candidates started their line at, for example, 5 seconds rather than at (0,0). A significant number did not respond to this question.

(iv) Most candidates realised that the rate increased. The commonest error was to write about the time taken rather than the rate.

(c) A minority of the candidates realised that transition elements such as nickel were good catalysts. The commonest error was to choose magnesium. Other incorrect choices frequently seen were sodium or sulfur.

(d) Many candidates know the correct test and result for oxygen. Others gave the incorrect test and consequently an incorrect result. Common errors included 'lighted splint pops', using sodium hydroxide or barium hydroxide as a test reagent, 'things burn in the presence of oxygen' or 'flame test'.

Question 8

This question was well answered by some candidates. Parts **(c)** and **(e)(i)** were generally well answered by candidates. Others made errors identifying the products of the reaction between iron and hydrochloric acid in **(a)** and in explaining in detail how to prepare crystals of pure, dry cobalt chloride in **(d)**. The colour change in **(b)(i)** was not well known.

(a) Some candidates gave the correct products for the reaction of iron with hydrochloric acid. Others needed more practice in revising basic chemical reactions. Common errors included iron hydroxide or iron oxide instead of iron chloride and water or oxygen instead of hydrogen. Many candidates did not write precisely and wrote iron salt instead of iron chloride.

(b) The commonest error was to tick the fourth box down (iron is oxidised by carbon). Many candidates also suggested that iron ore is bauxite. A significant number of candidates did not respond to the instruction to tick two boxes and only ticked a single box.

(c) A majority of the candidates gave the correct order of reactivity. The commonest error was to reverse iron and chromium.

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(d) The best responses mentioned filtering off the excess solid, heating to the point of crystallisation and drying with filter paper. Few candidates gave a fully complete answer and many did not write with sufficient precision. Most candidates wrote vague statements such as ‘heat to form the crystals’ or ‘evaporate the solution to get the crystals’. Others contradicted themselves or wrote their answers in a confusing sequence. Few candidates suggested washing the crystals with cold water or organic solvent. It was common to see references to the initial filtration and drying with filter paper. A significant number of candidates suggested heating in an oven, which would dehydrate the crystals unless a low temperature had been specified. A significant number of candidates did not respond to this question.

(e) (i) Most candidates identified the symbol for a reversible reaction. The commonest errors were to suggest ‘equals’, ‘interchanges’ or ‘equation is balanced’.

(ii) A minority of the candidates gave the correct colour change when water is added to anhydrous cobalt(II) chloride. Many candidates appeared to muddle the colour changes with those of anhydrous copper(II) sulfate. Few candidates gave colours other than blue, pink or white.

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Paper 0620/33
Theory (Core)

Key messages

- It is important that candidates read the stem of the question carefully in order to understand what is exactly being asked and not to repeat what is in the stem of the question.
- Some candidates needed more practice in answering questions with greater precision.
- Many candidates needed further practice in drawing organic formulae and in revising organic reactions.
- Interpretation of data from tables and graphs was generally well done, as were simple calculations.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Many candidates answered every part of each question, although others did not respond to one or more questions. The standard of English was generally good; some candidates needed more practice in writing with precision.

Some candidates needed more practice in reading and interpreting questions. In some questions, the candidates answered by repeating information that was already in the question. For example, in **Question 4(c)(ii)** many included the word 'decomposition' in their answer rather than describing its meaning. In **Question 5(e)**, many candidates wrote 'ethanol' or 'alcohol' as one of the reactants even though it was the stated product. In **Question 7(a)(ii)**, some candidates repeated the question by stating 'the mixture decreases in mass'. In **Question 8(e)(ii)**, many candidates suggested that heat is needed to turn yellow nickel(II) sulfate into green nickel(II) sulfate despite the fact that the question stated that heat is needed for the opposite reaction.

Some candidates needed practice in revising standard chemical reactions and chemical terms such as *incomplete combustion* (**Question 2(b)(i)**) and *thermal decomposition* (**Question 4(d)**). Others needed more practice in writing about chemical tests, e.g. for aluminium ions (**Question 1(a)(v)**), for carbon dioxide (**Question 2(e)(i)**) and for sulfur dioxide (**Question 8(d)**).

Some candidates needed further practice in writing precise answers rather than providing vague or unqualified statements. For example, in **Question 3(c)(ii)** (source of methane in the air), many just wrote 'fuels' or 'farms'. In **Question 3(b)** (properties of sodium chloride), many candidates only wrote about electrical conduction in the molten state and did not refer to the solid state. In **Question 4(d)** (use of slaked lime), many just referred to soils or neutralisation without giving a context. In **Question 6(a)** (electrolysis), many gave inaccurate labels for in their diagrams without using label lines. In **Question 6(d)** (reduction of carbon dioxide), many candidates did not refer to the correct species. In **Question 8(c)** (making crystals of magnesium chloride), many omitted essential details and wrote their answers in a disordered fashion.

Many candidates needed more revision of organic chemistry, particularly in writing and interpreting organic structures (**Questions 4(a)(i)** and **5(a)**). Many did not know the conditions for fermentation (**Question 5(d)**) and few knew the hydration of ethene to produce ethanol (**Question 5(e)**).

Many candidates were able to extract information from graphs as well as from tables. Many were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion; others need to revise these areas.

Questions involving atomic structure were generally tackled well by candidates, as was the completion of symbol equations.

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Comments on specific questions

Question 1

This was one of the better answered questions on the paper. Many candidates identified at least two of the elements correctly in **(a)**. Many performed well in **(b)(i)**, **(b)(ii)** and **(c)**.

(a) (i) A minority of the candidates identified hydrogen as a gaseous fuel. The commonest error was to suggest nitrogen. Argon or oxygen were also occasionally seen.

(ii) The majority of candidates identified chlorine. The commonest incorrect answers were argon fluorine or calcium.

(iii) Many candidates realised that aluminium forms an ion with a charge of 3+. The commonest incorrect answer was nitrogen which forms a 3– ion. Other common incorrect answers were argon or calcium.

(iv) Few candidates identified iodine as being a grey-black solid. The commonest incorrect answers were platinum, aluminium or potassium.

(v) A minority of the candidates recognised the test for aluminium ions. The commonest incorrect answers were calcium or one of the halogens, often chlorine.

(b) (i) Many candidates identified the correct statement about isotopes. The commonest error was to select the first statement (same number of neutrons and different number of protons). Others selected the third incorrect statement (same number of protons and different number of electrons).

(ii) Many candidates deduced the correct number of protons and neutrons. The commonest incorrect answer for the number of protons was 33 (mass number). The commonest incorrect answer for the number of neutrons was 16 (number of protons).

(c) Most candidates correctly completed the electronic structure of sulfur. The commonest errors were eight electrons in the outer shell, ten electrons in the outer shell or four electrons in the second shell.

Question 2

This was one of the better answered questions on the paper. Most candidates were able to extract the information from the table in **(a)(i)**. Fewer were able to calculate the mass of oxides of nitrogen in **(a)(ii)**. A minority of the candidates were able to define the term *incomplete combustion* in **(b)(i)** and state the effect of carbon monoxide on health in **(b)(ii)**. In **(c)(ii)**, few candidates gave a suitable source of methane in the air. In **(d)(i)**, most candidates were able to complete the equation. Fewer were able to complete the energy level diagram correctly or to explain why the reaction is exothermic in **(d)(ii)** and **(d)(iii)**. The test for carbon dioxide in **(e)(i)** was relatively well known but fewer candidates realised that carbon dioxide is an acidic oxide in **(e)(ii)**.

(a) (i) Most candidates were able to extract the information from the table. The commonest incorrect answer was sulfur dioxide.

(ii) Some candidates were able to use simple proportion to obtain the correct answer. Others needed more practice at this. The commonest error was 424 (obtained by multiplying 166 by 1000 then dividing 250).

(b) (i) Some candidates recognised that oxygen/air is limiting in incomplete combustion. Others did not write their answer precisely enough, e.g. 'combustion in the absence of oxygen' or 'not burned correctly'. Many candidates wrote answers unrelated to combustion, e.g. 'incomplete breakdown of fossil fuels', 'producing heat' or 'substances do not combine with each other'.

(ii) The best answers referred to carbon monoxide acting as a poison or being toxic. Many candidates wrote vague answers such as 'damages lungs' or 'breathing difficulties' or incorrect answers such as 'causes cancer'.

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(c) (i) Most candidates realised that catalysts increase the rate of a chemical reaction. Some candidates wrote vague statements such as 'makes a reaction happen' or made incorrect references to the time taken to complete the reaction.

(ii) A minority of the candidates gave a suitable source of methane in the air. The best answers related to waste gases for during digestion in cows or sheep. The commonest errors were 'cars' or 'fuels'. A considerable number of candidates gave the names of gases such as carbon dioxide or ozone or other elements such as sulfur, which contain neither carbon nor hydrogen.

(d) (i) Most candidates balanced the equation correctly. The commonest errors were to suggest 4CO or 6CO instead of 2CO and $3CO_2$ or $4CO_2$ instead of $2CO_2$.

(ii) Some candidates wrote either the words or the symbols in the correct places on the energy level diagram. Others wrote 'products' on the left and 'reactants' on the right. Another common error was to write products in the middle of the arrow. A considerable number of candidates did not respond to this question.

(iii) Some candidates gave a good explanation in terms of the reactants having more energy than the products. Others did not refer to the instruction to use the information from the diagram and just defined an exothermic reaction.

(e) (i) Some candidates knew the test for carbon dioxide. Some suggested incorrect test reagents such as 'lime' or 'limestone'. Many muddled the test with those for hydrogen or oxygen by suggesting the use of lighted or glowing splints. Some suggested using litmus; fewer suggested using sodium hydroxide or ammonia.

(ii) A minority of the candidates recognised that carbon dioxide is an acidic oxide and so has a pH value below pH 7. The commonest error was to suggest pH 7. The second most common incorrect answer was pH 8.

Question 3

Some candidates performed well in both **(a)** and **(b)**, giving answers which highlighted exactly why the substances were chosen based on their properties. Others tried to write about all the properties in the table and a considerable number of candidates ended up by contradicting themselves. Many candidates did not write with sufficient precision.

(a) Some candidates identified **A** as being sulfur with two relevant reasons. A few candidates gave only one reason. Candidates should recognise that if three marks are available, three points are required, in this case: the name of the element and two reasons. Other candidates wrote too much and included all the properties in the table. These candidates often wrote contradictory statements. The commonest incorrect answer was **C**. Many candidates suggested that sulfur has a high melting point and is soluble in water.

(b) Some candidates identified **D** as being sodium chloride with two relevant reasons. Others wrote too much and included all the properties in the table. These candidates often wrote contradictory statements. The commonest incorrect answer was **C**. Many candidates only referred to one of the conductivity columns. Reference to the conductivity of both solid and molten sodium chloride is necessary in order to distinguish it from either a metallic or non-metallic element.

Question 4

In **(a)** many candidates gave the correct molecular formula for crotonic acid in **(a)(ii)**. Fewer were able to identify the C=C functional group in **(a)(i)**. In **(a)(iii)** many candidates calculated the relative molecular mass of crotonic acid correctly. Some were able to name the products in **(b)**. Others needed more practice in revising standard chemical reactions. A minority of the candidates gave the correct answers to **(c)(i)** (naming the compound in limestone) and **(d)** (use of slaked lime). A greater number of candidates were able to give a partial definition of thermal decomposition in **(c)(ii)**.

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(a) (i) A minority of the candidates recognised the functional group that makes crotonic acid unsaturated. Common errors included circling the CH_3, OH or C=O groups or including the hydrogen atoms. A significant number of candidates circled extra atoms. For example, many circled the COOH group as well as including the C=C group.

(ii) Many candidates were able to deduce the correct molecular formula for crotonic acid. The commonest error was to miscount the number of oxygen atoms, C_4H_6O or being frequently seen. Another common error was to write the formula as C_3H_5COOH or CH_3CH_2COOH. A minority of the candidates wrote the formula as $C_4 + H_6 + O_2$ or 4C,6H,2O neither of which were accepted.

(iii) Many candidates were able to deduce the correct relative molecular mass of crotonic acid. Credit was given for those candidates who wrote the incorrect molecular formula in **(a)(ii)** but did the correct calculation using this formula. Some candidates did not use the correct atomic masses or made multiplication errors. This was not confined to those candidates who made counting errors in **(a)(ii)**. The commonest example of this was for the oxygen where $8 \times 16 = 128$ was written even when **(a)(ii)** was correct.

(b) Some candidates gave calcium nitrate and water as the correct products. Others seemed to guess the products and it was not uncommon to see atoms which were not present in the reactants. The commonest example of this was sulfur dioxide. Common errors included the inclusion of calcium, calcium hydroxide, calcium nitrate oxide and limewater. Oxygen was frequently seen instead of water. Some candidates thought that a general name was required and wrote ‘calcium salt’. Others wrote formulae instead of words.

(c) (i) A minority of the candidates knew that limestone is largely calcium carbonate. The commonest errors were to suggest ‘calcium’, ‘calcium hydroxide’ or ‘limewater’.

(ii) Some candidates gave good answers that included the idea of breaking down a compound and using heat to do this. Others mentioned heating but wrote ‘decomposition’ (which is in the stem of the question) rather than explaining it. Common errors included statements such as ‘the temperature for a chemical reaction to take place’, ‘produces new substances’ or ‘self-combustion’.

(d) A minority of the candidates gave a suitable use for slaked lime. Many wrote answers which were too vague such as ‘farming’, ‘to make roads’ or ‘fertilisers’. Those candidates who wrote ‘to neutralise the soil’ did not gain credit because of the absence of the essential word ‘acidic’. Candidates should be advised to follow the syllabus statements precisely.

Question 5

This was the least well answered question on the paper. Some candidates were able to draw the structure of ethanol, in **(a)** and describe the motion and separation of the particles in **(b)**. Others needed more practice in drawing the structures of organic molecules. Some candidates recognised the products of the complete combustion of ethanol in **(c)**. Others included the products of incomplete combustion. Few candidates were able to describe the conditions for fermentation in **(d)(i)** or name the method used to separate ethanol from the fermentation mixture in **(d)(ii)**. In **(e)**, few recognised the reaction of ethene with steam to produce ethanol.

(a) Some candidates drew a fully displayed formula for ethanol. Others forgot to put a bond line in the O–H group. Common errors included divalent hydrogen atoms, e.g. C–H–O, ether-like structures or omission of the oxygen atom.

(b) Many candidates did not gain credit for separation because they suggested that the particles were ‘a little way apart’. Others confused separation with arrangement and wrote statements such as ‘they are not in fixed positions’.

(c) A minority of the candidates named both carbon dioxide and water. Most gave answers which included the products of incomplete combustion, e.g. ‘carbon dioxide and carbon’ or ‘water and carbon monoxide’. A wide range of other incorrect answers were seen including ‘hydrogen’, ‘ethene’, ‘alcohol’, ‘glucose’ and ‘oxygen’.

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(d) (i) Few candidates recognised the conditions used for fermentation. The commonest errors were to suggest 'high temperature' or 'high pressure'. Many candidates thought that oxygen is needed for fermentation. A significant number of candidates did not respond to this question.

(ii) Better responses identified the method of fractional distillation. A significant proportion just suggested 'distillation'. The commonest incorrect answers were 'filtration' or 'evaporation'. A significant number of candidates did not respond to this question.

(e) A minority of the candidates gave both ethene and steam (or water). Many suggested ethane or alcohol. A significant number of candidates suggested the combination of elements such as carbon, hydrogen or oxygen.

Question 6

This was one of the better answered questions on the paper. In **(a)**, most candidates gained credit for their diagram. Fewer correctly named both products at each electrode. Most candidates were successful in balancing the equation in **(b)**. In **(c)**, few candidates were able to explain how the equation shows that carbon dioxide is reduced to carbon monoxide.

(a) Many candidates gained credit for their labelled diagram. In the first section of the question, many reversed the electrode products, suggesting that hydrogen is formed at the anode and chlorine at the cathode. Incorrect electrode products included 'oxygen' and 'carbon dioxide'. It is important that a power pack, if drawn as a rectangle, is labelled as it could be another piece of equipment. Some candidates labelled the rectangle with a 'V'. Many candidates did not show the surface of the electrolyte so that the electrodes were in the air. The labelling of the positive and negative electrodes (anode and cathode) was often not accurate enough. Candidates should be advised to draw a clear line linking the word to the body of the electrode. Many candidates positioned their labels next to the connecting wires rather than the electrodes. Others ignored the method of collecting the gases and just showed the electrodes dipping into the electrolyte without the test-tubes needed to collect the gases. Many of those who did show the test-tubes drew them above the surface of the electrolyte.

(b) Most candidates balanced the equation successfully. The commonest errors were $3NaCl$ as the first product and 2H, H or H_2 as the second product. HCl or OH were also seen as the incorrect second product.

(c) Some candidates overcomplicated their answers by writing about electrons. In order to get credit for this route, responses would have to state that the carbon in the carbon dioxide gains electrons. The best answers stated simply that 'carbon dioxide loses oxygen'. Many candidates focused on the carbon gaining oxygen instead of the carbon dioxide losing oxygen. Others wrote vague statements about the products such as 'the carbon monoxide has more oxygen than before', 'there is one O in CO and 2 in CO_2', 'the number of atoms is reduced' or 'carbon dioxide reacts to form carbon monoxide'.

Question 7

Parts **(b)(ii)** (deducing volume of carbon dioxide from the graph) and **(b)(iv)** (effect of temperature and concentration on rate of reaction) were answered well by a majority of the candidates. Few candidates gave a convincing explanation of the advantage of using a gas syringe rather than measuring change in **(a)(i)**. Many candidates confused volume of oxygen with rate of reaction in **(b)(i)**. In **(b)(iii)**, some candidates drew a correct line with a steeper gradient, levelling off at $48\,cm^3$.

(a) (i) Few candidates gave a convincing explanation of the advantage of using a gas syringe rather than measuring change in mass. The best answers referred to the fact that measurement is easier using a gas syringe or of the idea of the difficulty in measuring small decreases in mass using the balance. Most candidates wrote vague answers such as 'not as accurate' without further qualification.

(ii) The best answers referred to the carbon dioxide or gas escaping from the flask. A majority of the candidates gave vague or incorrect answers such as 'the solution evaporates', 'the reactants are being used up' or repeated the stem of the question by stating that 'the mass decreases'.

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(b) (i) A minority of the candidates realised that the rate was related to the change in gradient of the graph with time. A majority of the candidates incorrectly equated rate with the increase in volume and therefore suggested that the rate increased until it stopped. A few candidates recognised that the rate decreased but started their answer with ‘the rate increases at first’ before mentioning that it decreases.

(ii) Nearly all the candidates deduced correctly the time taken to collect 36 cm^3 of carbon dioxide.

(iii) The best answers showed a line of steeper gradient, which clearly starts at (0,0) and levels off at 48 cm^3 and before 110 seconds. Many candidates drew lines with a shallower gradient which levelled off below 48 cm^3. Others drew a line with a steeper initial gradient that crossed the line already present and levelled off after 110 seconds. A significant number of candidates did not respond to this question.

(iv) Many candidates realised that increasing the temperature, increases the rate of reaction. The commonest errors included reference to time taken for the reaction to be completed rather than referring to rate or ‘no change in rate’. Many candidates also realised that decreasing the concentration of acid decreases the rate of reaction. The commonest error was reference to time taken for the reaction to be completed rather than referring to rate.

Question 8

Many candidates gave good answers to **(a)** (Group I and changes of state), **(b)** (reactivity of metals) and **(d)** (test for sulfur dioxide). In **(c)**, only a minority of the candidates were able to explain in detail how to prepare crystals of pure, dry magnesium chloride. In **(e)**, some candidates were able to deduce how to turn yellow nickel(II) sulfate into green nickel(II) sulfate. Others gave vague answers or repeated the word ‘heat’ in the stem of the question.

(a) (i) Many candidates identified two correct properties of sodium. The commonest error was to suggest that sodium has a high melting point. A few candidates suggested, incorrectly, that sodium forms coloured chlorides.

(ii) A majority of the candidates gave the correct changes of state. The commonest errors were to suggest evaporation or boiling in place of freezing or freezing instead of boiling. A small number of candidates suggested ‘sublimation’ in place of boiling.

(b) A majority of the candidates gave the correct order of reactivity. The commonest error was to reverse nickel and iron.

(c) The best responses mentioned filtering off the excess magnesium, heating to the point of crystallisation and drying with filter paper. Many candidates did not write with sufficient precision. Most candidates wrote vague statements such as ‘heat to form the crystals’ or ‘evaporate the solution to get the crystals’. Others contradicted themselves or wrote their answers in a confusing sequence. Few candidates suggested washing the crystals with cold water or organic solvent. Many referenced initial filtration and drying with filter paper. A significant number of candidates suggested heating in an oven, which would dehydrate the crystals unless a low temperature had been specified.

(d) Many candidates recognised the test for sulfur dioxide. More candidates gave the correct colour change than the correct test reagent. The commonest incorrect test reagent given was sulfate. A few suggested chloride. The commonest incorrect colour given was blue.

(e) (i) Some candidates repeated the word heat from the stem of the question. Others did not explain what they would do and referred to the reversible reaction. For example, statements such as ‘reverse the reaction’ or ‘do the opposite’ were too imprecise. A significant number of candidates suggested ‘cooling the yellow nickel sulfate’ instead of adding water.

(ii) Some candidates recognised from the formula that green nickel(II) sulfate is hydrated. Many others suggested either ‘oxidised’ or ‘anhydrous’.

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Paper 0620/41
Theory (Extended)

Key messages

- Recall of definitions is an area that needs to be developed especially regarding equilibrium and electrolysis.
- It was noted that candidates found describing the structure of metals and alloys particularly challenging with responses requiring more detail into the structure of an alloy.
- Some candidates confuse equilibrium and rate with regards to temperature and pressure; this was seen in **Question 3(e)(i)** where the candidates were told the equilibrium yield was good for a lower temperature and high pressure but then were asked why these conditions are not used.
- Some factual content, for example the percentage of oxygen in air in **Question 4(a)**, was not known by candidates. Factual recall is an essential skill for application of knowledge to questions.
- It is important for candidates to understand the nuances of climate change, in that carbon dioxide is not responsible for every atmospheric change. Carbon dioxide is responsible for global warming and subsequent consequences of this such as rising sea levels but does not cause damage to the ozone layer.
- It is apparent that many candidates were not as prepared for questions on organic chemistry as they were for questions on the rest of the syllabus. This was evident mainly in answers to **Questions 6(c)(ii)**, **7(a)(i)**, **(b)(i)**, **(b)(ii)** and **(c)(ii)** where only a minority of candidates could successfully answer the organic chemistry questions.

Comments on specific questions

Question 1

(a) (i) This question was answered well with the majority of candidates choosing either carbon or hydrogen. Occasionally candidates chose sulfur as the fuel.

(ii) A common error was to choose carbon as having a similar structure to diamond.

(ii) Few candidates recognised that aluminium oxide was an amphoteric oxide; common answers were either sulfur or iron.

(iv) This question was answered well with the majority of candidates recognising that iron was a transition element and as such has variable oxidation states. Occasionally candidates chose two elements, but the question required the choice of only one element.

(v) This question was not answered well, with many candidates not recalling that aluminium was extracted from bauxite. The most common answers were iron, showing some confusion with hematite or silicon.

(vi) This question was answered very well with the majority of candidates knowing that the electronic structure of sulfur was 2,6.

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(b) (i) Candidates found this question challenging with the majority not being able to describe the process of sacrificial protection as a method of preventing rusting. A few candidates knew that the iron had to be coated with a more reactive metal, with some candidates choosing copper, which would not be appropriate. Most candidates thought this question required the definition of a 'barrier method', which prevents oxygen and water from contacting the metal and did not go on to describe the process of sacrificial protection. A few candidates said that the more reactive metal would rust instead of the iron. Candidates should be mindful of the difference between corrosion and rusting, i.e. only iron can rust.

(ii) Most candidates were able to offer an alternative barrier method such as galvanising, oiling, greasing or painting.

Question 2

(a) Few candidates could recall that zinc sulfide ore was zinc blende; answers such as hematite and limestone were commonly seen. Many candidates did not attempt this question.

(b) (i) Candidates answered this question with variable success. Despite the formula for zinc oxide, ZnO, being given in the question many candidates used an incorrect formula for zinc oxide.

(ii) Candidates found this question quite challenging with few candidates recognising that the zinc oxide was being reduced. A few candidates confused the process with oxidation. Many candidates focused on describing the process of displacement, while some candidates focused on the term 'chemical change' in the question and tried to describe a chemical reaction such as seeing bubbles or zinc forming a gas.

(iii) Candidates answered this with varying degrees of success. Many candidates thought that aluminium did not react or that its melting point was too high for the process of reduction with carbon.

(iv) The majority of candidates could recall that an alternative method of metal extraction was electrolysis (or displacement with another more reactive metal). Some candidates thought that heating alone would be sufficient for the process and a few candidates put responses such as fermentation, electroplating, fractional distillation or combustion.

(c) Candidates found this question very difficult. Few candidates could describe the idea that an alloy has layers with different sized atoms. The most common misconceptions were:

- particles were closer together
- bonds were stronger between particles
- there were stronger intermolecular forces between particles
- particles were more dense
- particles of the metal mixed with zinc were harder.

Question 3

(a) This question was answered well by most candidates who could successfully balance an equation.

(b) This question was answered reasonably well, with candidates recognising the need to take away the mass of the impurity in order to have the correct mass of ammonium sulfate. A commonly seen answer was 25% where candidates had simply divided 0.7 by 2.8 and had not taken the mass of the impurities into account.

(c) A good proportion of candidates were able to successfully describe the test for ammonia gas. Some candidates chose to test for the gas using HCl, although using damp red litmus which turns blue would be the favoured method. Some candidates used damp blue litmus. A few candidates described the test for ammonium ions by heating with dilute sodium hydroxide to liberate ammonia, which was not creditworthy.

(d) (i) The majority of candidates were able to describe the process of movement of gases as diffusion. A few candidates thought that the process was the Haber process.

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(ii) Candidates found this question difficult and often just stated gas could move to fill the space available rather than describing how the gas does this. Most candidates did not refer to particles in their answers, which is key to describing the process of diffusion. Some candidates were able to either describe the movement of particles down a concentration gradient or the random movement of particles, but very few candidates were able to do both.

(iii) Candidates found this question challenging and candidates referred to the density of the particles rather than focusing on the carbon dioxide **molecules** being heavier than the ammonia **molecules**.

(e) (i) Some candidates could explain why a lower temperature and higher pressure is used in the Haber process. Some candidates described equilibrium and the yield that a lower temperature and pressure would produce, often correctly, but the candidates were told this in the question. More candidates had an appreciation that a lower temperature made the reaction slower but less had an appreciation that a higher temperature was expensive.

(ii) Most candidates were able to recall that the role of iron in the Haber process is as a catalyst.

(f) (i) A good proportion of candidates were able to accurately describe a base as a proton acceptor. Some candidates used phrases such as the opposite of an acid, used for neutralisation and has a pH higher than 7 but these were not creditworthy for the definition of a base. A few candidates misunderstood the term base in a ‘chemical’ sense and described it as the main component or the foundation of something.

(ii) The majority of candidates knew that ammonia was a weak base and accordingly assigned the pH value as greater than 7 and up to 11. A few candidates recognised that ammonia was a base but assigned a pH value of 12 or 13 (the pH for a strong base). A number of candidates thought that ammonia was acidic.

Question 4

(a) Around half of candidates could recall that air contains 21% cent oxygen.

(b) (i) Candidates answered this question well with many being able to recall that nitrogen was obtained from the air by fractional distillation. A number of candidates made reference to nitrification and denitrification and a few mentioned separation processes such as separating funnels, filtration and condensation. A common spelling error was ‘destillation’, which was seen on the majority of scripts.

(ii) Generally candidates had a good appreciation that boiling point was the property required for fractional distillation to work, although some candidates made reference to melting point, freezing point, mass and particle size. No credit was given for high boiling point since the boiling points of the gases are very low.

(c) About half of all candidates could correctly draw the dot-and-cross diagram for carbon dioxide and drew the non-bonding electrons on the outer shell of oxygen as pairs. The most common misconception was that carbon dioxide only had single bonds. Several candidates put extra electrons not involved in the bonding on the outer shell of carbon.

(d) Candidates generally answered this question well and could see from the graph that the concentration of carbon dioxide is increasing. Most could identify carbon dioxide as a greenhouse gas and then go on to say that this caused global warming. A common contradiction to a fully correct answer was to say that carbon dioxide also damaged the ozone layer, caused acid rain or was a toxic gas. A few candidates discussed the burning of fossil fuels as a reason for the increase in carbon dioxide concentration but did not gain credit as the question asked them to consider the global concerns from the data given in the graph.

(e) The majority of candidates were able to recall that plants remove carbon dioxide by photosynthesis.

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Question 5

(a) (i) Candidates found this very challenging with many being unable to define the term electrolysis. Common phrases which did not gain any credit were 'separation of elements', 'breakdown into ions' and 'separation into ions'. While many candidates were able to identify that ionic compounds undergo electrolysis, they did not mention that these needed to be in the molten or aqueous state.

(ii) Around half of candidates were able to recognise that the electrodes needed to be inert so that they do not react. Many candidates discussed the movement of ions and quite a number had confused this with aluminium electrolysis and talked about the electrodes not wearing away.

(iii) Candidates found this very challenging with only a minority being able to predict the correct electrolysis products at the electrodes. More candidates were able to deduce that hydrogen was formed at the negative electrode but then formed sulfur at the positive electrode.

(iv) The candidates that had correctly identified hydrogen at the negative electrode were generally able to write an accurate ionic half-equation for the formation of hydrogen. Generally, those candidates who had not correctly identified hydrogen often attempted to write an ionic half-equation for the formation of hydrogen with the most common error being to form H rather than H_2. Many candidates attempted to write an equation for the formation of sulfate ions.

(b) (i) Generally this question was answered well with over half of candidates being able to correctly write an equation for the formation of sulfur dioxide.

(ii) This question was poorly answered. Common incorrect statements were:

- the backwards reaction equals the forwards reaction
- the reaction can go backwards and forwards
- the reaction is equal
- the reaction is reversible
- concentrations of products and reactants are equal
- concentrations of products and reactants are the same
- ratio of reactants and products becomes constant/is constant.

(iii) Most candidates were able to recognise that the graph was referring to an exothermic reaction but then could not extend this response by explaining that this was because the energy of the products was lower than that of the reactants. Most candidates made the same point twice, i.e. it is exothermic because energy is lost.

(c) A minority of candidates could recall the final stage of the contact process where oleum reacts with water. Common answers included sulfur trioxide, sulfuric acid, sulfur dioxide or $H_2S_2O_7$.

(d) This was answered well by most candidates

Question 6

(a) (i) The majority of candidates could correctly identify the series as alkanes.

(ii) This question was poorly answered. Common incorrect statements were:

- same properties/physical properties
- same empirical formula
- all saturated
- all hydrocarbons
- same structural formula
- same suffix
- has a functional group.

(b) Half of the candidates successfully found the number of moles and hence the number of molecules. The most common incorrect answer was 9.03×10^{23}.

(c) (i) About a third of candidates were able to identify the non-carbon containing product as HCl. H_2 was a very common incorrect answer.

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(ii) Many candidates found this question challenging and some did not attempt it at all. Common errors were to use the incorrect numbers of carbon atoms in the carbon backbone, to attempt to draw a dot-and-cross diagram, and to not use chlorine in the final structure.

(iii) Some candidates were able to identify the reaction as substitution, common incorrect responses included redox, displacement, physical, neutralisation and chlorination.

(d) (i) Many candidates could correctly state the colour change of bromine water. A common incorrect colour quoted was blue, possibly confusing the test for water with anhydrous copper(II) sulfate.

(ii) Many candidates explained that the lack of colour change was because alkenes have a double bond. Common misquoted answers were that the bonds were weaker or that alkanes were unreactive.

(e) (i) This question was answered well by the majority of candidates. The most common error was to draw butane twice but with the methyl groups simply pointing in different directions.

(ii) This question was done well by the majority of candidates.

(f) (i) The majority of candidates could accurately calculate an empirical formula. The most common error being to use the proton number of carbon and hydrogen instead of the atomic mass number.

(ii) This question was answered less well. Those that did calculate the correct number of 'repeating units' often quoted their answer as $8CH_2$ as opposed to C_8H_{16}.

Question 7

(a) (i) A minority of candidates were able to recognise that the advantage of fermentation is the use of renewable raw materials. Common incorrect responses were:

- it is less harmful
- it is cheaper
- carbon dioxide is produced
- it is faster
- more ethanol is produced.

(ii) This question was answered reasonably well with most candidates recognising the process was slower.

(b) (i) A minority of candidates could correctly identify the oxidation product of ethanol as ethanoic acid. Incorrect answers included acid, carboxylic acid, carbonic acid, carbon dioxide, ammonia, hydrogen chloride and potassium.

(ii) A minority of candidates could correctly identify that this was an oxidation reaction. Common incorrect answers included esterification, displacement, addition, condensation, hydrolysis, neutralisation and combustion.

(c) (i) Some candidates could correctly name the ester, with the most common error being methyl ethanoate instead of ethyl methanoate.

(ii) Candidates found this question challenging and many were unable to draw the structure of an ester. If they did correctly draw an ester bond, carbons or hydrogens were often missed off the structure. Common errors were to draw carboxylic acids or alcohols.

(d) This question was answered well with many candidates correctly identifying the strongest attractive force in sodium chloride as ionic bonding (attraction between oppositely charged ions). The attractive force in ethanol was identified less well with a common answer being covalent bonding rather than attraction between molecules.

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Paper 0620/42
Theory (Extended)

Key messages

- Candidates must ensure that they read questions carefully to ensure that the answer they give addresses what has been asked. This was particularly evident in parts of **Question 1** where questions related to ions but were answered in terms of atoms and in **Question 4(b)** where alcohols were drawn rather than the alkenes that formed the alcohols.

- When a chemical equation is asked for, this means a balanced symbol equation using correct symbols / formulae and not a word equation. Word equations were frequently seen in **Question 3(c)(ii)** and **Question 4(c)**.

- If a name is asked for, although a correct symbol / formula would get credit, a wrong or even a 'near-miss' incorrect formula would receive no credit.

- Candidates should be prepared to do calculations using moles and their ratios. If the calculation is unstructured, such as **Question 2(e)**, then candidates need to explain their shown working rather than presenting apparently random sums if partial marks are to be awarded.

- When describing physical properties (e.g. **Question 3(b)**) a substance having a high melting point will naturally have a high boiling point, so candidates need to treat these physical constants as being equivalent and not two different physical properties

General comments

Most candidates appeared to be well prepared for this paper. It was evident that some candidates were unfamiliar with some areas of the syllabus (such as organic chemistry).

Many candidates followed question rubrics and did not give more than one response when one was asked for; very few produced lists.

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 or even pentavalent carbon atoms were often seen.

Comments on specific questions

Question 1

(a) This was answered well by most candidates. Weaker responses tended to include errors as a result of counting the electrons in the structures and ignoring the fact that some were ions.

(b) Most candidates correctly identified **F** as the incorrect structure. Weaker responses had difficulty expressing the reason sufficiently well enough. The most common incorrect reasons given for choosing **F** were that 'electrons are not paired in the outer shell' or 'the *outer* shell is not complete'.

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(c) Candidates had to count the electrons (10) and realise that a 2+ charge meant that the number of protons exceeded the number of electrons by two. Many simply assumed number of electrons were equal to number of protons and gave 10 as their answer, whilst others assumed the number of protons was two less than the number of electrons.

(d) (i) This was found to be the most difficult part in the question. A species with two electrons and a charge of –1 needs to contain 1 proton, thus H^- was the answer. Although 'H' was accepted, many incorrectly gave 'hydrogen'.

(ii) Most candidates realised that aluminium was the element whose ion had a 3+ charge and 10 electrons. Weaker responses opted for nitrogen, incorrectly.

Question 2

(a) Many candidates knew that the correct acid was nitric but wrote the name, which was not credited. 'H_2NO_3' was a frequently seen error, as was 'NO_3^-'. A significant number of candidates opted to make things hard for themselves by writing an equation for the reaction between nitric acid and a carbonate. If 'HNO_3' was seen as a reactant, credit was given.

(b) (i) The majority of candidates appreciated the need to react all the acid.

(ii) Candidates need to be aware that observations are based upon what is seen rather than what can be concluded. Thus, 'no more carbon dioxide given off' received no credit as what would be seen is 'no more effervescence'.

Candidates who wrote 'a precipitate forms' received no credit for this response. Precipitates form when two solutions (react to) form a solid. Here, it was a solid not dissolving.

Weaker responses described the reaction rather than its cessation, and phrases such as 'fizzing' and 'dissolving' were seen.

(iii) Only the strongest of responses appreciated that (thoroughly) rinsing the residue would achieve a maximum yield of crystals.

(iv) Although many candidates have learnt this description, a large number did not describe the key points of a saturated solution – 'no more solute can dissolve' and 'at a stated temperature'.

Weaker responses tended to confuse the terms *solute* and *solvent* or tended to describe saturation of organic molecules.

(v) A common incorrect answer was iron(II) nitrate or the omission of the oxidation state when the oxide or hydroxide of iron was given. A large number of candidates gave oxides or hydroxides of metals other than iron, copper being a common example.

(c) Better performing candidates were able to work their way through this structured calculation. The M_r of $FeSO_4$, was the mostly commonly seen. The mass of water, '152', was often seen in working out but often did not feature on the answer line.

The importance of candidates showing working should be stressed as those candidates who did so, often picked up marks as a result of 'error carried forward'.

(d) (i) Very few candidates knew the term for making insoluble salts from solutions of two soluble salts was 'precipitation'. 'Filtration' was frequently seen, presumably as a result of candidates focussing upon **step 2** in the process.

(ii) Better performing candidates were able to recall that AgBr forms a cream precipitate.

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(iii) Candidates found this ionic equation for the formation of a binary insoluble compound difficult.

It was evident that the idea of an ionic equation is not understood by many candidates. Many candidates opted to make things more difficult by giving a full equation. Others omitted ionic charges or state symbols.

(e) Candidates need to be prepared to calculate answers by working with moles rather than reacting masses.

Although there were many ways through this unstructured calculation, it was expected that candidates would determine the number of moles of $NaCl$ being formed by dividing the mass formed by the M_r of $NaCl$ ($2.34 \div 58.5$) to give 0.04 mol.

The next step is to consider the stoichiometry and to realise the number of mol of Cl_2 used was half that of $NaCl$ formed ($0.04 \div 2$) to give 0.02.

The third step was to convert the mol of Cl_2 to its volume by multiplying by 24 000.

(f) (i) It was expected that candidates would understand that conductivity of $NaCl$ was based upon the fact it is ionically bonded and when solid, the ions are in fixed positions, whereas when molten, the ions are mobile. The best responses were succinct such as, 'when solid, the ions in $NaCl$ are in fixed positions and when molten, they can move'.

'Free ions' did not gain credit as it is not clear what they are free from. 'Ions are free to move', however, is creditworthy.

Weaker responses confused electrons and ions and switched, after mentioning ions, to describe electron movement or lack of movement.

Many candidates contradicted 'ionic bonding' as they introduced covalency into their response with phrases such as '$NaCl$ has ionic bonding with strong inter-molecular forces'.

(ii) Chlorine was well known as the product at the anode, although 'chloride' was commonly seen.

(iii) Candidates found this question about the redox process at an anode ('electron loss' and 'oxidation') during electrolysis challenging.

(iv) Nearly all candidates knew that aqueous conditions would also allow electrical conductivity.

Question 3

(a) This question required candidates to state two physical properties which are found in both Group I and transition elements. Most candidates were able to state either electrical conductivity, heat conductivity or malleability.

A large number of candidates gave typical physical properties of most metals (such as high melting point, hardness and high density), which show a difference rather than similarity between these two types of metal.

Other candidates gave more than two responses, a practice which should be discouraged if only two responses are asked for.

(b) This question required candidates to state two physical properties which are different between each type of metal. Better responses focused upon the lower melting points and lower densities of Group I metals. A significant number of candidates wrote about chemical properties such as variable oxidation state and catalytic activity.

(c) (i) Most candidates were able to name hydrogen as the gas evolved when sodium reacts with water.

(ii) The identity of the ion responsible for alkalinity was known by most.

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(iii) The equation for the reaction was reasonably attempted on the whole. Most took the information offered by **(i)** and **(ii)** and gave equations with sodium hydroxide as the product along with hydrogen gas.

(d)(i) Galvanising was widely known as the name of the process in which iron is coated in zinc.

(ii) Most candidates talked about sacrificial methods of rust protection rather than the obvious barrier to water / oxygen that a complete layer on the surface of the iron would afford.

(iii) This question asked how zinc blocks (rather than a complete layer of zinc) prevented rusting. Many responses indicated an understanding of rusting that goes beyond the requirements of IGCSE. At this level it was sufficient to state that zinc is more reactive than iron and therefore will corrode in preference to iron. Directions of electron flow / exchange are not needed. Candidates need to be aware that zinc does not *rust* in preference to iron.

Question 4

(a) Although the correct answer, 'hydrocarbons', was very widely known other responses such as 'carbohydrate' or 'hydrogen carbonate' were fairly regularly seen.

(b)(i) The idea that addition reactions are those which produce a single product was not widely known. Many candidates gave descriptions of addition polymerisation which, although one particular type of addition reaction, was far too narrow an answer.

(ii) Most candidates were able to draw a chain of three single-bonded carbon atoms. Only the best responses placed bromine atoms on positions 1 and 2. Common incorrect structures were 1,1-dibromopropane, 1,3-dibromopropane and monobromopropane.

(iii) The change in colour associated with the test for unsaturation was widely known.

(iv) This demanding question proved difficult for many candidates.

For those who understood that alkenes were required as the answer, the structure of but-2-ene was frequently seen, but usually accompanied by methylpropene.

Many weaker responses had structures with trivalent or pentavalent carbon atoms and many included alcohols.

(c) Many realised that HCl must be a product of this substitution reaction, but significantly fewer were able to construct the full equation.

Question 5

(a)(i) Many candidates omitted the one key condition, the presence of an acid (as a catalyst).

(ii) Most candidates knew the type of chemical change from ethanol to ethanoic acid was an oxidation.

(iii) The ability to convert the structure of ethanoic acid into a dot-and-cross diagram was done well. Candidates should understand that a single bond is one dot/cross pair and double bonds are two dot/cross pairs. All the non-bonding electrons were frequently omitted.

(b) Nearly every candidate knew that partial dissociation occurs in weak acids and full dissociation takes place in strong acids. 'High dissociation' was not credited.

Most candidates realised that two 'acidic' colours were required and that the colour of the strong acid should be more acidic than that of the weak acid. Typical successful combinations were orange and red.

Successful candidates gave effervescence as the observation and stated it was more vigorous with strong acids. Common errors were to say 'little or no effervescence' with a weak acid; failure to indicate the effervescence was greater with strong acids, or to say 'slow reaction and fast reaction' without including any observation.

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(c) (i) The vast majority of candidates knew water was produced during ester formation.

(ii) Many differing irrelevant sets of conditions were seen but as long as candidates knew an acid (as a catalyst) was needed, credit was given.

(iii) Candidates needed to identify that the 3-carbon alcohol was propan-2-ol, rather than the more commonly seen propan-1-ol.

Some candidates realised an alcohol was needed, but many candidates incorrectly drew trivalent carbon atoms in their structures.

(d) (i) Candidates found it difficult to explain the meaning of the term *functional group*. Many related it to the identification of molecules or to homologous series.

(ii) Empirical formula was not clearly understood with many giving the molecular formula as well as hybrid formulae such as C_2H_4COOH.

(iii) Many responses contained errors. These included, incorrect M_r values; not appreciating the total mass of oxygen present was 32; failure to give an answer to a whole number and inverted fractions yielding answers in excess of 100% were frequently seen.

(iv) Most candidates were able to draw an ester linkage showing all the bonds, but many could get no further due to either the incorrect orientation of ester links or the omission of continuation bonds.

(v) Many candidates were able to recall that *Terylene* was a polyester. Some candidates struggled to present an unambiguous spelling of *Terylene*.

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Paper 0620/43
Theory (Extended)

Key messages

- Candidates struggle to distinguishing between rates of reaction and equilibrium. This was evident in **Question 3(c)(iii)**. Candidates should realise that the topics are unrelated.
- Some candidates needed to learn details of the extraction of zinc from zinc blende.
- Candidates should be aware of the practical technique usually referred to as 'heating to constant mass' in quantitative analysis.

General comments

Candidates should learn definitions and meanings of important terms used in the syllabus.

Comments on specific questions

Question 1

All parts of **Question 1** were answered extremely well.

(a) Aluminium oxide was seen occasionally.

(b) Carbon monoxide was seen occasionally.

(c) Some non-gaseous substances, such as aluminium oxide were seen very occasionally.

(d) This was almost always correct.

(e) This was usually correct.

(f) Hydrated copper(II) sulfate was seen occasionally.

Question 2

(a) Candidates performed well on this question. Occasionally, 11, 23 and 24 were seen.

(b) Candidates performed well on this question. Occasionally, 20 was seen by those who confused neutrons with nucleons.

(c) This was almost always correct. The phrase 'electronic structure' was recognised by almost all the candidates.

(d) (i) The most common error was to give only one letter as the answer. **E** was often the only letter that was given. **B** was often omitted. Some candidates gave all five letters.

(ii) This was answered very well. Most candidates realised that positive ions have more protons than electrons.

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(iii) This was answered very well. Most candidates realised that negative ions have more electrons than protons.

(iv) This was answered very well. Most candidates realised that isotopes are atoms with the same number of protons.

Question 3

(a) This was answered reasonably well. Many candidates gave a double or single bond between the atoms. Quadruple bonds were seen occasionally.

(b) (i) Fractional distillation was often correct. Air was not always qualified as being in the liquid state. Details relating to the Haber process were occasionally seen here. There were suggestions that hydrogen was produced from ammonia by reversing the Haber process.

(ii) This was answered well. The most common omission was the reversible nature of the process. This could have been mentioned in words or by using a reversible arrow in the equation.

(c) (i) This was answered well by most candidates. Good responses stated that a catalyst is chemically unchanged at the end of the reaction it catalyses.

(ii) This was answered well by most candidates. Those who stated that oxidation is 'reaction with oxygen' should have gone further by reference to 'gain of oxygen'.

(iii) Questions on rate of reaction and equilibrium continue to be extremely challenging for candidates. Some candidates wrote the same word in all four spaces.

(d) This was answered quite well. The formula of nitric acid was occasionally incorrect. H_2NO_4 and H_2NO_5 were sometimes seen as the formula of nitric acid.

(e) This was usually answered correctly. Candidates sometimes did not notice there were two nitrogen atoms in the formula NH_4NO_3 and 17.5% was a common answer.

Question 4

(a) Candidates found this challenging. Sulfur and sulfur oxide were commonly seen.

(b) (i) There seemed to be confusion between the extraction of zinc and the blast furnace process for the extraction of iron. Some of the more common errors were to suggest that coke:

- is used to produce carbon dioxide
- is used to remove impurities
- displaces oxygen in zinc oxide
- is a catalyst
- is more reactive than zinc (without qualification).

(ii) This was answered reasonably well. A common error was to leave the equation unbalanced. Some candidates showed zinc oxide being decomposed without a reducing agent.

(iii) This was answered very well. A small number stated that the temperature inside the furnace was very high without qualification.

(iv) This was answered very well. Sublimation and reverse sublimation were seen very occasionally.

(c) (i) This was answered quite well. Zinc sulfate was a common answer, presumably from those who were unable to distinguish between residue and filtrate.

(ii) The definition of a saturated solution was known by a number of candidates. References to temperature were often absent. Others made statements about saturated solutions forming crystals when they cooled without describing what a saturated solution is.

A small but significant number of candidates referred to saturation in organic chemistry in terms of single and double bonds.

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(iii) This was answered quite well. Salts such as zinc chloride, zinc nitrate and zinc sulfate were seen occasionally. Some answers were not compounds and some did not contain zinc.

(d) (i) Candidates were largely unaware of the practical technique required for heating to a constant mass. The hydrated salt should be:

- weighed
- heated
- cooled
- reweighed.

These steps should be repeated until there is no loss in mass, i.e. the mass becomes constant. This indicates that all the water of crystallisation has been given off. Qualitative techniques, such as those involving copper(II) sulfate or cobalt(II) chloride, do not detect very small quantities of water which may still be present in the crystals.

(ii) This was answered extremely well by the majority of candidates. Candidates found the final step most challenging. Many were unaware that dividing the moles of H_2O by the moles of $MgSO_4$ would determine the value of *x*.

Question 5

(a) This was answered well by most candidates. Some mentioned that reactivity increased but did not make it clear in which direction. Others merely stated that the elements were very reactive.

(b) (i) Many candidates gave two correct observations. The two most common correct responses were fizzing / bubbling / effervescence and a flame.

Statements such as ‘vigorous reaction’, ‘gas / hydrogen given off’ or ‘alkaline solution’ were not credited. This also applies to names of products. A purple liquid was mentioned by some candidates. This may have been due to confusion with flame colour or even with change of colour of indicators.

(ii) Candidates found this very challenging. K_2O, KO, KO_2 were often seen as the formula of the potassium compound formed. H_2 was often missing as a product.

(c) (i) This was done correctly by some candidates. The most common errors were to see the formulae of Cl, I, KI_2 and KCl_2.

(ii) A variety of colours were seen. There was confusion with purple, which is the colour of iodine dissolved in an organic solvent. Green or yellow-green were also fairly common. Colourless was seen occasionally.

(d) (i) The definition of electrolysis was known by some candidates. The point that were most likely to be omitted was that the substance being electrolysed was an aqueous solution or molten.

(ii) In order to produce sodium at the cathode the electrolyte had to be molten sodium chloride. Dissolving in water was the most common incorrect answer. This would produce hydrogen at the cathode.

(iii) This was answered correctly by some candidates. Products other than sodium were often seen.

(e) (i) This was answered well by many candidates. The two most common correct properties were coloured compounds and catalytic behaviour. Comparisons were often given despite the requirement of the question to give two properties. Several candidates chose conduction of electricity, which is a property of *all* elements. Reference to colour should have been accompanied by ions or compounds.

(ii) This was answered well by many candidates. High melting point was often given as being a common property. Solubility in water had to be accompanied by compounds.

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Question 6

(a) (i) This was reasonably well answered. Some candidates suggested isomers have the same chemical, empirical or general formula rather than molecular formula; some used ‘similar’ rather than ‘same’ in their response. A statement that, ‘in isomers the atoms were arranged differently’ was insufficiently detailed to gain credit.

Same structural formula and different molecular formula were seen occasionally.

(ii) The name of ethanoic acid was often correct. Not drawing the O–H bond in the structure of ethanoic acid was a common error. Molecules with more than two carbon atoms were given by a number of candidates.

(b) (i) This was answered well by the majority of candidates. Some drew a circle around the ester linkage. Some omitted to answer this question.

(ii) This was answered correctly by some candidates. Addition (or additional) was the most common incorrect answer.

(iii) Candidates found this challenging. Common errors were to show two functional groups that were the same. O–H bonds were sometimes missing. Some drew a section of the polymer as opposed to a monomer. The carboxylic acid was seen more often than the alcohol group.

(c) Candidates found this challenging. Those that showed the linkage, with all atoms and bonds, often showed the boxes attached to two different groups, i.e. N– H and C=O (as in, e.g. nylon 6) instead of two groups that were the same (as in, e.g. nylon 6,6), which this molecule could have been (depending on the boxes).

(d) (i) Some candidates answered this correctly. The most common incorrect responses were ‘natural polymers’, ‘amide linkage’, ' carbohydrate' and ‘glucose.’

(ii) The most common incorrect responses were ‘protein’, ‘nylon’ and ‘glucose.’

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Paper 0620/51
Practical

Key messages

- When recording results from an experiment all data obtained from the same measuring device should be recorded to the same resolution (the same number of decimal places). In **Question 1(a)**, all burette readings and calculated volumes should have been given to one decimal place (or to the nearest 0.05).
- 'Clear' is not a colour. Clear means that an image can be seen through the substance. Things which are clear can be coloured – such as aqueous copper sulfate, which is a clear blue.
- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not.
- If a numerical answer is required, then if that number is rounded it must be rounded correctly.

General comments

The vast majority of candidates successfully obtained results for both the quantitative and qualitative tasks and attempted all of the questions. Many excellent results for the quantitative task were seen with the vast majority being close to the Supervisor value and to the expected results.

The paper was generally well answered, with very few blank spaces.

Comments on specific questions

Question 1

(a) Almost all candidates correctly recorded results for both titrations. The most common errors were not recording all values to one decimal place (or better) and recording the volume of the burette when full as '50.0' rather than '0.0'. A few candidates switched over their initial and final readings when recording their results. Candidates should know that the final burette reading will always be higher than the initial reading.

(b) The majority of candidates were able to correctly state the colour change of the indicator. Some centres used phenolphthalein indicator instead of thymolphthalein as required in the Confidential Instructions.

(c) While some excellent answers were seen, some candidates struggled to express themselves clearly. Often these candidates concentrated on the colour of the indicator, instead of mentioning the colour change or end point. A misconception was that universal indicator is not a liquid. Candidates should be familiar with both universal indicator paper and universal indicator solution.

(d) (i) Most candidates were able to correctly identify solution **B** as being the more concentrated and were able use their results to give an explanation for their conclusion.

(ii) This was very well answered.

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(e) Most candidates were able to calculate an acceptable value for the titre if 10 cm^3 of dilute ethanoic acid was used. Some vague answers were seen, such as 'less would be needed'; these did not receive credit since the question asked for the volume. Most candidates included the required units in their answer.

(f) Candidates continue to confuse reliability, accuracy and precision. Most mentioned repeating the experiment but continue to think that taking an average or mean is a method of checking the reliability of the results, rather than the correct answer of comparing them for consistency.

(g) (i) Almost all candidates could correctly state that a pipette is more accurate (gives values closer to the true value) than a measuring cylinder.

(ii) Very few candidates gave the expected answer that a 25 cm^3 pipette can only measure a fixed volume of 25 cm^3 and so is not suitable for measuring a volume which was not 25 cm^3.

(h) (i) Most candidates correctly stated that any remaining solution **A** would be removed from the burette by rinsing with water. A small number of candidates stated it would remove left over ethanoic acid; this was not credited since the burette was not used to measure the volume of ethanoic acid.

(ii) Many candidates correctly stated that the distilled water that remained in the burette needed to be removed. A few candidates incorrectly stated that solution **A** was still being removed.

(iii) Some fully correct answers were seen, although it was common to give vague answers such as 'the result would be inaccurate'.

Question 2

(a) Most candidates could correctly describe the appearance of solid **C**.

(b) Most candidates gained some credit on this part, full marks were rare. The most commonly awarded statement was that a liquid formed, although relatively few candidates stated that there was a change of colour as the substance was heated. The evolution of steam or the formation of condensation at the top of the test-tube was rarely noted.

(c) (i) The colour change to red or orange was noted by the vast majority of candidates; others stated that a precipitate formed.

(ii) The best responses included fully correct observations. Stating 'a gas is given off' is not an observation; the terms 'fizzing' or 'effervescence' were expected. Very few candidates noted the decrease in temperature or that the solid disappeared and a colourless solution formed. Some candidates reported results of gas tests that were totally impossible; the gas produced was carbon dioxide yet candidates reported positive tests for oxygen, hydrogen, ammonia and chlorine.

(d) Candidates should have concluded from the test in **(b)** that the solid was hydrated and from the tests in **(c)(i)** and **(c)(ii)** that it was acidic. A common error was to claim that solid **C** was a copper compound, despite there being no evidence for this.

(e) (i) Most candidates correctly reported the formation of a white precipitate. It should be noted that if a solution becomes cloudy during a reaction it will be due to the formation of a precipitate. Use of the term 'precipitate' is required.

(ii) Most candidates correctly stated that there was no further change on adding excess sodium hydroxide, although a few reported incorrectly that there was fizzing or a change in colour.

(f) Most candidates correctly stated that there was no change or that a faint white precipitate formed.

(g) The correct result from the halide ion test was given by most candidates.

(h) Many candidates correctly reported the fact that there was no change in the sulfate ion test. A few candidates stated they obtained white (or other coloured) precipitates. These candidates must have either used the wrong reagents or decided to guess an answer. Statements such as 'the solution became colourless' did not receive credit since the use of 'became' implies a change, the solution remained colourless throughout.

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(i) Most candidates, even those with some incorrect or incomplete observations, were able to correctly identify solid **D.**

Question 3

Most candidates were able to perform well on this planning task and were clearly becoming more familiar with this type of question.

The majority of candidates seemed not to realise that dilute hydrochloric acid contains a large amount of water and so the sodium fluoride and mint flavouring in the toothpaste would dissolve in dilute hydrochloric acid. Instead, they decided to first add a known mass of toothpaste to water to dissolve the two soluble components and then filter off the insoluble residue. This unnecessary step was ignored.

The most common errors were ones of omission. Candidates often did not state that an excess of dilute hydrochloric acid was required; simply stirring until the fizzing stops is not the same as using an excess, if all of the acid has reacted leaving unreacted calcium chloride the fizzing will still stop. A second common omission was the fact that the residue of silica, which is obtained by filtering the mixture after reaction with excess dilute hydrochloric acid, needs to be washed (to remove aqueous calcium chloride) and then dried (to remove water). There was some confusion between ‘residue’ and ‘filtrate’ in some answers.

Most candidates were able to state that the remaining silica should be weighed and correctly stated how to calculate the percentage of silica.

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Paper 0620/52
Practical

Key messages

- Candidates should go through their plans when answering **Question 3** before writing their response. Weaker responses tend to have extra sentences inserted to cover missing points that are realised later.
- 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 the mark will not be awarded.
- Candidates should be aware that the mark allocation is an indication of the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all three questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some centres performing very well.

Supervisors' results were submitted by all centres with the candidates' scripts. Supervisors' results are used when marking the scripts to check comparability in **Questions 1** and **2**.

Some comments were submitted by supervisors after carrying out the experiments. The results obtained by some supervisors and candidates in **Questions 1** and **2** suggested that some centres did not use the materials specified in the Confidential Instructions. It is the responsibility of the centre to make sure that the appropriate chemicals and apparatus are provided for the examination. For example, the starch solution should have been tested before the exam and any bungs required should have fitted the apparatus used.

Comments on specific questions

Question 1

(a) Almost all candidates correctly completed the table of results. Some candidates did not get the expected increase in time as the volume of potassium iodide decreased. A minority of candidates did not record times to the nearest whole second.

(b) The majority of candidates correctly stated the colour change. The starting colour of the solution was colourless and not white or clear.

(c) Most candidates plotted all points correctly. Candidates should be reminded that points should be marked clearly, ideally using an x, and lines drawn using a sharp pencil. Many candidates did not correctly draw a smooth curve of best fit. A smooth curve of best fit does not simply join the points together with a wobbly line and must not be drawn with a ruler.

(d) (i) Many candidates showed clearly where they had read their answer from the grid. A number did not show any working on their graph. The best answers showed a tie-line going from 16 cm^3 on the *x*-axis to the line and then a horizontal line running to the *y*-axis.

(ii) This was generally correctly answered. It was evident that a significant number of candidates had not read the first line of information in the 'instructions' that stated the total volume of liquid in each experiment was 45 cm^3.

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(e) Sketch lines above the original curve and lines that touched the top and/or the bottom of the original curve were not accepted.

(f) (i)(ii) This was well answered.

(g) Vague answers referred to equal volumes of potassium iodide and sodium metabisulfite. The idea of not diluting or changing the concentration of solutions showed a lack of knowledge and understanding. Many candidates did not realise that the volume of water was changing to keep the total volume constant.

(h) The use of a burette or pipette was well known. Good responses explained the use in terms of measuring volumes more accurately or compared to using a measuring cylinder.

(i) Repeating the experiments alone does not improve the reliability of the results, nor does taking a mean or average. If the results are compared and found to be similar, or if anomalies are discarded, then the results are more reliable.

Question 2

(a) A number of candidates did not note that there was effervescence. Candidates were expected to test the gas and report the observations for the positive test. The gas was carbon dioxide and should have turned limewater milky. Some impossible gas tests were reported. Most candidates did not note that some of the solid disappeared or that there was a temperature change.

(b) The majority of candidates identified carbon dioxide correctly.

(c) (i) The majority of candidates reported the formation of a white precipitate. Some candidates did not make it clear whether the observation they gave was for dropwise addition or addition in excess. When a reagent is added dropwise and then in excess, candidates are expected to give their observations in that order.

(ii) Some responses made references to other cations giving the same result. The best answers mentioned that both aluminium and zinc ions give the same result.

(iii) This was well answered with the use of ammonia or ammonium hydroxide being recognised. Some answers referred to ammonium alone and did not gain credit.

(d) Many candidates correctly noted the colour change on heating solid **Q**. However, it was evident that some candidates did not follow the instruction that told them to leave the solid to cool. Hence, they did not note the return to a white colour once cooled. Only a minority of candidates observed the condensation of water droplets near the top of the test-tube.

(e) The majority of candidates noted the yellow/orange colour caused by sodium ions in the flame. Evidence suggests that some candidates do not know how to perform a flame test. Some responses referred to the flame becoming more yellow suggesting that they were not using a roaring flame.

(f) (i) The bromine solution should have been yellow to start with so ‘turns yellow’ was not credited. Many candidates correctly noted the solution becoming darker or brown. Some reported no change.

(ii) Candidates should be familiar with the colours of the precipitates formed by halide ions when reacted with aqueous silver nitrate. There were many incorrect cream precipitates. Candidates should not put down multiple colours such as ‘cream-yellow’ as this suggests both iodide and bromide ions are present. This is evidence that some candidates lack practical laboratory experience and have not seen the three halide precipitates side by side for comparison.

(g) This was well answered; a common error was a misidentification of the halide ion.

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Question 3

The complete range of marks was seen in this planning question. The quality of responses was often centre dependent.

Good responses weighed the sample of brass and used hot dilute sulfuric acid to react with the zinc component. Filtration of the residue, then washing and drying it before weighing the copper were the expected steps. Common errors were not using an excess of acid and failing to wash or dry the residue.

Weaker responses were confused and started with separate samples of zinc and copper, instead of brass.

A large number of candidates attempted to crystallise the salt from the filtrate or react the filtrate with magnesium to form zinc, not realising that subtracting the mass of copper from the initial mass of brass gave the mass of zinc. Many responses gained credit for showing how the percentage of zinc could be calculated even from a wrong method used to obtain the zinc.

A minority of candidates used the wrong method such as fractional distillation or electrolysis. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.

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Paper 0620/53
Practical

Key messages

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(ii) The best responses included fully correct observations. Stating 'a gas is given off' is not an observation; the terms 'fizzing' or 'effervescence' were expected. Very few candidates noted the decrease in temperature or that the solid disappeared and a colourless solution formed. Some candidates reported results of gas tests that were totally impossible; the gas produced was carbon dioxide yet candidates reported positive tests for oxygen, hydrogen, ammonia and chlorine.

(d) Candidates should have concluded from the test in **(b)** that the solid was hydrated and from the tests in **(c)(i)** and **(c)(ii)** that it was acidic. A common error was to claim that solid **C** was a copper compound, despite there being no evidence for this.

(e) (i) Most candidates correctly reported the formation of a white precipitate. It should be noted that if a solution becomes cloudy during a reaction it will be due to the formation of a precipitate. Use of the term 'precipitate' is required.

(ii) Most candidates correctly stated that there was no further change on adding excess sodium hydroxide, although a few reported incorrectly that there was fizzing or a change in colour.

(f) Most candidates correctly stated that there was no change or that a faint white precipitate formed.

(g) The correct result from the halide ion test was given by most candidates.

(h) Many candidates correctly reported the fact that there was no change in the sulfate ion test. A few candidates stated they obtained white (or other coloured) precipitates. These candidates must have either used the wrong reagents or decided to guess an answer. Statements such as 'the solution became colourless' did not receive credit since the use of 'became' implies a change, the solution remained colourless throughout.

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(i) Most candidates, even those with some incorrect or incomplete observations, were able to correctly identify solid **D.**

Question 3

Most candidates were able to perform well on this planning task and were clearly becoming more familiar with this type of question.

The majority of candidates seemed not to realise that dilute hydrochloric acid contains a large amount of water and so the sodium fluoride and mint flavouring in the toothpaste would dissolve in dilute hydrochloric acid. Instead, they decided to first add a known mass of toothpaste to water to dissolve the two soluble components and then filter off the insoluble residue. This unnecessary step was ignored.

The most common errors were ones of omission. Candidates often did not state that an excess of dilute hydrochloric acid was required; simply stirring until the fizzing stops is not the same as using an excess, if all of the acid has reacted leaving unreacted calcium chloride the fizzing will still stop. A second common omission was the fact that the residue of silica, which is obtained by filtering the mixture after reaction with excess dilute hydrochloric acid, needs to be washed (to remove aqueous calcium chloride) and then dried (to remove water). There was some confusion between ‘residue’ and ‘filtrate’ in some answers.

Most candidates were able to state that the remaining silica should be weighed and correctly stated how to calculate the percentage of silica.

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Paper 0620/61
Alternative to Practical

Key messages

- Straight lines on graphs must be drawn with the aid of a ruler and not free hand. Points on graphs should be shown as a cross (×). A sharp pencil should be used for graph work. When drawing sketch graphs as a prediction, candidates should not make up points and plot them.
- When asked to identify a substance, candidates may use a name or correct formula. It should be noted, however, that an incorrect formula will not gain the mark(s) available. Hence, it is often better to give the name unless the formula is specifically asked for.
- In qualitative tests, when a reagent is stated to be 'added dropwise and then in excess', candidates are expected to give observations for the dropwise addition and then observations for the addition in excess.

General comments

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

Candidates in most centres are becoming more familiar with the planning task set in **Question 4**. Candidates would be well advised to plan out their answers before writing them, as this will avoid steps being out of sequence.

The vast majority of candidates were able to complete tables of results from readings on diagrams and then handle the data obtained.

Comments on specific questions

Question 1

(a) Almost all candidates were able to identify the thermometer correctly and the majority also successfully identified the condenser. A common incorrect answer referred to the condenser as a tube.

(b) Many candidates correctly identified the process as fractional distillation, although a few named the method as 'distillation' or 'simple distillation'. Weaker responses often just referred to one process that occurs during distillation, such as 'evaporation' or 'condensing'; these answers did not gain any credit.

(c) The flammability of alcohols was identified as a safety issue by the majority of candidates, although some incorrectly referred to the risk of the glassware breaking if it is heated.

(d) Many candidates gained credit for stating that if the mixture were heated to 97 °C then propanol would be boiled off and collected. Considerably fewer stated that the ethanol would be boiled off first. Simply heating the mixture to the boiling point of propanone would result in collecting a mixture of ethanol and propanol.

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(e) Many stronger responses realised that the boiling point of butanol is above the boiling point of water and so using a water bath would result in the water boiling off before the butanol. Some weaker responses claimed that the apparatus could not withstand such high temperatures

Question 2

(a) The vast majority of candidates were able to give correct readings from the measuring cylinder diagrams.

(b) Many fully correct graphs were seen. There were a number of common errors. Some candidates did not plot the point at (10,1.4). Despite the instruction to draw two straight lines which met, it was common for the lines to curve as they met.

(c) The majority of candidates were able to read an appropriate mass from their graph. However, despite the instruction in the question that candidates should show clearly on the grid how they worked out their answer, many did not do this and just recorded a numerical value with no working shown. These candidates could only gain the mark for the value.

(d) Better responses stated correctly that in Experiments 5, 6 and 7 the lead(II) nitrate was in excess or that all of the potassium iodide had reacted. Some weaker responses incorrectly stated that all of the lead iodide had reacted; as the lead iodide is a product it does not react in this experiment.

(e) Very few responses gained both marks. If the concentration of the potassium iodide is halved, then the volume of lead(II) nitrate required to react with all of the potassium iodide will also be halved; hence the maximum mass will be reached at half of the volume of lead(II) nitrate (so at around 18 cm^3 of lead(II) nitrate added). As the amount of potassium iodide and lead(II) nitrate reacted will halve, the maximum height of precipitate will also halve (to around 2.55 cm).

(f) (i) Almost all candidates could correctly state that a pipette is more accurate (gives values closer to the true value) than a measuring cylinder.

(ii) Very few candidates gave the expected answer that a 25 cm^3 pipette can only measure a fixed volume of 25 cm^3 and so is not suitable for measuring a volume which was not 25 cm^3.

(g) Better responses described all three steps required to find the mass of the precipitate (filter, wash to remove soluble salts and then dry before using a balance to fine the mass). The omission of either the washing or the drying stage was not uncommon. Some candidates incorrectly decided to attempt to use distillation.

Question 3

(a) The majority of candidates were able to use the observations from **test 3** to conclude the gas formed was ammonia. However, hydrogen was a common incorrect answer, despite the fact that no test for hydrogen had been carried out.

(b) The vast majority were able to identify solid **Y** at least partially, with many candidates identifying both ions present.

(c) Most candidates were able to either state that the test showed that the solution was acidic or suggest a suitable pH for the solution.

(d) Better responses stated that a green precipitate would form and that the precipitate would remain when excess aqueous ammonia was added. The formation of a white precipitate was a common incorrect answer among weaker responses. Vague observations such as ‘it changes colour’ were not credited.

(e) At the start of the tests on solid **Z** candidates were told that solid **Z** was iron(II) sulfate. As solid **Z** is not a carbonate, there should be no change. Better responses correctly stated that there would be no change, while weaker ones often seem to guess at possible observations.

(f) Parts **(e)** and **(f)** together make up a test for sulfite ions. As solid **Z** was a sulfate, and not a sulfite, there should be no change. Only the better performing candidates could state this. A common error was to state the filter paper becomes purple (incorrect because the filter paper soaked in acidified

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aqueous potassium manganate(VII) will start purple and remain purple) or will turn colourless (incorrect as this is the positive result for the sulfur dioxide formed in a positive sulfite test).

(g) Most candidates were able to correctly state the result of the positive sulfate test.

Question 4

Candidates needed to use both water and propanone to successfully obtain pure samples of all three substances in the mixture. Better performing candidates were able to gain full credit and most candidates could make some progress.

The most common mark awarded was for the use of a suitable container, such as a beaker. The soluble components are obtained by the addition of a suitable solvent, stirring, filtering and evaporating the solvent from the filtrate. The silicon is obtained as a residue from filtration after both soluble components have been dissolved. This residue will not be pure unless it is washed and dried.

Common errors included the omission of stirring to aid dissolving and a failure to wash and dry the silicon dioxide. There was some confusion between the terms *residue* and *filtrate*. The weakest responses often tried to use totally inappropriate methods, such as fractional distillation, or started with three pure substances rather than a mixture.

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Paper 0620/62
Alternative to Practical

Key messages

- Candidates should go through their plans when answering **Question 4** before writing their response. Weaker responses tend to have extra sentences inserted to cover missing points that are realised later.
- 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 the mark will not be awarded.
- Candidates should be aware that the mark allocation is an indication of the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some centres performing very well.

Many candidates showed familiarity with the planning task set in **Question 4**. Candidates would be well advised to plan out their answers before writing them as this will avoid steps being out of sequence.

The vast majority of candidates were able to complete tables of results from readings on diagrams and then handle the data obtained, as in **Question 2**.

Comments on specific questions

Question 1

(a) Many responses named the piece of apparatus as a beaker. A small number were confused and named a battery or electrolyte.

(b) (i) Vague references such as ‘not very reactive’, ‘does not corrode’ did not receive credit. References to being a ‘good conductor’ was a common answer, however, reference to electricity was needed.

Responses that referred to the price and availability of platinum were ignored.

(ii) Graphite/carbon were common correct answers. Other metals such as copper, iron and aluminium were rejected.

(c) Despite references to protective clothing in the stem of the question the majority of candidates used examples of this to answer the question. Few candidates realised that the safety precaution was a fume cupboard due to the toxic gas chlorine.

‘Use of a lab coat to prevent contact with acid’ and ‘keep your distance’ were common incorrect responses. Vague references to harmful and dangerous chemicals were ignored.

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Question 2

(a) Almost all candidates correctly completed the tables of results from the stop-clock diagrams**.** The commonest error was varying the volume of sodium metabisulfite. Many candidates did not realise that the volume should have stayed constant at $5\,cm^3$.

(b) Most candidates plotted all points correctly. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Wobbly curves were not accepted.

(c) (i) Many candidates clearly indicated on their graph to show where they had read their answer from the grid.

(ii) This was generally correctly answered.

(d) Sketch lines above the original curve and lines that touched the top and/or the bottom of the original curve were not accepted.

(e) This was well answered.

(f) Vague answers referred to equal volumes of potassium iodide and sodium metabisulfite. The idea of not diluting or changing the concentration of solutions showed a lack of knowledge and understanding. Many candidates did not realise that the volume of water was changing to keep the total volume constant.

(g) The use of a burette or pipette was well known. Good response explained the use in terms of measuring volumes more accurately or compared to using a measuring cylinder.

(h) Repeating the experiments alone does not improve the reliability of the results, nor does taking a mean or average. If the results are compared and found to be similar, or if anomalies are discarded, then the results are more reliable.

Question 3

(a) The observation that the solid dissolved or a colourless solution was formed was commonly missed. Statements such as ‘a gas was given off’ are not observations.

(b) The majority of candidates identified carbon dioxide correctly.

(c) (i) The majority of candidates reported the formation of a white precipitate. A significant number thought that the precipitate would be insoluble in excess aqueous sodium hydroxide when in fact it would dissolve.

(ii) Vague references to other cations giving the same result were not credited as specific mention of aluminium was required.

(iii) This was well answered with the use of ammonia or ammonium hydroxide being recognised. Some answers referred to ammonium alone and did not gain credit.

(d) Many candidates correctly identified the presence of sodium in solid **R** from the flame test. A number did not recognise the presence of iodide ions from the result of the halide test. Reference to iodine was common.

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Question 4

The complete range of marks was seen in this planning question. The quality of responses was often centre dependent.

Good responses weighed the sample of brass and used hot dilute sulfuric acid to react with the zinc component. Filtration of the residue, then washing and drying it before weighing the copper were the expected steps. Common errors were not using an excess of acid and failing to wash or dry the residue.

Weaker responses were confused and started with separate samples of zinc and copper, instead of brass.

A large number of candidates attempted to crystallise the salt from the filtrate or react the filtrate with magnesium to form zinc, not realising that subtracting the mass of copper from the initial mass of brass gave the mass of zinc. Many responses gained credit for showing how the percentage of zinc could be calculated even from a wrong method used to obtain the zinc.

A minority of candidates used the wrong method such as fractional distillation or electrolysis. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.

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Paper 0620/63
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Key messages

- Observations are those which can be seen. 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 the mark will not be awarded.
- Burette readings should be given to at least one decimal place and this includes '0.0' for a zero reading.

General comments

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

No question proved to be more demanding than the others; all discriminated equally well.

The vast majority of candidates were able to complete tables of results from burette readings on diagrams in **Question 2**. The most common error was to write a volume as 0 rather than 0.0.

Calculations were generally well done with correct rounding and inclusion of units.

Errors in **Questions 1(a)(c)(d)** and **2(b)(g)** suggest that some candidates have limited practical experience.

Question 4 was a planning task based on separating silica from toothpaste. Nearly all candidates used the correct sequence and generally performed well.

Comments on specific questions

Question 1

(a) The two pieces of apparatus that had to be identified were not well known; a delivery tube and a trough. Vague answers, such as container and tank, were not credited.

(b) Many candidates appreciated the role of the glass wool as holding the water. Some thought it was used as insulation or performed some absorption of products that were produced in the reaction.

(c) A small proportion of candidates appreciated the problem caused by the bung within the boiling tube as causing a build-up of pressure; many others misinterpreted the diagram. The most common error was stating that the apparatus would fall and break because there was a lack of support shown for the test-tube and boiling tube. Diagrams often do not show the position of clamps as it is assumed that apparatus cannot just float without being held in position. Other candidates focussed on the flammability of hydrogen or the fact that the collection tube was full of water; possibly evidence of a lack of practical experience.

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(d) A good proportion of candidates were able to correctly locate the position for heating under the zinc and glass wool; there were many other candidates who incorrectly heated the boiling tube or trough. A significant number of candidates did not answer this question, presumably because they did not see it because of the lack of an answer line. Candidates should be encouraged to read the entire paper.

(e) Most candidates knew the test and result for hydrogen.

Question 2

(a) Most candidates could read the burettes correctly and work out the volume used. The most common error was to write the zero volume as 0 rather than 0.0. Readings should be recorded in a consistent manner in terms of decimal places. Candidates should know that the final burette reading will always be higher than the initial reading.

(b) Candidates often struggled to express themselves clearly, possibly because they had a limited experience of titrations. Many concentrated on the colour of the indicator, instead of mentioning colour change or end point.

(c) (i) This question was well answered, although some candidates could not equate concentration and volume correctly.

(ii) Nearly all responses gave the correct ratio from the figures.

(d) The calculation and the unit were given correctly by a large majority of the candidates, with many correctly rounding 4.96 up to 5.

(e) Candidates continue to confuse reliability, accuracy and precision. Most mentioned repeating the experiment but continue to think that taking an average or mean is a method of checking the reliability of the results, rather than the correct answer of comparing them for consistency.

(f) (i) Nearly all responses stated that the pipette was more accurate than the measuring cylinder.

(ii) It was rarely mentioned that the pipette could only measure a fixed volume of $25\,cm^3$. Most candidates did realise that the volume of solution **A** ($37.2\,cm^3$) was more than $25\,cm^3$.

(g) (i) Nearly all responses stated that rinsing the burette with distilled water was to remove the remains of solution **A** from the first experiment.

(ii) Most candidates realised that the distilled water from the first rinsing needed to be removed from the burette. A minority incorrectly thought that solution **A** was still being removed.

(iii) Many candidates did not appreciate the dilution effect that distilled water in the burette would have if not removed by solution **B**. Those who did usually concluded that the volume would be greater. Some candidates gave vague answers such as that the burette reading would be inaccurate rather than specifying that it would be larger.

Question 3

(a) This question was very well answered by most candidates, who recognised the pH was within the range 3 to 6.

(b) This was possibly the best answered question on the paper with the vast majority recognising carbon dioxide.

(c) The conclusion that the compound was acidic was the most common correct response; a number also correctly said that it was hydrated. The black residue on heating led some better responses to suggest that it was organic or contained carbon, both of which were credited. However, some thought that it was a carbonate because of the evolution of carbon dioxide, forgetting that sodium carbonate was the other reagent.

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(d) (i) The formation of a white precipitate was very well known.

(ii) Most responses went on to say that the precipitate was insoluble in excess.

(e) The reaction with ammonia was found to be more challenging, partly because the few drops and excess were included in the same question part. Some candidates did not make it clear which part of the question their answer was referring to. However, many did realise that calcium ions gave little if any precipitate with ammonia.

(f) The white precipitate with silver nitrate was very well known.

(g) The negative test was also well known.

Question 4

Candidates are getting familiar with this type of question and their performance continues to improve.

Most candidates weighed the toothpaste and then unnecessarily dissolved it in water and filtered, washed and dried the residue before adding hydrochloric acid. At the second filtration, after adding the acid, some did not mention washing and drying again. Candidates rarely used an 'excess' when adding the hydrochloric acid. Many thought that waiting until the fizzing had stopped was the same as adding an excess, despite the fact that the acid could be the limiting reagent. Most candidates weighed the silica and correctly stated how the percentage in toothpaste would be calculated. Some confused the residue with the filtrate. A few incorrectly stated 'calculate the weight' rather than 'measure the weight' or even just 'weigh'.

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