

# CHEMISTRY

Paper 0620/11  
Multiple Choice (Core)

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

## General comments

Candidates found this to be a challenging paper. Although the average mark was similar to previous series, fewer candidates scored the higher marks.

Overall candidates found **Questions 4, 7, 13, 14, 23** and **30** to have the least challenge.

**Questions 8, 12, 18, 28, 32, 33** and **34** were most demanding.

Candidates did well in questions involving atomic structure and bonding.

In common with the theory paper and previous series, candidates found the recall of qualitative tests to be demanding.

Most of the questions on organic chemistry were challenging.

## Comments on specific questions

### Question 1

Most candidates recognised that the description of particles moving from high to low concentration must be describing diffusion. Most of the weaker candidates chose **Distractor D** which is the movement of particles in a liquid. Candidates could compare the movement of a scent in a large classroom to that of a dye in a swimming pool to consider which one would have the faster moving particles.

### Question 3

Most candidates recognised that Group II elements form ions with a charge of +2 and few chose **Distractor C** or **D**. There was an even split between **Distractor B** and the correct answer suggesting that many candidates did not know that a positive charge indicates a loss rather than a gain of electrons.

### Question 12

This was a demanding question with a large majority of candidates choosing **Distractor A**. When fuels are burned, thermal energy is released but the chemical products depend on the fuel burned. If hydrogen is burned then only water is produced.

### Question 18

Candidates needed to identify the solubility of many different salts and their mixtures. Very few identified the correct mixture with most choosing the first option, **Distractor A**.

### Question 21

Nearly all candidates identified structure 3 as a noble gas. A third of candidates did not recognise that structure 1 represents helium, another noble gas. **Distractor D** was therefore the most common incorrect answer.

### Question 25

This question discriminated well between the most and least able candidates. The least able were more likely to choose **Distractor B** or **C** as the metal extracted from bauxite.

### Question 26

Although most candidates recognised that metal ions in drinking water are not always beneficial, the other options were almost equally likely to be chosen. Weaker candidates in particular were more likely to confuse soluble and insoluble and choose **Distractor D**.

### Question 28

Candidates should take care to consider the whole statement. A large majority of candidates chose **Distractor B** which is partially correct but describes alkanes as having ionic bonds.

### Question 32

As a whole, the options were almost equally likely to be chosen suggesting that many candidates were guessing. Cracking is often a difficult concept for candidates and even amongst the more able candidates only a minority identified the production of both hydrogen and alkenes.

### Question 33

Many candidates confused the different methods of manufacturing ethanol. **Distractors A** and **B** were chosen by half of the candidates. These options give the correct temperature for fermentation, not the addition of steam to ethene.

### Question 34

**Distractor A** was the most common answer. Candidates should recall that hydrogen is only produced when a pure metal rather than a metallic compound reacts with an acid (or water).

### Question 38

Few candidates chose **Distractor A** or **C** showing recall of the filtration process. Whilst half of the candidates recognised that copper(II) hydroxide is insoluble, many did not identify both sand and calcium carbonate as both being insoluble.

**Question 39**

Two thirds of the candidates recognised that ammonia turns damp red litmus blue. There was, however, more confusion in distinguishing the tests for hydrogen and oxygen. **Distractor A** was chosen by over half of the weaker candidates.

**Question 40**

Many candidates were unable to recall the only ion from the list which gives a blue precipitate. All the distractors were functional.

# CHEMISTRY

Paper 0620/12  
Multiple Choice (Core)

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

## General comments

Candidates found this to be a challenging paper. Although the average mark was similar to previous series, fewer candidates scored the higher marks.

Overall candidates found **Questions 6, 16, 34 and 38** to have the least challenge.

**Questions 10, 13, 14, 15, 21, 28 and 30** were most demanding.

Questions involving the interpretation of practical tasks or observations were not well answered.

Most candidates recalled the terminology in atomic structure but application to form ionic bonds or the relative mass of the particles was not well known.

## Comments on specific questions

### Question 1

Only half of the candidates recalled that solids and liquids are not easily compressed. A quarter of candidates assumed that liquids can be easily compressed and chose **Distractor B**.

### Question 4

This question discriminated well between the weakest and strongest candidates overall. Half of the weaker candidates chose **Distractor A**, confusing the relative mass of the electron.

### Question 7

This question discriminated well between the weakest and strongest candidates overall. Weaker candidates were more likely to choose any of the distractors than the correct answer.

### Question 10

Many candidates thought that hydrogen is a product of combustion and chose **Distractor D**. Candidates should know that hydrogen is a reactive gas which combines with oxygen through its reaction in the test for hydrogen gas and in the hydrogen–oxygen fuel cell.

### Question 13

The gaseous products of the electrolysis of dilute sulfuric acid were not well known. More than half of the candidates assumed that one of the gases was brown and chose **Distractor A** or **D**.

### Question 14

The majority of candidates confused the direction of the temperature change during an exothermic reaction. The most common answer was **Distractor A**.

### Question 15

When determining the rate of a reaction, a variable is measured against time so a stop-watch would be essential. In an investigation of the effect of temperature, a thermometer would be needed. Other apparatus may or may not be used depending on the nature of the experiment. Perhaps distracted by the diagram in the preceding question, many candidates chose **Distractor B**.

### Question 21

This question was very demanding and across all the candidates, many appeared to be guessing with all the options equally chosen. The solubility of salts was not well known.

### Question 23

Just over a third of the candidates identified the correct change down Group I. **Distractor A** was the most common incorrect answer.

### Question 24

The appearance of the halogens was not well known. All the options were chosen with **Distractor A** being the most frequently chosen option.

### Question 28

Candidates found this a very challenging question. Although few thought that copper had a low density and was used in aircraft manufacture, many chose **Distractor C**, perhaps misunderstanding the meaning of the word 'ductility'.

### Question 30

The reactions within the blast furnace for the extraction of iron from its ore were not well known. Although the options described correct reactions, few identified the thermal decomposition. **Distractor B** was the most common answer.

### Question 35

This question discriminated between the weakest and strongest candidates overall. Although the stronger candidates found this a challenging question, weaker candidates chose each option equally and so appeared to be guessing. The link between reactions and the general formula of the homologous series was not well known.

# CHEMISTRY

Paper 0620/13  
Multiple Choice (Core)

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

## General comments

Candidates found this to be a challenging paper although most questions showed good discrimination between the candidates.

Overall **Questions 2, 9, 20, 28** and **37** had the least challenge.

**Questions 8, 10, 22, 31, 33, 35** were most demanding.

The general properties of matter in terms of particles were well known.

Most of the questions on organic chemistry particularly those on polymerisation were not answered correctly by many candidates.

The solubility rules and qualitative tests were not well known.

## Comments on specific questions

### Question 4

Weaker candidates found it difficult to predict the bonding type from the information given. Many chose **Distractor A** or **B**. Candidates could either use their Periodic Table to identify the 'real' elements represented by the diagrams or to recognise that these are Group I and Group VII elements and so will form an ionic compound.

### Question 7

The majority of the weaker candidates chose **Distractor B**. Although the attraction described is a strong electrostatic attraction an ionic bond is between the positively and negatively charged ions.

### Question 8

The properties of simple molecular compounds were not well known. It is recommended that candidates consider a known example such as carbon dioxide or water and to compare the properties of this substance with the options given. **Distractor A** was the most commonly chosen answer. Candidates should know that water does not have a high melting point (0 °C) and that it does not conduct electricity.

### Question 10

The most common answer was **Distractor A**. Although a molecular formula does show the total number of atoms in a molecule, it shows more information than that. A molecular formula such as C<sub>4</sub>H<sub>10</sub>O shows the number of each type of atom in the molecule.

### Question 16

The reversible reaction of hydrated copper(II) sulfate to anhydrous copper(II) sulfate was not well recalled, especially by the weaker candidates overall. Many of those candidates chose **Distractor A** or **B**.

### Question 18

The colour of thymolphthalein indicator was known by only a small majority of the candidates. Although there was a slight preference for the correct answer, all of the options were popular choices.

### Question 21

Most candidates recalled the trend in reactivity down Group I. Fewer recalled the trend down Group VII and chose **Distractor D**.

### Question 22

This question was not well answered. Candidates should recall that nitrates are always soluble. Most candidates appeared to have been guessing with **Distractor C** being slightly more popular.

### Question 23

Candidates were as likely to choose **Distractor D** as the correct answer. Candidates should be reminded that metals combine in many different ratios to form a mixture called an alloy. They do not form compounds.

### Question 26

Few candidates recalled the role of carbon in removing tastes and odours from the domestic water supply. **Distractor A**, chlorine, was the most common answer.

### Question 31

The different organic reactions were not well known. Although candidates chose all the options, the most common answer was polymerisation, **Distractor A**. Candidates are reminded that alkenes rather than alkanes polymerise and that other than combustion, alkanes react by substitution only.

### Question 33

This was one of the least well answered questions on the paper. The reactions involved in the manufacture of ethanol were not well recalled. Candidates were more likely to choose **Distractor B** or **C** than the correct answer.

### Question 35

This question, which does show polymerisation, was not well answered. Similarly to **Question 31**, candidates did not recall the homologous series involved in polymerisation. Only a minority recalled the name of the alkene monomer and less than a quarter of the candidates identified the correct polymer and monomer names.

# CHEMISTRY

Paper 0620/21  
Multiple Choice (Extended)

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

## General comments

Candidates found this to be an accessible paper overall with many questions showing good discrimination between candidates. A good spread of marks was seen with a small number of candidates answering all questions correctly.

Overall candidates found **Questions 1, 3, 4, 16 and 28**, to have the least challenge.

**Questions 8, 12, 17, 21, 24 and 38** were most demanding.

Candidates showed good understanding of atomic structure, nuclide notation, structure and bonding and the properties of substances.

In common with previous series and the theory papers, candidates struggled to recall qualitative tests and the rules about salt solubility.

Most of the questions on organic chemistry, particularly questions on polymerisation were challenging.

## Comments on specific questions

### Question 2

Fewer than half of the candidates answered this question correctly. Many candidates, particularly the weaker candidates recalled that the key factor was the rate of diffusion but chose option **B** which would give the opposite effect to the one observed.

### Question 8

This question discriminated well between the most and least able candidates. Option **A** which has an error in the formula and Option **C** which has an incorrect ratio of reactants were the most common incorrect answers.

### Question 12

Only one in five candidates answered this question correctly. The most popular answer was option **A**. Although oxygen is produced when aqueous copper(II) sulfate is electrolysed using *inert* electrodes, copper is not an inert electrode. When using copper electrodes, copper(II) ions are produced at the positive electrode at the same rate they are used up at the negative electrode.

### Question 13

Most candidates identified the correct products and so deduced the correct half-equations. The weaker candidates overall were much more likely to reverse their order and so choose option **B**.

### Question 17

The distribution of answers suggests that many candidates were guessing. Candidates should recall that the Contact process produces sulfur trioxide,  $\text{SO}_3$ , in a gaseous (not aqueous) reaction.

### Question 18

Oxidation numbers are a challenge for many candidates and this question discriminated well between the most and least able candidates. Weaker candidates were more likely to choose option **A** or option **B** missing the clue in the question regarding manganese(VII) ions.

### Question 19

Most candidates recognised that an increase in pressure would increase the yield of ammonia. The direction of equilibrium movement following a temperature change was less well known and a third of candidates chose option **D**.

### Question 21

The solubility of salts was not well recalled. Half of the candidates chose option **A**, perhaps not recalling the solubility of calcium sulfate.

### Question 24

This question was not well answered. Many candidates appeared to have been guessing. It was anticipated that most candidates would recall the trend in reactivity down Group I but option **A** and **C** were frequently chosen.

### Question 25

Most of the stronger candidates overall answered this correctly. Weaker candidates appeared to have been guessing. Whether considering Group VII or aqueous metal ion displacement reactions, candidates are reminded that the most reactive elements are the most likely to react to become ions at the end of the reaction.

### Question 29

Most of the stronger candidates answered this questions correctly. Weaker candidates were more likely to choose any one of the distractors. Overall option **D** was the most commonly chosen incorrect answer with candidates confusing the anode and cathode. Candidates are reminded that cations are attracted to the cathode.

### Question 35

Less than half of the candidates were able to identify the correct monomer and polymer. Option **B** shows a structure containing carbon atoms with 5 bonds so should be easily eliminated. For all addition polymers, the repeat unit of the basic chain is always 2 carbons long so option **D** should also be eliminated. Most of the weaker candidates chose these two distractors.

### Question 38

This question, also on polymers, was answered correctly by just over a third of the candidates. Although many examples of addition polymers contain carbon and hydrogen only, described by option **A**, addition polymers such as PVC or PTFE contain atoms of other elements.

# CHEMISTRY

Paper 0620/22  
Multiple Choice (Extended)

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

## General comments

Candidates found this to be an accessible paper overall with many questions showing good discrimination between candidates. A small number of candidates answered every question correctly although a few scored lower than the 'guessing average' and may have been better advised to consider Paper 1 rather than Paper 2.

Overall candidates found **Questions 4, 16, 25, 32 and 40** to have the least challenge.

**Questions 9, 10, 26 and 34** were most demanding.

Questions on atomic structure, ionic or covalent bonding were well answered as were most of the calculations.

More candidates answered question on pollutant gases correctly than on previous series.

Although not poorly answered, there was a noticeable drop in the number of candidates answering questions on organic chemistry correctly compared to the rest of the paper.

## Comments on specific questions

### Question 1

Most candidates recognised that the volume of a gas would increase when the temperature was increased. Fewer recognised that decreasing the pressure would also increase the volume and so chose option **C**.

### Question 3

Almost half of the weaker candidates overall thought that hydrogen chloride gas would not change the colour of damp blue litmus and chose option **D**. The  $\text{HCl}$  gas would dissolve in the water to form hydrochloric acid which would change the colour of the litmus to red.

### Question 9

Fewer than a third of the candidates answered this question correctly. Option **D** was chosen by almost half of the candidates. Metallic (and ionic) structures are always giant.

### Question 10

Just over a third of candidates answered this question correctly with the weaker candidates more likely to choose any of the other distractors. Option **B** was the most commonly chosen answer which has incorrect stoichiometry.

### Question 12

The hydrogen–oxygen fuel cell was not well recalled. Most candidates confused the process with electrolysis and chose option **A** or **B**. Similarly a third of candidates thought that hydrogen and oxygen were reaction products rather than the reactants in a chemical reaction.

### Question 15

Few candidates chose option **C** or **D** suggesting that most knew that thermal energy is absorbed during an endothermic reaction. The direction of temperature change was an even split between the correct answer and option **B**.

### Question 19

The concept of oxidation numbers was not well known with many candidates confusing oxidation number and the overall charge in a compound ion. Option **A** was the most common incorrect answer with relatively few choosing option **B** or **D**.

### Question 24

The more able candidates overall did not find this question difficult whereas most of the weaker candidates chose option **D** possibly confusing pure iodine with aqueous iodine which has a red-brown colour.

### Question 26

Only a quarter of the candidates answered this question correctly. When carbon is used to extract a metal from its oxide, such as in a blast furnace, the metal must be lower in the reactivity series than carbon. Reactive metals are not extracted from their oxides using carbon. Many candidates confused the reactivity order of T and S and chose option **B**.

### Question 34

Structural isomers have the same molecular formula but a different structure. The structures of 1, 2 and 3 are all identical showing four carbon atoms in a continual chain. Only structure 3 is different showing 3 carbons in a continual chain with one carbon atom as a side branch. Many candidates thought all four structures were different and chose option **A**.

### Question 39

The required volume was  $13.7 \text{ cm}^3$ . This is a volume not a mass so option **A** must be incorrect. The decimal place indicates that apparatus with a greater precision is needed so option **C** is incorrect. Volumetric pipettes measure fixed single volumes such as  $10 \text{ cm}^3$ ,  $20 \text{ cm}^3$  or  $25 \text{ cm}^3$  so option **D** is incorrect. The burette is the apparatus used to precisely measure volumes less than  $50.0 \text{ cm}^3$ .

# CHEMISTRY

Paper 0620/23  
Multiple Choice (Extended)

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

## General comments

Candidates found this to be an accessible paper overall with many questions showing good discrimination. The average mark was a little higher than in previous series although none of the candidates answered every question correctly.

Overall candidates found **Questions 3, 4, 7, 10, 23** and **37** to have the least challenge.

**Questions 30, 33, 35** and **36** were most demanding.

Questions involving atomic structure, nuclide notation, bonding and general properties of substances were well answered.

In common with other papers, questions requiring the use of oxidation numbers and half-equations were not well answered.

Most of the questions on organic chemistry were challenging, particularly those which required identification of the products of reaction or polymerisation.

### Comments on specific questions

#### Question 9

This question discriminated well between the most and least able candidates overall. Weaker candidates were more likely to choose any one of the distractors. With only one oxygen atom, butan-1-ol must have a molecular formula that is the same as its empirical formula. The most common incorrect answer was option **B**, but-1-ene.

#### Question 16

Few candidates chose option **A** or **D**. Weaker candidates were most likely to choose option **B**, confusing the formation of bonds with an endothermic process. The language used in this distractor was more complex than for other questions.

#### Question 19

Most candidates recognised that equilibrium yield is not affected by the additional of a catalyst. Weaker candidates were more likely to confuse the effects of temperature and pressure and choose option **B**.

#### Question 22

The use of oxidation numbers and the terms oxidation and reduction are often challenging for candidates. The weaker candidates appeared to be guessing in this question although fewer overall chose option **C** which suggests that there was some recognition that the copper metal did not gain electrons.

#### Question 25

Most of the stronger candidates identified the only amphoteric oxide as the metal oxide that would react with aqueous sodium hydroxide. Weaker candidates were more likely to any one of the distractors with option **A** being the most commonly chosen.

#### Question 27

Fewer than half of the candidates identified properties of Group I or Group VII elements. Many candidates chose option **C** which describes the incorrect trend of melting points in Group I elements.

#### Question 30

Nearly half of the candidates chose option **C**. Candidates are reminded that the Earth emits thermal energy and it is some of this energy that the greenhouse gases absorb and re-emit back to the surface.

#### Question 33

Only a minority of candidates recalled the reaction that erodes the electrodes in the extraction of aluminium from bauxite. Option **D** was the most common answer.

#### Question 35

This was one of the most challenging questions on the paper. Candidates needed to identify either a diol or a diamine or a monomer which contained both an amine group and a hydroxyl group. Most candidates identified only two of these possibilities and chose option **B**.

#### Question 36

Candidates are reminded that in the reaction of an alkene, the atoms present are added to the alkene to make a larger compound. If bromine,  $\text{Br}_2$ , is added, the product must contain two Br atoms. The most common answer was option **B** which only contains one Br atom.

#### Question 38

Although carboxylic acids and alcohols can react to form esters, the mixture described does not form ethyl methanoate. Weaker candidates in particular were most likely to choose option **C**.

### Question 39

This was a relatively difficult question, requiring candidates to identify two different ions tests. The most popular incorrect answer was option **A**. The yellow flame identifies sodium ions but sodium ions do not give a precipitate when tested with aqueous sodium hydroxide.

### Question 40

Although this question, on first inspection, appears to be complex, candidates could break the options down into simpler parts. In the options, step 3 and step 5 have a particular order. The drawing of the pencil line must appear early in the procedure, and the locating agent must be later. From this option **A** and **C** can be eliminated. A similar process can be used for other steps such as 3 and 6 to eliminate option **B**.

# CHEMISTRY

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Paper 0620/31  
Theory (Core)

## Key messages

- Candidates should read each question carefully, so they are sure to answer the question asked. Repeating the question or vague answers should be avoided.
- Candidates should be able to identify all the elements, ions and compounds named in the syllabus.
- Qualitative tests were poorly recalled, and further practice of practical work in this topic and in the reactivity of metals, with appropriate teacher demonstration, would be beneficial.

## General comments

Overall, a wide range of marks was seen on this paper, with discrimination between candidates.

Recall and application of knowledge of atomic structure, electron arrangement and bonding was good. Most candidates could interpret data presented numerically, **Questions 3(a)** and **4(f)**, graphically, **Question 8**, or descriptively, **Question 6(c)**, to make sensible conclusions.

The extraction and properties of metals and alloys were not well remembered in **Question 6**. Chemical reactions such as Group I metals with water, as seen in **Question 5(e)**, were not well known. It is recommended that candidates gain more practical experience to reinforce understanding in these essential reactions and to practice writing basic chemical formulae and equations. The lack of understanding among some candidates of practical chemistry was also seen in **Question 3(d)** where candidates confused distillation with filtration.

When answering descriptive questions or questions requiring a definition or use, candidates should read the question carefully to ensure they are answering the question asked and in sufficient detail. For example, in **Question 5(d)** candidates often gave chemical rather than physical properties; in **Question 6(b)(ii)** answers were often vague, and in **Question 7(a)** partial answers were common.

Chemical tests such as those in **Questions 1(a)**, **3(a)(iii)** and **5(e)(ii)**, were not well known. Many candidates did not attempt these questions.

## Comments on specific questions

### Question 1

- (a) Although most candidates recognised that the flame test is used to identify metallic ions, fewer than half of the candidates recalled the correct metal.
- (b) Most candidates recalled that diamond is one of the forms of carbon. Some candidates thought that diamond was metallic and suggested Cu, Zn or Fe.
- (c) Many candidates recalled the link between group number and the ionic charge. Some did not recognise the significance of the sign and chose Mg as the ion with a charge of 2–.
- (d) Iron, Fe, was the most common answer, with a small number choosing other elements, including some non-metals. Fewer than a third of candidates recalled that bauxite is an ore of aluminium.

- (e) This question was the best answered question in **Question 1**. All candidates recognised that a metallic element was required but some chose metals that are not used in electrical wiring.

### Question 2

- (a) This question was well answered. Nearly all candidates interpreted the nuclide notation to give the number of protons and neutrons.
- (b) (i) Candidates recognised the significance of the prefix 'mon' and described one or a single particle within their answer. Many were unsure about the 'atomic' part and described the number of electrons in an atom or the number of shells in an atom, or that there was only one element present.
- (ii) Although many candidates answered this question correctly, some candidates gave an incomplete answer and so did not gain credit. The question asks for an explanation using electronic configuration. The configuration alone is not sufficient. The significance of the configuration must be described. A small number of candidates made a correct statement about argon, but not one which answered the question, e.g. 'it is a non-metal' or 'it does not conduct electricity.'
- (c) The effect of changes in pressure and temperature on the volume of a gas was mostly well recalled, with most candidates gaining partial credit.

### Question 3

- (a) (i) Most candidates identified the positive ion with the greatest concentration. A small number chose the ion with a negative charge.
- (ii) The question was not well answered. Few candidates recalled the formula of a sulfate ion. A small number gave the formula without the correct charge, 'SO<sub>4</sub>', 'SO<sub>4</sub><sup>-</sup>' and some gave the sulfide ion 'S<sup>2-</sup>'.
- (iii) Very few candidates recalled the test for an iodide ion. A third of candidates did not attempt this question.
- (iv) This question was well answered, with most able to complete the calculation to find the mass of ions.
- (b) It was anticipated that candidates could use the formula of the ions to answer this question. A third of candidates did not recognise that the N, P and K of the fertiliser represent the chemical symbols of the elements present.
- (c) The pollutant ions responsible for deoxygenation were not well recalled. Some candidates identified either nitrate or phosphate, but hydrogencarbonate was a common incorrect answer, and some candidates appeared to have been guessing, suggesting ions such as sodium or lithium.
- (d) Although any form of distillation would be accepted as an answer, almost a third of candidates thought that the apparatus was showing filtration.

### Question 4

- (a) This question was well answered. A few candidates incorrectly gave their answer using commas, 'or (semi)colons, which is incorrect. No punctuation is used in a molecular formula.
- (b) Where candidates are required to modify or add onto a figure or diagram, there is often a high number of candidates who do not attempt the question. Here, nearly all the candidates attempted the question. When identifying the part of the molecule responsible for unsaturation, only the C=C should be circled. All other atoms, such as hydrogen or neighbouring carbons, should **not** be circled.
- (c) This question was well answered by candidates.

- (d) A hydrocarbon is a compound containing hydrogen and carbon only. Common incorrect answers described it as a 'mixture', or an 'atom', or an 'element' or did not indicate that carbon and hydrogen are the only elements present.
- (e) (i) Although a small majority answered this correctly, many sensibly assumed that the answer must be either the fraction at the top or at the bottom of the column. As a result, 'lubricating oil' was a common incorrect answer.
- (ii) Many also here assumed that the correct answer must be either at the top or the bottom of the column. A small number suggested 'petroleum', which is the whole mixture, not one of the fractions.
- (iii) Most candidates answered this correctly, although all the other fractions were chosen overall.
- (f) (i) This question was well answered by candidates.
- (ii) This question was well answered by candidates.
- (g) (i) Around one fifth of the candidates did not attempt this question. Cracking or thermal decomposition are correct terms for this reaction. Some candidates suggested other organic reactions such as reduction, oxidation or combustion, and a few gave answers which were close, such as 'decomposition' but omitted the essential part 'thermal'.
- (ii) Most candidates recognised that there were two carbon atoms in each ethene molecule. The most common errors were to show a C=C double bond and the hydrogen atoms per carbon, or a single bond and two hydrogen atoms per carbon.
- (h) (i) This was the least well answered question on the paper. Over a third of candidates did not attempt the question, and few of those could recall that this is an example of addition polymerisation. The most common responses were attempts to name the polymer produced or to name the homologous series, alkenes, used to produce this type of polymerisation.
- (ii) This question allowed a wide range of potential answers. Often the candidates' answers were too vague to be worthy of credit. Candidates tended to name many different environmental problems but not with a description of how the plastic caused these problems. For example, 'climate change' or 'acid rain' could be considered if the combustion of waste plastics was described but not if left unqualified.

#### Question 5

- (a) Few candidates achieved both marks. Chlorine was not well known to be a gas, although more knew that it was (yellow)-green in colour.
- (b) Candidates should note that chlorine is used in the treatment of the domestic water supply to kill harmful micro-organisms and not to remove them, which suggests a form of separation or extraction.
- (c) This question was well answered, although some candidates did not appear to use the information given and simply assumed that 195°C was sufficiently elevated to turn any substance to a gas.
- (d) Around a third of candidates recognised that potassium is a metal and so would have most of the characteristic properties of metals. Some candidates correctly recalled a property of potassium but gave a chemical rather than a physical property.
- (e) (i) It was anticipated that most candidates would recall the experimental demonstration of a Group I metal with water. However, one in ten of the candidates gave no response and many only noted that effervescence is seen. Many candidates did not understand the difference between an observation and an inference about products formed or their chemical names.
- (ii) A quarter of the candidates did not attempt this question and few of those who did could recall the test for hydrogen. Several candidates showed some knowledge of the test by naming it as 'the pop test', but this is insufficient to describe the procedure.

- (f) This question was well answered. A small number gave oxygen as O rather than O<sub>2</sub> and some gave potassium as K<sub>2</sub> rather than K.
- (g) This question was well answered by candidates.
- (h) Some candidates confused the charge of the ions or gave the electronic configuration of each atom rather than that of the ion but overall, this question was generally well answered.

### Question 6

This was the most demanding question on this paper. The processes and reactions in the blast furnace were not well known.

- (a) (i) The burning of carbon (coke) to provide heat was not well recalled. Very few candidates recalled the reduction of the iron(III) oxide.
- (ii) The formation of slag from impurities in the ore and the calcium oxide produced by thermal decomposition of limestone was not well known. Approximately a quarter of the candidates made no attempt at this question.
- (iii) Candidates were more familiar with this question. Common errors were to describe the iron(III) oxide rather than the carbon monoxide required or to not be clear which species they were describing.
- (b) (i) The metals in stainless steel were not well known. Many candidates suggested elements which are not metallic or suggested the metals present in brass such as zinc and copper.
- (ii) When describing a use for a metal or an alloy, candidates should be specific. Answers such as 'for buildings', 'for ships' or 'to conduct electricity' are too vague and do not gain credit.
- (c) (i) This question was well answered by candidates.
- (ii) Some candidates tried to answer questions involving word equations by simply swapping words around. Examples include 'calcium acid' or 'ethanoic.' Although a few candidates gave a perfect answer, many suggested water or carbon dioxide as reaction products.

### Question 7

- (a) When describing electrolysis, candidates should describe both the breaking down of the ionic compound and that this is caused by the passage of an electric current. Many candidates gave answers which did not include one or both points.
- (b) Around a quarter of candidates did not attempt this question. Candidates should be reminded that 'cations are attracted to the cathode' to help them remember which electrode is which.
- (c) When sulfuric acid is electrolysed, hydrogen and oxygen are produced. Some candidates suggested that the gas was sulfur dioxide or solid sulfur. Many appeared to be guessing and gave answers such as 'copper' or 'chlorine.'
- (d) (i) The term inert for unreactive was known by just over a third of candidates but almost one in five candidates made no attempt at this question. Incorrect answers include 'immobile', 'uncharged' or 'non-conductor.'
- (ii) Most candidates correctly identified a use for graphite either as a lubricant or as the core of a pencil.
- (e) (i) The difference between chemical and physical changes was not well known. Those that answered correctly recognised that new substances were made so a chemical change must have occurred.

- (ii) Just over half of the candidates recognised that a solid could be separated from an aqueous mixture by filtration. Some suggested evaporation, which would remove water but not the excess copper(II) carbonate.

(iii) Candidates should be able to recall several different reactants that could form a salt from a specific acid. These include oxides, hydroxides, carbonate or sometimes a pure metal. In this question, few candidates could suggest an alternative reactant, and many appeared to not understand the significance of the (II) of copper(II) sulfate. 'Add copper(II)' was a typical incorrect answer.

(f) This question was well answered by candidates.

### Question 8

(a) Although most candidates answered this correctly, a significant number did not answer the question asked and gave the maximum volume rather than the time taken. A small number gave 160 s, the highest time given on the graph.

(b)(i) Most candidates identified that a larger solid would slow the reaction, but many gave their answer in terms of rate. The question asked for the reaction time.

(ii) Only a small majority of candidate recognised that if the amount of reactant is constant, that the final amount of product will be constant, irrespective of reaction rate.

(c) Many candidates identified the reaction as exothermic. Fewer used the relative energy of the reactants and products in their answer, or they described information not given by the diagram, such as temperature change.

# CHEMISTRY

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Paper 0620/32  
Theory (Extended)

## Key messages

- Candidates should read each question carefully, so they are sure to answer the question asked. Repeating the question or vague answers should be avoided.
- Candidates should be able to identify all the elements, ions and compounds named in the syllabus.
- Qualitative and physical tests were poorly recalled as were expected observations during chemical reactions. Further practice with practical work and teacher demonstration would be beneficial.
- Extraction of data from tables, graphs and diagrams was good.
- Candidates should check that all questions are answered, especially those which require them to modify or add to a labelled figure.

## General comments

A wide range of marks was seen allowing discrimination between candidates.

Most candidates could select information from a table or graph, **Questions 3(a), 4(c), 4(f), 6(c) and 8(a)**, but further processing or describing the data was less well completed.

Atomic structure and bonding were well known, such as **Questions 2(a) and 5(g)**.

The reactions and reactivity of Group I elements were not well known. In **Question 1(c)**, many thought that Na or K would not react with steam and few candidates gave details of the reaction between sodium and cold water in **Question 5(d)**.

The least well answered questions often linked to practical work. Over a quarter of candidates confused chromatography with filtration or distillation in **Questions 3(d)(i) and 3(d)(ii)**. Few described the observations for the reaction of a Group I metal and water; qualitative tests were not well described in **Question 3(a)(iii)**, nor was the appearance of bromine in **Question 5(c)**. The colour of the indicator in **Question 5(f)(i)** was also not well recalled. Further practical work, coupled with the writing of relevant chemical names and formulae is recommended.

## Comments on specific questions

### Question 1

Many candidates found these initial questions more challenging than expected.

- (a) Only around a third of candidates recalled the use of carbon, in the form of graphite, as a lubricant. All the other elements were seen in the candidates' answers.
- (b) This question was not well answered. Just over a quarter of candidates recalled hydrogen ions being present in each dilute acid. Many candidates suggested an element that could provide the anion for a specific acid such as Cl or O, but others were possibly just guessing.

- (c) This was the best answered question part of **Question 1**, although fewer than half of the candidates identified silver, Ag, as the unreactive metal. Many candidates thought that Group I elements are unreactive and suggested sodium, Na, or potassium, K.
- (d) Many candidates remembered there is a link between group number and the charge of the ion that is formed. Most chose the positive rather than the negative ion and suggested sodium, Na, or potassium, K.

### Question 2

- (a) This question was well answered, with most candidates using the nuclide notation correctly. A small number inverted their answer or gave 36 for both electrons and neutrons, knowing that at least one would probably be correct.
- (b) Most candidates gained partial credit here, but few knew the effects for both changes. The effect of temperature on volume appeared to be the better known of the two changes.
- (c) Candidates are advised to learn clear descriptions of particle movement, separation and arrangement for each state of matter. Many answers were too vague. For example, 'the particles are closer together than in a gas', does not say whether they are touching or far apart when liquid and 'the particles move at a medium speed' does not describe their motion in a way that is clear. Some candidates described the bulk properties of liquids such as 'they take the shape of the container'.

### Question 3

- (a) (i) Most candidates identified the correct ion. A small number chose a positive ion such as potassium,  $K^+$ , or the negative ion with the second highest concentration, hydrogencarbonate,  $HCO_3^-$ .
- (ii) Very few candidates knew the ammonium ion. Some were close and suggested ammonia,  $NH_3$ , or ' $NH_3^{+}$ ' or gave the wrong charge, ' $NH_4$ ' or ' $NH_4^-$ ', but the most common answer was Am, where candidates assumed that the ammonium ion would have its own symbol on the Periodic Table.
- (iii) The test for a chloride ion was known by few candidates. Just under a quarter of candidates recalled that silver nitrate was used or that a white precipitate would form, but very few knew both. Around one in nine of the candidates did not attempt this question.
- (iv) A small majority of candidates completed this calculation correctly.
- (b) Many candidates were unclear why distilled water is used in practical chemistry. Some suggested a process that would add to the number of dissolved substances such as 'chlorination'. Many answers were too vague, such as 'purify it' or 'boil it'.
- (c) (i) Only around a third of candidates recalled why carbon is used in the treatment of water. The most common answer was to suggest 'killing micro-organisms'. Some gave vague answers such as 'to make it drinkable' or 'to make it safe'.
- (ii) Most candidates knew why water is chlorinated. The most common incorrect answer was 'to remove bacteria', which suggests a separation process. The crucial point is the bacteria are killed rather than extracted or removed from the water.
- (d) (i) Many of the candidates identified chromatography but almost a quarter of the candidates overall confused it with a different separation technique, such as filtration or distillation.
- (ii) Few candidates knew the terms associated with chromatography. Most labelled the solvent itself, some labelled one or more of the separated dots or the baseline. One in ten candidates did not attempt the question.

### Question 4

- (a) Most candidates answered this question correctly. Those that did not score, either did not give a molecular formula or used punctuation such as 'C<sub>10</sub>, H<sub>18</sub>, O' or 'C<sub>10</sub> + H<sub>18</sub> + O', which is not used in molecular formulae.
- (b) More candidates did not attempt this question than answered it correctly. Many chose a methyl group, -CH<sub>3</sub>, or the hydroxyl group, -OH. When circling the C=C double bond, candidates should be reminded to include both the C atoms and the double bond. Other atoms such as H should be excluded.
- (c) This question was well answered.
- (d) Many candidates were unaware that petroleum and crude oil are used interchangeably. As a result, crude oil or one of the fractions of petroleum were the most common responses.
- (e) (i)(ii) When considering the trends, most recognised that the correct answer was likely to be either the highest or the lowest fraction on the diagram. Unfortunately, most chose the wrong end of the list in each case or chose the bulk substance 'petroleum' rather than one of the fractions.
- (iii) All of the fractions listed were chosen as answers to this question suggesting that the uses of fractions are not well known.
- (f) (i) Most candidates identified nonene as the unsaturated compound.
- (ii) Almost one in ten candidates did not attempt this question. Many thought that unsaturation was linked to the melting or boiling point or the state at room temperature rather than the bonding and that both the formula and chemical name could help in identifying the compound.
- (g) (i) The reaction product of water (or steam) was not well recalled. Hydrogen and carbon monoxide were the most common incorrect answers.
- (ii) Candidates were asked to describe an adverse effect of the release of carbon dioxide. Effects such as climate change or changing weather patterns were the most common correct answers. A significant number of candidates gave references to UV light or ozone depletion, which is incorrect. A small number suggested acid rain.
- (h) (i) Many candidates recalled ethanol having two carbon atoms. The most common incorrect answers showed carbon with three or five (or more) bonds. Some candidates were unclear how the oxygen was attached to the rest of the molecule.
- (ii) Many candidates gained partial credit, but few could name the reactant, temperature and pressure. 'Glucose' or 'yeast' were seen as incorrect reactants and the temperature or pressure were often confused with that of fermentation rather than the catalytic addition of steam to ethene.

### Question 5

- (a) Some candidates only gave the electronic configuration. Questions requiring an explanation require more than a number. The prompt was to encourage candidates to identify the significance of the group number to outer-shell electrons. A small number of candidates identified the correct idea but mis-read the Roman numeral.
- (b) This is a common question type, but candidates seemed unsure how to answer it. Some did not give a physical state and described a change such as 'melting'. The reason given should have referred to both the melting point and the boiling points of tellurium, not just one, to indicate that the stated temperature is between these values. Some candidates only looked at the stated temperature, 650°C, and assumed that this was high enough for boiling to have occurred or referenced water and steam.
- (c) Most candidates could recall the colour. Fewer knew that bromine was a liquid at r.t.p. Some confused bromine with iodine or chlorine.
- (d) (i) This was not well recalled. 'Bubbles' was often the only observation stated. Although a wide range of potential answers was accepted, few recalled that sodium floats on water and moves around the

surface, sometimes giving a yellow-orange flame. Most candidates gave chemical names or the type of reaction or gas tests but not observations. Around one in eleven candidates did not attempt the question at all.

- (ii) Candidates found this challenging. Many confused sodium hydroxide for sodium oxide and some just gave sodium, which was the reactant.
- (e) Most candidates could identify the correct formula for water,  $\text{H}_2\text{O}$ . Few recalled the correct formula for sulfuric acid. Some deduced the formula by counting atoms in the equation rather than recall. The unusual formulae layout of ' $\text{SH}_2\text{O}_4$ ' or ' $\text{O}_4\text{H}_2\text{S}$ ' were seen.
- (f) (i) The colour of thymolphthalein in acidic and alkaline solutions was not well known.  
(ii) Most candidates recalled that an alkali is a soluble base.
- (g) This question was well answered by many candidates. Most recalled the correct charges on the ions. Some candidates tried to show the formation of the ions using extra electrons and arrows to show movement. This was not required, and many showed too many electrons or electrons on the wrong atom. Only the final ion should be shown.

### Question 6

- (a) (i) Over one in nine of the candidates did not attempt this question. The most common answers were 'hematite' or 'aluminium oxide' or 'aluminium ore'.  
(ii) The most common answer was to say that carbon is more reactive than aluminium. Some candidates contradicted the question and incorrectly said that aluminium is extracted in a blast furnace or gave the correct statement that aluminium is extracted by electrolysis, which does not answer the question asked.  
(iii) Many candidates described iron, or iron(II) losing oxygen rather than the iron(III) oxide. Some candidates described the effect on carbon, which was not asked.
- (b) (i) The majority of candidates answered this correctly. Some contradicted their answer by saying that the alloy was a mixture of a metal with another element to form a compound. The substance is only a mixture. It is not a compound.  
(ii) This question was well answered by candidates.  
(iii) It was anticipated that this would be a challenging question. Although it was only the better performing candidates overall who answered this correctly, some particularly good answers were seen.
- (c) (i) This question was well answered by candidates.  
(ii) This question was well answered by many candidates. Some became confused by use of the unfamiliar metal and changed one product to something more familiar, such as sodium chloride. Water was the most common incorrect other product. Candidates who performed less well tended to swap the names around to make 'strontium hydrochloric' or similar.

### Question 7

- (a) This question was well answered by candidates.
- (b) Most candidates identified the electrolyte, although a substantial number did not attempt this question.
- (c) Most candidates confused the electrodes and suggested magnesium as the product. A small number suggested chloride rather than chlorine.
- (d) (i) This question was well answered. Some candidates gave vague answers such as 'it is a metal' or 'it contains electrons'.

- (ii) Only a small majority recalled the use of carbon as graphite as a non-metal electrode. A large number of candidates suggested metallic elements.
- (e) This was the least well answered question on this paper. Few recognised that new substances are made during electrolysis, which describes a chemical change.
- (f) This question was well answered.

#### Question 8

- (a) Although a small majority answered this correctly, many gave either the time when the reaction first finished or misread the volume scale to give an incorrect value.
- (b)(i) The question asked for the reaction time. The most common incorrect answer described the reaction rate.
- (ii) Many candidates gave an incorrect answer, often assuming that a higher concentration increases reaction rate and the final yield rather than just the reaction rate.
- (c) Many candidates identified the exothermic reaction but explained their answer using information that was not given, such as temperature changes. Some candidates misinterpreted the diagram and assumed it described the energy released by the reactants and the energy released by the product rather than a change in energy between the two sets of substances.

# CHEMISTRY

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Paper 0620/33  
Theory (Core)

## Key messages

- Questions requiring simple answers to calculations were well answered, as were questions involving word equations. Candidates were able to easily calculate the relative molecular mass of a given compound, as in **Question 4(c)**.
- Candidates were easily able to put the metals in order of their reactivity, as in **Question 6(d)**. This showed that much practice had been done by the candidates using the past papers available.
- Questions where candidates had to deduce and predict a formula of an alcohol and a value for a melting point were answered well. Candidates were able to answer these types of questions well using the given data from the table, as in **Questions 4(e)(ii)** and **(iii)**.
- It is important that candidates read the question carefully to understand what exactly is being asked. This was evident in **Question 2(c)**, where candidates were mixing up the meaning of the words 'arrangement' and 'motion'.
- The answering of chemical test questions was not done well. The candidates' answers showed many large gaps in their knowledge. This is a part of the syllabus that needs to be practised more often. Candidates struggled with the question 'describe a test to identify the presence of nitrate ions in a sample of water', as in **Question 3(a)(iii)**, as well as the other chemical test questions seen on this paper.
- Organic chemistry questions were answered well. However, many candidates struggled to draw the structure of the organic compound, ethanoic acid, in **Question 4(h)**.
- Questions involving matching an element to a given statement were answered very well.

## General comments.

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Good answers were shown throughout the paper to several different questions. Most candidates found parts of every question challenging. Nearly all candidates were entered at the appropriate level. It was evident that many candidates are now using past paper practice as part of their revision programme, but more revision is needed on some aspects of the syllabus.

Misinterpretation of the question happened in some cases. The most common misinterpretation was in **Question 2(c)** which asked the candidates to 'describe the arrangement and motion of the particles in solid xenon'. Many candidates were confused with the meaning of these two words and some also described 'separation' instead. Many candidates also struggled with the different properties and uses of the fractions, as in **Question 4(d)**. Fractional distillation of petroleum is a topic that needs to be revisited many times during revision to consolidate.

The writing of word equations was good, demonstrating that candidates had practised these as part of their revision. Definitions from across the syllabus were well answered.

Questions with the command words 'deduce' and 'predict' were answered well by many candidates and many were able to justify their response to the prediction. Data handling type questions were answered better than in previous years. However, a few candidates were not precise enough when answering these types of questions.

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

### **Comments on specific questions**

#### **Question 1**

Candidates found this first question the easiest question on this paper. Candidates found **(a)** and **(d)** the easiest, and many achieved the correct answers.

- (a)** This question was answered extremely well. A few incorrect answers of Zn were seen.
- (b)** Candidates found this question slightly more challenging. Incorrect answers of Fe and Na were seen on a few occasions.
- (c)** Some candidates struggled with this question and thought that N was the correct answer.
- (d)** This question was answered well. Most candidates knew that the correct answer was C.

#### **Question 2**

Candidates found this question quite straightforward. However, some candidates confused the meaning of 'arrangement' and 'motion' in **(c)** and some described 'separation' instead.

- (a)** Most candidates knew how to work out the number of neutrons in the given element. However, there were quite a few candidates who did not know how to work out the number of nucleons.
- (b)** Candidates did find this question slightly more challenging. This is a topic that candidates need to practice and revise more.
- (c)** Candidates found this question challenging and many struggled with describing the arrangement and motion in solid xenon. Some candidates got 'arrangement' and 'separation' mixed up and others described the 'arrangement' and 'motion' in a liquid or a gas instead of correctly describing a solid.

#### **Question 3**

Candidates found this question one of the hardest on this paper. It also discriminated very well between candidates. Candidates found **(a)(iii)**, **(a)(v)** and **(c)(i)** challenging. This showed that more revision needs to be done on recalling the correct chemical tests and the sources of pollutant ions and microbes in river water.

- (a) (i)** Most candidates answered this question correctly.
- (ii)** Candidates found this question hard and struggled to name the ion correctly. Phosphorus oxide was a very common incorrect answer.
- (iii)** Candidates found this question one of the hardest on this paper. There were also many no response answers seen for this question. Candidates struggled to recall the chemical test needed to identify the presence of nitrate ions.
- (iv)** Many candidates were able to answer this calculation question correctly.
- (v)** Few candidates were able to state a source of a higher concentration of nitrate ions in river water.
- (b)** Most candidates answered this question correctly.
- (c) (i)** Candidates struggled to suggest a source of microbes in the water and many incorrect answers were seen.

- (ii) Many candidates could answer correctly with the use of 'chlorine' here. However, some thought that the answer was incorrectly 'filtration'.
- (d) This was a very good discrimination question. As expected only the better performing candidates could answer this question correctly.

#### Question 4

Candidates found this organic chemistry question quite hard, and it discriminated well between them. Candidates struggled especially on (h), which was drawing the displayed formula of ethanoic acid. However, candidates were able to easily deduce the formula of octanol in (e)(ii).

- (a) Candidates did well on this question, and many had practiced deducing the molecular formula of a compound. The elements can be placed in any order, but the numbers must be subscripts and not superscript.
- (b) Some candidates struggled to draw a circle around the part of the molecule which shows that the given molecule is unsaturated. This question had the most no response answers for a part question on this paper.
- (c) Most candidates were able to calculate the relative molecular mass of the given organic compound correctly. The candidates found this part question the easiest one on this paper.
- (d)(i) Candidates struggled with the properties of the fractions shown in the fractionating column and many did not know the fraction with the highest boiling point.
  - (ii) Candidates did slightly better on this question, and many knew the name of the fraction with the shortest chain length.
  - (iii) This question was not well answered. Many candidates did not know the fraction that is used to make waxes and polishes.
- (e)(i) Candidates struggled to give a correct definition of the term 'homologous series'.
  - (ii) Candidates found this part question to be one of the easiest on this paper. They could easily deduce the formula of octanol.
  - (iii) Most candidates could correctly predict the melting point of nonanol.
- (f)(i) Most candidates were able to name the other product that is produced when hexanol undergoes complete combustion. However, some candidates thought that the correct answer was incorrectly 'carbon monoxide' or 'hydrogen'.
  - (ii) Most candidates answered this question correctly.
- (g) This question was not well answered. Many candidates only achieved one of the three available marks and there were quite a few no response answers seen. Candidates did not know the reactant and conditions needed to manufacture ethanol by fermentation. Some candidates got this manufacturing process mixed up with the direct hydration manufacturing process and so answered with the incorrect substances and conditions. Conditions for other manufacturing processes in this syllabus were also seen as incorrect answers.
- (h) This question discriminated well between candidates. The only candidates that could draw the correct structure of ethanoic acid were those that went onto achieve the highest marks on this paper overall. However, more candidates are drawing correctly the displayed formulas of organic molecules which is good.

#### Question 5

This question discriminated very well between candidates. Candidates found (c), (e)(ii) and (f) particularly challenging.

- (a) Most candidates knew why silicon is placed in Group IV of the Periodic Table. However, some candidates answered with the gain or loss of electrons, which was incorrect.
- (b) This was a very good discrimination question. Only the better performing candidates knew the answer was 'solid' and could give a reason for this.
- (c) Candidates found this question very challenging and many could not give the correct answer.
- (d) (i) This question was not well answered. Candidates could not describe the observations seen when calcium is added to water. Many candidates just gave the products of this reaction. More practice on descriptions of observations needs to be carried out.
- (ii) Most candidates could correctly give one correct answer for this word equation. However, many candidates thought incorrectly that 'water' was one of the products instead of correctly 'hydrogen'.
- (e) (i) Most candidates answered this question correctly.
- (ii) This question was not well answered. Most candidates could not complete the given equation for the neutralisation of an acid. Some candidates knew that the correct answer was the 'OH' ion but forgot the negative charge on it.
- (iii) Candidates did much better on this part question. Many could answer with at least one correct colour although some candidates did get mixed up with the colour changes of other indicators which are in this syllabus.
- (f) Candidates did not do very well on this chemical test recall question. There was also a high level of no response answers seen. Some candidates got the correct chemical test but then answered with an incorrect colour.
- (g) Candidates who went onto achieve the highest marks on this paper performed well on this question. Most candidates were able to put the correct charges on the ions. However, some thought that the lithium ion had eight electrons in its outer shell. Most candidates achieved at least one mark on this part question.

### Question 6

Most candidates were able to name the other metal that is contained in brass and were able to put the metals in the correct order of their reactivity having been given observations about them. However, many candidates could not state the type of reaction that occurs when calcium carbonate is heated strongly or could not name the gas removed by calcium oxide in flue gas desulfurisation.

- (a) (i) Candidates found this question particularly challenging and few correct answers were seen. Some candidates thought that the correct answer was 'oxidation' or 'distillation'.
- (ii) Many candidates thought incorrectly that calcium oxide was an acidic oxide and others who knew that it was a basic oxide could not explain why.
- (iii) Few correct answers were seen for this part question. Candidates did not know which gas was removed by flue gas desulfurisation. Many different incorrect gases were seen.
- (b) (i) Candidates did much better on this part question. Most could state that there was a 'loss of oxygen'. However, many candidates then went on to state that it was from 'zinc' and not zinc oxide.
- (ii) Most candidates answered this question correctly.
- (iii) Candidates found this part question more challenging, and many could not suggest two reasons why brass is used to make water taps rather than pure zinc. Some candidates could give one correct reason.
- (c) (i) Most candidates knew that sulfur dioxide causes acid rain.
- (ii) Most candidates answered this question correctly and knew that 'planting trees' was one strategy that would help to remove carbon dioxide that is already in the atmosphere.

- (d) Candidates found this question one of the least challenging on this paper. They could easily put the four metals in order of their reactivity using the observations given.

### Question 7

Candidates found this question one of the most challenging questions on this paper. They particularly struggled to name a suitable aqueous electrolyte for the electroplating experiment shown and to state whether the electrolysis process was a physical or chemical change.

- (a) Candidates struggled to label the anode in this part question. There were also many no response answers seen.
- (b) Candidates found this part question one of the hardest on this paper. Many incorrect answers were seen including those of other metal salts such as zinc chloride.
- (c) Candidates found this part question more straightforward, and many could state the correct colour of the gas produced at the anode. However, some candidates got the halogen gas colour mixed up and answered incorrectly with 'green' or 'yellow'.
- (d) Candidates found this question the hardest one on this paper. They struggled to identify whether the electrolysis experiment shown was a physical or chemical change. Many could state that it was a 'chemical change', but they could not state why.
- (e) (i) Candidates did slightly better on this part question and many could name the dilute acid that was needed in the stated reaction.
- (ii) Most candidates answered this question correctly.
- (f) Candidates did exceptionally well on this part question and could correctly identify the correct forms of the given compound.

### Question 8

Candidates found this last question slightly less challenging. However, it discriminated well between them. Most candidates knew the state symbol in (a) and could also read off the graph to determine the total volume of carbon dioxide produced in (b). However, some candidates struggled to state what the effect of the change on the total volume of carbon dioxide was when the concentration was changed in (c)(ii).

- (a) Most candidates answered this question correctly showing a particularly good knowledge of the state symbols that are used in equations.
- (b) This was a very well answered question. Most candidates could read off the graph correctly.
- (c) (i) Candidates struggled more on this part question. Some candidates got mixed up with rates of reaction and answered using rates rather than with using time.
- (ii) Candidates found this part question very challenging, and a wide range of incorrect answers were seen.
- (d) This question discriminated very well between candidates. Some candidates got mixed up with the type of energy change shown but could explain correctly. Some incorrectly used the word 'reaction' in their answer instead of using the word 'reactants'.

# CHEMISTRY

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**Paper 0620/41**  
**Theory (Extended)**

## Key messages

- Candidates should not provide fractions as answers to calculations.
- Candidates should understand what the word 'observation' means and how to answer questions that ask for observations. This might include:
  - a solid dissolving or disappearing or ceasing to do so when a reaction has ended.
  - effervescence when a gas has evolved, or cessation of effervescence when a reaction has ended.
  - the formation of a precipitate, including its colour, when an insoluble solid is produced from the mixing of two solutions.
- Candidates would benefit from practice in deducing and drawing condensation polymers from unfamiliar monomers.
- Candidates should use the syllabus value for the Avogadro constant and not  $6 \times 10^{23}$ .

## General comments

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

Very few candidates felt the need to write on extra pages. If extra pages are used, the questions must be clearly numbered.

## Comments on specific questions

### Question 1

- (a) This was answered extremely well. The most common errors were omission of the plus sign for the proton charge; use of just a minus sign for the relative charge of an electron; and stating zero for the relative mass of a neutron.
- (b) (i) Candidates found the definition of the term isotopes challenging and frequently omitted the use of the word 'atoms'. Candidates should be able to recall the syllabus definition of 'different atoms of the same element that have the same number of protons but different numbers of neutrons'.
- (ii) This question was answered well with most candidates showing an understanding that the reason isotopes have the same reactivity is because they have the same number of electrons and hence the same electronic configuration. Credit was not given for stating that the atoms have the same number of electrons in their outer shell, as this explains why atoms in the same group have similar reactivity, and not why the isotopes have the same reactivity.
- (c) The majority of candidates were able to correctly work out the numbers of neutrons and electrons in atoms and ions.

While most candidates gained full credit for  ${}_{22}^{50}\text{Ti}$ , it should be noted that the following are not creditworthy due to the incorrect placement of the mass and atomic number:  ${}_{22}^{50}\text{Ti}$ ,  ${}_{50}^{22}\text{Ti}$ ,  ${}_{50}^{22}\text{Ti}$ .

- (d) The term nucleon number was well known as a term to define the total number of protons and neutrons in the nucleus of an atom. The word nucleon alone did not gain credit since a nucleon is a proton or a neutron. Relative atomic mass was the most common incorrect answer.
- (e) Better performing candidates could calculate the number of atoms in 2.00 g of argon. The correct answer was occasionally rounded to only two significant figures. The value in the question is to three significant figures, which is a good indication that three significant figures are required in the answer. Many candidates multiplied the Avogadro constant by two, rather than attempting to calculate the number of moles of argon. To gain partial credit, candidates had to attempt to find the number of moles of argon and then use the syllabus value of the Avogadro constant of  $6.02 \times 10^{23}$ .

## Question 2

- (a) Strontium was usually identified as the Group II element with five electron shells.
- (b) The candidates found the description of metallic bonding in Group II elements very demanding, with only the better performing candidates gaining full credit. The most common errors were references to negative ions, intermolecular forces and giant molecules. Candidates often omitted reference to attraction between positive ions and delocalised electrons. The terms 'force' and 'electrostatic' both needed to be qualified by reference to 'attraction'. Many candidates thought that the bonding in a metal was ionic and offered a description of ionic bonding whilst some thought that the bonding was covalent.
- (c) (i) The candidates were asked to give the observations when a piece of calcium was added to cold water. There was some confusion with the reactions of Group I elements with water where candidates stated that the calcium moved on the surface or floated. Most candidates stated that effervescence would be seen or that a solid dissolved or disappeared. Fewer candidates stated that the solution would turn blue due to the presence of the universal indicator. It should be noted that 'gas given off' is not an observation but a conclusion that can be made from observed effervescence.
- (ii) Many candidates correctly stated that hydrogen gas was produced because of the reaction between calcium and water. Fewer knew that calcium oxide was made, with many stating the second product was calcium hydroxide; again, some confusion with the reaction of Group I metals.
- (d) (i) A considerable number of candidates could not recall the colour of the flame when calcium burns in oxygen, with orange being the most common incorrect answer. There was some confusion with copper where candidates stated a blue/green flame would be seen.
- (ii) Most candidates knew that calcium oxide was a product of the reaction between calcium and oxygen. Fewer candidates could write an equation to represent the reaction. The formula for calcium oxide was well known.
- (e) (i) The term given to water molecules present in hydrated crystals was not well known. Common incorrect answers included aqueous, crystallised, anhydrous, hydrous and water crystals. Better performing candidates gained credit for water of crystallisation.
- (ii) The determination of the value of the water of crystallisation,  $x$ , in a sample of  $\text{Cu}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$  was done well by many candidates. Most correctly performed the calculation of the number of moles of calcium nitrate remaining and the number of moles of water. Candidates who performed well were able to successfully use the mole ratios to calculate that the value of  $x$  was 4.

A common error was to take the mass of water (1.44 g) away from the remaining moles of calcium nitrate (3.28 g) giving 0.01 moles of calcium nitrate, which resulted in the value of  $x$  being 8.

### Question 3

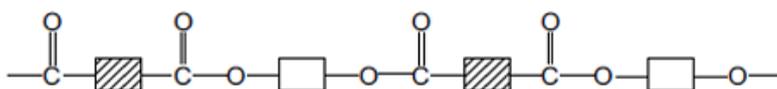
- (a) The candidates found this demanding. Of those candidates who appreciated that water was formed in the reaction between dilute sulfuric acid and aqueous sodium hydroxide, the majority did not then balance the equation. The state symbols were often incorrect with water described as (aq) rather than (l) and sodium sulfate being described as (s) rather than (aq). Confusion arose in the latter as the candidates were making solid sodium sulfate after the evaporation of water. It should be noted that (aQ), (Aq) and (AQ) are not acceptable state symbols for an aqueous solution, (aq).
- (b) A variety of answers were seen for the type of exothermic reaction occurring between dilute sulfuric acid and aqueous sodium hydroxide. These included titration (which is the process and not the type of reaction), redox and crystallisation. Many candidates stated the correct reaction type which is neutralisation.
- (c) The majority of candidates were able to correctly calculate the concentration of the aqueous sodium hydroxide.
- (d) Candidates suggested a variety of apparatus including pipette, flask and measuring cylinder. Most candidates did, however, correctly suggest that a burette should be used to add the aqueous sulfuric acid.
- (e) The candidates found this demanding and found converting the calculated volume into  $\text{cm}^3$  challenging. While some candidates had use the correct 2:1 mole ratio, they then did not convert the answer to  $\text{cm}^3$  and thus gave an incorrect answer of  $0.25 \text{ dm}^3$ . An answer of  $50 \text{ cm}^3$  was common as candidates had used a 1:1 mole ratio rather than a 2:1 ratio of sodium hydroxide to sulfuric acid.
- (f) Only the better performing candidates were able to recall the colour change of methyl orange from yellow to orange. There was much confusion between the colour changes of phenolphthalein and thymolphthalein.
- (g) This was found to be one of the most challenging questions on the paper. Only the better performing candidates were able to suggest that the experiment should be repeated using the same volumes of aqueous sodium hydroxide and dilute sulfuric acid without the indicator. A substantial number of candidates suggested that the mixture was filtered to remove the indicator, or distilled to remove the indicator, washed to remove the indicator or heated to remove the indicator.
- (h) (i) Few candidates could recall the syllabus definition for a saturated solution. Many made references to saturated organic compounds and, if the correct definition was attempted, the use of the terms solute and solvent were not accurate.
- (ii) This was found to be a very demanding question and the most common responses were that the solution solidifies, the solution freezes, the solution changes state or the solution reaches saturation point. Many candidates stated that the water evaporates so crystals appear. Only the better performing candidates had the understanding that the solubility of the sodium sulfate decreases as temperature decreases.
- (iii) This was found to be the most demanding question on the paper and most candidates did not have an appreciation that if the solution in the evaporating basin is allowed to dry without gentle heating, then the mass of the crystals formed would be the same. A sizeable number of candidates thought that water would remain on the crystals and so the mass would increase.

#### Question 4

- (a) Overall, many candidates could draw a reaction pathway diagram for an exothermic reaction, with the products at a lower energy level than the reactants. A small number of candidates labelled the product line as 'product' rather than HF and SO<sub>2</sub> and did not gain credit as the question asked candidates to label the product line with the formulae of the products. Common errors included a double headed arrow for the activation energy, a double headed arrow for  $\Delta H$ , or both the activation energy and  $\Delta H$  shown as vertical lines without arrowheads. A small number of candidates drew a diagonal line from the reactants to the product line, which did not gain credit.
- (b) This was answered very well. Most candidates were able to correctly calculate the S=O bond energy using bond energy data and  $\Delta H$  of the reaction.
- (c) The better performing candidates could access this question and had a good understanding of equilibrium shifts. Many candidates could recall that a catalyst only speeds up the rate of a reaction and thus has no effect on equilibrium. A considerable number of candidates showed confusion between rate and equilibrium shifts, with many responses referring to the rate of the reaction increasing and thus increasing the yield.
- (d) The candidates performed well on this question, with most understanding that if the temperature is lowered the particles have less energy and so have less frequent successful collisions. Only the better performing candidates developed their answers to say that a lower percentage of the collisions or of the particles have energy greater than or equal to the activation energy.

#### Question 5

- (a) (i) The general formula of an alcohol, C<sub>n</sub>H<sub>2n+1</sub>OH, was well known. No credit was given for C<sub>n</sub>H<sub>2n+1</sub>OH or C<sub>n</sub> + H<sub>2n+1</sub> + OH.
- (ii) Characteristics that are the same for each member of a homologous series were well known, with most candidates correctly stating that they have the same functional group.
- (b) (i) The syllabus conditions for fermentation, 25-35°C, yeast and absence of oxygen, and those for hydration of ethene, 300°C, acid catalyst and 60 atm, were not well known. There was much confusion regarding the conditions for the Haber process and the contact process, with random guesses at conditions usually involving use of a transition metal as a catalyst.
- (ii) The majority of candidates could recall the equation for fermentation using glucose as the raw material. The formula for glucose was well known.
- (iii) Candidates found the equation to represent the hydration of ethene more challenging than **5(b)(ii)**. Some produced water as a product or reacted the ethene with oxygen. Many left this question unanswered.
- (c) (i) Candidates found the deduction of the molecular formula of butane-1,4-diol challenging, with a common incorrect answer being C<sub>4</sub>H<sub>8</sub>(OH)<sub>2</sub>.
- (ii) The number of moles of ethanoic acid required to react with butane-1,4-diol was answered well, with a sizeable number of candidates getting the correct answer of 2.
- (d) (i) Most candidates could correctly deduce the empirical formula of butanedioic acid as C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>. Some candidates gave the correct molecular formula but then did not cancel to the simplest ratio of atoms.
- (ii) The majority of candidates could state that hydrogen was formed when butanedioic acid reacted with sodium.
- (e) (i) Candidates found this application question challenging. The structure of part of PET is shown in section 11.8.10(b) of the syllabus.



Candidates are not required to know the formulas of what the boxes represent but many tried to write the formula for butanedioic acid and butane-1,4-diol in these boxes without appreciating that it is the ends of the molecules that are reacting. Better performing candidates could apply their knowledge to the structure shown in the syllabus.

- (ii) This question was accessible with most candidates recognising that the type of polymerisation was condensation. Credit was not given for 'condensed polymerisation' or 'condensational polymerisation'.

# CHEMISTRY

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Paper 0620/42  
Theory (Extended)

## Key messages

- If candidates are asked to give names in an answer, they should refrain from using formulas. A misspelt name will usually be given credit, but an incorrect formula will not. For example, in **Question 3(h)**, incorrect formulae such as  $\text{BaNO}_3$ ,  $\text{KSO}_4$  and  $\text{BaCO}_2$  were not given credit.
- Candidates should learn the definitions as given in the syllabus. If a definition is asked for, then it is the syllabus definition which the candidate is required to recall as the answer. In this paper, four marks were given for definitions, **Questions 2(d)(i)**, **4(b)(i)** and **5(d)(iii)**, and it was clear many candidates had an idea of the definition but could not recall it as given in the syllabus.
- Candidates should use recognised IUPAC names when naming organic compounds, e.g. butanoic acid rather than butyric acid and ethanol rather than ethyl alcohol.

## General comments

If an  $M_r$  needs to be determined as part of a solution, if any error carried forward marks are to be awarded, the  $M_r$  needs to be given as a stated value and not left as an incomplete sum of  $A_r$  values.

If a single answer is asked for, two (or three) answers should not be given, as incorrect statements may contradict correct answers. There were many incidences of candidates giving more than one answer where only one was required and thus not gaining credit.

Candidates should write clearly and legibly enough that their answers are unambiguous. If a mistake is made, candidates should strike through their unwanted response and rewrite a new response.

## Comments on specific questions

### Question 1

- (a) The completion of the table was designed to be easy for candidates, yet many did not appreciate that a simple one-word term such as 'touching' or 'random' (and their opposites) was all that was required and many wrote extensive descriptions within the boxes provided.

Often candidates seemed unable to differentiate between the three ideas of separation, arrangement and motion and descriptions appeared in the wrong column, e.g. for arrangement of solids, 'touching' (a description of separation) was often seen.

- (b) Most candidates could name the physical change for solid to liquid and for gas to liquid but struggled with solid to aqueous. Most common incorrect responses seen for this change were: sublimation and melting.
- (c) (i) Many responses were not specific in terms of the particles and explained diffusion as 'gases spreading' rather than explaining how diffusion happens.
- (ii) Very few candidates gave the response expected from section 1.2.2 of the syllabus, which states: 'Describe and explain the effect of relative molecular mass on the rate of diffusion of gases.'

- (d) Many candidates gave vague answers about pollution, global warming or climate change. Many candidates repeated 'acid rain' from the question or described its effects rather than correctly stating the two other effects given in section 10.3.3(e) of the syllabus: 'State the adverse effects of (oxides of nitrogen) limited to acid rain, photochemical smog and respiratory problems.'
- (e) (i) Carbon monoxide was commonly known as the product of incomplete combustion of hydrocarbons.
- (ii) A wide range of gases were given here, suggesting that the products formed from the catalytic converter were not well known.

## Question 2

- (a) (i) Hematite was well known to candidates. An acceptable variety of spellings was seen, providing the ending was '-ite'.
- (ii) The source of heat in the blast furnace is given in section 9.6.2(a) of the syllabus: 'the burning of carbon (coke) to provide heat ...'. The key point is that the coke is combusted.
- Non-specific answers such as 'carbon reacting with oxygen' or 'hot air blown in' were commonly seen. Some candidates confused coke with coal or fossil fuels. Weaker responses did not mention any process and simply stated 'coke' or 'hot air'.
- (iii) Carbon monoxide was well known as the gaseous reducing agent.
- (iv) Candidates struggled with this equation, which is a recall of section 9.6.4(c) of the syllabus.
- (v) The equations for the role of limestone in removing silicon(IV) oxide are given in syllabus sections 9.6.4(d) and 9.6.4(e). Only the better performing candidates could recall these.
- (b) Many candidates were unfamiliar with the definition of isotopes in section 2.3.1 of the syllabus and did not refer isotopes as atoms of the same element. The idea that isotopes had the same number of protons, but different numbers of neutrons was well known.
- (c) (i) Most candidates correctly completed the table, with just the occasional error made in determining the numbers of electrons.
- (ii) Many candidates were unfamiliar with the test for  $\text{Fe}^{2+}$  ions. Many suggested using a flame test and of the very few who correctly stated the use of  $\text{NaOH}(\text{aq})$  or  $\text{NH}_3(\text{aq})$ , many did not give the correct observations.
- (d) (i) This was a straightforward recall question for well-prepared candidates who had learnt the definition of an oxidising agent as given in section 6.4.11 of the syllabus. Many weaker responses did not define oxidising agent but instead attempted to describe the action of oxidation (and reduction) in terms of electron transfer.
- (ii) This was well answered with most candidates realising  $\text{Fe}^{2+}$  ions lost an electron when converted to  $\text{Fe}^{3+}$  ions.
- (iii) This was correctly answered by only the better performing candidates. High temperature or use of a catalyst was a common incorrect answer.
- (e) Only a minority of candidates identified the other product as iodine. Iron iodide was a frequently seen incorrect answer.

## Question 3

- (a) This question was particularly poorly answered. Despite clearly stating in the question about preparing the insoluble salt barium sulfate, many candidates gave the state symbol as  $\text{BaSO}_4(\text{aq})$  and the state symbol for the well-known everyday soluble salt, sodium chloride as  $\text{NaCl}(\text{s})$ .

Very few candidates thought to balance the equation. Many who did realise there was a need for balancing opted to do this by giving sodium chloride the formula  $\text{Na}_2\text{Cl}_2$ .

- (b) Most candidates calculated the  $M_r$  of  $\text{BaCl}_2$  as 208 and then multiplied this value by 0.1 to determine a mass of 20.8 g.

The most common error was to see the  $M_r$  of  $\text{BaCl}_2$  stated as 172.5, presumably from adding the  $A_r$  of one  $\text{Cl}$  atom (35.5) to the  $A_r$  of  $\text{Ba}$  (137). When this occurred, candidates still managed to secure credit as an error carried forward for multiplication of 172.5 by 0.1.

Weaker responses did not achieve an error carried forward as their working did not state that a calculated number was meant to be the  $M_r$  of  $\text{BaCl}_2$ .

- (c) Although many candidates got this question correct, many were unable to convert  $\text{dm}^3$  to  $\text{cm}^3$  and answers such as  $0.08 \text{ cm}^3$  and  $8 \times 10^{-5} \text{ cm}^3$  were seen.
- (d) Although  $\text{BaSO}_4$  is the precipitate formed in the sulfate test, only a minority of candidates appreciated the colour of  $\text{BaSO}_4$  is white.
- (e) Just under half the candidates erroneously thought the solid formed in a filter paper was called a filtrate, but the majority knew residue was the correct term.
- (f) Most candidates knew the missing step was the lack of rinsing of the residue, although many candidates stated that the residue should be heated to constant mass.

Only the better performing candidates knew that it was the presence of sodium chloride which caused a greater mass of residue. Many candidates believed that the extra mass was caused by water, despite the question stating that the solid was dried.

Another common misconception was to suggest that water of crystallisation was adding to the mass.

- (g) Although most candidates knew that preparation of insoluble salts involved the method known as precipitation, a wide variety of other processes were suggested such as crystallisation, filtration and even titration.
- (h) Very few candidates answered this fully correctly.

Section 7.3.2(b) of the syllabus gives the relevant solubilities of salts, and it was expected that candidates would choose different soluble salts to barium chloride and sodium sulfate as well as an alternative insoluble barium salt to barium sulfate.

Many candidates did not give different names and frequently barium chloride and barium sulfate were seen rather than different compounds. Formulas were often attempted and rarely correct.

Barium oxide and barium hydroxide were not accepted as answers as these are both bases, not salts.

#### Question 4

- (a) (i) Most candidates correctly identified  $\text{H}^+$  as the common cation of all acids.
- (ii) Most candidates correctly applied the term 'complete' to the dissociation of the strong acid and 'partial' to the dissociation of the weak acid.

Candidates who performed less well wrote in terms of strong dissociation and weak dissociation, which was essentially repeating the question. A common misconception was to state that the ions dissociate rather than the acid molecules.

Another incorrect explanation was to write in terms of 'more  $\text{H}^+$  ions' and 'less  $\text{H}^+$  ions'.

- (iii) Invariably, one of the two strong acids (usually sulfuric, on the basis that it had two hydrogens per molecule) was named. Only the better performing candidates appreciated that it was the weakest acid that would have the highest pH.

- (iv) Although most candidates gave the correct answer, a variety of other colours were seen.
  - (v) Good responses gave correct ions, but others omitted charges, wrote equations of various types or gave hydroxide ions or protons.
  - (vi) The majority of candidates named the two products. Weaker responses identified hydrogen but put sulfur dioxide rather than oxygen.
  - (vii) Most candidates identified calcium ethanoate as the salt formed.
- (b) (i) Although many irrelevant statements about high pH or neutralising acids were seen, provided the definition given in section 7.1.9 of the syllabus, i.e. 'proton acceptor' was seen, credit was often awarded.
- (ii) The idea that bases need to be soluble to be called alkalis was known and the reverse argument that  $Al(OH)_3$  must be insoluble was known by many. Low solubility was not given credit.
  - (iii) Most candidates opted correctly for aluminium oxide or aluminium carbonate as the other compound. A high number of candidates chose aluminium hydroxide, which was the original example used in the question.
  - (iv) There were many ways through this question, which was a calculation based upon the information given in the question that O has an oxidation number of  $-2$  and aluminium, due to its  $3+$  charge, has an oxidation number of  $+3$ .

The better performing candidates correctly determined N to have an oxidation number of  $+5$ . A few omitted the key '+' sign.

One simple approach was to determine the numbers of each atom present in  $Al(NO_3)_3$ .

So  $1Al (+3) + 3N + 9O$  (total of  $-18$ ) had a combined oxidation number of  $0$ .

The total oxidation numbers of  $3N = +3 -18 = +15$ .  $\therefore$  each  $N = +5$ .

### Question 5

- (a) The question limited the choices available to candidates by listing many properties of alkanes and asking for two others.
- Most candidates stated they had the same general formula and quite a substantial proportion of these also stated that each member differed by a  $-CH_2$  unit from the next.
- Weaker responses repeated information already given or gave information that did not apply to alkanes, e.g. 'same functional group', 'similar chemical properties.'
- (b) (i) Nearly every candidate correctly stated the trend was an increase in boiling points.
- (ii) Most candidates performed well, with many opting to describe an increase in viscosity as the description of a trend in physical properties.
- Candidates that performed less well were unsure as to what was meant by a physical property and instead suggested chemical properties such as flammability or gave general factual descriptions, such as increasing by a  $-CH_2$  unit or increase in the number of carbon atoms.
- (c) Many candidates had the correct idea that saturation depends upon single C–C bonds but did not qualify this by stating alkanes have only C–C single bonds (propene has a C=C bond).
- Other candidates correctly stated there were no C=C bonds present.
- (d) (i) Most candidates knew ultraviolet light was the one condition needed. Candidates who performed less well appeared to guess at 'heat', despite the question telling them the reaction was happening at room temperature or the use of a catalyst.

- (ii) This question proved difficult for candidates. Many candidates did not read the question, as many answers had an organic structure followed by the structure of  $\text{HCl}$ . In others, di-substitutions were common.

Most of the candidates who attempted to draw both  $\text{C}_3\text{H}_7\text{Cl}$  structures drew both correctly.

Naming proved difficult. Most candidates were unfamiliar with section 11.2.1(e) of the syllabus, which states candidates should be able to 'Name ... the products of the reactions stated in sections 11.4–11.7'.

- (iii) For a relatively straightforward question, many candidates found this challenging. Often the definition given was a near-miss attempt. Instead of 'same molecular formula', terms such as 'same general formula' or 'same empirical formula'.

### Question 6

- (a) This question was frequently omitted but of those candidates who attempted it, the responses were usually correct.
- (b) The name of the ester was well known. A sizeable number assumed it was ethyl propanoate, as many candidates seemed to think that the carbon that is part of the carbonyl group and subsequently part of the ester linkage is not included when naming the carboxylic acid part of the ester.
- (c) Most candidates were able to deduce the empirical formula, although many gave the molecular formula.
- (d)(i) Most candidates performed well. Sometimes, despite naming the ester correctly, candidates simply wrote 'acid' and 'alcohol'.

For candidates who had assumed the name of the ester was ethyl propanoate, an error carried forward mark for 'propanoic acid' was allowed.

- (ii) Most candidates could name a suitable catalyst, but some candidates opted erroneously for a transition metal-based catalyst. Others wrote 'heat' or 'high temperature', despite being asked for a catalyst.
- (e) Very few candidates gave the correct number, 4. There was a strong suspicion that many candidates made educated guesses.
- (f) Many candidates omitted  $\text{O}_2$  as a reactant in a combustion reaction and had the ester as the only reactant. Of those who had the correct species, balancing proved to be a problem.

# CHEMISTRY

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Paper 0620/43  
Theory (Extended)

## Key Messages

- If candidates are asked for the name of a substance, they should give a name as opposed to a formula.
- The ability to write chemical formulas is a continued weakness applicable to many candidates.
- Candidates should know that ionic equations and ionic half-equations are only balanced when the number of atoms of each element are equal on both sides and the charges are equal on both sides.

## General comments

If a single answer is asked for, two (or three) answers should not be given, as incorrect statements may contradict correct answers. There were many incidences of candidates giving more than one answer where only one was required and thus not gaining credit.

Candidates should write clearly and legibly enough that their answers are unambiguous. If a mistake is made, candidates should strike through their unwanted response and rewrite a new response.

## Comments on specific questions

### Question 1

- (a) This was answered very well. A common error was to miss out the positive sign for the charge on a proton.
- (b) This was answered very well. The mass of an oxide ion was sometimes identified as 10 or 16 and the symbol was sometimes given as Cl, Ne or F. Some gave the number of electrons in a calcium ion as 20.
- (c) (i) Some candidates attempted to give a definition of isotopes rather than answer the question. Those who identified carbon as isotope **X** often omitted the nucleon number.
- (ii) Candidates found this question difficult. A wide variety of errors was seen.

### Question 2

- (a) (i) This was answered very well. **E** and **D** were seen occasionally.
- (ii) Candidates found this the most difficult part of **2(a)**. **E** was the most common incorrect answer.
- (iii) This was answered well. There were no common incorrect answers.
- (b) (i) This was answered quite well. **G** was a common incorrect response, although candidates did gain credit for giving high melting point or high boiling point as a reason.
- (ii) This was answered quite well. Those who identified **C** often referred to good conductivity when molten, although they often omitted reference to poor conductivity when solid.

### Question 3

- (a) (i) This was answered well. Some gave formulae instead of names.
- (ii) This was answered less well. Water and sodium hydroxide were common incorrect answers.
- (iii) This was answered quite well. Platinum, copper or aluminium were seen occasionally.
- (iv) This was answered quite well. Some candidates gave the wrong charge on an aluminium ion.  $Al^{3+} + 3e^{-} \rightarrow 3Al$  was one of the most common incorrect answers. Other incorrect answers included  $Al^{3+} \rightarrow Al + 3e^{-}$  and  $Al \rightarrow Al^{3+} + 3e^{-}$ .
- Some candidates wrote an equation for the discharge of hydroxide ions producing oxygen.
- (b) (i) Candidates found this difficult. Answers often referred incorrectly to differences in the reactivity of zinc and aluminium despite the information provided in the stem. Those who realised that the correct answer related to a coating of aluminium oxide often omitted reference to the uncreativity of the coating.
- (ii) This was answered poorly. The most common wrong answer was  $3Al + 2Zn^{2+} \rightarrow 3Al^{3+} + 2Zn$
- (iii) This was answered well. Some gave 2 instead of +2.
- (iv) Many answered in terms of electrons despite the requirement of the question to answer in terms of oxidation number. 'Loss of oxidation number' was a common incorrect response.
- (c) (i) This was answered quite well. Many referred to enthalpy but very few spelt the word correctly. Common errors seen were: energy change (alone) or enthalpy (alone).
- (ii) This was answered well. Endothermic was the most common wrong answer.
- (d) This was answered well.
- (e) Products of the reaction often included  $GaO_2$ ,  $GaO_2^{-}$  or  $NaGaO_2$ .  $GaO_2Na$  and  $GaNao_2$  were also seen occasionally.
- (f) Some attempted the formula of gallium(III) sulfide or sulfite instead of sulfate.  $Ga_2Br_3$  was a common wrong formula for gallium(III) bromide.

### Question 4

- (a) (i) Some candidates transposed the answers, e.g. rates remain the same and concentrations are equal. Candidates were more likely to answer correctly in terms of rate of reaction than concentration.
- (ii) This was answered well, although many candidates chose to ignore the instruction to use 'only the words **increases**, **decreases** or **no change**.'
- (iii) This was answered quite well. Endothermic was the most common wrong answer. Some referred to the position of equilibrium shifting.
- (b) This was answered quite well. Some candidates omitted the C-C bond when calculating the total energy released when the bonds form. The bond energy of the C-Cl was also sometimes omitted when calculating the total energy needed to break the bonds.
- (c) This was answered extremely well. Diagrams were usually very well presented.
- (d) (i) In general, there has been an improvement in the way candidates answer questions that require observations. A few candidates thought that effervescence, fizzing and bubbling have separate meanings in this context. Another common error was to state that dissolving occurs but without qualifying what would dissolve or disappear.

- (ii) This was answered well. A common error was to use 24 instead of 24 000. Mole ratios of 1:1 or 1:2 were used occasionally.

### Question 5

- (a) (i) This type of question continues to be challenging for large numbers of candidates. Formulas of the ions and formula of the precipitate were often incorrect. Common errors in the formula of lead sulfate were  $\text{PbS}$ ,  $\text{Pb}(\text{SO}_4)_2$  and  $\text{Pb}_2\text{SO}_4$ . Some candidates attempted full equations.
- (ii) Answers were not always the names of compounds. Candidates seemed to misunderstand the question. Lead halides, oxide and hydroxide were seen often.
- Candidates should be aware that all nitrates are soluble in water.
- (iii) Answers were not always the names of compounds. Candidates seemed to misunderstand the question.
- Candidates should be aware that all sodium, potassium and ammonium salts are soluble in water.
- (iv) Filtrate was the most common incorrect answer.
- (v) Those who knew that washing and drying were required often did not 'describe' how washing and drying should be carried out. Water was often absent from the washing process. The method of drying needed a brief description rather than 'dry' on its own. Crystallisation of the filtrate was occasionally described.
- (b) (i) This was answered extremely well.
- (ii) This was answered extremely well.

### Question 6

- (a) This was answered very well. Errors that were seen occasionally included rounding of 1.5 to 2.
- (b) Many candidates divided 116 by 29 to achieve an answer of 4. However, the 4 was often processed incorrectly. Incorrect answers included  $(\text{CHO})_4$ ,  $4\text{CHO}$  and 4 on its own.
- (c) (i) This was answered very well. Ester and polymer were common incorrect answers.
- (ii) Despite the question asking for the 'type of catalyst' the majority of candidates decided to ignore this instruction and name a particular compound. 'Yeast' and 'enzymes' were seen occasionally. 'Transition metals' was a common answer, as was named metals such as nickel. Iron, vanadium(V) oxide and potassium manganate(VII) were also seen occasionally.
- (iii) Propanoic acid was usually correctly named.
- All alcohols containing more than two carbon atoms have a number included in their name. There is no alcohol called butanol. But-1-ol and but-1-anol were seen occasionally.
- (d) (i) 'Condensation' was seen occasionally. 'Additional' was also an incorrect answer that was seen occasionally.
- (ii) Most candidates gave answers in term of the large size of polymer molecules as opposed the polymer molecule being of being of indefinite size.
- (iii) This was answered fairly well. The most common incorrect answer was 6.
- (iv) Most answers drew part of the polymer chain. Those who attempted to draw an alkene often left the  $\text{CH}_3$  groups not displayed.

- (e) (i) Only a minority of candidates could draw the fully displayed functional groups. Some drew two  $\text{NH}_2$  groups but there were many other incorrect answers including  $-\text{OH}$  and  $-\text{NH}_3$ . Some added boxes on to the central carbon atom.
- (ii) A common error was to circle an entire repeat unit and not the amide linkage.
- (iii) Polyesters and other synthetic polymers were seen quite often.

# CHEMISTRY

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Paper 0620/52  
Practical Test

## Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Question 1** and **Question 2** and record the results on a copy of the question paper. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of supervisor's results are for which session or laboratory, and which candidates were in which session or laboratory.
- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice. A centre can also contact Cambridge Assessment for advice if unsure how to make up a solution of the required concentration. CLEAPSS ([www.cleapss.org.uk](http://www.cleapss.org.uk)), mentioned in the syllabus, is also a good source of information.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- When a question asks candidates to identify a substance, the name or formula is acceptable. However, incorrect names or formulae will not be accepted. For example, 'iodine' is not an acceptable alternative for 'iodide'.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.
- In the qualitative analysis question (**Question 2**), where a question states, 'Test any gas produced' then candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed.

## General comments

The majority of candidates successfully attempted all questions. The paper was generally well answered, with very few unanswered questions.

In answering the planning question (**Question 3**), there is no need for candidates to write a list of variables, a list of apparatus, or the aims of the experiment. Where there is credit available for the use of suitable apparatus, this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

### Comments on specific questions

#### Question 1

- (a) Most candidates were able to obtain results in line with those expected but fewer were able to calculate the volumes added to reach the first and second end-points. Candidates needed to subtract the initial burette reading from the burette readings at the first and second end points. Some candidates wrote the volume of acid **B** used. Others calculated the volume added to reach the second end-point by adding the volume needed to reach the second end-point to the volume needed to reach the first end-point, counting the volume needed to reach the first end-point twice. As all figures in Table 1.1 were either from a burette or calculated using readings from a burette, all should have been given to the same number of decimal places. The expected titres in Experiment 1 were around 18 cm<sup>3</sup> for the first end-point, about twice that for the second end-point, with the titres in Experiment 2 being about half of those in Experiment 1.
- (b)(i) The need to clean the apparatus to remove any residue from Experiment 1 was well known.
- (ii) Stronger candidates were able to clearly explain that water left in the burette would dilute solution **C** and so a greater volume would need to be added from the burette to reach the end-point. Some candidates gave vague responses such as 'the concentration will change and so the volume will change' and needed to give more specific detail.
- (iii) Most candidates correctly stated that the white tile makes the colour change in the flask easier to see. The idea of the improvement of visibility of the colour change is important; without a white tile the colour change can still be seen but it is less obvious. A few candidates thought the white tile made the flask level or protected the bench.
- (c) Stronger responses clearly explained that the volume of solution **D** required was less than the volume of solution **C** and that, therefore, solution **D** was more concentrated. As the volume of solution **D** added at both end-points was about half the volume of solution **C** added, solution **D** must have been about twice as concentrated as solution **C**. Some candidates repeated the titres in Table 2.1 alone and needed to use comparative phrases such as 'more' or 'less'. A few candidates seemed to confuse concentration with volume and used the terms interchangeably.
- (d)(i) Most candidates realised that doubling the volume of solution **B** would mean the volume of solution **C** would also need to be doubled. However, it was not uncommon for candidates to double the burette reading at the first end-point rather than double the volume added to reach the first end-point. A significant number of candidates did not include the unit (cm<sup>3</sup>) in their answer; all physical quantities should be accompanied by a unit.
- (ii) Weaker responses often stated, 'the volume of **C** needed would be large'. Candidates needed to explain that the volume of solution **C** required would exceed the capacity of a burette causing a problem in the titration.
- (e) Many candidates incorrectly stated that the volume needed is reduced because the reaction is faster and so it takes less time to reach the end point. Volumes added in a titration are not related to reaction rate and depend only on the number of moles of reagent present. As warming the contents of the flask will not change the number of moles of **B** present, the volume of **D** required will not change.
- (f) The expected answer was that a pipette, or burette, should be used to measure the volume of solution **B**. Many candidates stated that a pipette should be but needed to also explain what it would be used for. Some candidates incorrectly suggested using a pipette instead of a conical flask or burette.

## Question 2

- (a) (i) Most candidates correctly stated that there was no visible change when aqueous sodium hydroxide was added to solution **E**.
- (ii) The instruction for this question said, 'test any gas produced' and so candidates were expected to test the gas and record the details for the gas test that gave a positive result. In this case the gas should have turned damp red litmus paper blue.
- (b) The majority of candidates stated correctly that a white precipitate forms.
- (c) In this test, a purple solution of acidified aqueous potassium manganate(VII) is added to a colourless solution of ammonium sulfate. As no reaction takes place, the colourless solution should become pink or light purple due to the unreacted manganate(VII) ions. While many candidates correctly reported that the solution became pink/purple, it was not uncommon for candidates to state 'no change'. This is not a correct observation as the solution changes from colourless to pink/purple. A significant number of candidates incorrectly stated that the acidified aqueous potassium manganate(VII) became colourless.
- (d) While stronger candidates correctly identified solid **E** as ammonium sulfate, there were several common errors. These included naming the cation 'ammonia', identifying the cation as chloride (presumably due to the formation of the white precipitate in **2(b)**, although this was the sulfate test and not the halide test) and identifying one of the ions as nitrate (presumably because the nitrate ion test also produced ammonia).
- (e) The expected flame test colour for the sodium ion flame test was yellow. Many candidates reported seeing a yellow flame.
- (f) (i) Most candidates correctly reported seeing a yellow precipitate. Candidates should try to avoid giving multiple colours, such as 'yellow-cream' as that includes the colours expected from two different halide ions.
- (ii) Many candidates reported the expected observation of the formation of a white precipitate which then dissolved in excess.
- (iii) Many candidates reported the expected observation of the formation of a white precipitate which then dissolved in excess.
- (g) Many candidates correctly identified the three ions in solid **F**.

## Question 3

This planning task was a quantitative task, and so candidates were expected to make measurements as part of their plan. There are two suitable approaches: either measure how long it takes to increase the temperature of the water by a known amount or measure the temperature increase in a specified time.

Both approaches should include:

- using appropriate apparatus to measure the volume of the water being heated
- measuring the initial temperature of the water used before it was heated.

Candidates were then expected to either:

- start heating and start a stop-watch at the same time
- measure the time taken to reach a specified temperature increase or a specified temperature
- make a conclusion linking the time taken to which alcohol heated the water the fastest

**OR**

- heat the water for a specified time
- measure the final temperature of the water and calculate the temperature change
- make a conclusion linking the temperature increase to which alcohol heated the water the fastest.

Many candidates made sure the volume of each alcohol was the same in each experiment. This is not necessary as not all of the alcohol will be used to heat the water; some will remain in the spirit burner. Some candidates described how to clean the spirit burners between each experiment. This is not necessary as the question states that three spirit burners are provided.

The conclusion needed to make a connection between time taken or temperature increase obtained and the rate of heating. It was not uncommon for candidates to state 'the alcohol which heated the water the fastest was the fastest'. These candidates needed to show how they would use the data to make this conclusion by indicating how they would know which is the fastest based on what was measured.

Some candidates wrote out lists of apparatus, dependent variables, independent variables and control variables. Credit will not be awarded for a list of apparatus; if credit is available for apparatus, then it will only be awarded if the apparatus is used appropriately in the method.

# CHEMISTRY

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Paper 0620/53  
Practical Test

## Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Question 1** and **Question 2** and record the results on a copy of the question paper. It is important that the observations recorded are the actual observations obtained and not just the expected observations; the expected observations are known but the actual observations obtained are required as contaminated samples can cause different results, especially in a flame test. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of supervisor's results are for which session or laboratory, and also which candidates were in which session or laboratory.
- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and **not** just a small dot which is obscured by the graph line, which should be drawn using a sharp pencil. A line of best fit can be curved or straight – whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. A best-fit line should have an approximately equal number of points on each side of the line (excluding anomalous results). Candidates will need to decide if the line should be curved or straight; if a straight line has the points at either end of the line on one side of the line and the points in the middle on the other side, then the best-fit line should probably be a curve. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10<sup>n</sup>) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- In the qualitative analysis question (**Question 2**), where a question instructs the candidate to test any gas given off then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).
- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance, then candidates may answer using names or formulae.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.

## General comments

The vast majority of candidates successfully attempted all of the questions. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few unanswered questions.

In **Question 1**, most candidates obtained results that were in line with those expected.

In **Question 2**, when reagents are added to a solution in a test-tube, the components of the mixture should be combined in some way (such as by shaking). Observations describing different coloured layers suggest that some candidates did not ensure the reagents were mixed. Candidates often described the change as 'going back to the original colour' without stating the colour of the original solution and this would not gain any credit.

In answering the planning question (**Question 3**), there is no need for candidates to spend time writing a list of variables, a list of apparatus, or the aims of the experiment. Where there is credit available for the use of suitable apparatus, then that will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

### **Comments on specific questions**

#### **Question 1**

- (a) The majority of candidates successfully recorded ten temperatures and completed the table of results showing a greater increase in temperature with a lower volume of acid – thus, getting the expected results. It was expected that all temperatures and temperature changes would be recorded to the same resolution. A common error was not to record all acid volumes to one decimal place, which they should have been as the volume was measured using a burette. The instructions the candidates had to follow showed the volumes added from the burette to one decimal place and this should have indicated to the candidates to use consistent decimal places.
- (b) Most candidates produced sensible graph scales. Those who chose difficult scales, such as going up in increments of each large square being 3, 4 or 6, often made errors in the plotting and so did not gain the credit available for the correct plotting of all five points.

Graph lines were often not creditworthy, with straight lines often being drawn through points that were on a curve or wobbly lines meandering from point to point. Many candidates incorrectly drew straight lines, often just from the first point to last, when the points were clearly on a curve of decreasing gradient. Straight lines which have the points at either end of the line on one side of the line and the points in the middle on the other side suggest that the points lie on a curve. Some candidates drew graph lines in pen; this means that if an error is made the line cannot be erased and so multiple graph lines are seen.

Very few candidates used non-linear scales. If a scale is non-linear, then credit for the scale or the plotting of the data cannot be awarded.

- (c) This was the most demanding question on the paper and candidates found it particularly challenging. Many, incorrectly, based their explanation on the increasing rate or an increase in concentration of the acid as the volume of the sulfuric acid decreased.

However, around half of the candidates could recognise that, as the volume of sulfuric acid increases, the temperature increase also increases. However, very few went on to explain that the heat energy produced was the same in every reaction (as the mass of magnesium, the limiting factor, was the same in every reaction) and, as the volume increased, that the energy had to raise the temperature of more of the solution.

- (d) Most candidates were able to extrapolate their graph line so that a reading could be made at  $33\text{cm}^3$  with a small number of candidates reading from  $31.5\text{cm}^3$  on the graph rather than  $33\text{cm}^3$ .

A sizeable number of candidates did not include the unit ( $^{\circ}\text{C}$ ) in their answer; all physical quantities should be accompanied by a unit.

- (e) This was a demanding question as not only did line **E** have to be below the original line at all values, but it could not touch or cross the x-axis. The temperature increase cannot be zero or negative as an exothermic reaction would still occur and so there will still be a temperature increase.

However, most candidates realised that a shorter length of magnesium ribbon would result in a smaller increase in temperature.

Better performing candidates realised that using half the quantity of magnesium meant that the temperature increase would be halved and thus gained full credit as they sketched the expected line at approximately half of the temperature increases obtained in the investigation.

Several candidates did not answer this question, perhaps overlooking the question because it had no answer lines.

- (f) (i) Most candidates correctly stated that a burette measures volumes more accurately than a measuring cylinder. Candidates who performed less well stated that the burette was only used for fixed volumes or it could add the solution more slowly.
- (ii) Most could successfully answer this and better performing candidates gave clear explanations based on the temperature of the reaction mixture being uniform throughout or that the reaction mixture was stirred to evenly distribute the sulfuric acid. Other common acceptable answers were to mix the reactants, to increase the rate of reaction or to ensure that all the magnesium reacted or dissolved. To ensure all the sulfuric acid reacted did not gain credit as the sulfuric acid was added in excess.
- (g) As the dependent variable in the investigation is the temperature increase, candidates were expected to realise that insulating the boiling tube in some way would reduce the loss of heat energy from the solution to the surroundings. Less heat energy lost would mean a larger temperature rise.

There were many other suggestions which did not gain credit. These included the use of a water bath, which would actually prevent the desired increase in temperature. Other incorrect suggestions included not stirring with the thermometer, using a more accurate thermometer and replacing the burette with a volumetric pipette. Using a volumetric pipette in place of a burette was not accepted as that would require a volumetric pipette with five different volumes.

## Question 2

- (a) Candidates were expected to give an observation after adding the aqueous sodium thiosulfate and another observation after leaving the test-tube to stand.

The expected observations were the formation of a red/purple solution which became pale yellow/green.

- (b) (i) The candidates found this challenging, and observations often referred to the formation of a grey solid or precipitate. However, a precipitate is a solid formed in a reaction; in this case the grey solid was zinc which was added as one of the reagents and so is not formed as a precipitate.

The possible creditworthy observations were that addition of the dilute sulfuric acid forms a colourless solution (the original solution should have been yellow), that effervescence is seen and that the solution becomes green (due to the reduction of iron(III) to iron(II)).

- (ii) As the zinc reduces the iron(III) ions to iron(II) ions, the expected observation was the formation of a green precipitate. While many candidates gained the mark available, incorrect colours such as blue were relatively common. The formation of a red-brown precipitate was also common.
- (c) Most candidates correctly stated that a brown precipitate, which remains in excess, was formed.

- (d) This was the test for sulfate ions, as solid **D** was iron(III) nitrate. There should have been no precipitate formed. While most candidates gave a correct observation, some candidates described seeing the positive result for the sulfate test (the formation of a white precipitate) – this was impossible given the reagents used.
- (e) Candidates should have recognised this as the test for nitrate ions and so tested the gas given off using damp red litmus paper. As two marks were available, another observation was required, this being that bubbles are seen in the solution.
- (f) (i) The addition of aqueous iodide ions to a solution containing iron(III) ions results in the formation of iodine in solution, hence the expected observation was the formation of a brown solution. A few candidates reported no reaction. Solid iodine may also be formed in the reaction but there will still be a brown colour visible.
- (ii) The majority of candidates correctly stated that a black or blue-black solid is formed due to the reaction between the starch and the iodine formed in **2(f)(i)**.
- (iii) Addition of aqueous sodium thiosulfate reduces the iodine back to iodide ions and so the blue-black solid and the brown colour should both disappear and the solution should return to being yellow or colourless. Many candidates gave a correct observation, but some reported no change or simply stated that the solution goes back to its original colour without stating the original colour of the solution.
- (g) Many candidates could correctly identify iron(III) nitrate from their noted observations.

The more common errors were to state the salt was an ammonium salt (presumably due to the ammonia produced in **2(e)**) or that it was iron(II) – possibly not realising the test in **2(b)(ii)** was carried out on solution **B** rather than solution **A**.

### Question 3

This planning task was a quantitative task, and so candidates were expected to make measurements as part of the plan. They were asked to calculate the percentage of aluminium in *duralumin*, an alloy of aluminium, copper, magnesium and manganese. They were given information about the solubility of these four metals in dilute hydrochloric and nitric acids.

The simplest plan, which many followed, involved:

- weighing a sample of *duralumin*
- adding it to dilute nitric acid (to dissolve the magnesium and manganese)
- ensuring the acid was in excess
- heating it (to dissolve the copper)
- filtering (to obtain aluminium as residue)
- washing, drying and weighing the aluminium
- calculating the percentage of aluminium.

Whilst there was no need to use the hydrochloric acid at all, some did use it to calculate the percentage of copper in the *duralumin* and full credit was still available.

However, if both acids were used on one sample, then all the alloy would dissolve and full marks could not be gained.

A common misconception was that after treatment with hydrochloric acid, the nitric acid could be added to the filtrate to precipitate or crystallise the aluminium, which would not happen.

# CHEMISTRY

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Paper 0620/61  
Alternative to Practical

## Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. A line of best fit can be curved or straight – whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10<sup>n</sup>) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names or formulae.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.

## General comments

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

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus, the aims of the experiment, a list of safety precautions, or a list of dependent and independent variables. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

## Comments on specific questions

### Question 1

- (a) The majority of candidates could identify the item of apparatus in Figure 1.1 as a conical flask.
- (b) Candidates found this question challenging and found identifying the substance in the dropping funnel as hydrochloric acid demanding.

A considerable number of candidates stated that the substance was solid MnO<sub>2</sub> or tried to name the apparatus – most commonly stating that the dropping funnel was a burette.

- (c) Almost all the candidates correctly stated that a Bunsen burner could be used to heat the conical flask. Other correct answers seen were a heating plate or a water bath. Use of 'a flame' was insufficient to gain credit.

- (d) Candidates found this challenging with the majority wanting to use a bung in the collection vessel to prevent the chlorine gas from escaping. There were some vague references to where the tube should be pointing and incomplete descriptions of collection over water. Some candidates stated that the boiling tube should not be pointing downwards as chlorine is denser than air but did not develop their response by saying how the apparatus should be changed, for example, 'so the collection tube needs to be the other way up'.

The use of a gas syringe gained credit for a small number of candidates.

- (e) Most candidates appreciated that a fume cupboard should be used as the chlorine gas produced is toxic. A small number of non-credit worthy responses made reference to  $\text{HCl}$  being corrosive or use of a fume cupboard to keep the conditions the same.

## Question 2

- (a) Candidates performed well on this question and the majority gained all five marks available. The most common errors were either not recording the volume of dilute hydrochloric acid or the volume of aqueous sodium hydroxide to the same resolution (number of decimal places); the most common error being for Experiment two and stating the volume of aqueous sodium hydroxide was  $40 \text{ cm}^3$  and not  $40.0 \text{ cm}^3$ .
- (b) The ideal scale to use was one where each big grid square was equivalent to  $10 \text{ cm}^3$  and this was commonly seen. Often, 50 was omitted from the very top of the scale but candidates who did this still gained full credit. Candidates who used this scale were usually able to plot all five points correctly. The question asked for a straight line of best fit and most candidates joined the five plotted points with a straight line, using a ruler, thus gaining full credit.
- (c) Credit was awarded for:
- extrapolation of the best-fit line to the x-axis
  - a correct reading from the x-axis when the extrapolated line crossed the x-axis
  - units.

Most candidates were able to extrapolate their graph line so that a reading could be made at the x-axis.

A sizeable number of candidates did not include the unit (g) in their answer; all physical quantities should be accompanied by a unit.

- (d)(i) The fact that a volumetric pipette is more accurate than a measuring cylinder was well known. Candidates who performed less well stated that the volumetric pipette was only used for fixed volumes but did not make the link that the pipette is more accurate than the measuring cylinder for those fixed volumes or used the pipette to add the solution more slowly.
- (ii) As the volume of aqueous sodium hydroxide required was not known before the experiment (it is the dependent variable) the apparatus used must be capable of measuring any volume added rather than just measure a pre-known fixed volume. Therefore, it was not possible to use a volumetric pipette as the volume of each experiment was not fixed. Most candidates had a good understanding of this and gained full credit. A small number of candidates referred to volumetric pipettes not being large enough, pipettes not having a scale or being more accurate than a burette and these did not gain credit.
- (e) The candidates found this question challenging. Many knew that universal indicator is not used in acid–base titrations but could not express why this was not the case. Candidates often appreciated that universal indicator has a wide range of colours. Most candidates did not develop their explanation to say this was a problem as it is then difficult to tell the end-point or when neutralisation occurred.

- (f) This was a demanding question, which the candidates found challenging.

However, most candidates realised that if the concentration of sodium hydroxide increased then a lower volume would be required.

Better performing candidates realised if the concentration of the sodium hydroxide was doubled this meant that the volume required would be halved and thus gained full credit as they sketched the expected line at approximately half of the volumes obtained in the original experiment.

Several candidates did not answer this question, presumably overlooking it because it had no answer lines.

### Question 3

- (a) (i) The majority of candidates were able to state that a red flame was produced by lithium chloride.

- (ii) The candidates found this difficult. A minority appreciated that the yellow Bunsen burner flame is not used for a flame test as is not hot enough. Most candidates offered an explanation in terms of the yellow flame masking the flame colour or making the colour hard to see or yellow being the colour for sodium and these were given credit.

- (b) (i) Most candidates could state that a white precipitate was formed on the addition of aqueous silver nitrate to lithium chloride due to the presence of chloride ions.

- (ii) The candidates found this question more challenging as they often think that something needs to happen when solutions are added together. The addition of excess sodium hydroxide to lithium chloride would not show any change and thus the correct observation was 'no change'. Several candidates said that a white precipitate would be formed, or effervescence would be seen.

- (c) This proved challenging for candidates. Condensation forming at the top of a boiling tube is an indication that the solid is hydrated or contains water of crystallisation. In addition, the test for water was also given in the table (anhydrous cobalt(II) chloride goes from blue to pink) which showed that water was given off and so heating the solid must release water.

- (d) (i) The candidates performed well on this question with the majority being able to identify the two possible cations as chromium(III) or iron(II). A small number of candidates stated that one of the ions was iron(III) and not iron(II).

- (ii) The candidates performed well on this question with the majority using excess sodium hydroxide to distinguish between chromium(III) and iron(II). The use of excess aqueous ammonia did not gain credit since this test was used in the stem of the question. Partial credit was given for 'leave the precipitates to stand' and 'the green precipitate for iron (II) would turn brown near the surface' and 'the green precipitate for chromium(III) would not'. This did not gain full credit as the question asked the candidates for an additional test. A common phrase was to state 'put on a surface' and 'iron(II) turns brown'. 'Leave to stand' would be a much clearer statement.

- (e) Almost all candidates correctly identified the gas produced as carbon dioxide.

- (f) Most candidates could identify that the anion in solid **K** was sulfate due to the white precipitate formed with aqueous barium nitrate in **test 3**.

A small number of candidates suggested that the anion was carbonate, which was probably due to the confusion of carbon dioxide being produced from the reaction of **K** with aqueous sodium carbonate in **test 4**.

#### Question 4

This planning task was a quantitative task, and so candidates were expected to make measurements as part of the plan. They were asked to find the order of reactivity of three metals and were told that when these three metals react with aqueous copper(II) sulfate the temperature increases.

The simplest plan involved:

- using a known volume of aqueous copper(II) sulfate
- measuring this volume using a pipette or a measuring cylinder or a burette
- measuring the initial temperature of the copper(II) sulfate
- using a known mass of each metal
- adding the metal to the aqueous copper(II) sulfate and stirring
- measuring the final or highest temperature of the solution
- stating that the largest temperature rise is the most reactive metal.

Most candidates did not gain full credit for this planning task. It was rare for the candidates to state which item of apparatus they would use to measure the known volume of copper(II) sulfate and quite often they did not state that the copper(II) sulfate and the metal added to the copper(II) sulfate needed to be mixed or stirred. Candidates often suggested that the results were compared at the end of the experiment without drawing a conclusion relating highest temperature change to most reactive.

In an attempt to control the starting temperature, several candidates put the aqueous copper(II) sulfate into a water bath at the start. Unfortunately, they did not remove the copper(II) sulfate from the water bath before adding the metal powder and thus it would be impossible to measure the temperature rise or the temperature change.

A minority of candidates tried to add copper powder to the aqueous solutions of the cobalt, manganese and nickel. This could not gain full credit as the reactions would not occur, but partial credit was given for using a known volume of solution, a known mass of copper, taking the initial temperature of the solution and mixing the two together.

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## Key messages

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- In the qualitative analysis question (**Question 3**), where a question states that any gas produced is tested then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).
- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names or formulae.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.

## General comments

The majority of candidates were able to complete all questions in the time available, and the full range of marks was seen. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus, the aims of the experiment, a list of safety precautions or a list of dependent and independent variables. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

## Comments on specific questions

### Question 1

- (a) (i) The majority of the candidates correctly stated that effervescence or bubbling would be seen. Some candidates stated that 'a gas would be made'. Whilst this is a conclusion made from the observation of seeing bubbling, candidates were asked to describe what is seen and so needed to give the observation in their response.
- (ii) The expected answer was for candidates to identify an acid-base indicator that could be added to the reaction mixture and then state the colour that would be seen if the acid is in excess, or to state that more acid should be added and that if the acid was already in excess then there would be no more bubbling. A small number of candidates suggested adding more eggshell (which would ensure the acid is not in excess) or stated that all of the solid would dissolve if the acid was in excess. This is incorrect because candidates were told that part of the eggshell is insoluble in acid.

**(b)(i)** Candidates were expected to draw the apparatus used for filtration and label the diagram. The minimum required was:

- a funnel drawn with a filter paper visible inside
- the filter paper rising up the sides of the funnel and not just shown as a horizontal line
- no gap/hole in the bottom of the filter paper
- the funnel should be labelled correctly.

It was clear that most candidates were familiar with the apparatus used for filtration. However, holes in the bottom of the filter paper, missing filter paper, filter paper shown as just a horizontal line and mislabelled funnels were all relatively common.

Candidates should be encouraged to make diagrams 2-dimensional cross-sectional representations of the apparatus. It is more difficult to clearly show how the apparatus is arranged when drawing 3-dimensional 'pictures'.

- (ii)** When a residue obtained from filtration is washed with distilled water, water-soluble substances are removed. The two water-soluble substances present were hydrochloric acid and calcium chloride, which were shown as being aqueous in the equation in the introduction to the question. It is impossible for insoluble substances to be removed as they will not pass through the filter paper during washing. Many candidates identified one or more insoluble substance as being removed.
- (iii)** Stronger candidates normally correctly calculated the percentage as 94.5%. A very common error was to calculate the percentage of the eggshell that was not calcium carbonate and give an answer of 5.5%.

## Question 2

- (a)** Most candidates were able to read the burette diagrams correctly and complete the top three rows of the table. Some candidates read the scale upwards (as you would with a measuring cylinder scale) and gave, for example, 2.4 instead of 1.6 for the initial burette reading in Experiment 1. Stronger candidates were able to calculate the volumes added to reach the first and second end-points. To do this candidates needed to subtract the initial burette reading from the burette readings at the first and second end-points. Some candidates wrote the volume of acid **B** used. For the volume added to reach the second end-point, some candidates added the volume needed to reach the second end-point to the volume needed to reach the first end-point (e.g. in Experiment 2,  $9.8 + 19.7 = 29.5$ ), meaning that the volume to reach the first end-point had been counted twice. As all figures in Table 2.1 were either from a burette or calculated using readings from a burette, all should have been given to the same number of decimal places.
- (b)(i)** The need to clean the apparatus to remove any residue from Experiment 1 was well known.
- (ii)** Stronger responses clearly explained that water left in the burette would dilute solution **C** and so a greater volume would need to be added from the burette to reach the end-point. Some candidates gave responses such as 'the concentration will change and so the volume will change' and needed to give more specific detail.
- (iii)** Most candidates correctly stated that the white tile makes the colour change in the flask easier to see. The idea of the improvement of visibility of the colour change is important; without a white tile the colour change can still be seen but it is less obvious. A few candidates thought the white tile made the flask level or protected the bench.

- (c) Stronger responses clearly explained that the volume of solution **D** required was less than the volume of solution **C** and that therefore solution **D** was more concentrated. As the volume of solution **D** added at both end-points was half the volume of solution **C** added, solution **D** must have been twice as concentrated as solution **C**. Some candidates only repeated the titres in Table 2.1 and needed to use comparative phrases such as 'more' or 'less' in their response. A few candidates confused concentration with volume and used the terms interchangeably.
- (d) (i) Most candidates realised that doubling the volume of solution **B** would mean the volume of solution **C** would also need to be doubled. However, it was not uncommon for candidates to double the burette reading at the first end-point rather than double the volume added to reach the first end-point. A significant number of candidates did not include the unit ( $\text{cm}^3$ ) in their answer; all physical quantities should be accompanied by a unit.
- (ii) The problem with using  $50 \text{ cm}^3$  of solution **B** is that the required volume of solution **C** would be greater than  $50 \text{ cm}^3$  and so exceed the capacity of the burette. Weaker responses stated, 'the volume of **C** needed would be too large' or 'solution **C** would run out' and needed to give more specific detail.
- (e) Many candidates incorrectly stated that the volume needed is reduced because the reaction is faster and so it takes less time to reach the end-point. Volumes added in a titration are not related to reaction rate and depend only on the number of moles of reagent present. As warming the contents of the flask will not change the number of moles of **B** present, the volume of **D** required will not change.
- (f) The expected answer was that a pipette, or burette, should be used to measure the volume of solution **B**. Many candidates just stated that a pipette should be used and needed to explain what it would be used for. Some candidates incorrectly suggested using a pipette instead of a conical flask or instead of a burette.

### Question 3

- (a) (i) In this question, candidates were told that the student 'tests any gas produced'. This indicates that candidates are expected to give a positive test and result for the gas produced. Many candidates stated that bubbles would be seen. When a gas is made it is common for bubbles to be seen, but in the reaction of the ammonium ion with an alkali, bubbles are not seen unless the reaction mixture is boiled rather than warmed gently. The gas formed dissolves in the water and warming the solution gently causes the gas to leave the liquid.
- (ii) The majority of candidates stated correctly that the gas made was ammonia, although a number identified other gases despite often naming ammonia in **3(a)(i)**. It should be noted that 'ammonium' is incorrect and is not a valid alternative for 'ammonia'.
- (b) The majority of candidates stated correctly that a white precipitate would form.
- (c) In this test, a purple solution of acidified aqueous potassium manganate(VII) is added to a colourless solution of ammonium sulfate. As no reaction takes place, the colourless solution should become pink or light purple due to the unreacted manganate(VII) ions. A common incorrect answer was 'no reaction' or 'no change'. The question asks for observations, and while there is no reaction the observation is that the solution becomes pink/purple.
- (d) Many candidates correctly identified the three ions in solid **F**. The most common errors were to identify one of the ions as aluminium or to call the iodide ion 'iodine'.

#### Question 4

This planning task was a quantitative task, and so candidates were expected to make measurements as part of their plan. There are two suitable approaches: either measure how long it takes to increase the temperature of the water by a known amount or measure the temperature increase in a specified time.

Both approaches should include:

- using appropriate apparatus to measure the volume of the water being heated
- measuring the initial temperature of the water used before it was heated.

Candidates were then expected to either:

- start heating and start a stop-watch at the same time
- measure the time taken to reach a specified temperature increase or a specified temperature
- make a conclusion linking the time taken to which alcohol heated the water the fastest

**OR**

- heat the water for a specified time
- measure the final temperature of the water and calculate the temperature change
- make a conclusion linking the temperature increase to which alcohol heated the water the fastest.

Many candidates made sure the volume of each alcohol was the same in each experiment. This is not necessary as not all of the alcohol will be used to heat the water, and some will remain in the spirit burner. Some candidates described how to clean the spirit burners between each experiment, this is not necessary as the question states that three spirit burners are provided.

The conclusion had to make a connection between time taken or temperature increase obtained and the rate of heating. It was not uncommon for candidates to state, 'the alcohol which heated the water the fastest was the fastest'. These candidates needed to show how they would use the data to make this conclusion by indicating how they would know which is the fastest based on what was measured.

Some candidates wrote out lists of apparatus, dependent variables, independent variables and control variables. Credit will not be awarded for a list of apparatus; if credit is available for apparatus, then it will only be awarded if the apparatus is used appropriately in the method.

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## Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not just a small dot which is obscured by the graph line, which should be drawn using a sharp pencil. A line of best fit can be curved or straight – whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. A best-fit line should have an approximately equal number of points on each side of the line (excluding anomalous results), candidates will need to decide if the line should be curved or straight; if a straight line has the points at either end of the line on one side of the line and the points in the middle on the other side, then the best-fit line should probably be a curve. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10<sup>n</sup>) – this is indicated in the Presentation of Data section of the syllabus in the section entitled ‘Graphs’ (and also recommended by the Association for Science Education (A.S.E.)).
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- In the qualitative analysis question (**Question 3**), where a question states that any gas produced is tested then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term ‘precipitate’ when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).
- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names or formulas.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is not in the compound being tested.

## General comments

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

As has been noted previously, some candidates omit questions when the answer needs to be written on a diagram and there is no dotted answer line. These errors of omission would not occur if candidates read all of the questions on the examination paper rather than just looking for dotted lines on which answers should be written.

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus, the aims of the experiment, a list of safety precautions, or a list of dependent and independent variables. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

### Comments on specific questions

#### Question 1

- (a) The majority of the candidates correctly named the inverted filter funnel in Figure 1.1. 'Funnel' alone was an acceptable answer.
- (b) This proved to be a challenging question, with many giving a generic answer, such as 'to turn the gas into liquid', rather than one specific to the question, such as 'to condense the steam into water'.
- (c) Many candidates could give a correct test for the presence of water. The most common error was to miss out 'anhydrous' before the copper(II) sulfate or cobalt chloride. Colour changes were also well known, although sometimes they were given the wrong way around or given for the other chemical. A few thought that anhydrous copper(II) sulfate was colourless rather than white.
- (d) Nearly everyone could correctly identify the test-tube or boiling tube.
- (e) Around half of the candidates identified the mistake in the diagram by ringing the end of the left-hand tube, which should have ended below the surface of the acidified aqueous potassium manganate(VII). Some candidates incorrectly ringed both tubes. However, a significant minority completely omitted this question as there was no answer line. It is important to read everything in a question.
- (f) Several candidates knew that the gas decolourising the potassium manganate(VII) solution was sulfur dioxide. Others knew that the manganate(VII) ions had been reduced, which was also an acceptable answer.

#### Question 2

- (a) Nearly all candidates successfully read the temperatures correctly and completed the table of results. It was expected that all temperatures and temperature changes would be recorded to the same resolution, i.e. to the nearest half division on the thermometer, the nearest 0.5 °C. This meant, for example, that 8.0 was expected, but 8 was insufficient. There has always been a small proportion of candidates who do not record to one decimal point for whole numbers, but there appeared to be fewer instances this session.
- (b) Most candidates produced sensible graph scales, the most common being each large grid square being 5 °C. Those who chose to use difficult scales often made errors in the plotting and so did not gain the credit available for the correct plotting of all five points. The best-fit line was a smooth curve based on the data given in the question. The point at 25cm<sup>3</sup> was clearly anomalous and should have been ignored when drawing the best-fit line, however, some candidates deviated their curve to include it. Many candidates incorrectly drew straight lines, often just from the first point to the last point, when the points were clearly on a curve of decreasing gradient. Straight lines which have the points at either end of the line on one side of the line and the points in the middle on the other side suggest that the points lie on a curve. Some candidates are still drawing graph lines in pen; this means that if an error is made the line cannot be erased and so multiple graph lines are seen. Very few candidates now use non-linear scales. If a scale is non-linear, then credit for the scale or the plotting of the data cannot be awarded.
- (c) This was the most challenging question on the paper. Around half of the candidates could recognise that, as the volume of sulfuric acid increases, the temperature increase also increases. However, very few went on to explain that the heat energy produced was the same in every reaction (as the mass of magnesium, the limiting factor, was the same in every reaction). However, as the volume increased, the energy had to raise the temperature of more of the solution.
- (d) Most candidates were able to continue their graph line to the right so that a reading could be made at 33cm<sup>3</sup>. A considerable number of candidates did not include the unit (°C) in their answer; all physical quantities should be accompanied by a unit.

- (e) This was found to be difficult as not only did line **E** have to be below the original line at all values, but it could not touch or cross the *x*-axis. The temperature increase cannot be zero or negative. The best answers came from candidates who realised that using half the quantity of magnesium meant that the temperature increase would be halved. Again, several candidates did not answer this question, perhaps because it had no answer lines.
- (f) (i) The vast majority of candidates correctly stated that a burette measures volumes more accurately than a measuring cylinder.
- (ii) Most could successfully explain that the reaction mixture was stirred to evenly distribute the sulfuric acid. It was also accepted 'to mix the reactants', 'to increase the rate of reaction' or 'to ensure that all the magnesium reacted or dissolved'.
- (g) The required answer was based on the fact that insulating the boiling tube or using a polystyrene cup would function as an insulator and so reduce heat loss from the solution. Less heat energy lost would mean a larger temperature rise. There were many other suggestions which did not gain credit. These included the use of a water bath, which would actually prevent the desired increase in temperature. Other incorrect suggestions included not stirring with the thermometer, using a more accurate thermometer and replacing the burette with a pipette.

### Question 3

Candidates were told that solution **A** was iron(III) nitrate.

A few candidates still appear not to realise that there are the Qualitative Analysis Notes on the last two pages of the question paper.

- (a) Most candidates correctly gave the formation of a red-brown precipitate on the dropwise addition of aqueous sodium hydroxide. The precipitate should have remained when excess aqueous sodium hydroxide was added. A small number of candidates stated that the precipitate was green, confusing iron(II) ions with iron(III) ions.
- (b) (i) Most candidates got the insoluble red-brown precipitate. However, a significant minority thought this was an extension of **3(a)** and answered that there would be no change. The question does clearly say 'to the second portion of solution **A** ...'.
- (ii) When a question states that any gas produced is tested, then candidates are expected to record the details for the gas test that gives a positive result. In this case, it was that damp red litmus paper went blue.
- (iii) Nearly everyone identified the gas as ammonia.
- (c) This was the test for sulfate ions. As there are no sulfate ions in solution **A** there should have been no change. A common error was to state 'white precipitate', the expected result for a positive sulfate test.
- (d) Nearly all could identify carbon dioxide from a positive test result.
- (e) Many candidates correctly identified solid **B** as barium carbonate. It was not uncommon for candidates to identify just one of the ions, normally the barium ion from the flame test colour.

#### Question 4

This planning task was a quantitative task, and so candidates were expected to make measurements as part of the plan. They were asked to calculate the percentage of aluminium in *duralumin*, an alloy of aluminium, copper, magnesium and manganese. They were given information about the solubility of these four metals in dilute hydrochloric and nitric acids.

The simplest plan, which many followed, involved:

- weighing a sample of *duralumin*
- adding it to dilute nitric acid (to dissolve the magnesium and manganese)
- ensuring the acid was in excess
- heating it (to dissolve the copper)
- filtering (to obtain aluminium as residue)
- washing, drying and weighing the aluminium
- calculating the percentage of aluminium.

Whilst there was no need to use the hydrochloric acid at all, some did use it to calculate the percentage of copper in the *duralumin* and full credit was still available.

However, if both acids were used on one sample, then all the alloy would dissolve and full marks could not be gained.

A common misconception was that after treatment with hydrochloric acid, the nitric acid could be added to the filtrate to precipitate or crystallise the aluminium, which would not happen.