Cambridge Assessment International Education

Example Candidate Responses – Paper 3

Cambridge IGCSE™ / IGCSE (9-1)

Chemistry 0620 / 0971

For examination from 2021

Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge IGCSE™ / IGCSE (9-1) Chemistry 0620 / 0971, and to show how different levels of candidates' performance (high, middle and low) relate to the subject's curriculum and assessment objectives.

In this booklet, candidate responses have been chosen from the June 2021 series to exemplify a range of answers.

For each question, the response is annotated with a clear explanation of where and why marks were awarded or omitted. This is followed by examiner comments on how the answer could have been improved. In this way, it is possible for you to understand what candidates have done to gain their marks and what they could do to improve their answers. There is also a list of common mistakes candidates made in their answers for each question.

This document provides illustrative examples of candidate work with examiner commentary. These help teachers to assess the standard required to achieve marks beyond the guidance of the mark scheme. Therefore, in some circumstances, such as where exact answers are required, there will not be much comment

The questions and mark schemes used here are available to download from the School Support Hub. These files are:

0620 June 2021 Question Paper 31

0620 June 2021 Mark Scheme 31

Past exam resources and other teaching and learning resources are available on the School Support Hub:

www.cambridgeinternational.org/support

How to use this booklet

This booklet goes through the paper one question at a time, showing you the high-, middle- and low-level response for each question. The candidate answers are set in a table. In the left-hand column are the candidate answers, and in the right-hand column are the examiner comments.

Example Candidate Response – high	Examiner comments
(a) Answer these questions using only the information in the table. **(i)** State which negative ion has the highest mass in 1000 cm^3 of fruit juice. Chloride 1 [1] **(ii)** Give the formulae of the ions in ammonium sulfate. NH_4^+ and SO_4^{2-} 2 [1] **(iii)** Calculate the mass of sodium ions in 200 cm^3 of fruit juice. $\frac{200}{1000} \times 120 = 24\,mg$ 3 mass = 24 mg [1] **(b)** Describe a test for lithium ions.	1 The candidate identifies the chloride ion as having the highest mass of the negative ions and so gains the mark. 2 The candidate identifies both ions in ammonium sulfate correctly by referring to the information in the table. 3 The candidate uses the method of direct proportion to

Answers are by real candidates in exam conditions. These show you the types of answers for each level. Discuss and analyse the answers with your learners in the classroom to improve their skills.

Examiner comments are alongside the answers. These explain where and why marks were awarded. This helps you to interpret the standard of Cambridge exams so you can help your learners to refine their exam technique.

How the candidate could have improved their answer

- **(a)(i)** The candidate could also have obtained the mark by writing the formula of the ion.
- **(a)(iii)** The candidate would have also gained the mark if no working were shown. However, candidates should always be advised to show their working in full, especially in longer calculations.
- **(c)** The candidate wrote the correct answer for nitrogen a… …d, this is the preferred way rather than writing a symbol or f… careful reading of the question. The name of an element… (phosphate). The candidate should remember NPK (for …

This section explains how the candidate could have improved each answer. This helps you to interpret the standard of Cambridge exams and helps your learners to refine their exam technique.

Common mistakes candidates made in this question

- **(a)(i)** The most common error was to suggest 'potassium' through not reading the question carefully enough and selecting the positive ion instead of the negative ion.
- **(a)(ii)** Some candidates did not refer to the information in the table and wrote the formulae for sulfide ions or, for example, SO_2– for sulfate. Another common error was to write NH_3 ammonium. Others wrote the correct symbols but without the charges or with incorrect charges.
- **(a)(iii)** Some candidates tried to use moles, e.g. 200/23 = 8.7 or 23 x 2 = 46. Candidates should realise that there are no moles calculations in the core paper.
- **(b)** Many candidates gave an incorrect flame colour, usu… …king of a…
- **(** … …ch was i… …tes. A fe… …

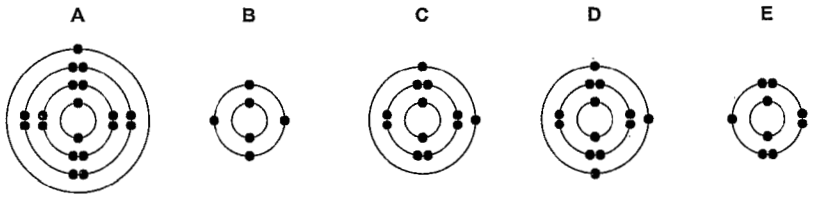
Often candidates were not awarded marks because they misread or misinterpreted the questions.

Lists the common mistakes candidates made in answering each question. This will help your learners to avoid these mistakes and give them the best chance of achieving the available marks.

Question 1

Example Candidate Response – high

1 **(a)** The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group II of the Periodic Table

C 1 [1]

(ii) an atom with a proton number of 13

D 2 [1]

(iii) an atom that forms a stable ion with a single negative charge

E 3 [1]

(iv) an atom of a non-metal that forms a giant covalent structure

B 4 [1]

(v) an atom of a metal used in food containers.

D 5 [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the vanadium atom and calcium ion shown.

	number of electrons	number of neutrons	number of protons
$^{51}_{23}V$	23	28	23
$^{48}_{20}Ca^{2+}$	18	28	20

[3]

6

Examiner comments

1 The candidate identifies magnesium correctly, relating the group number to the number of electrons in the outer shell, and is awarded the mark.

2 The candidate gains the mark by relating the number of protons (13) to the same number of electrons.

3 The candidate is awarded the mark by realising that Group VII elements (7 electrons in the outer shell) form ions by gaining an electron, and therefore giving the particle a charge of -1.

4 The candidate gains the mark by identifying carbon as the only giant covalent structure on the syllabus. The candidate recognises that carbon has four electrons in its outer shell.

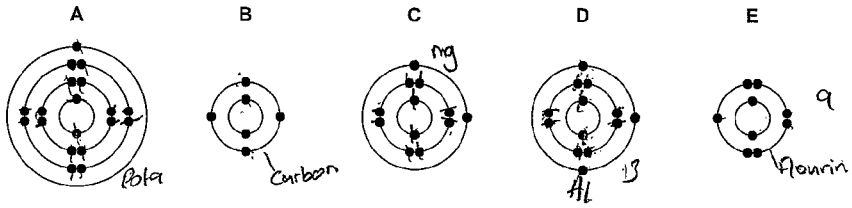
5 The candidate gains the mark by recognising that aluminium is used in food containers and knows that aluminium is in Group III of the Periodic Table. Therefore, aluminium has three electrons in its outer shell.
Mark for (a) = 5 out of 5

6 The candidate appreciates that the species shown is a calcium ion, meaning that two electrons have been lost from a calcium atom giving 18 electrons. The candidate calculates the number of neutrons in a vanadium atom correctly (51−23 = 28) and realises that the bottom number in the symbol is the number of protons.
Mark for (b) = 3 out of 3

Total mark awarded =
8 out of 8

Example Candidate Response – middle

1 (a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group II of the Periodic Table

C ..... 1 ..... [1]

(ii) an atom with a proton number of 13

D ..... 2 ..... [1]

(iii) an atom that forms a stable ion with a single negative charge

A ..... 3 ..... [1]

(iv) an atom of a non-metal that forms a giant covalent structure

C ..... 4 ..... [1]

(v) an atom of a metal used in food containers.

D ..... 5 ..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the vanadium atom and calcium ion shown.

	number of electrons	number of neutrons	number of protons
$^{51}_{23}V$	23	28	23
$^{48}_{20}Ca^{2+}$	20	28	20

[3]

6

Examiner comments

1 The candidate identifies magnesium correctly, realising that it is in Group II and therefore has two electrons in its outer shell.

2 The candidate realises the number of electrons in an atom is equal to the number of protons and therefore chooses the correct answer.

3 The candidate does not heed the essential words in the question stem relating to the formation of the ion from the atom shown. In order to form a stable outer shell of eight electrons, structure E needs to gain an electron and so form an ion with a -1 charge. The candidate focuses on the single electron in the outer shell of the atom, rather than the formation of an ion.

4 The candidate does not gain the mark because they choose a metallic giant structure rather than a non-metallic giant structure.

5 The candidate realises that aluminium is used in food containers and selects the atom with three electrons in its outer shell.
Mark for (a) = 3 out of 5

6 The candidate does not appreciate that the species shown is a calcium ion, meaning that two electrons have been lost from a calcium atom giving 18 electrons. The candidate calculates the number of neutrons in a vanadium atom correctly (51−23 = 28) (1 mark) and realises that the bottom number in the symbol is the number of protons (1 mark).
Mark for (b) = 2 out of 3

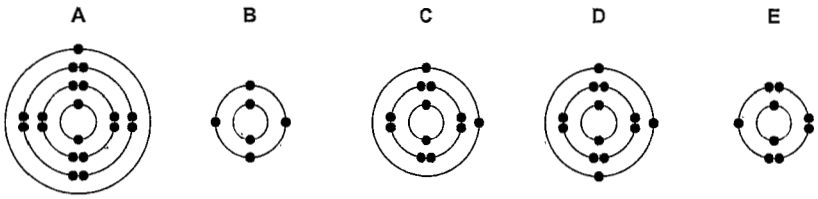
Total mark awarded = 5 out of 8

How the candidate could have improved their answer

- **(a)(iii)** The candidate did not read the stem of the question, which required the structure of the ion to be derived from the atom rather than the atom itself. The candidate focussed on the single electron in the outer shell rather than trying to make a complete shell of eight electrons.
- **(a)(iii)** Candidates should remember that ions are formed by the gain or loss of electrons to form a complete stable shell of eight (or two) electrons. Negative ions are formed by gain of electrons and so structure **E** is correct. The question paper stated that fluorine is a Group 7 element and these elements form ions with a -1 charge.
- **(a)(iv)** The candidate selected a metallic giant structure, rather than a non-metallic structure. For Paper 3, it is only the giant covalent structure of carbon that candidates should know. If the candidate remembers this, then looks for the electronic configuration of carbon, they should arrive at structure **B**.
- **(b)** In answering this question, the candidate needed to appreciate that the species required was a 2+ ion rather than an atom: The atom has a 2+ charge because it has lost two electrons (20−2 = 18 electrons).

Example Candidate Response – low

1 (a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group II of the Periodic Table

A 1 ..... [1]

(ii) an atom with a proton number of 13

C 2 ..... [1]

(iii) an atom that forms a stable ion with a single negative charge

B 3 ..... [1]

(iv) an atom of a non-metal that forms a giant covalent structure

B 4 ..... [1]

(v) an atom of a metal used in food containers.

B 5 ..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the vanadium atom and calcium ion shown.

	number of electrons	number of neutrons	number of protons
$^{51}_{23}V$	23		
$^{48}_{20}Ca^{2+}$	20	28	28

[3]

6

Examiner comments

1 The candidate does not appreciate the number of electrons in the outer shell is equal to the group number, so does not gain the mark. The correct answer is **C**.

2 The candidate does not gain the mark because either they do not appreciate that the number of protons in an atom equals the number of neutrons, or they may have miscounted the number of dots. The correct answer is **D**.

3 The candidate does not gain the mark because they do not appreciate that halogen atoms have seven electrons in their outer shell, and therefore need one more electron in the outer shell to form a stable ion with a 1- charge.

4 The candidate recognises carbon is a giant structure and has four electrons in its outer shell and so gains the mark.

5 The candidate is not awarded the mark because they either do not appreciate that aluminium is used in food containers, or that aluminium has three electrons in its outer shell. Mark for (a) = 1 out of 5

6 The candidate does not appreciate that the species shown is a calcium ion, meaning that two electrons had been lost from a calcium atom giving 18 electrons. The candidate does not calculate the number of neutrons in a vanadium atom (28) despite the example given for calcium. The candidate thinks the number of protons in a calcium ion is equal to the number of neutrons, rather than the bottom number in the symbol. Mark for (b) = 0 out of 3

Total mark awarded = 1 out of 8

How the candidate could have improved their answer

- **(a)(i)** The candidate should have recognised that the number of outer shell electrons, shown by dots, is equal to the group number.
- **(a)(ii)** The candidate should have recognised that the number of protons in an atom is equal to the number of electrons.
- **(a)(iii)** The candidate should have used the Periodic Table to ascertain that fluorine is in Group VII and then recognise that the number of outer shell electrons is equal to the group number.
- **(a)(iv)** The candidate gained the mark; the rationale being that the only giant structure the candidates should know at this level is carbon, which has four electrons in its outer shell and six electrons in total.
- **(a)(v)** The candidate should firstly recognise that aluminium is used in food containers. The candidate should then go on to find the electronic structure required by reference to the Periodic Table (Group III) and knowing that the number of outer shell electrons is equal to the group number.
- **(b)** The candidate needed to remember that in isotopic symbols, the bottom number is the number of protons, the top number is the number of protons + neutrons and the number of neutrons is calculated by subtracting the bottom number from the top number. In calculating the number of electrons, the candidate needed to appreciate that the species required was a 2+ ion rather than an atom: The atom has lost two electrons (20−2 = 18 electrons).

Common mistakes candidates made in this question

- **(a)(i)** It was common for candidates to give the number of electron shells rather than the number of electrons.
- **(a)(ii)** Miscounting the number of electrons to give structure **C** rather than **D** was frequently seen.
- **(a)(iii)** Some candidates misread the question by ignoring the phrase ‘forms an ion’ and to suggest structure **A**, which has one electron in its outer shell.
- **(a)(iv)** A misunderstanding of the term ‘giant structure’ was evident, by thinking that these structures must have atoms with more electrons than others. This led to many candidates giving the incorrect structure **A**.
- **(a)(v)** The wide variety of incorrect answers suggested that many candidates did not know that aluminium is used for food containers, with many giving magnesium (structure **C**) instead.
- **(b)** Many candidates did not recognise isotopic notation. The most common errors in deducing the number of protons were to muddle the mass number and proton number or suggest that the calcium ion has 18 protons, even when the number of electrons was incorrect. The most common in deducing the number of neutrons was to give the mass number or to add the number of protons to the mass number. Most candidates ignored the charge on the calcium ion and gave the number of electrons in an atom of calcium.

Question 2

Example Candidate Response – high

2 The table shows the masses of some of the ions in 1000 cm^3 of fruit juice.

name of ion	formula of ion	mass of ion in 1000 cm^3 of fruit juice / mg
	NH_4^+	43
calcium	Ca^{2+}	79
chloride	Cl^-	135
lithium	Li^+	1
magnesium	Mg^{2+}	80
nitrate	NO_3^-	35
phosphate	PO_4^{3-}	120
potassium	K^+	575
sodium	Na^+	120
	SO_4^{2-}	105

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the highest mass in 1000 cm^3 of fruit juice.

Chloride (1) [1]

(ii) Give the formulae of the ions in ammonium sulfate.

NH_4^+ and SO_4^{2-} (2) [1]

(iii) Calculate the mass of sodium ions in 200 cm^3 of fruit juice.

$\frac{200}{1000} \times 120 = 24 mg$ (3)

mass = 24 mg [1]

(b) Describe a test for lithium ions.

test Flame test

observations The flame will turn red. (4) [2]

(c) Ions of the element potassium, K, are present in most fertilisers.

State the names of two **other** elements that are in most fertilisers.

1 Nitrogen

2 Phosphate (5) [2]

Examiner comments

(1) The candidate identifies the chloride ion as having the highest mass of the negative ions and so gains the mark.

(2) The candidate identifies both ions in ammonium sulfate correctly by referring to the information in the table.

(3) The candidate uses the method of direct proportion to calculate the mass correctly. The candidate shows the working clearly.
Mark for (a) = 3 out of 3

(4) The candidate gains both marks by realising that a flame test is used to identify Group I elements, and by giving the correct flame colour.
Mark for (b) = 2 out of 2

(5) The candidate gains one mark for recognising nitrogen as an element, other than potassium, which is present in most fertilisers. The mark is not given for 'phosphates' because the stem of the question asks for the name of an element, not the name of an ion.
Mark for (c) = 1 out of 2

Example Candidate Response – high, continued

(d) Orange juice is acidic.

Draw a circle around the pH of orange juice.

pH 4 (6) pH 7 pH 10 pH 13 [1]

(e) Some soils are acidic.

Give the names of **two** compounds that are used to make soils less acidic.

1 calcium carbonate

2 calcium hydroxide (7) [2]

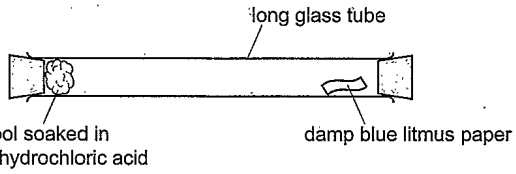
(f) Hydrogen chloride is an acidic gas produced when concentrated hydrochloric acid evaporates.

(i) Describe the arrangement and separation of the molecules in hydrogen chloride gas.

arrangement The particles ~~are~~ have no fixed arrangements ~~and~~

separation The particles are seperated and far apart (8) [2]

(ii) A long glass tube is set up as shown.



At first, the blue litmus paper does not turn red.
After a short time, the litmus paper turns red.

Explain these observations using the kinetic particle model.

The hydrochloric acid particles from the cotton wool gain enough energy to overcome forces of attraction and evaporate into the surroundings. The HCl gas now undergoes diffusion, and travel towards the other end of the tube, from higher concentration to lower concentration down a concentration gradient. [3]

The HCl gas reacts with the blue litmus paper turning it red. (9) [Total: 15]

Examiner comments

(6) The candidate gains the mark for realising that acidic pH values are below pH 7.
Mark for (d) = 1 out of 1

(7) The candidate is awarded both marks available by realising that calcium hydroxide is basic and so neutralises acidic soils. The candidate also chooses a different type of compound, calcium carbonate, which reacts with acids.
Mark for (e) = 2 out of 2

(8) The candidate gains a mark for realising that there is no fixed arrangement of molecules in a gas. The candidate also gains the second mark for stating that the separation is 'far apart'.

(9) The candidate gains three marks for:
(1) the idea of hydrochloric acid particles gaining energy to escape into the surroundings; (2) identifying the process as diffusion; (3) moving from a higher to a lower concentration.
Mark for (f) = 5 out of 5

Total mark awarded = 14 out of 15

How the candidate could have improved their answer

- **(a)(i)** The candidate could also have obtained the mark by writing the formula of the ion.
- **(a)(iii)** The candidate would have also gained the mark if no working were shown. However, candidates should always be advised to show their working in full, especially in longer calculations.
- **(c)** The candidate wrote the correct answer for nitrogen as a full name. If asked to name an element or compound, this is the preferred way rather than writing a symbol or formula. The candidate could improve their marks by a careful reading of the question. The name of an element was required (phosphorus) and not the name of an ion (phosphate). The candidate should remember NPK (for nitrogen, phosphorus and potassium).
- **(f)(i)** The candidate gained both marks but could improve their answer by writing 'random arrangement' instead of 'no fixed arrangement' and not using phrases such as 'the particles are separated' when the word separation is part of the question. Fortunately, the candidate also included the words 'far apart', which gained the mark.
- **(f)(ii)** Although the candidate gained all three marks, the answer could be improved by referring to 'particles' of hydrochloric acid moving randomly rather than just, 'The HCl gas … travels…'. All candidates should read the stem of the question carefully noting that the kinetic particle model is required, i.e. particles / molecules are (on average) moving randomly from where they are at a higher concentration to where they are at a lower concentration.

Example Candidate Response – middle

2 The table shows the masses of some of the ions in 1000 cm^3 of fruit juice.

	name of ion	formula of ion	mass of ion in 1000 cm^3 of fruit juice / mg
✗		NH_4^+	43
✗	calcium	Ca^{2+}	79
	chloride	Cl^-	135
✗	lithium	Li^+	1
✗	magnesium	Mg^{2+}	80
	nitrate	NO_3^-	35
	phosphate	PO_4^{3-}	120
✗	potassium	K^+	575
✗	sodium	Na^+	120
		SO_4^{2-}	105

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the highest mass in 1000 cm^3 of fruit juice.

Chloride (1) [1]

(ii) Give the formulae of the ions in ammonium sulfate.

NH_4^+ and SO_4^{2-} (2) [1]

(iii) Calculate the mass of sodium ions in 200 cm^3 of fruit juice.

If 120 ← 1000
200

$\frac{200 \times 120}{1000} = 24$ (3)

mass = 24 mg [1]

(b) Describe a test for lithium ions.

test Silver Nitrate (4)

observations it will form a white presipitate when present.

[2]

(c) Ions of the element potassium, K, are present in most fertilisers.

State the names of two **other** elements that are in most fertilisers.

1 Magnesium

2 ~~Nitrate~~ Sodium (5)

[2]

Examiner comments

1 The candidate identifies the negative ion with the highest mass and so gains the mark.

2 The candidate identifies both ions in ammonium sulfate correctly by referring to the information in the table.

3 The candidate uses the method of direct proportion to calculate the mass correctly. The candidate shows the working clearly.
Mark for (a) = 3 out of 3

4 The candidate does not gain the marks because they do not realise that the test for Group I elements involves a flame test, rather than a precipitation reaction.
Mark for (b) = 0 out of 2

5 The candidate does not gain the marks because they choose two metals rather than the two non-metals, nitrogen and phosphorus. Candidates should remember NPK as the symbols for important elements in fertilisers.
Mark for (c) = 0 out of 2

Example Candidate Response – middle, continued

(d) Orange juice is acidic.

Draw a circle around the pH of orange juice. 6

pH 4 pH 7 pH 10 pH 13 [1]

(e) Some soils are acidic.

Give the names of **two** compounds that are used to make soils less acidic.

1 Calcium oxide.

2 Magnesium oxide. 7 [2]

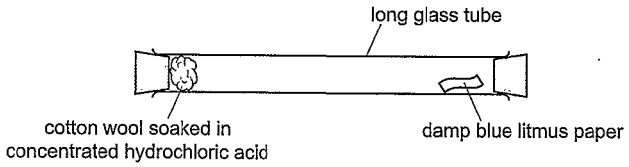
(f) Hydrogen chloride is an acidic gas produced when concentrated hydrochloric acid evaporates.

(i) Describe the arrangement and separation of the molecules in hydrogen chloride gas.

arrangement They are not banded totogethes and have are random arrangement of molecules.

separation Due to heat the molecules broke these bonds. 8 changing these physical state and causing the molecules to separate [2]

(ii) A long glass tube is set up as shown.



At first, the blue litmus paper does not turn red.
After a short time, the litmus paper turns red.

Explain these observations using the kinetic particle model.

Due to the kinetic energy present the particles moved and bounced of the walls of the glass tube and increasedg in force lead to the particles being more active and causing the colour to change after it detected the acidic particles bouncing. 9 [3]

Examiner comments

6 The candidate gains the mark for realising that acidic pH values are below pH 7.
Mark for (d) = 1 out of 1

7 The candidate gains one of the two marks available by realising that calcium oxide is basic and so neutralises acidic soils. Magnesium oxide was awarded credit (as benefit of doubt), if calcium oxide had not been selected, but two different types of compound are required, e.g. calcium carbonate, calcium hydroxide (not two types of oxide).
Mark for (e) = 1 out of 2

8 The candidate gains a mark for realising that the arrangement of molecules in a gas is random but does not gain the second mark because they just repeat the word separation in the question. The correct answer is far apart. The idea about breaking bonds also confuses the issue and suggests that the candidate does not understand the physical structure of molecules.

9 The candidate realises that the kinetic particle model involves movement of particles and so gains a mark for this. No other marks are given because there is no indication that the movement is random, or that the particles are spreading out from where the concentration is high, to where it is low. In addition, no mention is made of diffusion.
Mark for (f) = 2 out of 5

Total mark awarded = 7 out of 15

How the candidate could have improved their answer

- **(a)(i)** The candidate could also have obtained the mark by writing the formula of the ion.
- **(a)(iii)** The candidate would also have gained the mark if no working were shown. However, candidates should always be advised to show their working in full, especially in longer calculations as credit may be awarded for the method used.
- **(b)** The candidate should have recognised that the test for Group I metals / metal ions involves a flame test and not a precipitation reaction. Candidates should make sure that they memorise the tests given in the qualitative analysis section of the syllabus.
- **(c)** The candidate gave the names of two metals rather than two relevant non-metals. The candidate should remember the symbols for the three essential elements in fertilisers as NPK (nitrogen, phosphorus, potassium).
- **(e)** The candidate needed to give the names of three distinct types of compounds rather than the name of two oxides. The candidate would be advised to think of the different types of compound that react with acids, e.g. carbonates, oxides, hydroxides.
- **(f)(i)** The candidate should realise that when answering a question, they should try not to repeat words from the stem of the question and only include relevant information. The candidate's answer just repeated the word 'separate'. The word separation needs to be explained, e.g. referring to the distance between the particles. The candidate should also realise that an (incorrect) explanation is not required because the command word is 'describe' not 'explain'.
- **(f)(ii)** The candidate should have named the process as diffusion and read the stem of the question carefully. The candidate did note that the kinetic particle model is required, i.e., particles / molecules are moving, but some further description of the movement is also needed, e.g. 'randomly' and 'particles moving from a higher concentration to a lower concentration'. This is indicated by the command word 'explain' in the stem of the question.

Example Candidate Response – low

2 The table shows the masses of some of the ions in 1000 cm³ of fruit juice.

name of ion	formula of ion	mass of ion in 1000 cm³ of fruit juice / mg
	NH_4^+	43
calcium	Ca^{2+}	79
chloride	Cl^-	135
lithium	Li^+	1
magnesium	Mg^{2+}	80
nitrate	NO_3^-	35
phosphate	PO_4^{3-}	120
potassium	K^+	575
sodium	Na^+	120
	SO_4^{2-}	105

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the highest mass in 1000 cm³ of fruit juice.

chloride [1]

(ii) Give the formulae of the ions in ammonium sulfate.

Nitrogen and Hydrogen [1]

(iii) Calculate the mass of sodium ions in 200 cm³ of fruit juice.

$\frac{200\text{cm}^3 \times 120\text{mg}}{1000\text{cm}^3} = \frac{24000}{1000}$

$= 24\text{mg}$

mass = 24 mg [1]

(b) Describe a test for lithium ions.

test flame test

observations if carbon dioxide is observe you will hear a popping sound [2]

(c) Ions of the element potassium, K, are present in most fertilisers.

State the names of two **other** elements that are in most fertilisers.

1 Nitrogen

2 Phosphorus [2]

Examiner comments

1 The candidate correctly identifies the chloride ion which has the highest concentration of the negative ions.

2 The candidate does not appreciate the term ions and disregards the sulfate. The candidate only gives the name of the elements in the ammonium ion, and so does not gain the mark.

3 The candidate calculates the mass correctly by simple proportion showing all the working.
Mark for (a) = 2 out of 3

4 The candidate correctly identifies that a flame test is needed but does not realise that a colour (red) is required for the second mark, rather than the test for a gas given off.
Mark for (b) = 1 out of 2

5 The candidate gives the names of the two other elements important for plant growth which are present in most fertilisers.
Mark for (c) = 2 out of 2

Example Candidate Response – low, continued

(d) Orange juice is acidic.

Draw a circle around the pH of orange juice.

6

pH 4 **pH 7** **pH 10** **pH 13** [1]

(e) Some soils are acidic.

Give the names of **two** compounds that are used to make soils less acidic.

1 potassium nitrate

2 phosphate ion 7 [2]

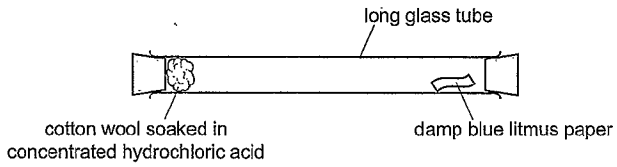
(f) Hydrogen chloride is an acidic gas produced when concentrated hydrochloric acid evaporates.

(i) Describe the arrangement and separation of the molecules in hydrogen chloride gas.

arrangement hydrogen chloride gas together with hydrochloric acid.

separation you will remove the concentrated hydrochloric acid and see reactions observed. 8 [2]

(ii) A long glass tube is set up as shown.



At first, the blue litmus paper does not turn red.
After a short time, the litmus paper turns red.

Explain these observations using the kinetic particle model.

Because of the wool which was soaked in hydrochloric acid(concentrated). We know that any litmus paper to change its colour has to be wet. So the first the litmus paper didn't change but when it absorbed the little amount of water it changed its colour. 9 [3]

[Total: 15]

Examiner comments

6 The candidate identifies the correct pH for an acidic solution (pH 4).
Mark for (d) = 1 out of 1

7 The candidate is still thinking about fertilisers when answering this question and gives the name of a compound and an ion present in fertilisers.
Mark for (e) = 0 out of 2

8 The candidate does not understand the meaning of the terms 'arrangement' and 'separation' in terms of particles. The candidate is referring to physical separation of one substance from another and has read on to (ii) of the question where hydrochloric acid is mentioned. This should be discouraged. The correct answers are random or no pattern for arrangement, and far apart for degree of separation.

9 The candidate does not understand the meaning of the term 'kinetic particle model' and therefore does not use the essential words 'particles' or 'molecules'. There is no reference to movement or randomness of movement of the particles. The process itself (diffusion) is not mentioned.
Mark for (f) = 0 out of 5

Total mark awarded = 6 out of 15

How the candidate could have improved their answer

- **(a)(i)** The candidate could also have obtained the mark by writing the formula of the ion.
- **(a)(ii)** The candidate should have focused on reading the stem of the question carefully. The essential words ions and ammonium sulfate supported the candidate in answering this question.
- **(a)(iii)** The candidate would also have gained the mark if no working were shown. However, candidates should always be advised to show their working in full, especially in longer calculations.
- **(b)** The candidate should have recognised that the result of a flame test will always be a colour rather than the test for a gas given off.
- **(c)** The candidate wrote the correct answer as a full name. If asked to name an element or compound, this is the preferred way, rather than writing a symbol or formula.
- **(d)** The candidate realised that acidic pH values are those below pH 7.
- **(e)** The candidate needed to learn the names of suitable compounds that react with acids in the soil, e.g. calcium oxide, calcium carbonate rather than give the names of compounds in fertilisers.
- **(f)(i)** The candidate should be advised not to read on to the next part on the question or try to use information from further on to try to answer a previous question. The candidate needs to realise that the meaning of 'separation between particles' refers to the distance between them. It does not refer to methods of separation such as differential diffusion, filtration, distillation etc. The word 'particles' should always be taken to refer to atoms, ions or molecules.
- **(f)(ii)** The candidate should have named the process as diffusion and have read the stem of the question carefully, noting that the kinetic particle model is required, i.e. particles / molecules are (on average) moving randomly from where they are at a higher concentration to where they are at a lower concentration.

Common mistakes candidates made in this question

- **(a)(i)** The most common error was to suggest 'potassium' through not reading the question carefully enough and selecting the positive ion instead of the negative ion.
- **(a)(ii)** Some candidates did not refer to the information in the table and wrote the formulae for sulfide ions or, for example, SO_2– for sulfate. Another common error was to write NH_3 ammonium. Others wrote the correct symbols but without the charges or with incorrect charges.
- **(a)(iii)** Some candidates tried to use moles, e.g. 200/23 = 8.7 or 23 x 2 = 46. Candidates should realise that there are no moles calculations in the core paper.
- **(b)** Many candidates gave an incorrect flame colour, usually lilac or yellow. A few candidates suggested using litmus or universal indicator paper, perhaps thinking of alkaline solution formed when lithium reacts with water.
- **(c)** Some candidates suggested potassium, which was in the stem of the question. Others gave the names of compounds rather than elements, e.g. phosphates. A few candidates gave other elements such as calcium, sulfur or sodium.
- **(d)** A small number of candidates suggested pH values other than 4, pH 7 being the most common incorrect answer.
- **(e)** A majority of the candidates gave the names of elements rather than compounds. Many of these elements were those found in fertilisers, e.g. phosphorus, potassium. Calcium or sulfur were also commonly seen as incorrect answers. The most common incorrect compounds seen were also components of fertilisers, e.g. nitrates.
- **(f)(i)** Some candidates did not appear to know the meaning of the term 'arrangement' and wrote answers relating to motion or separation of the particles. The degree of separation of the particles in a gas was often not well explained. Many candidates suggested that the particles were 'separated' (which cannot be given because the word is in the stem of the question). Others wrote vague statements such as, 'there is a lot of room' or 'they move from each other'. A few candidates muddled separation with motion or wrote about separation in terms of practical physical separation, e.g. distillation.
- **(f)(ii)** Some candidates did not gain marks because they did not refer to particles or molecules but just stated that 'the hydrochloric acid moves', 'the gas spreads out' or 'the gas reacts with the litmus'. The most common correct answers related to the occasional use of the word 'diffusion', but others muddled diffusion with Brownian motion.

Question 3

Example Candidate Response – high (1)

3 The table shows some properties of four Group I elements.

element	melting point /°C	boiling point /°C	atomic radius /nm
sodium	98	883	0.191
potassium	63	760	0.219
rubidium	39	716	0.250
caesium	29	671	0.272

(a) (i) Complete the table by predicting:
- the boiling point of rubidium
- the atomic radius of potassium.

[2]

(ii) Describe the trend in the melting point of the Group I elements down the group.

The melting point decreases down the group. [1]

(iii) Deduce the physical state of potassium at 60 °C.
Explain your answer.

It would be a solid. Potassium only changes from solid to liquid state at the melting point of 63. Thus ~~at~~ 60°C ~~is not hot enough~~. Potassium is still a solid. [2]

(b) Caesium is a radioactive element with a proton number of 55.

(i) Define proton number.

Proton number is the number of protons the atom has. [1]

(ii) State **one** industrial use of radioactive isotopes.

Radioactive energy. [1]

(c) Sodium hydride, NaH, reacts with iron(III) oxide.

(i) Balance the equation for this reaction.

$Fe_2O_3 + 3NaH \rightarrow 2Fe + 3NaOH$ [2]

(ii) Explain how this equation shows that iron(III) oxide is reduced.

Iron (III) oxide lost 3 oxygen molecules thus is reduced. [1]

Examiner comments

1 The candidate gains both marks by giving suitable values which follow the trend in melting point and atomic radius.

2 The candidate gives the correct statement about the trend decreasing and includes the direction of the trend (down the group).

3 The candidate deduces correctly that potassium is a solid and gains the mark. The explanation is too vague to be awarded a mark because, although it mentions the melting point and 60 degrees Celsius, it does not include the essential statement that '60 degrees Celsius is below the melting point'.
Mark for (a) = 4 out of 5

4 The candidate is awarded the mark although the answer is not very accurate. The answer expected is, 'The number of protons in the nucleus of an atom'.

5 The candidate is not awarded the mark because the answer is too vague. A more specific answer about energy, such as 'nuclear power plants' or 'producing electricity' is required for the mark.
Mark for (b) = 1 out of 2

6 The candidate is able to balance the equation correctly, so gains two marks.

7 The candidate gains the mark for the idea of iron (III) oxide losing oxygen.
Mark for (c) = 3 out of 3

Total mark awarded = 8 out of 10

How the candidate could have improved their answer

- **(a)(ii)** The candidate recognised the trend in the data. When answering such questions, it is best to make the trend clear, as this candidate did, e.g. 'the boiling point decreases down the group'.
- **(a)(iii)** The candidate needed more practice in writing with precision by comparing the stated temperature with the melting point values and stating how exactly how they differ, e.g. 'the melting point is above 60°C'.
- **(b)(i)** The candidate could have improved their answer by learning definitions in the syllabus in greater detail. A more exact definition such as 'proton number is the number of protons in the nucleus of an atom' is more likely to gain credit.
- **(b)(ii)** The candidate gave too vague a use for radioactive isotopes. When giving uses of particular substances, candidates should give answers that are as specific as possible.
- **(c)(i)** The candidate was able to balance the equation.
- **(c)(ii)** The candidate followed the rule that in questions involving reference to an equation, the name of the substance that is losing oxygen should be mentioned, e.g. iron oxide loses oxygen. However, the candidate could have improved their answer by referring to oxygen atoms rather than oxygen molecules.

Example Candidate Response – high (2)

3 The table shows some properties of four Group I elements.

element	melting point /°C	boiling point /°C	atomic radius /nm
sodium	98	883	0.191
potassium	63	760	0.220
rubidium	39	700	0.250
caesium	29	671	0.272

(a) (i) Complete the table by predicting:
- the boiling point of rubidium
- the atomic radius of potassium.

[2]

(ii) Describe the trend in the melting point of the Group I elements down the group.

As you go down the group the melting pon decreases. [1]

(iii) Deduce the physical state of potassium at 60 °C.
Explain your answer.

The Potassium will be a solid because the melting point is 63°C while 60°C for potassium is below ~~meaning it will be solid~~ [2]

(b) Caesium is a radioactive element with a proton number of 55.

(i) Define proton number.

This is the number of atoms in the nucleus [1]

(ii) State **one** industrial use of radioactive isotopes.

For energy like electricity. [1]

(c) Sodium hydride, NaH, reacts with iron(III) oxide.

(i) Balance the equation for this reaction.

$Fe_2O_3 + 3NaH \rightarrow 2Fe + 2NaOH$ [2]

(ii) Explain how this equation shows that iron(III) oxide is reduced.

Fe_2O_3 does not have oxygen anymore [1]

Examiner comments

1 The candidate gains both marks by giving suitable values which follow the trend in melting point and atomic radius.

2 The candidate gives the correct statement about the trend decreasing and includes the direction of the trend (down the group).

3 The candidate deduces correctly that the potassium is a solid and gains this mark. The explanation is given the benefit of the doubt for the second mark because it implies that 60 degrees Celsius is below the melting point.
Mark for (a) = 5 out of 5

4 The candidate does not gain the mark because they use incorrect terminology, 'atoms' rather than 'protons'.

5 Although the answer 'for energy' by itself is rather vague, the addition of 'like electricity' is sufficient to give the candidate the mark.
Mark for (b) = 1 out of 2

6 The candidate obtains one mark for balancing the Fe correctly, but the second mark is not obtained because 2NaOH is written instead of 3NaOH.

7 The candidate's answer is rather vague but is given the benefit of the doubt for a mark.
Mark for (c) = 2 out of 3

Total mark awarded =
8 out of 10

How the candidate could have improved their answer

- **(a)(iii)** Although the candidate's answer was just about acceptable, the candidate needs more practice in writing with precision by comparing the stated temperature with the melting point values and stating how exactly how they differ, e.g. the melting point is above 60°C / 60°C is below the melting point.
- **(b)(i)** The candidate should have made sure that they use precise scientific terms and not confuse them. The candidate's marks could also be improved by listing, then learning the definitions in the syllabus.
- **(b)(ii)** The candidate gave a suitable use for radioactive isotopes. The mark was gained even although their answer was rather vague. 'For the production of electricity in nuclear power stations', is a more accurate statement than 'for energy' or 'for electricity'.
- **(c)(i)** The candidate needed more practice in balancing equations.
- **(c)(ii)** The candidate wrote a vague statement, which was given the benefit of the doubt for a mark. However, the candidate needs to be more accurate in writing answers as it cannot always be guaranteed that vague statements will be given credit. It will help if the candidate learns definitions from the syllabus such as 'reduction is loss of oxygen'.

Example Candidate Response – middle

3 The table shows some properties of four Group I elements.

element	melting point /°C	boiling point /°C	atomic radius /nm
sodium	98	883	0.191
potassium	63	760	0.082
rubidium	39	975	0.250
caesium	29	671	0.272

(a) (i) Complete the table by predicting:
- the boiling point of rubidium
- the atomic radius of potassium.

[2]

(ii) Describe the trend in the melting point of the Group I elements down the group.

The lower you go down the group the lower the melting point [1]

(iii) Deduce the physical state of potassium at 60 °C.
Explain your answer.

~~liquid~~ solid, because potassium melts at 63°C.

[2]

(b) Caesium is a radioactive element with a proton number of 55.

(i) Define proton number.

proton number is an atomic number [1]

(ii) State **one** industrial use of radioactive isotopes.

~~to scan the~~ to kill cancer cells and positive. [1]

(c) Sodium hydride, NaH, reacts with iron(III) oxide.

(i) Balance the equation for this reaction.

$Fe_2O_3 + 3NaH \rightarrow 2Fe + 3NaOH$ [2]

(ii) Explain how this equation shows that iron(III) oxide is reduced.

it has gained oxygen [1]

Examiner comments

1 The candidate does not follow the trends of the boiling point and atomic radius and seems to guess values. The values for both boiling point and atomic radius should be between the values either side of the blank space.

2 The candidate recognises that the melting point decreases and makes the direction of decrease clear, i.e. 'the lower in the group, the lower the melting point'.

3 The candidate correctly identifies the correct physical state (solid) for one mark but gives a reason which is too vague because it does not refer to the 60 degrees Celsius. The correct answer is to refer to 60 degrees Celsius being below the melting point.
Mark for (a) = 2 out of 5

4 The candidate needs to recognise the meaning of the command word 'define'. They write an alternative name for the proton number rather than a definition, such as 'the number of protons / positive charges in the nucleus of an atom'.

5 The candidate gives a suitable answer for a mark to be awarded. Other suitable answers include 'detecting leaks in pipes' or 'producing energy in nuclear power stations'.
Mark for (b) = 1 out of 2

6 The candidate is able to balance the equation and scores a mark for each substance balanced.

7 The candidate gives an answer which refers to oxidation rather than reduction. Even if the candidate writes that 'it had lost oxygen', the mark will not be given because it is necessary to include the species from which oxygen is lost (iron oxide) in order to gain the mark.
Mark for (c) = 3 out of 3

Total mark awarded =
6 out of 10

How the candidate could have improved their answer

- **(a)(i)** The candidate needed to be able to identify trends in tables of data and interpolate values rather than guess them.
- **(a)(ii)** The candidate recognised the trend in the data. When answering such questions, it is best to make the trend absolutely clear, e.g. 'the boiling point decreases down the group'.
- **(a)(iii)** The candidate needs more practice in writing with precision by comparing the stated temperature with the melting point and boiling point values and stating how exactly how they differ, e.g. the melting point is above 60°C.
- **(b)(i)** The candidate should have made sure that the meaning of specific command words such as 'define' and 'explain' were known. The candidate's marks could be improved by listing, then learning the definitions in the syllabus.
- **(c)(ii)** The candidate needed to distinguish between oxidation as gain of oxygen by a substance and reduction as loss of oxygen from a substance. In questions involving reference to an equation, the name of the substance that is losing oxygen should be mentioned, e.g. iron oxide loses oxygen.

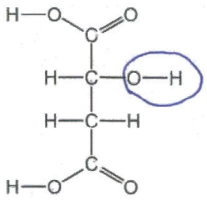
Common mistakes candidates made in this question

- **(a)(i)** The most common errors were to suggest that the boiling point of rubidium is less than 671°C or that the atomic radius of potassium is less than 0.191 nm. Few candidates gave negative values for the atomic radius or boiling point.
- **(a)(ii)** Some candidates tried to link the melting point to the atomic radius, boiling point or reactivity of the elements.
- **(a)(iii)** Some candidates suggested that the physical state was between a liquid and a solid. Others suggested that potassium is a gas at 60°C. The reasons given were often too vague, e.g. 'not yet changed to liquid' or 'it has not gone to its melting point'. The best answers referred to 60°C being below the melting point. Some candidates suggested, incorrectly, 'below the boiling point'.
- **(b)(i)** Many candidates just paraphrased the stem of the question and gave the simple answer 'the number of protons' with adding any qualifying statements such as 'in the nucleus of an atom'. Others wrote 'the number of protons in an element' which is not accurate enough because many elements have more than one atom in a molecule / giant structure.
- **(b)(ii)** The best answers referred to 'measuring thickness of paper' or 'checking for leakages in pipes'. Some candidates referred, incorrectly, to medical applications, X-rays or batteries. Others wrote vaguely about explosions or bombs, which are not industrial uses.
- **(c)(i)** The most common errors were to attempt to balance with 2NaOH, 6NaOH or to reverse the balance as 3Fe + 2 NaOH.
- **(c)(ii)** Some candidates suggested that oxygen is being removed from iron, which is not accurate enough, since iron is on the right of the equation. Others just gave a definition of reduction as 'loss of oxygen' without referring to the equation as requested in the question. Candidates should be encouraged to read the question carefully to make sure that they understand exactly what is being asked.

Question 4

Example Candidate Response – high

4 The structure of malic acid is shown.



1

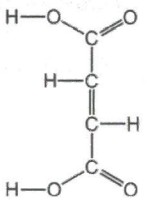
(a) (i) On the structure draw a circle around the alcohol functional group. [1]

(ii) Deduce the formula of malic acid to show the number of carbon, hydrogen and oxygen atoms.

$C_4H_6O_5$ 2 [1]

(b) When malic acid is heated it forms compound **F**.

The structure of compound **F** is shown.



Explain why compound **F** is described as unsaturated. 3

It has a double carbon bond C=C [1]

(c) Compound **F** can form polymers.

(i) State the meaning of the term *polymer*.

A polymer is the joining of monomers through links to form chains 4 [2]

(ii) State the name of the polymer formed when ethene is polymerised.

Polyethene 5 [1]

Examiner comments

1 The candidate identifies the alcohol functional group correctly and so gains the mark.

2 The candidate obtains the mark by counting the number of atoms in the molecule correctly.
Mark for (a) = 2 out of 2

3 The candidate identifies the C=C double bond as being responsible for the compound being unsaturated.
Mark for (b) = 1 out of 1

4 The candidate gains one mark for the idea of monomers joining together. The second mark is not obtained because the word 'chain' on its own is insufficient.

5 A mark is given for 'polyethene', although poly(ethene) would have been preferred.
Mark for (c) = 2 out of 2

Example Candidate Response – high, continued

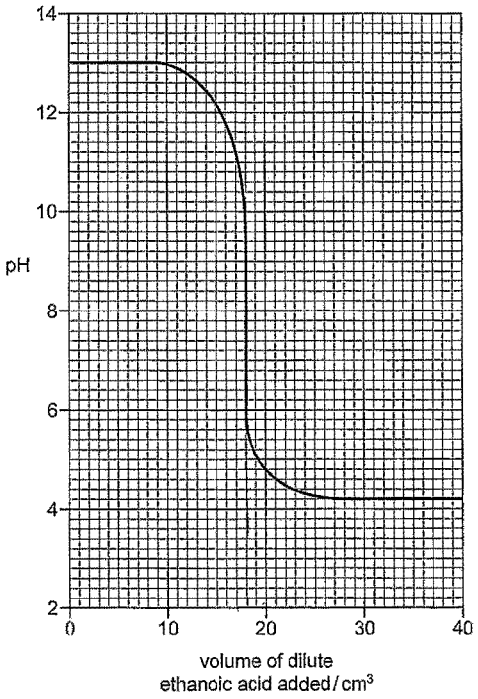
(d) Ethanoic acid is a carboxylic acid.

Describe the observations made when dilute ethanoic acid reacts with:

magnesium ...fizzes / bubbles vigorously...

litmus solution. ...turns litmus paper blue... 6 [2]

(e) The graph shows how the pH changes when dilute ethanoic acid is added slowly to aqueous sodium hydroxide.



(i) Deduce the pH of the aqueous sodium hydroxide before the addition of dilute ethanoic acid.

pH = ...13... 7 ... [1]

(ii) Deduce the volume of dilute ethanoic acid added when the pH is neutral.

8 ...18... cm³ [1]

Examiner comments

6 Two suitable observations are given for the reaction of magnesium with acid, although there is only one mark for the answer. The second mark is not given because the candidate gives the colour of litmus in alkaline solution (blue), rather than in acidic solution (red).
Mark for (d) = 1 out of 2

7 The candidate deduces the starting pH correctly by reference to the starting volume on the y-axis of the graph.

8 The candidate correctly deduces the volume of dilute ethanoic acid needed to make a neutral pH. They do this by reading a value on the x-axis of the graph corresponding to pH 7.
Mark for (e) = 2 out of 2

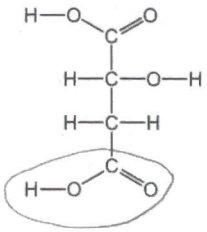
Total mark awarded =
8 out of 10

How the candidate could have improved their answer

- **(a)(ii)** The candidate deduced the molecular formula correctly. With more complex examples, candidates could improve their performance by realising that the deduction of a molecular formula from a given structure can be obtained by counting the individual atoms one by one, crossing them off the structure on the exam paper as they go.
- **(c)(i)** The candidates knew the term ‘monomer’ but wrote too vague a statement to be awarded the first mark. The candidate should remember that polymers are macromolecules, large molecules or long chain molecules.
- **(c)(ii)** The candidate named the polymer correctly but could improve their answer by putting the ethene in brackets, i.e. poly(ethene).
- **(d)** The candidate gave a good answer for the reaction of magnesium with ethanoic acid but could have improved the answer for the reaction of litmus by learning the colours of different indicators in acidic and alkaline solutions.

Example Candidate Response – middle

4 The structure of malic acid is shown.



1

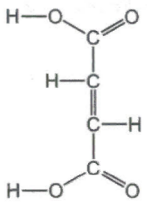
(a) (i) On the structure draw a circle around the alcohol functional group. [1]

(ii) Deduce the formula of malic acid to show the number of carbon, hydrogen and oxygen atoms.

$C_4O_5H_6$ 2 ..... [1]

(b) When malic acid is heated it forms compound **F**.

The structure of compound **F** is shown.



Explain why compound **F** is described as unsaturated.

Because other elements can be added to it and it will mix. 3 ..... [1]

(c) Compound **F** can form polymers.

(i) State the meaning of the term *polymer*.

it is a long chain of compounds that 4 .....

..... [2]

(ii) State the name of the polymer formed when ethene is polymerised.

Ethanol 5 ..... [1]

Examiner comments

1 The candidate draws a circle around the carboxylic acid group rather than the alcohol group (OH), and so does not gain the mark.

2 The candidate obtains the mark by counting the number of atoms in the molecule correctly.
Mark for (a) = 1 out of 2

3 The statement that 'other elements can be added to it' is too vague to gain a mark. The correct answer is to refer to the fact that the compound has a C=C double bond.
Mark for (b) = 0 out of 1

4 The candidate gains one mark for the idea of a long chain. The statement about compound is not sufficient to get the second mark since the word 'monomers' or 'small units' is required.

5 The candidate seems to guess the answer and does not realise that the names of polymers begin with poly.
Mark for (c) = 1 out of 3

Example Candidate Response – middle, continued

(d) Ethanoic acid is a carboxylic acid.

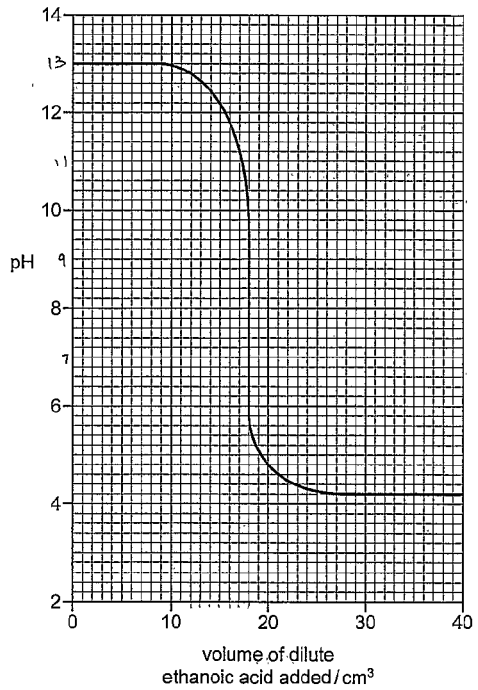
Describe the observations made when dilute ethanoic acid reacts with:

magnesium ..Will not react..

litmus solution. ..will turn red.. 6

[2]

(e) The graph shows how the pH changes when dilute ethanoic acid is added slowly to aqueous sodium hydroxide.



(i) Deduce the pH of the aqueous sodium hydroxide before the addition of dilute ethanoic acid.

pH = ..13.. 7 [1]

(ii) Deduce the volume of dilute ethanoic acid added when the pH is neutral.

..18.. cm³ [1]

8

Examiner comments

6 The candidate does not gain the first mark because they do not relate the properties of ethanoic acid to general acidic properties. They should realise that all acids react with magnesium. The candidate gains the second mark for an understanding that acids turn litmus red.
Mark for (d) = 1 out of 2

7 The candidate deduces the starting pH correctly by reference to the starting volume on the y-axis of the graph.

8 The candidate deduces correctly the volume of dilute ethanoic acid needed to make a neutral pH. They do this by reading a value on the x-axis of the graph corresponding to pH 7.
Mark for (e) = 2 out of 2

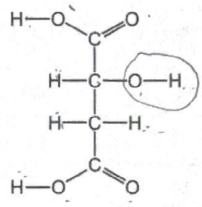
Total mark awarded =
5 out of 10

How the candidate could have improved their answer

- **(a)(i)** The candidate could have improved their performance by learning the specific functional group mentioned in the syllabus.
- **(a)(ii)** The candidate counted the number of atoms correctly. With more complex examples, the candidate should consider crossing the atoms off the structure one by one.
- **(b)** Candidates should remember that an unsaturated compound contains carbon-carbon double bonds. Candidates should not refer to reactions of unsaturated compounds if only a structure is shown, and they are not asked for chemical reactions. If chemical reactions related to the presence of a C=C bond are asked for, the candidates should describe the specific reaction with aqueous bromine.
- **(c)(i)** The candidate should remember that polymers are formed from small molecules or small units called monomers. It is not sufficient to write that they are 'formed from compounds' because some compounds have very large structures which cannot combine.
- **(c)(ii)** The candidate should realise that the names of polymers are in the form poly(X), where X is the name of the monomer.
- **(d)** The candidate could improve the answer by understanding the meaning of the key word 'observations' as what you see, hear or feel. Reference to reactivity or lack of reactivity is not an observation.

Example Candidate Response – low

4 The structure of malic acid is shown.



1

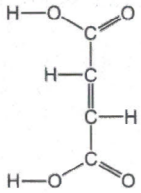
(a) (i) On the structure draw a circle around the alcohol functional group. [1]

(ii) Deduce the formula of malic acid to show the number of carbon, hydrogen and oxygen atoms.

~~$H_6C_4O_5$~~ $C_6H_4O_5$ 2 [1]

(b) When malic acid is heated it forms compound **F**.

The structure of compound **F** is shown.



Explain why compound **F** is described as unsaturated.

because it has a double bond 3 [1]

(c) Compound **F** can form polymers.

(i) State the meaning of the term *polymer*.

a group of a element formed when small monomers combine. 4 [2]

(ii) State the name of the polymer formed when ethene is polymerised.

Polysthene 5 [1]

Examiner comments

1 The candidate identifies the alcohol functional group correctly.

2 The candidate either miscounts the number of carbon and hydrogen atoms incorrectly or makes the common error of trying to balance them by reversing the numbers.
Mark for (a) = 1 out of 2

3 The candidate does not gain the mark because the answer is too vague. There are two types of double bond in the structure C=C and C=O. The candidate should include reference to the C=C double bond rather than an unspecified double bond.
Mark for (b) = 0 out of 1

4 The candidate gains a mark for the idea of monomers joining together but does not get the second mark because they refer to an element being formed rather than a large molecule or long-chain molecule.

5 The candidate gains the mark for the term polyethene, although a clearer writing of the second 'e' would have been preferred. If writing is not clear, candidates may not obtain the mark.
Mark for (c) = 2 out of 3

Example Candidate Response – low, continued

(d) Ethanoic acid is a carboxylic acid.

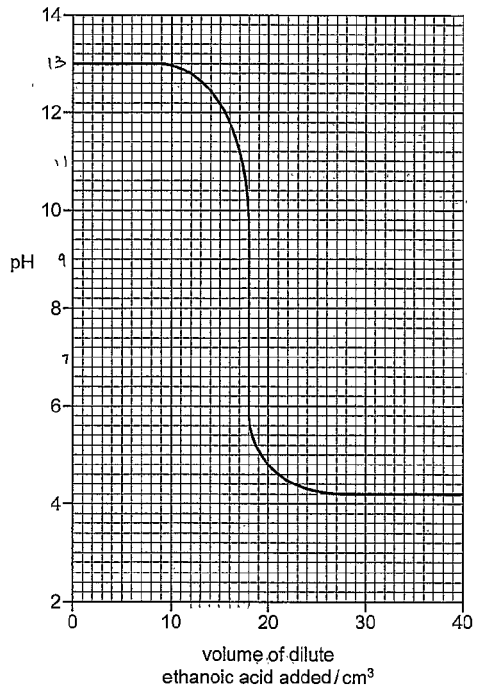
Describe the observations made when dilute ethanoic acid reacts with:

magnesium ..Will not react..

litmus solution. ..will turn red.. 6

[2]

(e) The graph shows how the pH changes when dilute ethanoic acid is added slowly to aqueous sodium hydroxide.



(i) Deduce the pH of the aqueous sodium hydroxide before the addition of dilute ethanoic acid.

pH = ..13.. 7 [1]

(ii) Deduce the volume of dilute ethanoic acid added when the pH is neutral.

..18.. cm³ [1]

8

Examiner comments

6 The candidate does not obtain a mark for the reaction between magnesium and acid because the statement about dissolving is inaccurate. In order to gain the mark, the candidate could have replaced the phrase 'magnesium dissolves' by 'magnesium disappears' or 'magnesium gets smaller'. The candidate also gives the incorrect colour of litmus in acidic solution (red rather than blue).
Mark for (d) = 0 out of 2

7 The candidate correctly deduces the pH of the aqueous sodium hydroxide at the start of the experiment and shows it on the graph as well.

8 The candidate does not realise that a neutral pH is pH7 and gives a value for the pH at the end of the experiment when there is an excess of alkali, and the pH is near 4.
Mark for (e) = 1 out of 2

Total mark awarded =
4 out of 10

How the candidate could have improved their answer

- **(a)(ii)** By realising that the deduction of a molecular formula from a given structure can be obtained by counting the individual atoms one by one, crossing them off the structure on the exam paper as they go.
- **(b)** The candidate should remember that an unsaturated compound contains carbon-carbon double bonds rather than any other double bond.
- **(c)(i)** The candidate should remember that polymers are macromolecules or large molecules or long-chain molecules and that they are molecules because they contain more than one type of atom bonded together.
- **(c)(ii)** The candidate named the polymer correctly, but care is needed not to write polyethane instead of polyethene.
- **(d)** The candidate could have improved the answer by understanding the meaning of the key word 'observations' as what you see, hear or feel. The candidate also needed to realise that dissolving is a physical process whilst the addition of magnesium to acid results in a reaction.
- **(e)(ii)** In pH-volume or pH-time graphs, candidates should have realised that the neutral pH is read from where the pH is 7 and not when the reaction is complete.

Common mistakes candidates made in this question

- **(a)(i)** The most common errors were to circle the –COOH group or the –OH of this group or to include the CH next to the alcohol functional group. A considerable number of candidates included larger parts of the structure, e.g. circling the top two carbon atoms and all the atoms attached.
- **(a)(ii)** The most common error was to include a functional group, e.g. $C_3H_5O_3COOH$. Others did not count the number of each type of atom correctly, the most common errors being to have too few carbon or hydrogen atoms.
- **(b)** Many candidates wrote answers which, although carbon atoms were mentioned, were too vague, e.g. 'there is a carbon with a double bond' or 'there are double bonds' (without mentioning carbon-carbon). Others wrote even more vague or incorrect statements such as 'the structure is not complete' or 'the compound is an alkene'.
- **(c)(i)** Some candidates recognised that a polymer is made from monomers or small units. Others wrote statements about 'atoms combining' or 'polymers joining'. Few candidates wrote about polymers being long-chain molecules or macromolecules. Some suggested 'giant structures' but this is too generalised.
- **(c)(ii)** Many candidates gave examples of other polymers such as 'nylon' or monomers such as esters or ethene. Others gave the names of alkanes such as 'methane' or 'ethane'.
- **(d)** Some candidates knew that blue litmus turns red on addition of acid. Others suggested that litmus turns blue or brown. Very few candidates described the observations when magnesium reacts with ethanoic aid. Many focussed on the products such as 'hydrogen is formed' (or more often the incorrect 'carbon dioxide is formed'). A considerable number of candidates gave colour changes of the solution or colour changes after litmus was added to the solution formed by reaction of magnesium with acid. Others suggested 'white precipitate'.
- **(e)(i)** The most common error was to suggest pH 4.2, the pH value when there is excess acid.
- **(e)(ii)** A common error was to suggest 40 cm3 (the volume at the far right of the graph), rather than focussing on the pH value at pH 7. Another common error was to suggest 11.6 cm3; this was obtained by not interpreting the values on the horizontal axis of the graph correctly.

Question 5

Example Candidate Response – high

5 (a) Calcium oxide is made by the thermal decomposition of calcium carbonate.

(i) State the meaning of the term *thermal decomposition*.

Thermal decomposition is the breakdown of a substance using heat 1 [2]

(ii) Describe a test for calcium ions.

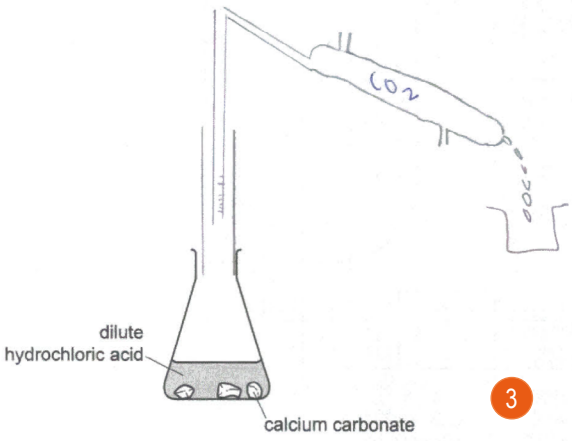
test Add sodium hydroxide

observations A green precipitate is formed 2 [2]

(b) Carbon dioxide is produced when dilute hydrochloric acid reacts with calcium carbonate.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete the diagram to show how to measure the volume of carbon dioxide produced during this reaction.



3 [2]

Examiner comments

1 The candidate gives an accurate definition of the term 'thermal decomposition' mentioning both 'using heat' (1 mark) and 'breakdown' (1 mark).

2 The candidate gives a suitable test reagent for the first mark. The second mark is not obtained because the colour of the precipitate should have been white rather than green.
Mark for (a) = 3 out of 4

3 The candidate does not earn any marks. The candidate realises that a volume should be measured, and shows a graduated tube attached to a condenser in one part of the apparatus. Presumably the condenser is used to turn the carbon dioxide gas into liquid, but no indication of measurement is present apart from the lines on the delivery tube. A suitable piece of apparatus would be a gas syringe or upturned measuring cylinder over water. The second mark is not obtained because the apparatus is not airtight, and so gas could escape.

Example Candidate Response – high, continued

(ii) Describe the effect of each of the following on the rate of reaction of dilute hydrochloric acid with calcium carbonate.

- The concentration of hydrochloric acid is decreased.

All other conditions stay the same.

Rate of reaction decreases

- The temperature is increased.

All other conditions stay the same.

Rate of reaction increases 4

[2]

(c) Carbon dioxide is also formed when the hydrocarbon C_3H_8 is completely combusted.

(i) State the meaning of the term *hydrocarbon*.

Hydrocarbon is a compound containing hydrogen and carbon only 5 [2]

(ii) The hydrocarbon C_3H_8 is called propane.

Name the homologous series that propane belongs to.

Alkanes 6 [1]

(iii) Name two substances formed by the incomplete combustion of propane.

Carbon Monoxide and Water [2]

7 [Total: 13]

Examiner comments

4 The candidates realises, correctly, that the rate decreases when the concentration of acid decreases, and the rate increases when the temperature increases. The candidate makes it absolutely clear that the answer refers to rate rather than extent of reaction.
Mark for (b) = 2 out of 4

5 This is a correct answer: 'a compound containing hydrogen and carbon' (1 mark) 'hydrogen and carbon only' (1 mark).

6 The candidate identifies the correct homologous series and so obtains the mark.

7 The candidate selects two of the correct products of the incomplete combustion of propane, and so gains two marks. Another correct answer which could have been given is carbon or (carbon) particulates.
Mark for (c) = 5 out of 5

Total mark awarded = 10 out of 13

How the candidate could have improved their answer

- **(a)(ii)** The candidate knew the correct test reagent but needed to revise the test results for the qualitative analysis of cations. Although the candidate knew there was a precipitate, the colour was that corresponding to iron (II).
- **(b)(i)** The candidate should have realised that when gas volumes are being measured, there must be no gaps in the apparatus to allow the escape of gas. This can be shown in this drawing by a stopper at the mouth of the flask with a delivery tube going through it. The candidate would also be advised to practice drawing apparatus for gas measurement such as syringes and upturned measuring cylinders since questions involving drawing of apparatus are set as every few years.

Example Candidate Response – middle

5 (a) Calcium oxide is made by the thermal decomposition of calcium carbonate.

(i) State the meaning of the term *thermal decomposition*.

The rotting of heat in the ground

1 [2]

(ii) Describe a test for calcium ions.

test Soak Paper (indicator)

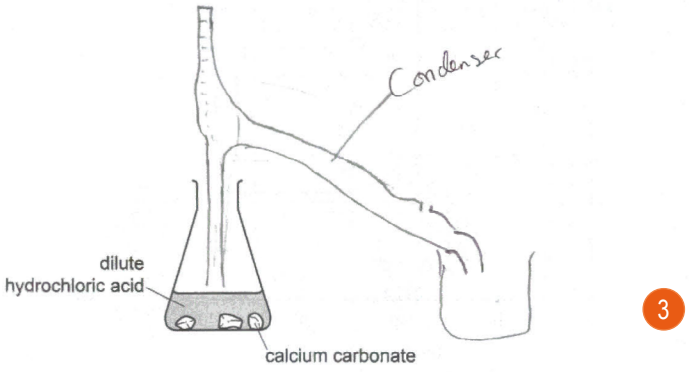
observations litmus paper turns yellow 2

[2]

(b) Carbon dioxide is produced when dilute hydrochloric acid reacts with calcium carbonate.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete the diagram to show how to measure the volume of carbon dioxide produced during this reaction.



3

[2]

Examiner comments

1 Although heat is mentioned, it is in the wrong context. In order to gain the 'heat' mark, it has to be made clear that thermal energy is being absorbed by the calcium carbonate, or that there is an input of heat. The candidate does not describe the term decomposition even though it is in italics.

2 The candidate needs to revise tests for qualitative analysis.
Mark for (a) = 0 out of 4

3 The candidate does not score any marks. The candidate realises that a volume should be measured and shows a graduated tube. This is, however, not a suitable piece of apparatus because a gas syringe or upturned measuring cylinder over water is required. The second mark is not obtained because the apparatus is not airtight and so gas could escape.

Example Candidate Response – middle, continued

(ii) Describe the effect of each of the following on the rate of reaction of dilute hydrochloric acid with calcium carbonate.

- The concentration of hydrochloric acid is decreased.

All other conditions stay the same.

The reaction decrease.

- The temperature is increased.

All other conditions stay the same.

The reaction increase 4

[2]

(c) Carbon dioxide is also formed when the hydrocarbon C_3H_8 is completely combusted.

(i) State the meaning of the term *hydrocarbon*.

This is a compound that is only contain hydrogen and oxygen 5 [2]

(ii) The hydrocarbon C_3H_8 is called propane.

Name the homologous series that propane belongs to.

Alkane 6 [1]

(iii) Name two substances formed by the incomplete combustion of propane.

Carbon monoxide and water [2]

7 [Total: 13]

Examiner comments

4 The candidate realises, correctly, that the rate decreases when the concentration of acid decreases, and the rate increases when the temperature increases. On this occasion, benefit of the doubt is given even although it is not absolutely clear whether the answer refers to rate or extent of reaction.
Mark for (b) = 2 out of 4

5 The candidate does not think about the word 'hydrocarbon' closely enough and thinks that they contained oxygen rather than carbon. Although the candidate writes the essential words 'only' and 'compound', the presence of the wrong type of atom means that neither mark can be accessed.
A single mark could have been obtained for either 'it contains only hydrogen and carbon' or 'it is a compound of hydrogen and carbon'.

6 The candidate identifies the correct homologous series and so obtains the mark.

7 The candidate selects two of the correct products of the incomplete combustion of propane and so gains two marks. Another correct answer which could have been given was 'carbon'.
Mark for (c) = 3 out of 5

Total mark awarded =
5 out of 13

How the candidate could have improved their answer

- **(a)(i)** When answering definitions which appear as two words in italics in the question paper, candidates should ensure that the meaning of both words is made clear. In this case, the candidate needs to define decomposition as 'the breakdown of a compound' and not just repeat word in the stem of the question.
- **(a)(ii)** The candidate needed to revise the test reagents for the qualitative analysis of cations. For metal cations apart from Group I cations, it should be remembered that the test reagent is aqueous sodium hydroxide or aqueous ammonia. The candidate also needs to bear in mind that the essential words 'precipitate' or 'solution' are required for the results as well as the colour. An alternative answer in this instance was a flame test with the flame colour 'orange' or 'brick-red'.
- **(b)(i)** The candidate should have realised that when gas volumes are being measured, there must be no gaps in the apparatus to allow the escape of gas. This can be shown in this drawing by a stopper at the mouth of the flask with a delivery tube going through it. The candidate would also be advised to practice drawing apparatus for gas measurement such as syringes and upturned measuring cylinders since questions involving drawing of apparatus are set every few years.
- **(b)(ii)** Although the marks were gained, the candidate's response was rather vague. Candidates should read the stem of the question carefully, noting that this question is about rate of reaction not extent of reaction (as might be inferred by the candidate's answer to the question).
- **(c)(i)** By learning definitions carefully and improving their basic chemical knowledge by analysing words carefully, e.g. hydrocarbon is a combination of the words, 'hydrogen' and 'carbon'.

Example Candidate Response – low

5 (a) Calcium oxide is made by the thermal decomposition of calcium carbonate.

(i) State the meaning of the term *thermal decomposition*.

This when substance and molecules dem decompose by heat 1 [2]

(ii) Describe a test for calcium ions.

test by addin nitrates 2

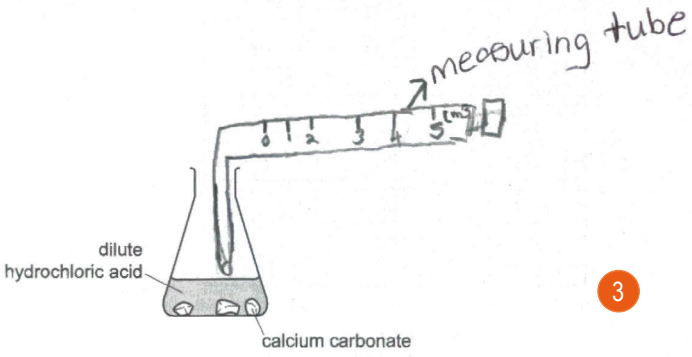
observations it turns white

[2]

(b) Carbon dioxide is produced when dilute hydrochloric acid reacts with calcium carbonate.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

(i) Complete the diagram to show how to measure the volume of carbon dioxide produced during this reaction.



3

[2]

Examiner comments

1 The candidate describes the meaning of the term ‘thermal’ for one mark but does not describe the meaning of decomposition as a ‘breakdown of a compound’.

2 The candidate does not realise that sodium hydroxide or ammonia are the test reagents needed and so does not obtain the first mark. The second mark is not obtained because, although the candidate realises that a white colour is seen, the essential word ‘precipitate’ is missing.
Mark for (a) = 1 out of 4

3 The ‘measuring tube’ has some syringe character in it (the plunger at the end), so benefit of the doubt is given for this part of the drawing, despite the incorrect label (candidates are not asked to label the apparatus). The second mark is not awarded because gas could escape from the flask: the system is not closed.

Example Candidate Response – low, continued

(ii) Describe the effect of each of the following on the rate of reaction of dilute hydrochloric acid with calcium carbonate.

- The concentration of hydrochloric acid is decreased.

All other conditions stay the same.

It ~~decreases because of the~~ increases because it's a more reactive element

- The temperature is increased.

All other conditions stay the same.

The temperature ~~decreases~~ increases because

[2] 4

(c) Carbon dioxide is also formed when the hydrocarbon C_3H_8 is completely combusted.

(i) State the meaning of the term *hydrocarbon*.

It's the mixture of two ~~by~~ molecules ~~shuch~~ such as hydrogen and carbons [2] 5

(ii) The hydrocarbon C_3H_8 is called propane.

Name the homologous series that propane belongs to.

group VII elements [1] 6

(iii) Name two substances formed by the incomplete combustion of propane.

methane and polythene [2] 7

[Total: 13]

Examiner comments

4 The candidate does not gain the mark for the effect of increasing concentration because they suggest that the rate increased rather than decreased. The second part of the question does not gain any marks, not only because 'decreases' is incorrect, but also the candidate refers to temperature rather than rate.
Mark for (b) = 1 out of 4

5 Although the candidate mentions carbon and hydrogen, the suggestion that a hydrocarbon is a mixture negates this point. Candidates should describe hydrocarbons as molecules or compounds. In addition, the essential word 'only' is missing from the correct definition ('a compound of carbon and hydrogen only').

6 The candidate muddles up homologous series with groups of compounds in the Periodic Table. The correct answer is alkanes.

7 The candidate does not understand the term incomplete combustion and gives the names of other compounds containing carbon and hydrogen. The correct answers are carbon and carbon monoxide.
Mark for (c) = 2 out of 5

Total mark awarded =
4 out of 13

How the candidate could have improved their answer

- **(a)(i)** When answering definitions which appear as two words in italics in the question paper, the candidate should have ensured that the meaning of both words is made clear. In this case the candidate needs to define decomposition as 'the breakdown of a compound' and not just repeat word in the stem of the question.
- **(a)(ii)** The candidate needed to revise the test reagents for the qualitative analysis of cations. The candidate also needed to bear in mind that the essential words 'precipitate' or 'solution' are required for the results as well as the colour.
- **(b)(i)** The candidate should have realised that when gas volumes are being measured, there must be no gaps in the apparatus to allow the escape of gas. This can be shown in this drawing by a stopper at the mouth of the flask with a delivery tube going through it. The candidate would also be advised to practice drawing apparatus such as syringes with a greater accuracy.
- **(b)(ii)** The candidate could have improved their chances of getting more marks by reading the stem of the question carefully, noting that the question is about rate of reaction not equilibrium (as suggested by the candidate's answer to the second part of the question).
- **(c)(i)** The candidate could have improved their marks by learning definitions carefully and improving their basic chemical knowledge by learning the differences between compounds and mixtures.
- **(c)(ii)** The candidate could have improved their marks by learning the meaning of particular chemical terms in the syllabus such as 'hydrocarbons' and 'homologous series'.
- **(c)(iii)** The candidate could have improved their marks by learning the meaning of particular chemical terms such as 'combustion'.

Common mistakes candidates made in this question

- **(a)(i)** Many candidates did not describe the word 'decomposition' as 'breaking down'. Others simply repeated the word decomposition from the stem of the question. Candidates should be advised that if there are two distinct words in a definition, both need to be defined. Some did not gain the mark for heating because the word was used out of context, e.g. 'heat is given out during the reaction'.
- **(a)(ii)** A number of candidates chose the wrong test reagent, silver nitrate being a common error. Candidates who opted for the addition of aqueous sodium hydroxide as a test reagent often did not gain the mark because they went on to suggest that the white precipitate is soluble in excess.
- **(b)(i)** Some candidates did not gain the first mark because the apparatus they drew did not have anything resembling a plunger. Many candidates drew a measuring cylinder connected directly to the reaction flask. A significant minority did not draw a reaction vessel. Many candidates drew unworkable apparatus, including apparatus which allowed gas to escape into the air.
- **(b)(ii)** Some candidates referred to time taken rather than rate of reaction whilst other candidates wrote answers in terms of the kinetic particle theory and did not mention rate of reaction.
- **(c)(i)** The most common errors were to write about mixtures or molecules of hydrogen and carbon or to omit the essential word 'only' to imply that there are no other elements present. Other candidates suggested that hydrocarbons contain oxygen.
- **(c)(ii)** The most common errors, in terms of homologous series, were to suggest either alkenes or alcohols. Others named specific compounds, 'hydrogen' or 'methane' often being seen as incorrect answers.
- **(c)(iii)** Many candidates suggested, incorrectly, that hydrogen is formed. Other suggested specific hydrocarbons.

Question 6

Example Candidate Response – high

6 This question is about water.

(a) The water in rivers often contains pollutants such as acids.

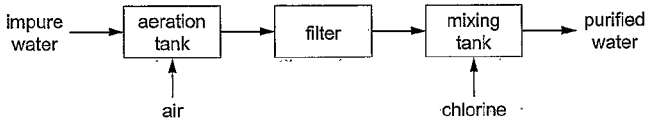
Describe how universal indicator paper can be used to determine the pH value of the water.

dip the indicator paper in the water and compare the colour to a pH colour chart

..... [2]

1

(b) The diagram shows some of the stages in water treatment.



(i) Air is blown through the aeration tank.

Name the **two** gases that make up most of the air.

Nitrogen and oxygen [2]

2

(ii) After aeration, the water still contains large insoluble particles.

The filter is made up of fine sand and stones.

Explain how the filter helps purify the water.

The filter traps the insoluble particles while allowing only the water to pass through

..... [2]

3

(iii) Explain why chlorine is used in water treatment.

it kills bacteria ..... [1]

4

(c) Anhydrous cobalt(II) chloride is used to test for water.

State the colour change in this test.

from white to blue [2]

5

Examiner comments

1 The candidate gains a mark for describing the dipping of the indicator paper into the water. The second mark is also gained because the candidate writes about comparing the colour of the indicator with a pH colour chart. Mark for (a) = 2 out of 2

2 The candidate identifies the two gases (oxygen and nitrogen) correctly and so gains two marks.

3 The candidate gains both marks. The candidate is given the benefit of the doubt for the first mark, although the answer is rather vague. The candidate mentions 'insoluble particles' getting trapped, rather than focusing on large insoluble particles getting trapped by the filter. The second mark is obtained for the idea of water passing through the filter.

4 The candidate gives a short but correct answer.
Mark for (b) = 5 out of 5

5 The candidate mistakes the colour change of copper(II) sulfate for the colour change of cobalt(II) chloride, and so does not gain any marks. The correct colour change should be blue to pink.
Mark for (c) = 0 out of 2

Total mark awarded = 7 out of 9

How the candidate could have improved their answer

- **(a)** Although the candidate obtained both marks, the answer could be improved by referring to a universal indicator colour chart rather than a pH colour chart.
- **(b)(i)** The candidate knew the two most common gases in the air and named them rather than giving the formula. The latter should be discouraged if the command word is 'name'.
- **(b)(ii)** The candidate could have improved their answer by suggesting that 'the large impurities get trapped between the stones'. The candidate could have improved the answer for the second marking point, by referring to the water flowing through the gaps in the stones, rather than just 'water will exit'.
- **(b)(iii)** The candidate's answer was concise and contained the two important words 'kills' and 'bacteria'. The candidate, however, would be advised not to suggest that 'impurities are killed' as well as bacteria because this is very vague and could be considered incorrect.
- **(c)** The candidate muddled the colour of hydrated and anhydrous copper(II) sulfate with the colours of hydrated and anhydrous cobalt(II) chloride. Candidates should make sure that they know the colour tests in the different sections of the syllabus by listing the tests and learning them by heart together with the correct colour change.

Example Candidate Response – middle

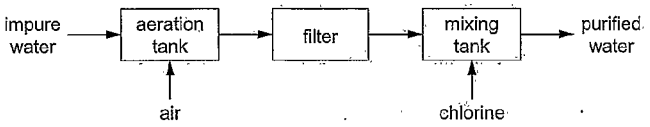
6 This question is about water.

(a) The water in rivers often contains pollutants such as acids.

Describe how universal indicator paper can be used to determine the pH value of the water.

This can be used because the universal indicator is placed in water and by the colour given it tell how acid it is and what PH it is. 1 [2]

(b) The diagram shows some of the stages in water treatment.



(i) Air is blown through the aeration tank.

Name the **two** gases that make up most of the air.

oxygen and Nitrogen 2 [2]

(ii) After aeration, the water still contains large insoluble particles.

The filter is made up of fine sand and stones.

Explain how the filter helps purify the water.

It helps because a mash paper is place on the the filter and as water is put in the mash paper has tiny holes to trap the large insoluble particles. 3 [2]

(iii) Explain why chlorine is used in water treatment.

Chlorine is used to kill bacteria. 4 [1]

(c) Anhydrous cobalt(II) chloride is used to test for water.

State the colour change in this test.

from pink to blue 5 [2]

Examiner comments

1 The candidate gains one mark for describing the placing of the indicator paper in the water. The results are too generalised. In order to gain the second mark, the candidates has to compare the colour of the indicator with a colour chart.
Mark for (a) = 1 out of 2

2 The candidate identifies the two gases (oxygen and nitrogen) correctly and so gains two marks.

3 The candidate obtains the first mark for an explanation in terms of 'large insoluble particles trapped' in the filter. On this occasion, benefit of the doubt is given for this mark because the candidate refers to a paper filter rather than filtration through stones. The second mark is not obtained because there is no indication of water passing through the filter.

4 The candidate gives a short but correct answer.
Mark for (b) = 4 out of 5

5 The candidate knows the colour change, but the direction of the colour change is incorrect. It should have been blue to pink rather than pink to blue. One mark is given for two correct colours in the wrong direction.
Mark for (c) = 1 out of 2

Total mark awarded = 6 out of 9

How the candidate could have improved their answer

- **(a)** The candidate could have improved their answer by realising that a general method of determining pH by comparison is required, e.g. ‘compare the colour obtained with the colour on an indicator colour chart’.
- **(b)(ii)** The candidate understood the meaning of the command word ‘explain’ and focussed on the difference in particle size. Candidates should realise, however, that in a two-mark question, two separate points are required, the second mark being for the water flowing through the gaps in the stones. The candidate should also be careful to read the stem of the question carefully. The stones are acting as a filter and not a filter paper. For a similar question, graded at a higher level, the implication that a filter paper is involved could result in the loss of the mark.
- **(c)** The candidate knew the correct colours for cobalt chloride but muddled the colour of the anhydrous cobalt chloride with the colour of the hydrated cobalt chloride. Candidates should make sure that they know the colour tests in the different sections of the syllabus by listing the tests and learning them by heart together with the correct colour change.

Example Candidate Response – low

6 This question is about water.

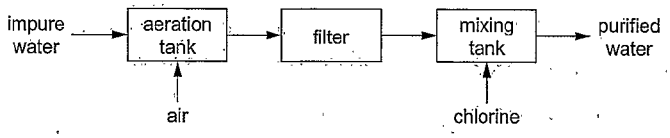
(a) The water in rivers often contains pollutants such as acids.

Describe how universal indicator paper can be used to determine the pH value of the water.

Universal indicator will turn to Yellow orange if the acid in the water is weak, and if the acid is strong then it will turn to red color. [2]

1

(b) The diagram shows some of the stages in water treatment.



(i) Air is blown through the aeration tank.

Name the **two** gases that make up most of the air.

Carbon and ~~dioxide~~ oxygen [2]

2

(ii) After aeration, the water still contains large insoluble particles.

The filter is made up of fine sand and stones.

Explain how the filter helps purify the water.

- because it removes impurities
- it makes the residues remains on the Sand and stones, so only pure water passes through [2]

3

(iii) Explain why chlorine is used in water treatment.

it kills pathogens e.g bacteria. [1]

4

(c) Anhydrous cobalt(II) chloride is used to test for water.

State the colour change in this test.

from ~~not~~ colorless to blue [2]

5

Examiner comments

1 No marks are given here. The candidate does not describe how the universal indicator is used. There is no indication of dipping indicator paper into the water or adding indicator solution to a sample of water. The results are too specific: 'yellow orange if the water is acid' rather than generalised. In order to gain the second mark, the candidate needs to compare the colour of the indicator with a colour chart.
Mark for (a) = 0 out of 2

2 The candidate identifies oxygen as being one of the gases which make up most of the air. The second mark, for nitrogen, is not obtained. The candidate does not take into consideration that the physical state of carbon at room temperature is solid.

3 The candidate obtains a mark for the idea of water passing through the filter. The first mark was not obtained because an explanation in terms of 'large particles getting trapped on the stones' is required, rather than a vague statement about 'residues remaining on the stones'.

4 The candidate gives a good answer and so gains the mark.
Mark for (b) = 2 out of 5

5 The candidate does not gain the marks because they confuse the test for water using cobalt(II) chloride with the test for water using copper(II) sulfate. The correct answer is blue to pink.
Mark for (c) = 0 out of 2

Total mark awarded = 2 out of 9

How the candidate could have improved their answer

- **(a)** The candidate could have improved their answer by revising the meaning of the command word 'describe'. This word indicates that you need to show how something is carried out, e.g. by dipping the indicator paper into the solution. Candidates should realise that a general method is required rather than specific results, i.e. 'compare the colour obtained with and indicator colour chart'.
- **(b)(i)** The candidate was unsure about the composition of the air. The candidate should also learn the states at room temperature of some common elements and compounds so that simple errors such as thinking that carbon is a gas do not arise.
- **(b)(ii)** The candidate could have improved their answer by revising the meaning of the command word 'explain'. This word indicates that you need to give detailed ideas of how something happens using chemical or physical theory (in this case difference in particle size).
- **(b)(iii)** The candidate's answer was concise and contained the two important words 'kills' and 'bacteria'. 'Kills pathogens' would also gain the mark.
- **(c)** The candidate muddled the two tests for water. Candidates should make sure that they know the colour tests in the different sections of the syllabus by listing the tests and learning them by heart.

Common mistakes candidates made in this question

- **(a)** Many candidates just referred to 'using the universal indicator to find the pH'. Others did not gain the second mark because they just stated various colours that might be seen at different pH values, e.g. 'if its pH 4 the colour is red'. Others did not seem to know about universal indicator and just wrote about litmus changing from red to blue or blue to red.
- **(b)(i)** The most common errors were to suggest either 'carbon dioxide' or 'hydrogen'.
- **(b)(ii)** Many candidates did not gain the marks because they wrote about filter papers and the sand being trapped on the filter paper. A considerable minority thought that the question was about separating sand and stones or sand and insoluble particles. Others suggested, incorrectly, that the separation occurs because the insoluble particle 'stick to the sand'.
- **(b)(iii)** The most common incorrect answers referred to 'acidifying the water' or the vague 'cleaning water' Other vague answers were 'to kill pollutants' or 'to kill particles'. The test for water using anhydrous cobalt(II) chloride was not well known, with many candidates confusing it with the test for water using anhydrous copper(II) sulfate. Some candidates gained a mark for 'blue' or 'red' in the appropriate place, but few candidates gained both marks. Other common incorrect colours were 'orange' or 'colourless'.

Question 7

Example Candidate Response – high

7 **(a)** Molten lead(II) bromide is electrolysed using carbon electrodes.

(i) State the products of this electrolysis at:

the negative electrode Lead

the positive electrode. bromine 1

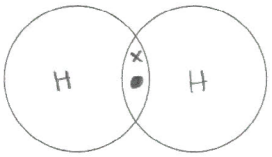
[2]

(ii) State the name of **another** substance which can be used as an inert electrode.

platinum 2 [1]

(b) When aqueous magnesium chloride is electrolysed using carbon electrodes, hydrogen gas is produced at the negative electrode.

Complete the dot-and-cross diagram to show the electron arrangement in one molecule of hydrogen.



3

[1]

[Total: 4]

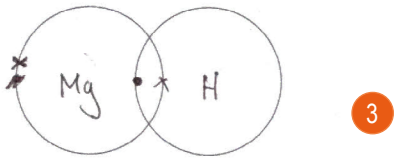
Examiner comments

1 The candidate deduces the correct products formed at both the negative electrode (lead) and the positive electrode (bromine), and so scores both marks.

2 The candidate chooses the alternative electrode to graphite mentioned in the syllabus, and so gains the mark.
Mark for (a) = 3 out of 3

3 The candidate draws the correct dot-and-cross diagram for hydrogen and does not add extra electrons.
Mark for (b) = 1 out of 1

Total mark awarded =
4 out of 4

Example Candidate Response – middle	Examiner comments
7 (a) Molten lead(II) bromide is electrolysed using carbon electrodes. (i) State the products of this electrolysis at: the negative electrode ..... Lead ..... the positive electrode. ..... Bromine ..... 1 [2] (ii) State the name of **another** substance which can be used as an inert electrode. ..... graphite ..... 2 ..... [1] (b) When aqueous magnesium chloride is electrolysed using carbon electrodes, hydrogen gas is produced at the negative electrode. Complete the dot-and-cross diagram to show the electron arrangement in one molecule of hydrogen.  3 [1] [Total: 4]	1 The candidate deduces the correct products formed at both the negative electrode (lead) and the positive electrode (bromine) and so scores both marks. 2 The candidate does not heed the use of the word 'carbon' in the stem of the question, or the word 'other' in the question part (ii). Graphite is a form of carbon, so cannot be awarded the mark. The correct answer is platinum. Mark for (a) = 2 out of 3 3 Although the student draws a bonding pair of electrons between the atoms, the presence of another electron in the left-hand atom means that the mark is not scored. In addition the candidate does not read the question properly and confuses the magnesium in the first sentence of the question, with hydrogen in the second sentence. The candidate thinks that the left-hand atom is magnesium rather than hydrogen. Mark for (b) = 0 out of 1 **Total mark awarded = 2 out of 4**

How the candidate could have improved their answer

- **(a)(ii)** By reading the stem of the question and the question itself more carefully. The candidate should also ensure that they know that platinum is a suitable inert electrode in place of carbon / graphite.
- **(b)** By reading the stem of the question and the question itself more carefully so that incorrect atoms are not included in the dot-and-cross diagram. The candidate should remember that a hydrogen atom is the simplest atom and has a single electron and so a hydrogen molecule must have two electrons that are shared.

Example Candidate Response – low

7 **(a)** Molten lead(II) bromide is electrolysed using carbon electrodes.

(i) State the products of this electrolysis at:

the negative electrode ..bromide..

the positive electrode. ..lead (II).. 1

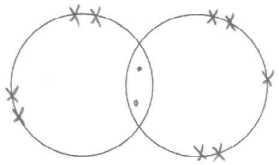
[2]

(ii) State the name of **another** substance which can be used as an inert electrode.

..iron.. 2 [1]

(b) When aqueous magnesium chloride is electrolysed using carbon electrodes, hydrogen gas is produced at the negative electrode.

Complete the dot-and-cross diagram to show the electron arrangement in one molecule of hydrogen.



3 [1]

[Total: 4]

Examiner comments

1 The candidate realises that the electrode products are related to the lead and bromide in the molten compound but gives the names of the ions rather than the elements. The correct answer is lead (at the negative electrode) and bromine (at the positive electrode). In addition, the species are at the wrong electrodes. No marks are scored.

2 The candidate does not get the mark because they choose a metal that is relatively reactive. Platinum is the relatively unreactive metal stated in the syllabus.
Mark for (a) = 0 out of 3

3 The candidate draws a pair of bonding electrons between the two atoms but does not get the mark because of the extra non-bonding electrons added, four on one atom and five on the other.
Mark for (b) = 0 out of 1

Total mark awarded =
0 out of 4

How the candidate could have improved their answer

- **(a)(i)** In order to improve, the candidate should revise the patterns that elements are produced at the electrodes during the electrolysis of molten salts and that a metal is produced at the cathode and a non-metal is produced at the anode when a metal salt is electrolysed.
- **(a)(ii)** The candidate should ensure that they know the suitable electrodes mentioned in the syllabus (carbon / graphite or platinum).
- **(b)** The candidate should remember that a hydrogen atom is the simplest atom and has a single electron and so a hydrogen molecule must only have two electrons.

Common mistakes candidates made in this question

- **(a)(i)** Many candidates wrote lead (II), which implies a lead compound, or lead ions instead of lead and bromide instead of bromine. Many candidates did not heed the statement about the lead bromide being molten and suggested oxygen or hydrogen forming at either electrode. A minority of the candidates wrote answers related to the electrodes rather than the electrode products, e.g. ‘cathode’ and ‘anode’; others gave observations.
- **(a)(ii)** The most common error was to suggest ‘graphite’ or ‘carbon’ even although the question asked for another substance (other than carbon). Many candidates suggested improbably electrode materials suggested improbably electrode materials such as ‘carbon dioxide’ or ‘water’.
- **(b)** Many candidates forgot that the first electron shell only contains a maximum of two electrons and added extra non-bonding electrons to one or both hydrogen atoms. Others gave the electronic configuration for hydrochloric acid instead of hydrogen and included the symbols H and Cl. Other candidates did not show the bonding pair of electrons and showed the two electrons as a non-bonding pair or as one non-bonded electron on each hydrogen atom.

Question 8

Example Candidate Response – high

8 This question is about elements in the Periodic Table.

(a) The table shows some properties of five elements, **P**, **Q**, **R**, **S** and **T**.

element	melting point /°C	density in g/cm³	electrical conductivity of the solid	atomic radius /nm
P	1535	7.86	very good	0.125
Q	–7	3.12	does not conduct	0.114
R	1495	8.90	very good	0.126
S	–157	0.0035	does not conduct	0.110
T	839	1.54	very good	0.174

Use only the elements shown in the table to answer this question.

State which two of the elements, **P**, **Q**, **R**, **S** and **T**, are covalent molecules.
Give **two** reasons for your answer.

elements Q and S

reason 1 Covalent molecules have low melting points 1

reason 2 Covalent molecules do not conduct electricity [3]

(b) Element **T** is on the left-hand side of the Periodic Table.
Suggest whether its oxide is acidic or basic.

Give a reason for your answer.

Basic oxide. Elements on the left hand side are metals and metals are bases. 2 [1]

(c) Krypton is an element in Group VIII of the Periodic Table.

Explain, using ideas about electronic structure, why krypton is unreactive.

Krypton has ∞ full electrons on it's outer Shell 3 [1]

Examiner comments

1 The candidate gives a model answer. The candidate identifies the elements which are covalent molecules, so scores the first mark. The candidate realises that simple molecular structures have low melting points and do not conduct electricity.
Mark for (a) = 3 out of 3

2 The candidate gains the mark by making the link between metal oxides and basic character.
Mark for (b) = 1 out of 1

3 The candidate's answer is rather ungrammatical, but the idea of a full shell of outer electrons is there.
Mark for (c) = 1 out of 1

Example Candidate Response – high, continued

(d) Sodium is an element in Group I of the Periodic Table. Iron is a transition element.

Iron has a higher melting point and higher boiling point than sodium.

Give **two** other ways in which the properties of transition elements differ from the properties of Group I elements.

1 Transition elements form coloured compounds

2 Transition elements have high densities 4

[2]

(e) The table compares the reactivity of four metals with dilute hydrochloric acid.

metal	reaction with dilute hydrochloric acid
calcium	reacts very rapidly
copper	no reaction
iron	reacts rapidly
nickel	reacts slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive

Copper | Nickel | Iron | Calcium

5

[2]

(f) Hot iron reacts with steam. The reaction is reversible.

Complete the equation by writing the symbol for a reversible reaction in the box.

$3Fe + 4H_2O$ ⇌ $Fe_3O_4 + 4H_2$ 6

[1]

(g) Steel is an alloy of iron.

State the meaning of the term *alloy*. 7

An alloy is the combination of two or more metals [1]

Examiner comments

4 The candidate gains both marks for remembering two relevant properties of transition element compounds. The candidate makes their answer clear by referring to transition elements rather than starting the sentence with 'They...'.
Mark for (d) = 2 out of 2

5 The candidate deduces the correct order of reactivity and so gains both marks.
Mark for (e) = 2 out of 2

6 The candidate draws a suitable equilibrium sign with the half arrows pointing in the correct direction.
Mark for (f) = 1 out of 1

7 The candidate does not gain the mark because the essential word 'mixture' is absent. In addition, the word 'combination' suggests chemical bonding and should not be used when defining an alloy.
Mark for (g) = 0 out of 1

Total mark awarded = 10 out of 11

How the candidate could have improved their answer

- **(c)** The answer could be improved by mentioning that 'a full outer shell is a stable electronic structure'.
- **(d)** The candidate gave two specific properties which differentiate transition elements from Group I elements. For reference, candidates should note that the following properties should be avoided: conductivity, magnetism and malleability (or ductility) unqualified by words such as more / less.
- **(g)** The candidate needs more practice with definitions. The candidate could have got the mark by writing the essential word 'mixture' instead of the word 'combination'. In general, marks can be increased by making a list of definitions of chemical terms in the syllabus, taking particular note of the essential words in each definition.

Example Candidate Response – middle

8 This question is about elements in the Periodic Table.

(a) The table shows some properties of five elements, **P**, **Q**, **R**, **S** and **T**.

element	melting point /°C	density in g/cm³	electrical conductivity of the solid	atomic radius /nm
P	1535	7.86	very good	0.125
Q	–7	3.12	does not conduct	0.114
R	1495	8.90	very good	0.126
S	–157	0.0035	does not conduct	0.110
T	839	1.54	very good	0.174

Use only the elements shown in the table to answer this question.

State which two of the elements, **P**, **Q**, **R**, **S** and **T**, are covalent molecules.
Give **two** reasons for your answer.

elements P and R

reason 1 Very high melting points.

reason 2 High density. 1 [3]

(b) Element **T** is on the left-hand side of the Periodic Table.
Suggest whether its oxide is acidic or basic.

Give a reason for your answer.

Its basic, because its a metal. 2 [1]

(c) Krypton is an element in Group VIII of the Periodic Table.

Explain, using ideas about electronic structure, why krypton is unreactive.

Because it is stable and has eight electrons on the outer most shell. 3 [1]

Examiner comments

1 The candidate does not identify the elements which are covalent molecules, so does not score the first mark. The candidate should realise that simple molecular structures have low melting points, and do not conduct electricity.
The density is an irrelevant factor chosen by the candidate perhaps because they think that they are comparing transition elements with other elements. No marks are scored.
Mark for (a) = 0 out of 3

2 The candidate gains the mark by making the link between metal oxides and basic character.
Mark for (b) = 1 out of 1

3 The candidate gains the mark although the answer is weak.
Mark for (c) = 1 out of 1

Example Candidate Response – middle, continued

(d) Sodium is an element in Group I of the Periodic Table. Iron is a transition element.

Iron has a higher melting point and higher boiling point than sodium.

Give **two** other ways in which the properties of transition elements differ from the properties of Group I elements.

1 It has a high density.

2 It is harder 4

[2]

(e) The table compares the reactivity of four metals with dilute hydrochloric acid.

metal	reaction with dilute hydrochloric acid
calcium	reacts very rapidly
copper	no reaction
iron	reacts rapidly
nickel	reacts slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive

Copper | Nickel | Iron | Calcium

[2]

5

(f) Hot iron reacts with steam. The reaction is reversible.

Complete the equation by writing the symbol for a reversible reaction in the box.

$3Fe + 4H_2O$ ⇋ $Fe_3O_4 + 4H_2$ 6

[1]

(g) Steel is an alloy of iron.

State the meaning of the term *alloy*.

It is the compination of two or more metals. 7 [1]

Examiner comments

4 The candidate gains both marks for remembering two relevant properties of transition element compounds.
Mark for (d) = 2 out of 2

5 The candidate deduces the correct order of reactivity and so gains both marks.
Mark for (e) = 2 out of 2

6 The candidate draws a suitable equilibrium sign, but with the half arrows pointing in the incorrect direction. The mark is awarded, however, because the essential idea of the equilibrium sign is shown.
Mark for (f) = 1 out of 1

7 The candidate does not gain the mark because the essential word 'mixture' is absent. In addition the word 'compination' (combination) suggests chemical bonding and should not be used when defining an alloy.
Mark for (g) = 0 out of 1

Total mark awarded = 7 out of 11

How the candidate could have improved their answer

- **(a)** The candidate needs to revise the differences between simple covalent molecules and metallic or covalent giant structures. The candidate needs to read the stem of the question carefully since they gave answers relating to transition elements rather than simple covalent molecules.
- **(b)** The candidate related the basic nature of the oxide to the fact that it was the oxide of a metal. Although the mark was gained, the answer could be improved by writing a more detailed answer, e.g. 'it is basic because element T is the oxide of a metal'.
- **(c)** The candidate gave a suitable answer. The answer could be improved by mentioning that 'a full outer shell is a stable electronic structure'.
- **(d)** The candidate gave two specific properties which differentiate transition elements from Group I elements. Candidates should make it clear which element is being referred to and if there is a choice of elements, candidates should be advised to make it clear which element is being written about, e.g. transition elements have a high density. For reference, candidates should note that the following properties should be avoided: conductivity, magnetism and malleability (or ductility) unqualified by words such as more / less.
- **(f)** A suitable drawing of an equilibrium sign was given but the candidate could improve their answer by drawing the top half arrow to the right and the bottom half arrow to the left.
- **(g)** The candidate needs more practice with definitions. The candidate could have been awarded the mark by writing the essential word 'mixture' instead of the word 'compination' (combination). In general, marks can be increased by making a list of definitions of chemical terms in the syllabus, taking particular note of the essential words in each definition.

Example Candidate Response – low

Examiner comments

8 This question is about elements in the Periodic Table.

(a) The table shows some properties of five elements, **P**, **Q**, **R**, **S** and **T**.

element	melting point /°C	density in g/cm³	electrical conductivity of the solid	atomic radius /nm
P	1535	7.86	very good	0.125
Q	–7	3.12	does not conduct	0.114
R	1495	8.90	very good	0.126
S	–157	0.0035	does not conduct	0.110
T	839	1.54	very good	0.174

Use only the elements shown in the table to answer this question.

State which two of the elements, **P**, **Q**, **R**, **S** and **T**, are covalent molecules.
Give **two** reasons for your answer.

elements Q and S

reason 1 covalent molecules never conduct

reason 2 covalent molecules always are negative 1

[3]

(b) Element **T** is on the left-hand side of the Periodic Table.
Suggest whether its oxide is acidic or basic.

Give a reason for your answer.

it is basic 2

[1]

(c) Krypton is an element in Group VIII of the Periodic Table.

Explain, using ideas about electronic structure, why krypton is unreactive.

cause its in group VIII and we know most of them are unreactive. 3 [1]

1 The candidate gains a mark for the correct identification of the two covalent molecules and another mark for the reason that covalent compounds do not conduct (electricity). The candidate does not use the data in the table to elicit a second reason but shows a lack of basic chemical knowledge by suggesting that covalent molecules are charged (negative).
Mark for (a) = 2 out of 3

2 Although the candidate recognises that element T forms a basic oxide, no reason is given. In order to get the mark two points are required: basic because T is a metal.
Mark for (b) = 0 out of 1

3 The candidate gives too simplistic an answer, just paraphrasing the stem of the question. The candidate should give an explanation in terms of electronic structure, e.g. 'it has a complete outer electron shell'.
Mark for (c) = 0 out of 1

Example Candidate Response – low, continued

(d) Sodium is an element in Group I of the Periodic Table. Iron is a transition element.

Iron has a higher melting point and higher boiling point than sodium.

Give **two** other ways in which the properties of transition elements differ from the properties of Group I elements.

1 Not all of them react. 4

2 Some are good conductors and bad conductors of electricity.

[2]

(e) The table compares the reactivity of four metals with dilute hydrochloric acid.

metal	reaction with dilute hydrochloric acid
calcium	reacts very rapidly
copper	no reaction
iron	reacts rapidly
nickel	reacts slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive 5

copper | nickel | iron | ~~re~~ calcium

[2]

(f) Hot iron reacts with steam. The reaction is reversible.

Complete the equation by writing the symbol for a reversible reaction in the box. 6

$3Fe + 4H_2O$ [⇌] $Fe_3O_4 + 4H_2$

[1]

(g) Steel is an alloy of iron.

State the meaning of the term *alloy*.

an alloy is a substance that is made from plastic. 7 [1]

Examiner comments

4 The candidate gives answers that are too vague to warrant any marks being given. Definite differences between transition metals and Group I metals are required, such as transition elements have high densities, form coloured compounds and form ions with different charges.
Mark for (d) = 0 out of 2

5 The candidate deduces the order of reactivity correctly.
Mark for (e) = 2 out of 2

6 The candidate draws the equilibrium sign clearly and correctly.
Mark for (f) = 1 out of 1

7 The candidate does not understand the term alloy, confusing it with the term plastic. The correct answer should be 'a mixture of a metal with another element'.
Mark for (g) = 0 out of 1

Total mark awarded = 5 out of 11

How the candidate could have improved their answer

- **(a)** The candidate should have given a second reason by extracting another piece information from the table.
- **(b)** The candidate needed to read the stem of the question carefully noting key phrases such as ‘give a reason for your answer’. Candidates should be advised that some questions require two pieces of information for a single mark. Candidates should always look out for this type of question, perhaps by underlining the key words.
- **(c)** The candidate needed to read the stem of the question carefully noting the phrase ‘explain using ideas about electronic structure’. Candidates should also be encouraged not to use words or phrases already present in the stem of the question.
- **(d)** The candidate should revise the specific properties which differentiate transition elements from Group I elements. The following properties should be avoided: conductivity, magnetism and malleability (or ductility) unqualified by words such as more / less.
- **(e)** The candidate used the data to give the correct order of reactivity.
- **(f)** A clear drawing of an equilibrium sign was given with the half arrow in the correct direction.
- **(g)** The candidate needs more practice with definitions. Marks could be increased by making a list of definitions of chemical terms in the syllabus and learning these.

Common mistakes candidates made in this question

- **(a)** Many candidates suggested **P** and **R** rather than **Q** and **S**. Other candidates seemed to guess the properties and gave one correct answer related to simple covalent compounds or wrote about properties not in the table.
- **(b)** Many candidates suggested that element **T** forms a basic oxide. Few related this to metallic character. Common incorrect answers included ‘because its acidic’ or ‘because its reactive’.
- **(c)** The best answers referred to a full outer shell of electrons. Common incorrect answers ranged from the vague ‘because it’s a noble gas’ to incorrect statements such as ‘it’s got no free electrons’.
- **(d)** Few candidates gave two differences between transition elements and Group I metals. Many confused the differences, suggesting that sodium ‘has a high melting point’ or ‘sodium is denser’. Some candidates chose malleability or ductility but did not get the mark because they suggested that transition elements were not malleable or ductile rather than less malleable or less ductile. A significant number of candidates referred, incorrectly, to rusting or magnetism, properties which only apply to iron (for rusting) or iron, nickel and cobalt for ferromagnetic properties.
- **(e)** The most common errors were to suggest that nickel is less reactive than copper or to reverse the order completely.
- **(f)** The most common error was to draw a single double-headed arrow. A few candidates drew a circle with an arrowhead.
- **(g)** Many candidates did not gain the mark because they did not write the essential word ‘mixture’ or contradicted themselves by including the word ‘compound’. A significant minority did not mention that one of the components must be a metal.

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