



Cambridge IGCSE™ (9–1)

CANDIDATE
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CHEMISTRY

0971/42

Paper 4 Theory (Extended)

May/June 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.



1 The symbols of the elements of Period 3 of the Periodic Table are shown.

Na	Mg	Al	Si	P	S	Cl	Ar
----	----	----	----	---	---	----	----

Answer the following questions about these elements.
Each symbol may be used once, more than once or not at all.

Write the symbol of the element which:

- (a) forms a stable ion with a 2+ charge [1]
- (b) is the least reactive in the period [1]
- (c) is used in water treatment [1]
- (d) forms an oxide which is the main impurity in iron ore [1]
- (e) is an important component of fertilisers [1]
- (f) is stored under oil [1]
- (g) is used in food containers [1]
- (h) is found in the ore zinc blende. [1]

[Total: 8]

Question 2 starts on the next page.

2 Calcium hydroxide, Ca(OH)_2 , is slightly soluble in water.

(a) Calcium hydroxide can be made by the reaction of calcium with water.

(i) Write the chemical equation for this reaction.

..... [2]

(ii) Name another substance that reacts with water to form calcium hydroxide.

..... [1]

(b) When calcium hydroxide dissolves in water, it dissociates into ions and forms a weakly alkaline solution.

(i) Suggest the pH of aqueous calcium hydroxide.

..... [1]

(ii) Give the formula of the ion responsible for making the solution alkaline.

..... [1]

(c) Limewater is a saturated solution of calcium hydroxide, $\text{Ca(OH)}_2(\text{aq})$.

(i) Name the gas limewater is used to test for.

..... [1]

(ii) Suggest what is meant by the term *saturated solution*.

.....
 [2]

(iii) Describe how you would make a sample of limewater starting with solid calcium hydroxide.

.....

 [2]

(iv) Describe how you would test for the presence of calcium ions in a sample of limewater.

test

observations

.....
 [3]

(d) A 25.0 cm³ sample of limewater is placed in a conical flask. The concentration of Ca(OH)₂ in the limewater is determined by titration with dilute hydrochloric acid, HCl.

(i) Name the item of apparatus used to measure the volume of acid in this titration.

..... [1]

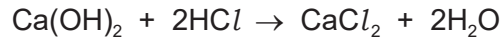
(ii) State the type of reaction which takes place.

..... [1]

(iii) As well as limewater and dilute hydrochloric acid, state what other type of substance must be added to the conical flask.

..... [1]

(iv) The equation for the reaction is shown.



20.0 cm³ of 0.0500 mol/dm³ HCl reacts with the 25.0 cm³ of Ca(OH)₂.

Determine the concentration of Ca(OH)₂ in g/dm³. Use the following steps.

- Calculate the number of moles in 20.0 cm³ of 0.0500 mol/dm³ HCl.

..... mol

- Determine the number of moles of Ca(OH)₂ in 25.0 cm³ of the limewater.

..... mol

- Calculate the concentration of Ca(OH)₂ in mol/dm³.

..... mol/dm³

- Determine the concentration of Ca(OH)₂ in g/dm³.

..... g/dm³
[5]

[Total: 21]

3 Transition elements are found in the middle block of the Periodic Table.

(a) Chromium has several isotopes. Manganese has only one isotope.

(i) State what is meant by the term *isotopes*.

.....
 [2]

(ii) State the nucleon number of manganese.

..... [1]

(iii) Complete the table to show the number of protons, neutrons and electrons in a ${}_{24}^{52}\text{Cr}^{3+}$ ion.

protons	neutrons	electrons

[3]

(b) One chemical property of transition elements is that they form coloured compounds.

(i) Give the colours of the following hydrated salts.

- hydrated copper(II) sulfate
 - hydrated cobalt(II) chloride
- [2]

(ii) State two **other** chemical properties of transition elements.

- 1
- 2
- [2]

(c) Transition elements and Group I elements are metals. They share many physical properties including the ability to:

- conduct electricity
- be hammered into shape.

(i) Explain why transition elements and Group I elements conduct electricity.

..... [1]

(ii) State the property that describes a material which can be hammered into shape.

..... [1]

- (d) Transition elements and Group I elements differ in other physical properties. Transition elements are harder and stronger than Group I elements.

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

1

2

[2]

[Total: 14]

4 Fluorine and chlorine are halogens.

(a) Suggest the appearance of fluorine.

..... [1]

(b) Fluorine reacts with sulfur to form a compound which has 25.2% sulfur by mass and a relative molecular mass of 254.

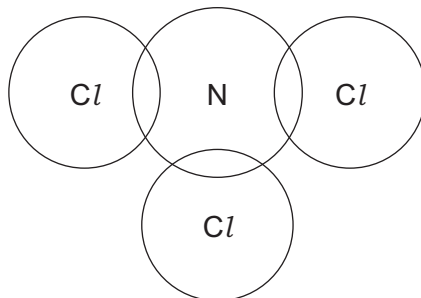
Determine the molecular formula of this compound.

molecular formula = [3]

(c) Nitrogen trichloride, NCl_3 , is a covalent compound.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of NCl_3 .

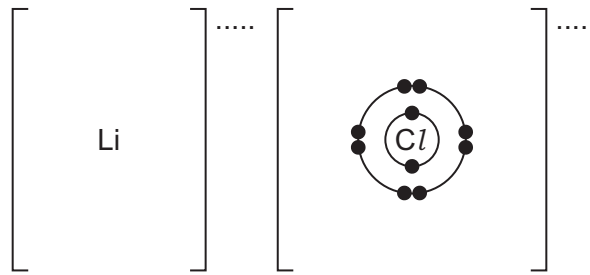
Show outer electrons only.



[3]

(d) Lithium chloride, LiCl , is an ionic compound.

Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in lithium chloride.



[3]

(e) Explain, in terms of attractive forces between particles, why LiCl is a solid at room temperature but NCl_3 is a liquid with a relatively low boiling point.

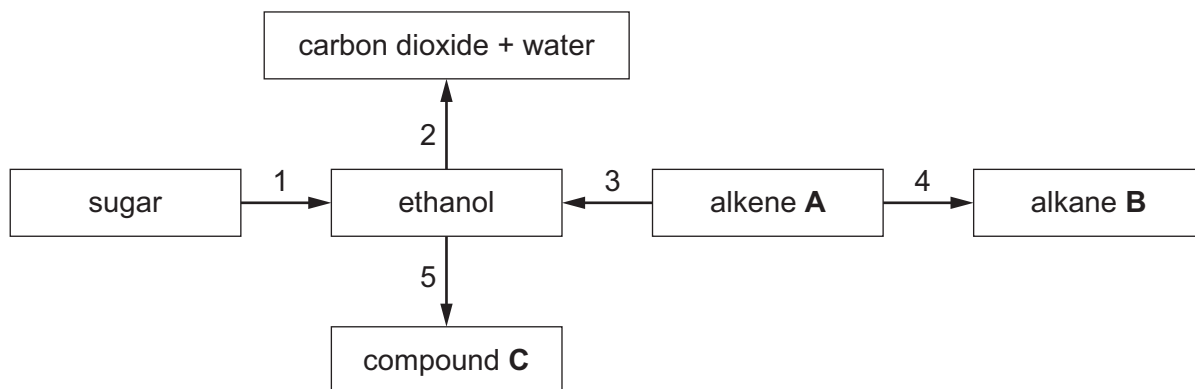
.....

.....

..... [3]

[Total: 13]

5 The reaction scheme shows five organic reactions, numbered 1 to 5.



(a) Name reaction 1.

..... [1]

(b) Name reaction 2 and write the chemical equation for this reaction.

name

equation

[3]

(c) Reaction 3 forms ethanol from alkene **A**.

(i) Identify alkene **A**.

..... [1]

(ii) State the type of reaction that occurs during reaction 3.

..... [1]

(iii) State the reagents and conditions needed for reaction 3.

.....

..... [2]

(d) Alkene **A** is converted into alkane **B** in reaction 4.

(i) State the reagent and conditions for reaction 4.

.....

..... [3]

(ii) State the general formula of alkanes.

..... [1]

(e) Ethanol is oxidised in reaction 5 by heating it with dilute sulfuric acid and one other reagent.

(i) Identify the other reagent in reaction 5.

..... [1]

(ii) Name the homologous series compound **C** belongs to.

..... [1]

(iii) Draw the structure of compound **C**.

Show all of the atoms and all of the bonds.

[1]

[Total: 15]

6 This question is about polymers.

(a) Polymer **X** is a condensation polymer.

Part of the structure of polymer **X** is shown.



(i) How many molecules of water are produced when this part of polymer **X** is formed from its monomers?

..... [1]

(ii) Complete the structures of the **two** monomers used to make polymer **X**.

Show all of the atoms and all of the bonds in the functional groups.



and



[2]

(iii) What type of condensation polymer is **X**?

..... [1]

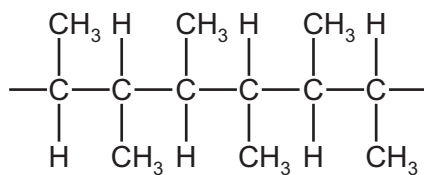
(b) Part of polymer **Y** has the structure shown.



State the number of different types of monomer needed to make polymer **Y**.

..... [1]

(c) Part of polymer **Z** has the structure shown.



(i) Draw and name the structure of the monomer which forms polymer **Z**.

Show all of the atoms and all of the bonds.

name

[3]

(ii) Name the chemical process used to make the monomer that forms polymer **Z**.

..... [1]

[Total: 9]

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