



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, $\text{Ca}(\text{OH})_2$, 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, $\text{Ca}(\text{OH})_2(\text{aq})$.

(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]

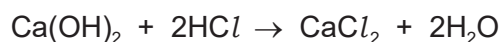
(ii) State the type of reaction which takes place.

..... [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.

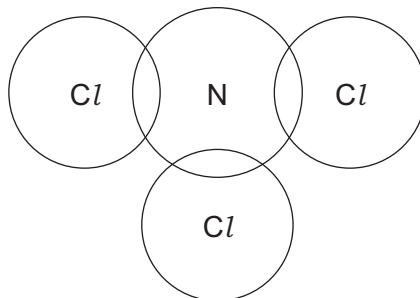
Determine the molecular formula of this compound.

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 .

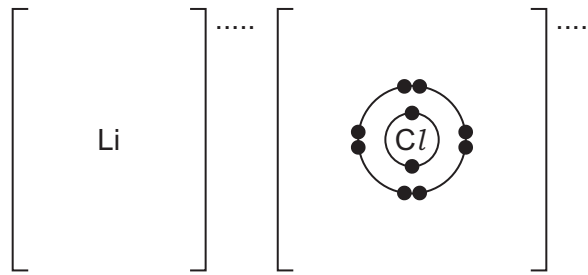
Show outer electrons only.



[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.

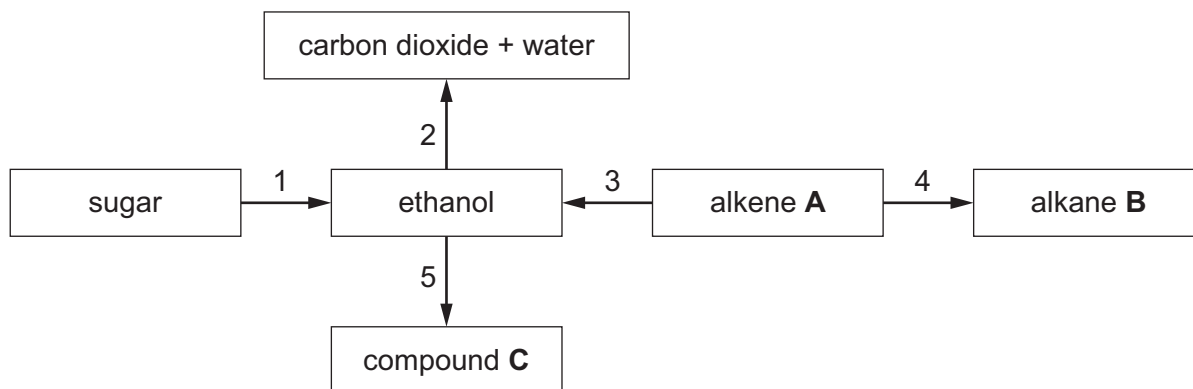
.....

.....

..... [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.

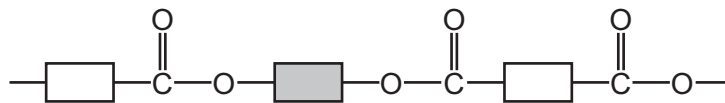
[1]

[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]

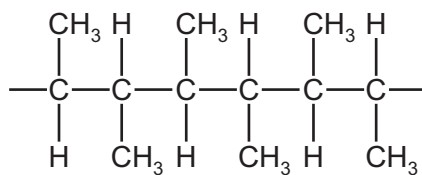
(b) Part of polymer **Y** has the structure shown.



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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The Periodic Table of Elements

		Group							
I	II	III	IV	V	VI	VII	VIII		
1	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
Key									
atomic number									
atomic symbol									
name									
relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
11	12	13	14	15	16	17	18		
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40		
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Cn copernicium —	Nh nihonium —	Dl dubnium —	Fl flerovium —
67	68	69	70	71	72	73	74	75	76
Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —
99	100	101	102	103	104	105	106	107	108
Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —
66	67	68	69	70	71	72	73	74	75
Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144
98	99	100	101	102	103	104	105	106	107
Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238
65	66	67	68	69	70	71	72	73	74
Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175	La lanthanum 139	Ce cerium 140	Pr praseodymium 141
97	98	99	100	101	102	103	104	105	106
Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	Ac actinium —	Th thorium 232	Pa protactinium 231

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).