



# Cambridge IGCSE™ (9–1)

CANDIDATE  
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## CHEMISTRY

0971/42

Paper 4 Theory (Extended)

May/June 2021

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
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Answer the following questions about these elements.

Each element may be used once, more than once or not at all.

Write the symbol of an element which:

(a) is malleable

..... [1]

(b) has only two electrons in its outermost shell

..... [1]

(c) forms an oxide which leads to acid rain

..... [1]

(d) forms an ion with a 2– charge

..... [1]

(e) is extracted from an ore called bauxite

..... [1]

(f) does **not** form an oxide

..... [1]

(g) forms an oxide with a macromolecular structure

..... [1]

(h) forms an amphoteric oxide

..... [1]

(i) exists as diatomic molecules

..... [1]

(j) forms a binary compound with hydrogen that is a strong acid.

..... [1]

[Total: 10]

2 Silver has an atomic number of 47.

(a) Naturally occurring atoms of silver are  $^{107}_{47}\text{Ag}$  and  $^{109}_{47}\text{Ag}$ .

(i) State the name given to atoms of the same element with different nucleon numbers.

..... [1]

(ii) Complete the table to show the number of protons, neutrons and electrons in each atom and ion of silver shown.

	$^{107}_{47}\text{Ag}$	$^{109}_{47}\text{Ag}^+$
protons		
neutrons		
electrons		

[3]

(iii) Complete this definition of relative atomic mass.

Relative atomic mass is the ..... mass of naturally occurring atoms of an element on a scale where the ..... atom has a mass of exactly ..... units.

[3]

(iv) A sample of silver has a relative atomic mass of 108.0.

Deduce the percentage of  $^{107}\text{Ag}$  present in this sample of silver.

..... [1]

(b) Silver nitrate is a salt of silver made by reacting silver oxide with an acid.

Write the formula of the acid which reacts with silver oxide to form silver nitrate.

..... [1]

(c) Aqueous silver nitrate is a colourless solution containing  $\text{Ag}^+(\text{aq})$  ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium iodide,  $\text{NaI}(\text{aq})$ .

..... [1]

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium iodide.  
Include state symbols.

..... [3]

(d) In the positive test for aqueous nitrate ions, aqueous sodium hydroxide and one other substance are warmed with the nitrate ions.

Name this other substance and the gas formed.

name of substance .....

name of gas ..... [2]

(e) When silver nitrate is exposed to sunlight, silver is formed.

Name the type of reaction which needs light to make it happen.

..... [1]

(f) Members of one homologous series only react with chlorine in the presence of sunlight.

(i) Name a member of this homologous series.

..... [1]

(ii) Name **two** products that form when the compound in (i) reacts with chlorine.

1 .....

2 ..... [2]

[Total: 19]

3 Sodium hydrogencarbonate is found in baking powder.

When sodium hydrogencarbonate is heated it forms three products.



(a) Name the type of reaction that takes place when sodium hydrogencarbonate reacts in this way.

..... [1]

(b) Calculate the volume of carbon dioxide formed at room temperature and pressure when 12.6 g of  $\text{NaHCO}_3$  is heated using the following steps:

- determine the mass of one mole of  $\text{NaHCO}_3$

..... g

- calculate the number of moles of  $\text{NaHCO}_3$  used

..... moles

- determine the number of moles of carbon dioxide formed

..... moles

- calculate the volume of carbon dioxide formed at room temperature and pressure.

.....  $\text{dm}^3$   
[4]

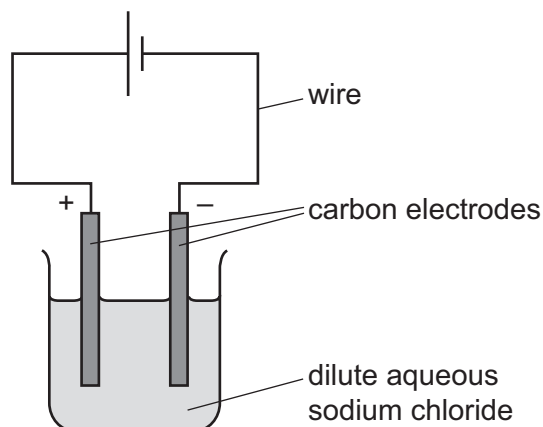
(c) Limewater is aqueous calcium hydroxide. Carbon dioxide turns limewater milky because a white precipitate forms.

Write the formula of:

- calcium hydroxide .....
  - the white precipitate that forms when limewater turns milky. ....
- [2]

[Total: 7]

- 4 A student carries out an electrolysis experiment using the apparatus shown.



The student uses dilute aqueous sodium chloride.

- (a) State the name given to any solution which undergoes electrolysis.

..... [1]

- (b) Hydroxide ions are discharged at the anode.

- (i) Complete the ionic half-equation for this reaction.



- (ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

..... [1]

- (c) Describe what the student observes at the cathode.

..... [1]

- (d) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(e) The student repeats the experiment using concentrated aqueous sodium chloride.

(i) Describe what the student observes at:

- the cathode .....
  - the anode. ....
- [2]

(ii) The student added litmus to the solution after the electrolysis of concentrated aqueous sodium chloride.

State the colour seen in the solution. Give a reason for your answer.

colour of solution .....

reason .....

[2]

(f) Carbon electrodes are used because they are inert.

State another element that can be used instead of carbon.

..... [1]

[Total: 12]

5 This question is about compounds of nitrogen.

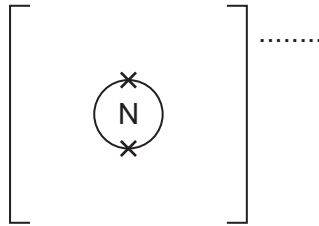
(a) Nitrogen reacts with lithium to form lithium nitride,  $\text{Li}_3\text{N}$ .

(i) Write the chemical equation for the reaction between lithium and nitrogen.

..... [2]

(ii) Lithium nitride is ionically bonded.

Complete the diagram to show the electronic structure of the nitride ion.  
Show the charge on the nitride ion.

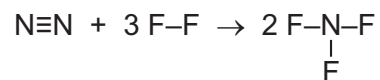


[2]



(b) Nitrogen reacts with fluorine to form nitrogen trifluoride,  $\text{NF}_3$ .

(i) The chemical equation can be represented as shown.



Some bond energies are shown in the table.

bond	bond energy in kJ/mol
$\text{N}\equiv\text{N}$	945
$\text{F}-\text{F}$	160
$\text{N}-\text{F}$	300

Calculate the energy change for the reaction between nitrogen and fluorine, using the following steps:

- energy taken in to break bonds

..... kJ

- energy released when bonds are formed

..... kJ

- energy change during the reaction.

..... kJ/mol  
[3]

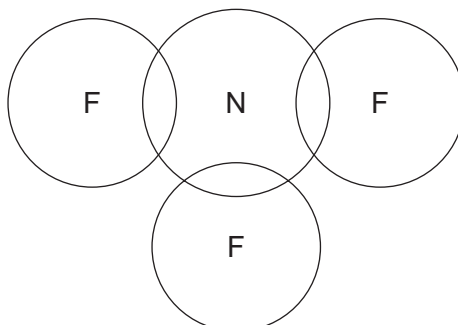
(ii) Use your answer to (i) to deduce whether this reaction is endothermic or exothermic. Explain your answer.

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

- (iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of  $\text{NF}_3$ .

Use dots for nitrogen electrons and crosses for fluorine electrons.

Show outer electrons only.



[3]

- (c) Lithium nitride melts at  $813^\circ\text{C}$ . Nitrogen trifluoride melts at  $-206^\circ\text{C}$ .

Explain in terms of attractive forces why lithium nitride has a much higher melting point than nitrogen trifluoride.

In your answer refer to the types of attractive forces between particles and their relative strengths.

.....

.....

.....

..... [3]

- (d) Ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , is a compound of nitrogen.

- (i) Calculate the percentage by mass of nitrogen in ammonium nitrate.

percentage by mass of nitrogen = ..... [2]

- (ii) State a use of ammonium nitrate in agriculture.

..... [1]

- (iii) State the name of a compound that will displace ammonia from ammonium nitrate.

..... [1]

(e) Ammonia is a base which forms a weakly alkaline solution when dissolved in water.

(i) Define the term *base*.

..... [1]

(ii) Suggest the pH of aqueous ammonia.

..... [1]

[Total: 20]

6 Molecules **A** and **B** can form condensation polymers.



(a) Each molecule has two identical functional groups.

(i) Name the functional group in **B**.

..... [1]

(ii) Draw the part of the structure of the synthetic polymer that would form when two molecules of **A** and two molecules of **B** combine. Show all of the bonds in the linkages.

[3]

(iii) Name the other product formed when molecules of **A** and **B** undergo polymerisation.

..... [1]

(b) Molecule **A** is a simple sugar unit which can be made by hydrolysis of complex carbohydrates.

(i) Draw part of the complex carbohydrate that could be hydrolysed to make molecules of **A**.

Include **one** linkage and show all of the bonds in the linkage.

[1]

(ii) State **two** sets of conditions which could be used to hydrolyse the complex carbohydrate to form **A**.

1 .....

2 .....

[2]

(iii) Name the technique used to identify the individual sugar units made by the hydrolysis of a complex carbohydrate.

..... [1]

13

(c) Ethanol can be made from the simple sugar glucose,  $C_6H_{12}O_6$ .

(i) State the name of this process.

..... [1]

(ii) Complete the chemical equation for this reaction.



[Total: 12]



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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		
<b>Key</b>									
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	Ar argon 40	
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 —	Fr francium —	Ra radium —	Ac actinium —	Th thorium 232
91	92	93	94	95	96	97	98	99	100
Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
109	110	111	112	113	114	115	116	117	118
Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessium —	Og oganesson —	Uue unbinilium —	Uub unbinilium —	Uuo unbinilium —

lanthanoids

actinoids

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).