



Cambridge IGCSE™

CANDIDATE
NAME

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

* 0 3 0 6 7 0 1 0 7 1 *



CHEMISTRY

0620/41

Paper 4 Theory (Extended)

October/November 2023

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 A list of gases is shown.

ammonia
carbon dioxide
carbon monoxide
ethene
fluorine
oxygen
sulfur dioxide
xenon

Answer the following questions using only the gases from the list.
Each gas may be used once, more than once or not at all.

Give the name of the gas that:

(a) causes acid rain

..... [1]

(b) forms an alkaline solution when dissolved in water

..... [1]

(c) is inert

..... [1]

(d) is a product of photosynthesis

..... [1]

(e) can form a polymer

..... [1]

(f) is produced in the test for nitrate ions.

..... [1]

[Total: 6]

2 Boron and aluminium are Group III elements.

(a) Boron has only two naturally occurring isotopes, ^{10}B and ^{11}B .

Complete Table 2.1 to show the numbers of protons, neutrons and electrons in an atom of ^{11}B .

Table 2.1

number of protons	number of neutrons	number of electrons

[2]

(b) The relative atomic mass of boron to one decimal place is 10.8.

(i) Determine the relative abundance of ^{10}B present in boron. Give your answer as a percentage.

..... % [1]

(ii) Use the relative atomic mass of boron to calculate the number of atoms in 0.540 g of boron. Give your answer in standard form.

number of atoms = [2]

(c) Aluminium is extracted from its purified ore as shown in Fig. 2.1.

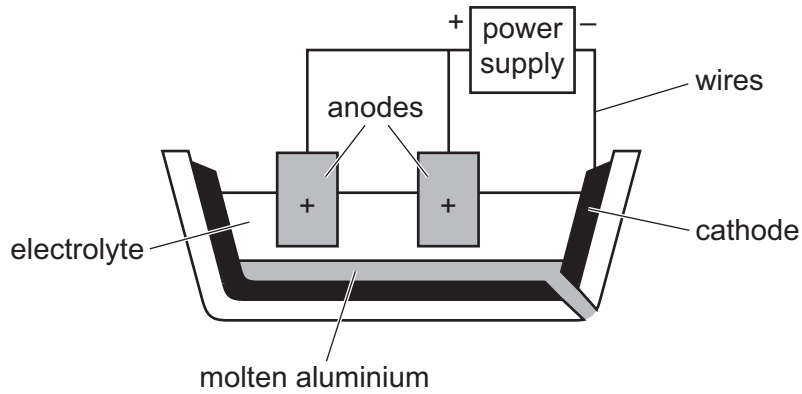


Fig. 2.1

(i) Name the ore of aluminium.

..... [1]

(ii) The electrolyte contains aluminium oxide and one other substance.

Name the other substance and explain why it is used.

name

explanation

..... [2]

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

..... [2]

(iv) Explain why the anodes need frequent replacement.

.....

..... [2]

(d) State **two** physical properties of aluminium that make it suitable for use in overhead electrical cables.

1

2

[2]

(e) Explain the apparent unreactivity of aluminium.

.....
 [2]

(f) Aluminium reacts with fluorine to form aluminium fluoride, AlF_3 , an ionic compound.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) Complete Fig. 2.2 to show the electronic configuration of one aluminium ion and one fluoride ion.

Show the charges on the ions.

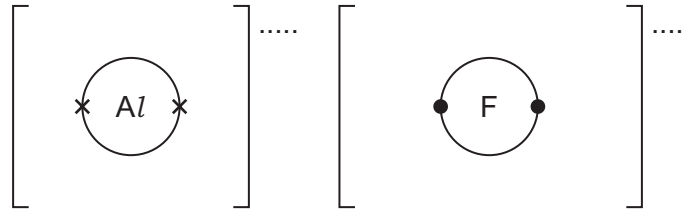


Fig. 2.2

[3]

[Total: 21]

3 Order of reactivity can be determined by displacement reactions.

(a) A student investigates the reactivities of four metals by carrying out a series of experiments.

Each of the metals lead, manganese, silver and zinc are added separately to aqueous metal nitrates of the other metals.

(i) Table 3.1 shows some of the results.

Table 3.1

aqueous solution	lead Pb	manganese Mn	silver Ag	zinc Zn
lead(II) nitrate		✓		
manganese(II) nitrate				
silver nitrate	✓	✓		✓
zinc nitrate	x	x		

key

✓ = displacement reaction occurs

x = displacement reaction does not occur

Complete Table 3.1 and place the four metals in their order of reactivity with the most reactive first.

1 most reactive

2

3

4

[3]

(ii) Suggest why the metal nitrates and not the metal sulfates of these four metals are used as the aqueous solutions.

..... [1]

(iii) Write the symbol equation for the reaction between zinc and silver nitrate.

..... [2]

(b) The reactivity of Group VII elements can be investigated experimentally.

A student bubbles chlorine gas into a test-tube containing aqueous potassium bromide.

(i) Describe the colour change seen in the test-tube.

from to [2]

(ii) Complete the ionic equation for this reaction.

Include state symbols.

..... +Br⁻(aq) → + [3]

(iii) The reactivity trend seen in Cl, Br and I applies to all the elements in Group VII.

Use the Periodic Table to identify the Group VII element which **cannot** displace any other Group VII elements.

..... [1]

[Total: 12]

- 4 Aqueous hydrogen peroxide, H_2O_2 , slowly forms water and oxygen at room temperature and pressure, r.t.p. This reaction is catalysed by manganese(IV) oxide.

The equation is shown.



- (a) State the test for oxygen gas.

test

observations

[1]

- (b) A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p. The results are plotted onto the graph in Fig. 4.1.

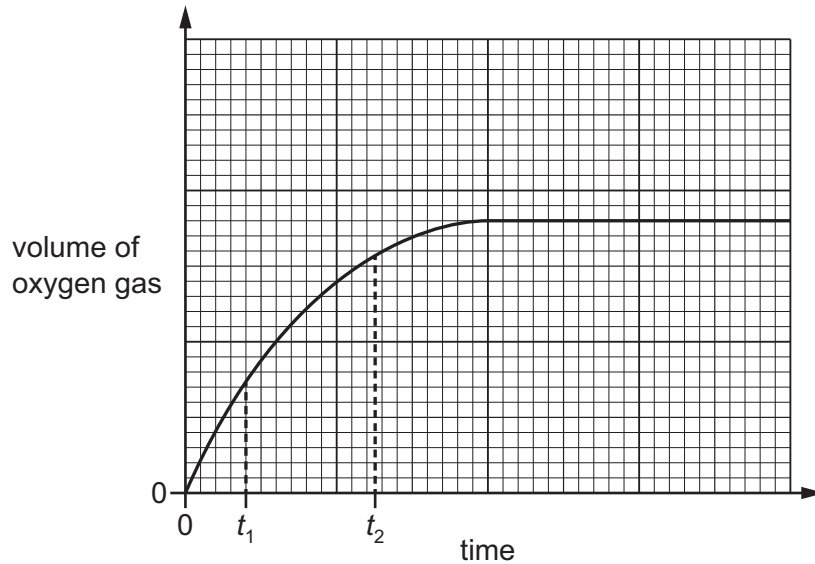


Fig. 4.1

- (i) State how the graph in Fig. 4.1 shows the rate of reaction at time t_2 , is lower than at time t_1 .

..... [1]

- (ii) Explain, using collision theory, why the rate of reaction at time t_2 is lower than at time t_1 .

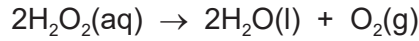
.....

.....

..... [2]

- (iii) On Fig. 4.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [2]

- (c) Manganese(IV) oxide is added to 20 cm³ of aqueous hydrogen peroxide. The total volume of oxygen gas produced is 72 cm³ at r.t.p.



Calculate the concentration of the aqueous hydrogen peroxide in g/dm³ using the following steps.

- Calculate the number of moles of oxygen gas produced.

..... mol

- Determine the number of moles of hydrogen peroxide which reacts.

..... mol

- Calculate the concentration of aqueous hydrogen peroxide in mol/dm³.

..... mol/dm³

- Calculate the concentration of aqueous hydrogen peroxide in g/dm³.

..... g/dm³
[5]

- (d) Suggest the identity of one **other** metal oxide which also catalyses this reaction.

..... [1]

[Total: 12]

- 5 Methane reacts with steam to produce hydrogen gas.



The reaction takes place at 1000 °C and 100 kPa pressure.

- (a) The reaction is reversible and reaches an equilibrium in a closed system.

State **two** features of an equilibrium.

1

2

[2]

- (b) State and explain, in terms of equilibrium, what happens to the concentration of hydrogen when:

- (i) the pressure is increased

.....

..... [2]

- (ii) the temperature is increased

.....

..... [2]

- (iii) a catalyst is used.

.....

..... [2]

- (c) Methane is a greenhouse gas which contributes to global warming.

- (i) Name a greenhouse gas found in clean, dry air.

..... [1]

- (ii) Explain, in terms of thermal energy, how greenhouse gases cause global warming.

.....

.....

.....

.....

..... [3]

[Total: 12]

6 Ethanol is manufactured by **two** methods:

method 1 fermentation of aqueous glucose

method 2 catalytic addition of steam to an alkene.

(a) Method 1 takes place at room temperature and pressure.

State **two** other conditions needed in method 1.

1

2 [2]

(b) (i) State the typical temperature and pressure used in method 2.

temperature °C

pressure kPa

[2]

(ii) Name the alkene used in method 2.

..... [1]

(iii) State why the reaction in method 2 is referred to as an addition reaction.

..... [1]

(c) The catalyst in method 2 is phosphoric acid, H_3PO_4 . Dilute phosphoric acid is a weak acid which contains phosphate ions, PO_4^{3-} .

(i) State what is meant by the term acid.

..... [1]

(ii) State the meaning of weak in the term weak acid.

..... [1]

(iii) Determine the oxidation number of phosphorus in the PO_4^{3-} ion.

Show your working.

oxidation number = [2]

(d) Give **one** advantage of each method of production of ethanol.

method 1

method 2

[2]

(e) Ethanol can be converted to ethanoic acid by reacting it with an acidified oxidising agent.

(i) Name the acidified oxidising agent.

..... [1]

(ii) State, in terms of redox, what type of reagent ethanol is in this reaction.

..... [1]

(f) Ethanoic acid reacts with calcium to form a salt and one other product.

(i) Name the salt.

..... [1]

(ii) Write the formula of the salt.

..... [1]

(iii) Identify the other product.

..... [1]

[Total: 17]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

The Periodic Table of Elements

		Group																																	
I	II	III	IV	V	VI	VII	VIII																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																		
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36								
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	Cs caesium 133	Ba barium 137	La lanthanum 139	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium 210	At astatine 210	Rn radon 222
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	Fr francium 87	Ra radium 88	Ac actinium 89	Rf rutherfordium 104	Db dubnium 105	Sg seaborgium 106	Bh bohrium 107	Hs hassium 108	Mt meitnerium 109	Ds darmstadtium 110	Rg roentgenium 111	Cn copernicium 112	Nh nihonium 113	Fl flerovium 114	Mc moscovium 115	Lv livermorium 116	Ts tennessine 117	Og oganeson 118

1
H
hydrogen
1

Key
atomic number
atomic symbol
name
relative atomic mass

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

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