Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME

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3287040796

CHEMISTRY **0971/42**

Paper 4 Theory (Extended) **May/June 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 **12** pages.

[Turn over

1 A list of oxides, **A** to **H**, is shown.

A calcium oxide

B aluminium oxide

C silicon(IV) oxide

D sulfur dioxide

E carbon dioxide

F iron(III) oxide

G silver oxide

H carbon monoxide

Answer the following questions about the oxides, **A** to **H**.
Each letter may be used once, more than once or not at all.

State which of the oxides, **A** to **H**:

(a) is responsible for acid rain

..... [1]

(b) has a giant covalent structure

..... [1]

(c) is a reducing agent in the blast furnace

..... [1]

(d) is the main constituent of bauxite

..... [1]

(e) is the main impurity in iron ore

..... [1]

(f) can be reduced by heating with copper.

..... [1]

[Total: 6]

2 Fluorine, chlorine and bromine are in Group VII of the Periodic Table.

(a) State the name given to Group VII elements.

..... [1]

(b) Explain why Group VII elements have similar chemical properties.

..... [1]

(c) Complete Table 2.1 to show the colour and state at r.t.p. of some Group VII elements.

Table 2.1

element	colour	state at r.t.p.
fluorine	pale yellow	
chlorine		
bromine		liquid

[3]

(d) Bromine has two naturally occurring isotopes, ^{79}Br and ^{81}Br.

(i) State the term given to the numbers 79 and 81 in these isotopes of bromine.

..... [1]

(ii) Complete Table 2.2 to show the number of protons, neutrons and electrons in the atom and ion of bromine shown.

Table 2.2

	^{79}Br	$^{81}Br^-$
protons		
neutrons		
electrons		

[3]

(iii) Table 2.3 shows the relative abundances of the two naturally occurring isotopes of bromine.

Table 2.3

isotope	^{79}Br	^{81}Br
relative abundance	55%	45%

Calculate the relative atomic mass of bromine to **one** decimal place.

relative atomic mass = ... [2]

(e) Chlorine displaces bromine from aqueous potassium bromide but does **not** displace fluorine from aqueous sodium fluoride.

(i) Write the symbol equation for the reaction between chlorine and aqueous potassium bromide.

..... [2]

(ii) State why chlorine does **not** displace fluorine from aqueous sodium fluoride.

..... [1]

(f) Aqueous silver nitrate is a colourless solution containing $Ag^+(aq)$ ions.

(i) Describe what is seen when aqueous silver nitrate is added to aqueous sodium chloride.

..... [1]

(ii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous sodium chloride.

Include state symbols.

..... [3]

[Total: 18]

3 Over 200 million tonnes of sulfuric acid are manufactured every year.

(a) State the name of the process used to manufacture sulfuric acid.

..... [1]

(b) Part of the manufacture of sulfuric acid involves converting sulfur dioxide to sulfur trioxide.

(i) Describe **two** methods by which sulfur dioxide is obtained.

1 .....

2 .....
[2]

The conversion of sulfur dioxide to sulfur trioxide is a reversible reaction which can reach equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(ii) State **two** features of an equilibrium.

1 .....

2 .....
[2]

(iii) State the typical conditions and name the catalyst used in the conversion of sulfur dioxide to sulfur trioxide.

temperature ..... °C

pressure ..... kPa

catalyst .....
[3]

(iv) Complete Table 3.1 to show the effect, if any, when the following changes are applied to the conversion of sulfur dioxide to sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.

Only use the words **increases**, **decreases** or **no change**.

Table 3.1

change	effect on the rate of the forward reaction	effect on the concentration of $SO_3(g)$ at equilibrium
temperature decreases	decreases	
pressure increases		
no catalyst	decreases	

[4]

(v) Explain in terms of collision theory why reducing the temperature decreases the rate of the forward reaction.

.....

.....

.....

.....

..... [3]

(c) Sulfuric acid contains SO_4^{2-} ions.

The oxidation number of O atoms in SO_4^{2-} ions is –2.

Determine the oxidation number of S atoms in SO_4^{2-} ions. Show your working.

oxidation number = ... [2]

[Total: 17]

4 Solid sodium hydroxide is a base which dissolves to form an aqueous solution, NaOH(aq).

(a) State what is meant by the term base.

..... [1]

(b) State the term given to a base which dissolves to form an aqueous solution.

..... [1]

(c) State the colour of thymolphthalein in NaOH(aq).

..... [1]

(d) Complete the word equation for the reaction of NaOH(aq) with ammonium chloride.

sodium hydroxide + ammonium chloride → ..... + ... + ...
.....

[3]

(e) Some metal oxides react with NaOH(aq).

(i) State the term given to metal oxides which react with bases such as NaOH(aq).

..... [1]

(ii) Name a metal oxide which reacts with NaOH(aq).

..... [1]

(f) Ethanoic acid, CH_3COOH, is a weak acid.

(i) Complete the dot-and-cross diagram in Fig. 4.1 of a molecule of ethanoic acid.

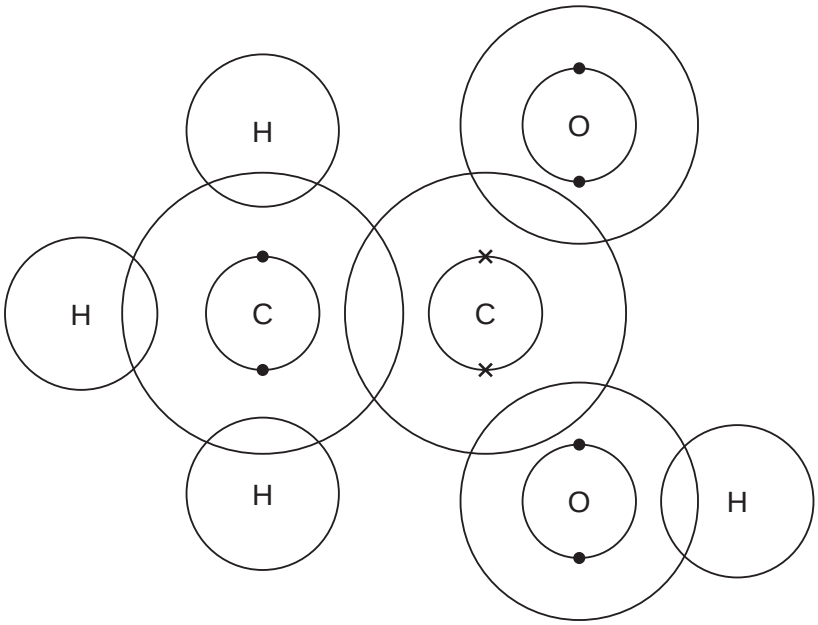

Fig. 4.1

[3]

(ii) Suggest the pH of dilute ethanoic acid.

..... [1]

(iii) Complete the symbol equation to show the dissociation of ethanoic acid.

CH_3COOH ..... [3]

(iv) Write the ionic equation for the reaction when an acid neutralises a soluble base.

..... [1]

(g) In a titration, 25.0 cm^3 of 0.0800 mol / dm^3 aqueous potassium hydroxide, KOH(aq), is neutralised by 20.0 cm^3 of dilute sulfuric acid, H_2SO_4(aq).

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration of H_2SO_4, in g / dm^3 using the following steps.

- Calculate the number of moles of KOH used.

..... mol

- Determine the number of moles of H_2SO_4 which react with the KOH.

..... mol

- Calculate the concentration of H_2SO_4 in mol / dm^3.

..... mol / dm^3

- Calculate the concentration of H_2SO_4 in g / dm^3.

..... g / dm^3
[5]

[Total: 21]

5 Propane and propene both react with chlorine.

(a) When a molecule of propane, C_3H_8, reacts with chlorine in the presence of ultraviolet light, one atom of hydrogen is replaced by one atom of chlorine.

(i) State the term given to reactions in which one atom in an alkane is replaced by another atom.

..... [1]

(ii) State the purpose of ultraviolet light in this reaction.

..... [1]

(iii) State the term given to any reaction which requires ultraviolet light.

..... [1]

(iv) Write the symbol equation for the reaction between propane and chlorine.

..... [2]

(b) A molecule of propene, C_3H_6, is unsaturated and will react with chlorine at room temperature.

(i) State why propene is an unsaturated molecule.

..... [1]

(ii) Give the structural formula of the product of this reaction.

..... [1]

(c) Propene undergoes addition reactions with steam.
There are two possible products, **A** and **B**.

Draw the displayed formula and name each product.

displayed formula of product **A**

name of product **A** .....

displayed formula of product **B**

name of product **B** .....
[4]

[Total: 11]

6 Carboxylic acids can be converted to esters.

(a) Name the ester formed when butanoic acid, $CH_3CH_2CH_2COOH$, reacts with ethanol, CH_3CH_2OH.

..... [1]

(b) Identify the other product formed in this reaction.

..... [1]

(c) Deduce the empirical formula of the ester formed.

..... [1]

(d) PET is a polyester. Part of the structure of PET is shown in Fig. 6.1.

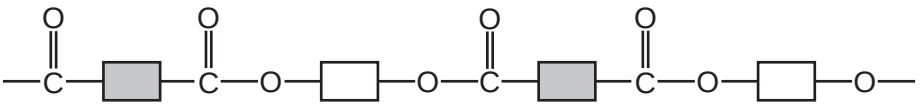

Fig. 6.1

(i) Circle **one** repeat unit of this polymer. [1]

(ii) Draw the structures of the monomers which make up PET. Draw the functional groups using displayed formulae.

[2]

(iii) State the type of polymerisation used in making PET.

..... [1]

[Total: 7]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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 dm^3 at room temperature and pressure (r.t.p.).