Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7935709268

CHEMISTRY **0971/41**

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 **16** pages. Any blank pages are indicated.

[Turn over

1 Some symbol equations and word equations, **A** to **J**, are shown.

A $Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3$

B $H^+ + OH^- \rightarrow H_2O$

C ethane + chlorine → chloroethane + hydrogen chloride

D $C_{12}H_{26} \rightarrow C_8H_{18} + C_4H_8$

E ethene + steam → ethanol

F chlorine + aqueous potassium iodide → iodine + aqueous potassium chloride

G $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

H ethanoic acid + ethanol → ethyl ethanoate + water

I calcium carbonate → calcium oxide + carbon dioxide

J $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Use the equations to answer the questions that follow.
Each equation may be used once, more than once, or not at all.

Give the letter, **A** to **J**, for the equation that represents:

(a) a neutralisation reaction ..... [1]

(b) a precipitation reaction ..... [1]

(c) the formation of an ester ..... [1]

(d) photosynthesis ..... [1]

(e) fermentation ..... [1]

(f) cracking. ..... [1]

[Total: 6]

2 **(a)** The symbols of the elements in Period 2 of the Periodic Table are shown.

Li Be B C N O F Ne

Use the symbols of the elements in Period 2 to answer the questions that follow.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(i) makes up approximately 78% of clean, dry air ..... [1]

(ii) contains atoms with only three electrons in the outer shell ..... [1]

(iii) contains atoms with only nine protons ..... [1]

(iv) exists as graphite ..... [1]

(v) is an alkali metal ..... [1]

(vi) **only** has an oxidation number of zero. ..... [1]

(b) Boron, B, has two isotopes.

(i) State the meaning of the term isotopes.

.....

..... [2]

(ii) Table 2.1 shows the relative masses and the percentage abundances of the two isotopes of boron.

Table 2.1

relative mass of isotope	percentage abundance of isotope
10	20
11	80

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

relative atomic mass = ... [2]

[Total: 10]

3 This question is about ionic and covalent compounds.

(a) (i) Sodium reacts with oxygen to form the ionic compound sodium oxide.
The electronic configurations of an atom of sodium and an atom of oxygen are shown in Fig. 3.1.

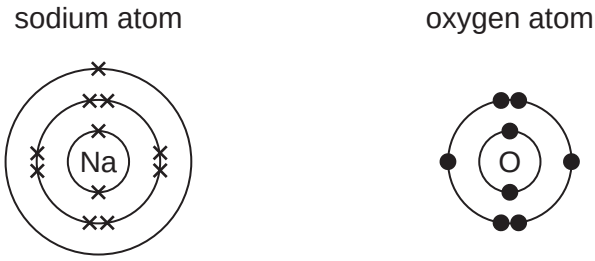

Fig. 3.1

Ions are formed by the transfer of electrons from sodium atoms to oxygen atoms.

Complete the dot-and-cross diagrams in Fig. 3.2 to show the electronic configuration of **one** sodium ion and **one** oxide ion. Show the charges on the ions.

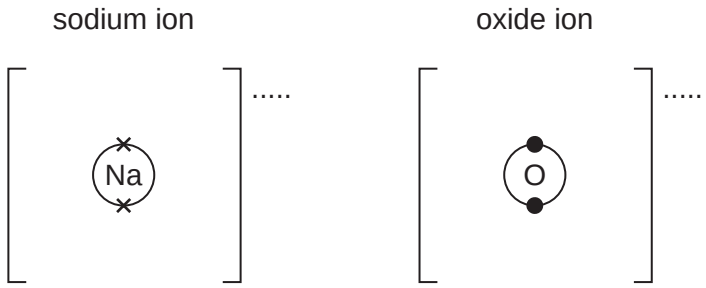

Fig. 3.2

[3]

(ii) Write the formula of sodium oxide.

..... [1]

(b) Carbon dioxide, CO_2, is a covalent compound.

Complete the dot-and-cross diagram in Fig. 3.3 to show the electronic configuration in a molecule of carbon dioxide. Show outer shell electrons only.

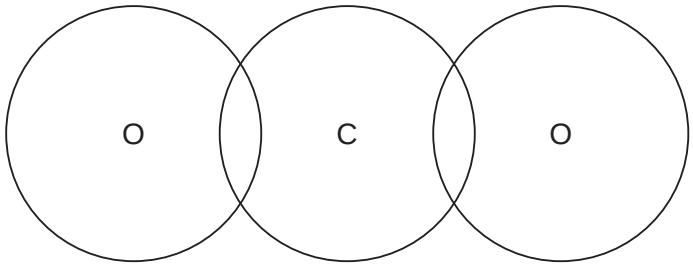

Fig. 3.3

[2]

(c) The melting points of sodium oxide and carbon dioxide are shown in Table 3.1.

Table 3.1

	melting point / °C
sodium oxide	1275
carbon dioxide	–78

(i) Explain, in terms of bonding, why sodium oxide has a high melting point.

.....

.....

.....

..... [2]

(ii) Carbon dioxide has a low melting point.

State the general term for the weak forces that cause carbon dioxide to have a low melting point.

..... [1]

[Total: 9]

4 Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide, MnO_2, is a catalyst for this reaction.

(a) State the meaning of the term catalyst.

.....

..... [2]

(b) A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Fig. 4.1. The mass of the conical flask and its contents is measured at regular time intervals. The mass decreases as time increases.

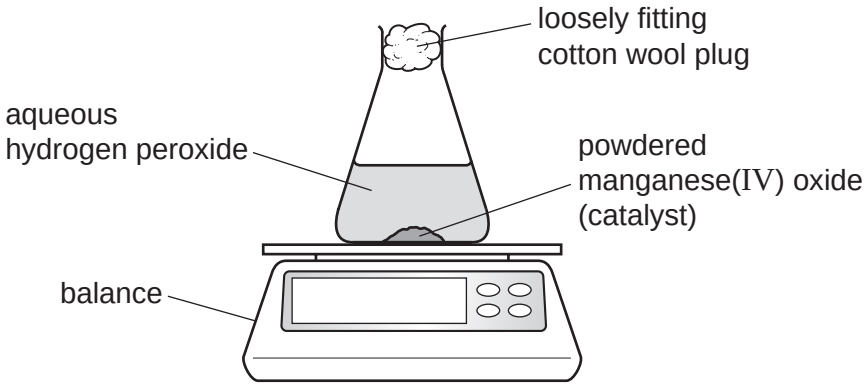

Fig. 4.1

(i) State why the mass of the conical flask and its contents decreases as time increases.

..... [1]

(ii) The rate of reaction is highest at the start of the reaction. The rate decreases and eventually becomes zero.

Explain why the rate of reaction is highest at the start of the reaction.

.....

..... [1]

(iii) Explain why the rate of reaction eventually becomes zero.

.....

..... [1]

(c) The experiment is repeated at an increased temperature.
All other conditions stay the same.

Explain in terms of collision theory why the rate of reaction is higher at an increased temperature.

.....

.....

.....

..... [3]

(d) The equation for the decomposition of aqueous hydrogen peroxide, $H_2O_2(aq)$, is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

50.0 cm^3 of a 0.200 mol/dm^3 solution of $H_2O_2(aq)$ is used.

Calculate the mass of O_2 that forms.
Use the following steps.

- Calculate the number of moles of H_2O_2 used.

..... mol

- Determine the number of moles of O_2 produced.

..... mol

- Calculate the mass of O_2 produced.

..... g
[3]

(e) State the effect on the mass of oxygen produced if the mass of powdered manganese(IV) oxide catalyst is increased.

..... [1]

(f) Oxygen can also be produced by the decomposition of mercury(II) oxide, HgO.
The only products of this decomposition are mercury and oxygen.

Write a symbol equation for this decomposition.

..... [2]

[Total: 14]

5 This question is about electricity and chemical reactions.

(a) The electrolysis of concentrated aqueous potassium bromide using graphite electrodes forms:
- hydrogen at the cathode
- bromine at the anode.

The electrolyte becomes aqueous potassium hydroxide.

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

.....

..... [2]

(ii) State why graphite is suitable for use as an electrode.

..... [1]

(iii) Write an ionic half-equation for the formation of hydrogen at the cathode.

..... [2]

(iv) Name the type of particle responsible for the transfer of charge in the conducting wires.

..... [1]

(v) Name the type of particle responsible for the transfer of charge in aqueous potassium bromide.

..... [1]

(vi) State the names of the products formed when electricity is passed through **dilute** aqueous potassium bromide using graphite electrodes.

at the anode .....

at the cathode.....
[2]

(b) Bauxite is an ore containing aluminium.
Aluminium is extracted by electrolysis of purified bauxite in molten cryolite using carbon electrodes.

(i) Name the aluminium compound in purified bauxite.

..... [1]

(ii) State **two** reasons why cryolite is used in this electrolysis.

1 .....

2 .....
[2]

(iii) The anode is made from carbon.

Explain why the carbon anode has to be replaced regularly.

.....

..... [1]

(c) Hydrogen–oxygen fuel cells can be used to produce electricity in vehicles.

(i) Write the symbol equation for the overall reaction in a hydrogen–oxygen fuel cell.

..... [2]

(ii) State **one** advantage of using hydrogen–oxygen fuel cells instead of petrol in vehicle engines.

..... [1]

[Total: 16]

6 This question is about sulfur and compounds of sulfur.

Sulfur is converted into sulfuric acid, H_2SO_4, by the Contact process.

The process involves four stages.

stage 1 Molten sulfur is converted into sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide combines with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum reacts to form concentrated sulfuric acid.

(a) (i) In **stage 1**, iron pyrites, FeS_2, can be used instead of molten sulfur.
The iron pyrites is heated strongly in air.

Balance the equation for the reaction occurring when iron pyrites reacts with oxygen in the air.

$$.....FeS_2 + ...O_2 \rightarrow .....Fe_2O_3 + ...SO_2$$ [1]

(ii) Name Fe_2O_3. Include the oxidation number of iron.

..... [1]

(b) The equation for **stage 2** is shown.

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

The forward reaction is exothermic.
The reaction is carried out at a temperature of 450 °C and a pressure of 2 atm.

Using explanations that do **not** involve cost:

(i) explain why a temperature greater than 450 °C is **not** used

.....

..... [1]

(ii) explain why a pressure lower than 2 atm is **not** used.

.....

..... [1]

(c) When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the symbol equation for this reaction.

..... [2]

(d) Lead(II) sulfate is an insoluble salt.

Lead(II) sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

(i) Name a solution that can be added to aqueous ammonium sulfate to produce a precipitate of lead(II) sulfate.

..... [1]

(ii) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(iii) The precipitate of lead(II) sulfate forms in an aqueous solution.

Describe how pure lead(II) sulfate can be obtained from the mixture.

.....

.....

..... [3]

[Total: 13]

7 This question is about organic compounds.

(a) Butane reacts with chlorine in a photochemical reaction.

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

(i) State the meaning of the term photochemical.

..... [1]

(ii) An organic compound with the formula C_4H_9Cl is formed when one molecule of butane reacts with one molecule of chlorine.

Draw the displayed formulae of **two** possible structural isomers with the formula C_4H_9Cl formed in this reaction.

[2]

(b) The structure of compound **A** is shown in Fig. 7.1.

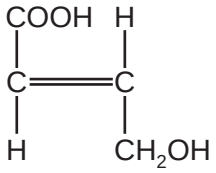

Fig. 7.1

(i) Deduce the molecular formula of compound **A**.

..... [1]

(ii) There are three functional groups in compound **A**.

Name the homologous series of compounds that contain the following functional groups:

–C=C– .....

–OH .....

–COOH. .....

[3]

(iii) State what is observed when compound **A** is added to:

aqueous bromine .....

aqueous sodium carbonate. .....

[2]

(iv) Compound **A** can be used as a single monomer to produce two different polymers.

Draw **one** repeat unit of the addition polymer formed from compound **A**.

[2]

(v) Compound **A** can be converted into a dicarboxylic acid.

Name the type of condensation polymer formed from a dicarboxylic acid and a diol.

..... [1]

[Total: 12]

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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.).