Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0352185624

CHEMISTRY **0971/31**

Paper 3 Theory (Core) **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.

[Turn over

1 Fig. 1.1 shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII
							H										He
													C	N	O		
Na	Mg											A*l*				C*l*	
K	Ca						Fe			Cu						Br	
																I	

Fig. 1.1

Answer the following questions using only the elements in Fig. 1.1.
Each symbol of the element may be used once, more than once or not at all.

Give the symbol of the element that:

(a) forms 78% by volume of clean, dry air

..... [1]

(b) has an atom with a complete outer electron shell

..... [1]

(c) has an atom with five occupied electron shells

..... [1]

(d) forms an ion with a charge of 2–

..... [1]

(e) forms an ion that gives a green precipitate on addition of aqueous sodium hydroxide

..... [1]

(f) is used in food containers because of its resistance to corrosion.

..... [1]

[Total: 6]

2 **(a)** Table 2.1 shows some properties of the halogens.

Table 2.1

halogen	melting point in °C	boiling point in °C	density at room temperature and pressure in g / cm^3
fluorine	–220	–188	0.0016
chlorine	–101	–35	0.0032
bromine		+59	3.1
iodine	+114	+184	

Use the information in Table 2.1 to predict:

(i) the melting point of bromine

..... [1]

(ii) the density of iodine at room temperature and pressure

..... [1]

(iii) the physical state of chlorine at –10 °C. Give a reason for your answer.

physical state .....

reason .....

.....
[2]

(b) The equation for the reaction of aqueous chlorine with aqueous potassium iodide is shown.

$$Cl_2 + 2KI \rightarrow I_2 + 2KCl$$

(i) Choose the word which best describes this type of chemical reaction.
Draw a circle around your chosen answer.

addition **displacement** **neutralisation** **polymerisation** [1]

(ii) Explain why aqueous iodine does **not** react with aqueous potassium chloride.

..... [1]

[Turn over

(c) Complete the diagram in Fig. 2.1 to show the electronic configuration of a chlorine atom.

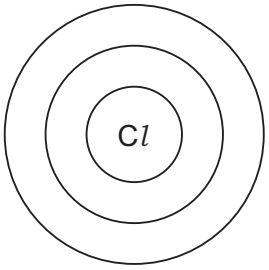

Fig. 2.1

[1]

(d) Describe a test for chlorine.

test .....

observations .....

[2]

[Total: 9]

3 **(a)** Water from natural sources contains dissolved gases.

Choose from the list, the gas that is essential for aquatic life.
Draw a circle around your chosen answer.

argon **hydrogen** **nitrogen** **oxygen** [1]

(b) Polluted water may contain harmful substances such as metal compounds, plastics, nitrates and phosphates.

(i) Name one **other** harmful substance which is present in polluted water.

..... [1]

(ii) State why nitrates are harmful to aquatic life.

..... [1]

(c) Table 3.1 shows the masses of ions, in mg, present in a 1000 cm^3 sample of polluted water.

Table 3.1

name of ion	formula of ion	mass of ion present in mg / 1000 cm^3 of polluted water
	NH_4^+	0.5
calcium	Ca^{2+}	2.2
chloride	Cl^-	2.5
hydrogencarbonate	HCO_3^-	12.0
magnesium	Mg^{2+}	0.8
nitrate	NO_3^-	0.4
potassium	K^+	8.3
silicate	SiO_3^{2-}	8.0
sodium	Na^+	10.2
sulfate	SO_4^{2-}	0.2
tin(II)	Sn^{2+}	0.4

Answer these questions using information from Table 3.1.

(i) Name the negative ion present in the highest concentration.

..... [1]

(ii) State the name of the NH_4^+ ion.

..... [1]

(iii) Calculate the mass of calcium ions present in 200 cm^3 of polluted water.

mass = ... mg [1]

(d) Copper(II) sulfate can be used to test for the presence of water.

$$CuSO_4(s) + 5H_2O(l) \rightleftharpoons CuSO_4 \cdot 5H_2O(s)$$

anhydrous copper(II) sulfate — hydrated copper(II) sulfate

(i) State the meaning of the term hydrated.

..... [1]

(ii) Describe how hydrated copper(II) sulfate is changed to anhydrous copper(II) sulfate.

..... [1]

(e) Complete the symbol equation for the reaction of sodium with water.

$$2Na + ...H_2O \rightarrow 2NaOH + ...$$ [2]

[Total: 10]

4 This question is about sulfur and compounds of sulfur.

(a) Sulfur has several isotopes.

Define the term isotopes.

.....

..... [2]

(b) Deduce the number of protons, neutrons and electrons in the sulfide ion shown.

$^{36}_{16}S^{2-}$

number of protons .....

number of neutrons .....

number of electrons .....

[3]

(c) Sulfur burns in oxygen to produce sulfur dioxide.

Fig. 4.1 shows an incomplete reaction pathway diagram for this reaction.

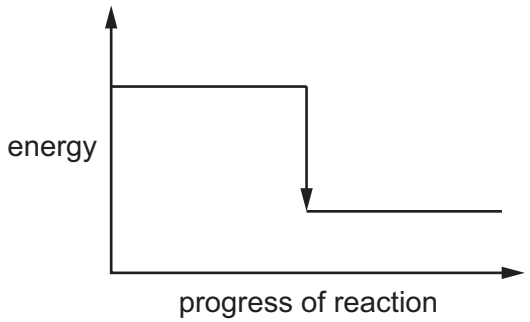

Fig. 4.1

(i) Complete Fig. 4.1 by writing these formulae on the diagram:
- $S + O_2$
- SO_2. [1]

(ii) Explain how Fig. 4.1 shows that the reaction is exothermic.

.....

..... [1]

(iii) Complete this sentence about an exothermic reaction using a word from the list.

products **reactants** **sulfur** **surroundings**

An exothermic reaction transfers thermal energy to the ..... . [1]

(d) Fig. 4.2 shows the apparatus used for the electrolysis of dilute sulfuric acid using graphite electrodes.

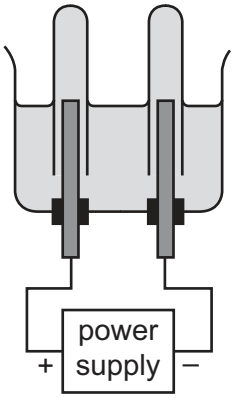

Fig. 4.2

(i) Label Fig. 4.2 to show:
- the cathode
- the electrolyte. [2]

(ii) Name the products and state the observations at the positive and negative electrodes.

product at the positive electrode

.....

observations at the positive electrode

.....

product at the negative electrode

.....

observations at the negative electrode

.....
[4]

(e) Complete the word equation for the reaction of dilute sulfuric acid with sodium carbonate.

sulfuric acid	+	sodium carbonate	→	....	+	....	+	.....

[3]

(f) A few drops of thymolphthalein indicator are added to dilute sulfuric acid.

State the colour of the solution.

..... [1]

[Total: 18]

5 This question is about metals.

(a) Iron is a transition element. Potassium is an element in Group I of the Periodic Table.

State **two** differences in the physical properties of iron compared to potassium.

1 .....

2 .....
[2]

(b) Carbon is used to extract iron from iron ore in a blast furnace.

State **two** uses of carbon in the extraction process.

1 .....

2 .....
[2]

(c) Steel is an alloy of iron.

(i) State the meaning of the term alloy.

.....

..... [1]

(ii) State why alloys are more useful than pure metals.

..... [1]

(d) Table 5.1 shows the observations made when four different metals react with dilute hydrochloric acid of the same concentration.

Table 5.1

metal	observations
iron	bubbles form slowly
lead	no bubbles formed
magnesium	bubbles form rapidly
nickel	bubbles form very slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

[Total: 8]

6 **(a)** A student investigates the reaction of small pieces of zinc of the same mass and size with three different concentrations of dilute hydrochloric acid in the presence of a catalyst.

The three concentrations of dilute hydrochloric acid are:
- 1.0 mol / dm^3
- 1.5 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Table 6.1 shows the time taken for each reaction to finish.

Table 6.1

concentration of hydrochloric acid in mol / dm^3	time taken for the reaction to finish in s
	200
	100
	150

(i) Complete Table 6.1 by writing the concentrations of hydrochloric acid in the first column. [1]

(ii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid with no catalyst present.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the zinc to finish reacting with 2.0 mol / dm^3 hydrochloric acid when the surface area of the zinc is increased.

All other conditions stay the same.

..... [1]

(b) Crystals of zinc chloride can be prepared by reacting excess zinc with dilute hydrochloric acid.

Choose from the list, the method used to separate the unreacted zinc from the reaction mixture.

Draw a circle around your chosen answer.

chromatography **crystallisation** **evaporation** **filtration** [1]

(c) Zinc chloride is soluble in water.

Choose one **other** compound that is soluble in water.

Tick (✓) **one** box.

calcium carbonate	☐
lead(II) chloride	☐
silver chloride	☐
sodium nitrate	☐

[1]

[Total: 5]

7 **(a)** Fig. 7.1 shows the displayed formula of mesaconic acid.

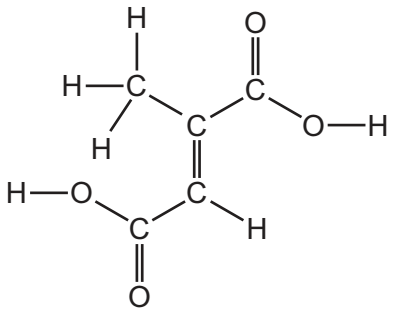

Fig. 7.1

(i) On Fig. 7.1 draw a circle around **one** carboxylic acid functional group. [1]

(ii) Deduce the molecular formula of mesaconic acid.

..... [1]

(iii) Mesaconic acid is a colourless compound.

Describe the colour change when excess mesaconic acid is added to aqueous bromine.

from ..... to ..... [2]

(b) Ethanoic acid belongs to the homologous series of carboxylic acids.

Define the term homologous series.

.....

..... [2]

(c) Complete the word equation for the reaction of ethanoic acid with magnesium.

ethanoic acid	+	magnesium	→	....	+	.....

[2]

(d) Ethanoic acid reacts with ethanol.
The organic product has the molecular formula $C_4H_8O_2$.

Complete Table 7.1 to calculate the relative molecular mass of $C_4H_8O_2$.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	4	12	$4 \times 12 = 48$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(e) Ethanol can be manufactured by fermentation.

Complete the word equation for one **other** method of manufacturing ethanol.

..... + ... → ethanol [2]

[Total: 12]

8 This question is about nitrogen and compounds of nitrogen.

(a) Nitrogen is a non-metal. Nitrogen is a poor electrical conductor.

Describe two **other** physical properties which are typical of non-metals.

1 .....

2 .....

[2]

(b) Oxides of nitrogen are air pollutants which contribute to acid rain.

(i) State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) State one **other** adverse effect of oxides of nitrogen.

..... [1]

(c) Ammonia is a simple molecule with covalent bonds.

(i) Describe a covalent bond.

.....

..... [2]

(ii) Complete Fig. 8.1 to show the dot-and-cross diagram for a molecule of ammonia.

Show outer shell electrons only.

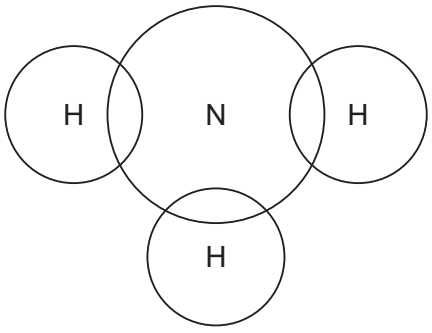

Fig. 8.1

[2]

(iii) Aqueous ammonia is alkaline.

Choose from the list, the pH value that is alkaline.

Draw a circle around your chosen answer.

pH 1 **pH 5** **pH 7** **pH 10** [1]

(iv) Aqueous ammonia releases ammonia gas.

Ammonia gas turns damp red litmus paper blue.

A long glass tube is set up as shown in Fig. 8.2.

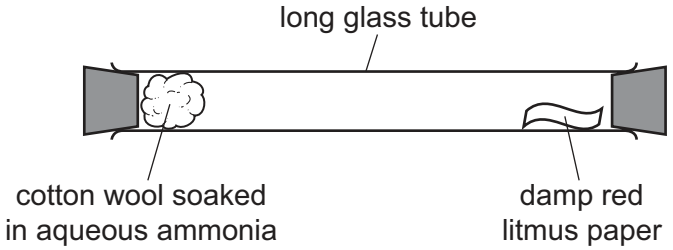

Fig. 8.2

At first, the litmus paper does **not** turn blue.
After a short time, the litmus paper turns blue.

Explain these results in terms of the kinetic particle theory.

.....

.....

.....

.....

..... [3]

[Total: 12]

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.).