Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

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CHEMISTRY **0971/04**

Paper 4 Theory (Extended) **For examination from 2023**

SPECIMEN PAPER **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.

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1 Element **X** can undergo the following physical changes.

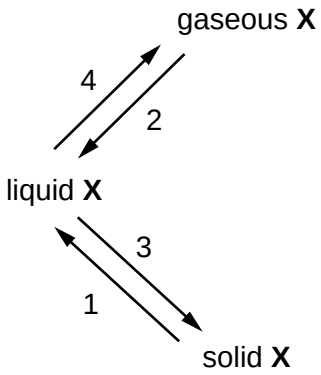

Fig. 1.1

(a) **(i)** Name each of the numbered physical changes shown in Fig. 1.1.

1 .....

2 .....

3 .....

4 .....

[4]

(ii) One difference between boiling and evaporation is the rate at which the processes occur.

State one **other** difference between boiling and evaporation.

.....

..... [1]

(b) Describe the separation, arrangement and motion of particles of element **X** in the solid state.

separation .....

arrangement .....

motion .....

[3]

(c) Element **X** is a Group III metal. It burns in air to form an oxide $\mathbf{X}_2O_3$.

Write a symbol equation for this reaction.

..... [2]

[Total: 10]

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2 Magnesium, calcium and strontium are Group II elements.

(a) Complete Table 2.1 to show the electronic configuration of a calcium atom.

Table 2.1

shell	1st	2nd	3rd	4th
number of electrons				

[1]

(b) Describe how the electronic configuration of a strontium atom is:

(i) similar to the electronic configuration of a calcium atom

.....

..... [1]

(ii) different from the electronic configuration of a calcium atom.

.....

..... [1]

(c) Calcium reacts with cold water to form two products:
- a colourless gas, **P**, which 'pops' with a lighted splint
- a weakly alkaline solution, **Q**, which turns milky when carbon dioxide is bubbled through it.

(i) Name gas **P**.

..... [1]

(ii) Identify the ion responsible for making solution **Q** alkaline.

..... [1]

(iii) Suggest the pH of solution **Q**.

..... [1]

(iv) Write a symbol equation for the reaction of calcium with cold water.

..... [2]

(d) Magnesium reacts with chlorine to form magnesium chloride, $MgCl_2$.

Magnesium chloride is an ionic compound.

(i) Complete the dot-and-cross diagram in Fig. 2.1 of the ions in magnesium chloride.

Show the charges on the ions.

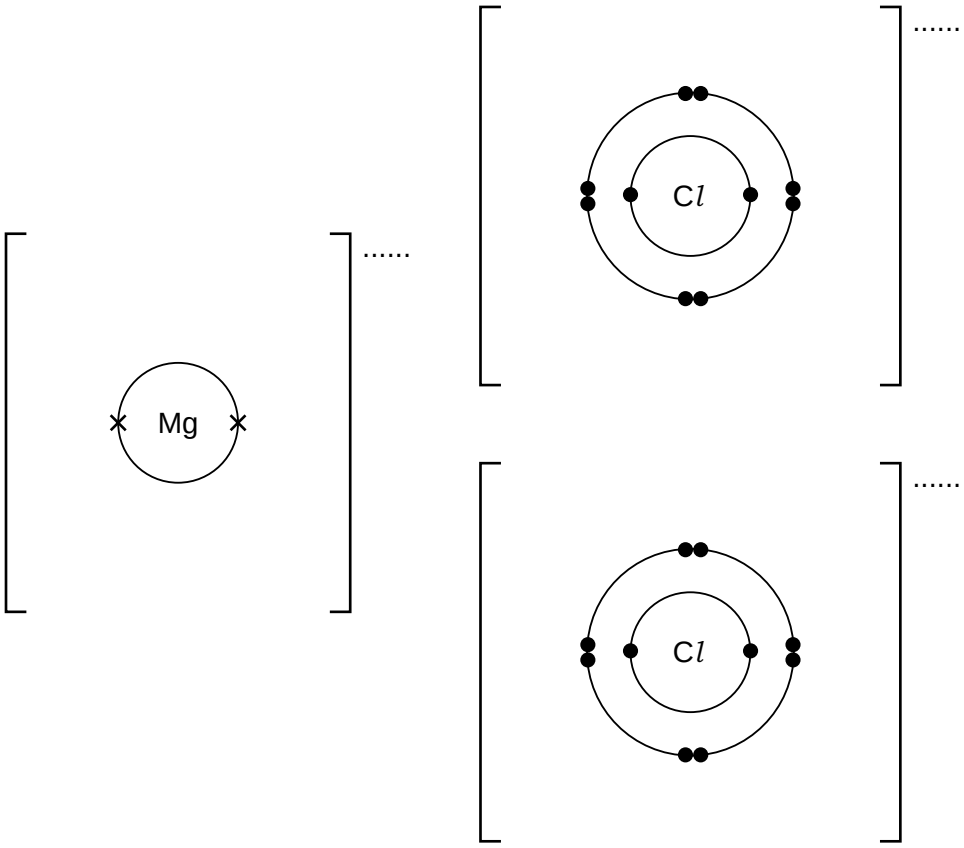

Fig. 2.1 [3]

(ii) One physical property typical of ionic compounds, such as $MgCl_2$, is that they are soluble in water.

Give two **other** physical properties that are typical of ionic compounds.

1 .....

2 .....

[2]

(e) Aqueous silver nitrate is added to aqueous magnesium chloride.

A white precipitate forms.

Write an ionic equation for this reaction. Include state symbols.

..... [2]

[Total: 15]

3 Copper is a transition element. It has variable oxidation states.

(a) State **two** other chemical properties of transition elements which make them different from Group I elements.

1 .....

2 .....
[2]

(b) When copper(II) oxide is heated at 800 °C it undergoes the reaction shown by the equation.

$$4CuO \rightarrow 2Cu_2O + O_2$$

(i) Identify the changes in oxidation numbers of copper and oxygen in this reaction.

Explain in terms of changes in oxidation numbers why this is a redox reaction.

change in oxidation number of copper: from …… to ……

change in oxidation number of oxygen: from …… to ……

explanation .....

.....
[3]

(ii) Calculate the volume of oxygen, measured at r.t.p., which is formed when 1.60 g of CuO reacts as shown in the equation.

$$4CuO \rightarrow 2Cu_2O + O_2$$

..... dm^3 [3]

(c) Copper metal is obtained when scrap iron is added to aqueous copper(II) sulfate.

(i) The reaction between iron and aqueous copper(II) sulfate is a displacement reaction.

State why this displacement reaction takes place.

.....

..... [1]

(ii) Write a symbol equation for the reaction between iron and aqueous copper(II) sulfate.

..... [1]

(iii) A displacement reaction is one method for obtaining copper metal from aqueous copper(II) sulfate.

Identify **another** method for obtaining copper metal from aqueous copper(II) sulfate.

..... [1]

[Total: 11]

4 Sulfuric acid has many uses.

(a) Sulfuric acid is a strong acid.

(i) Define the term acid.

..... [1]

(ii) Define the term strong acid.

..... [1]

(b) Dilute sulfuric acid is used to make salts known as sulfates.

A method consisting of three steps is used to make zinc sulfate from zinc carbonate.

step 1 Add an excess of zinc carbonate to 20 cm^3 of 0.4 mol / dm^3 dilute sulfuric acid until the reaction is complete.

step 2 Filter the mixture.

step 3 Heat the filtrate until a saturated solution forms and then allow it to crystallise.

(i) Suggest **two** observations which show that the reaction is complete in **step 1**.

1 .....

2 .....
[2]

(ii) State why it is important to add an excess of zinc carbonate in **step 1**.

.....

..... [1]

(iii) Define the term saturated solution.

.....

.....

..... [2]

(iv) Name **another** zinc compound which can be used to make zinc sulfate from dilute sulfuric acid using this method.

..... [1]

(v) Suggest why this method would **not** work to make barium sulfate from barium carbonate and dilute sulfuric acid.

..... [1]

(c) In a titration, a student added 25.0 cm^3 of 0.200 mol / dm^3 aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask.

Dilute sulfuric acid is then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was 20.0 cm^3.

The reaction is shown by the equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) State the colour of methyl orange in aqueous sodium hydroxide.

..... [1]

(ii) Determine the concentration of the dilute sulfuric acid in g / dm^3 using the following steps.

- Calculate the number of moles of aqueous sodium hydroxide added to the conical flask.

..... mol

- Calculate the number of moles of dilute sulfuric acid added from the burette.

..... mol

- Calculate the concentration of the dilute sulfuric acid in mol / dm^3.

..... mol / dm^3

- Calculate the concentration of the dilute sulfuric acid in g / dm^3.

..... g / dm^3
[4]

[Total: 14]

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5 A student investigates the progress of the reaction between dilute hydrochloric acid, HC*l*, and an excess of large pieces of marble, $CaCO_3$, using the apparatus shown in Fig. 5.1.

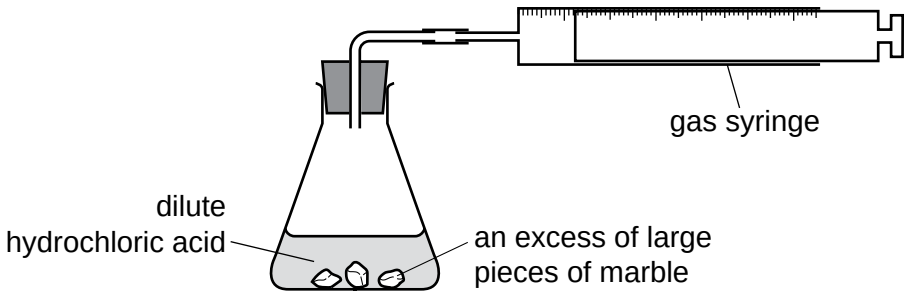

Fig. 5.1

(a) A graph of the volume of gas produced against time is shown in Fig. 5.2.

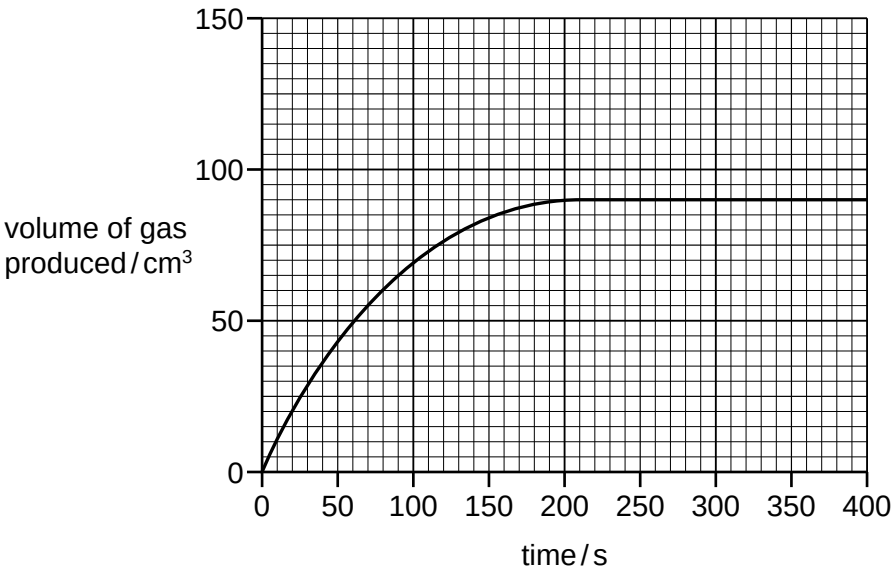

Fig. 5.2

(i) State how the shape of the graph shows that the rate of reaction decreases as the reaction progresses.

.....

..... [1]

(ii) Suggest why the rate of reaction decreases as the reaction progresses.

.....

..... [1]

(iii) Deduce the time at which the reaction finishes.

..... s [1]

(b) The experiment is repeated using the same mass of smaller pieces of marble.

All other conditions are kept the same.

Draw a line **on the grid** in Fig. 5.2 to show the progress of the reaction using the smaller pieces of marble. [2]

(c) The original experiment is repeated at a higher temperature. All other conditions are kept the same. The resulting increase in rate of reaction can be explained in terms of activation energy and collisions between particles.

(i) Define the term activation energy.

.....

..... [2]

(ii) Explain why the rate of a reaction increases when temperature increases, in terms of activation energy and collisions between particles.

.....

.....

.....

.....

..... [3]

[Total: 10]

6 Alkynes and alkenes are homologous series of unsaturated hydrocarbons.

All alkynes contain a C≡C triple bond.

(a) Complete Table 6.1 showing information about the first **three** alkynes.

Table 6.1

formula	C_2H_2	C_3H_4	
structure	H–C≡C–H	H–C≡C–CH_3	H–C≡C–CH_2–CH_3
names	ethyne		but-1-yne

[2]

(b) Compounds in the same homologous series have the same general formula.

(i) Give two **other** characteristics of members of a homologous series.

1 .....

2 .....

[2]

(ii) Deduce the general formula of alkynes.

Use the information from Table 6.1 to help you.

..... [1]

(iii) Alkynes are unsaturated.

Describe a test for unsaturation.

test .....

result .....

[2]

(c) Ethene and but-2-ene are alkenes.

(i) Draw the displayed formula of but-2-ene.

[2]

(ii) Draw a dot-and-cross diagram to show a molecule of ethene, $CH_2=CH_2$.

Show outer shell electrons only.

[2]

(d) Ethene can be converted to ethanoic acid by a two-stage process.

In stage one, ethene is converted to ethanol by catalytic addition.

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(i) Suggest why stage one is called an addition reaction.

..... [1]

(ii) A catalyst is used in stage one.

State one **other** condition that must be used.

..... [1]

(iii) State what must be reacted with ethanol to form ethanoic acid.

..... [2]

[Total: 15]

7 Carboxylic acids can be converted into esters.

(a) Propanoic acid and methanol react to form an ester that has the molecular formula $C_4H_8O_2$.

(i) Name this ester and draw its displayed formula.

name of ester .....

displayed formula

[2]

(ii) Name **another** ester with the molecular formula $C_4H_8O_2$.

..... [1]

(b) Polyesters are polymers made from dicarboxylic acids.

(i) Name the **other** type of organic compound used in the formation of polyesters.

..... [1]

(ii) Name the type of polymerisation used in the manufacture of polyesters.

..... [1]

[Total: 5]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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.).

PMT

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