



**Cambridge International Examinations**  
Cambridge International General Certificate of Secondary Education (9–1)

CANDIDATE  
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**CHEMISTRY**

**0971/42**

Paper 4 Theory (Extended)

**October/November 2018**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

You may lose marks if you do not show your working or if you do not use appropriate units.

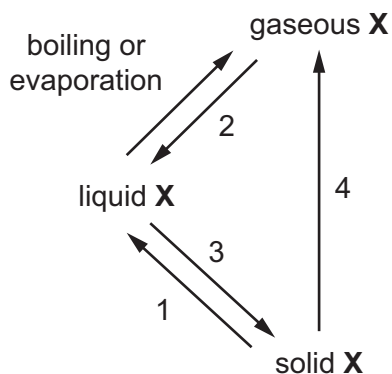
At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **13** printed pages and **3** blank pages.



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



(a) (i) Give the scientific name for each of the numbered physical changes.

- 1 .....
- 2 .....
- 3 .....
- 4 ..... [4]

(ii) Explain why the changes shown are physical changes.

- .....
- ..... [1]

(iii) 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 I metal. It burns in air to form an oxide  $X_2O$ .

Write a chemical equation for this reaction.

- ..... [2]

[Total: 11]

2 Magnesium, calcium and strontium are Group II elements.

(a) Complete the table to show the arrangement of electrons in a calcium atom.

shell number	1	2	3	4
number of electrons				

[1]

(b) Describe how the arrangement of electrons in a strontium atom is:

(i) similar to the arrangement of electrons in a calcium atom

.....  
 .....

(ii) different from the arrangement of electrons in a calcium atom.

.....  
 .....

[2]

(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**.

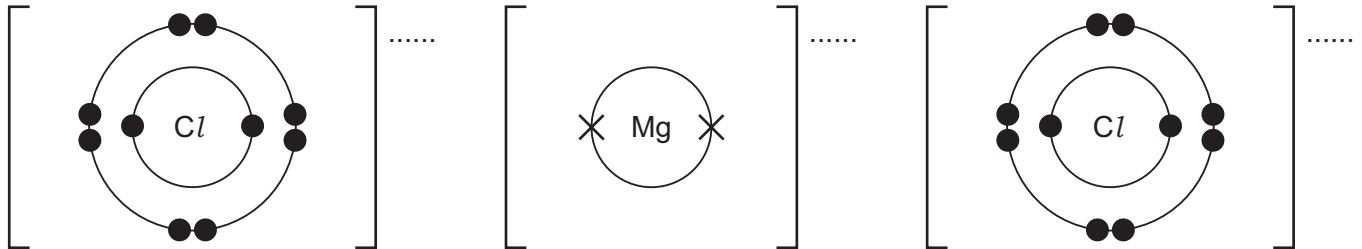
..... [1]

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

..... [2]

(d) Magnesium reacts with chlorine to form magnesium chloride,  $\text{MgCl}_2$ . Magnesium chloride is an ionic compound.

(i) Complete the diagrams to show the electronic structures of the ions in magnesium chloride. Show the charges on the ions.



[3]

(ii) Give **three** physical properties that are typical of ionic compounds such as  $\text{MgCl}_2$ .

1 .....

2 .....

3 .....

[3]

(e) Aqueous magnesium chloride is added to aqueous silver nitrate. A white precipitate forms.

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

..... [2]

[Total: 16]

3 Sulfur is an important element.

(a) Explain how burning fossil fuels containing sulfur leads to the formation of acid rain.

.....  
.....  
..... [2]

(b) Sulfuric acid is manufactured by the Contact process. One step in the Contact process involves a reversible reaction in which sulfur trioxide,  $\text{SO}_3$ , is formed.

(i) Write a chemical equation for this reversible reaction. Include the correct symbol to show that the reaction is reversible.

..... [2]

(ii) State the conditions and name the catalyst used in this reversible reaction.

temperature .....

pressure .....

catalyst .....

[3]

(iii) Describe how the sulfur trioxide formed is converted into sulfuric acid in the next steps of the Contact process.

.....  
.....  
..... [2]

(c) 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<sup>3</sup> of 0.4 mol/dm<sup>3</sup> 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) Name a suitable piece of apparatus for measuring 20 cm<sup>3</sup> of dilute sulfuric acid in **step 1**.

..... [1]

(ii) State **two** observations which would show that the reaction is complete in **step 1**.

1 .....

2 ..... [2]

(iii) Why is it important to add an excess of zinc carbonate in **step 1**?

..... [1]

(iv) What is meant by the term *saturated solution* in **step 3**?

..... [2]

(v) The equation for the reaction is shown.



Complete the equation by inserting the state symbol for zinc sulfate. [1]

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

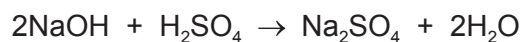
..... [1]

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

..... [1]

- (d) In a titration, a student added  $25.0\text{ cm}^3$  of  $0.200\text{ mol/dm}^3$  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 was then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was  $20.0\text{ cm}^3$ .



- (i) What was the colour of the methyl orange in the aqueous sodium hydroxide?

..... [1]

- (ii) Determine the concentration of the dilute sulfuric acid in  $\text{g/dm}^3$ .

- 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  $\text{mol/dm}^3$ .

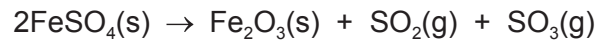
.....  $\text{mol/dm}^3$

- Calculate the concentration of the dilute sulfuric acid in  $\text{g/dm}^3$ .

.....  $\text{g/dm}^3$   
[4]

8

(e) Iron(II) sulfate decomposes when heated strongly.



15.20 g of  $\text{FeSO}_4(\text{s})$  was heated and formed 4.80 g of  $\text{Fe}_2\text{O}_3(\text{s})$ .

[ $M_r$ ,  $\text{FeSO}_4 = 152$ ;  $M_r$ ,  $\text{Fe}_2\text{O}_3 = 160$ ]

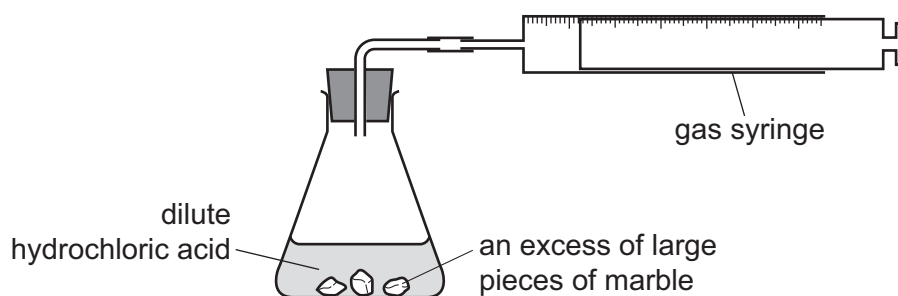
Calculate the percentage yield for this reaction.

..... % [3]

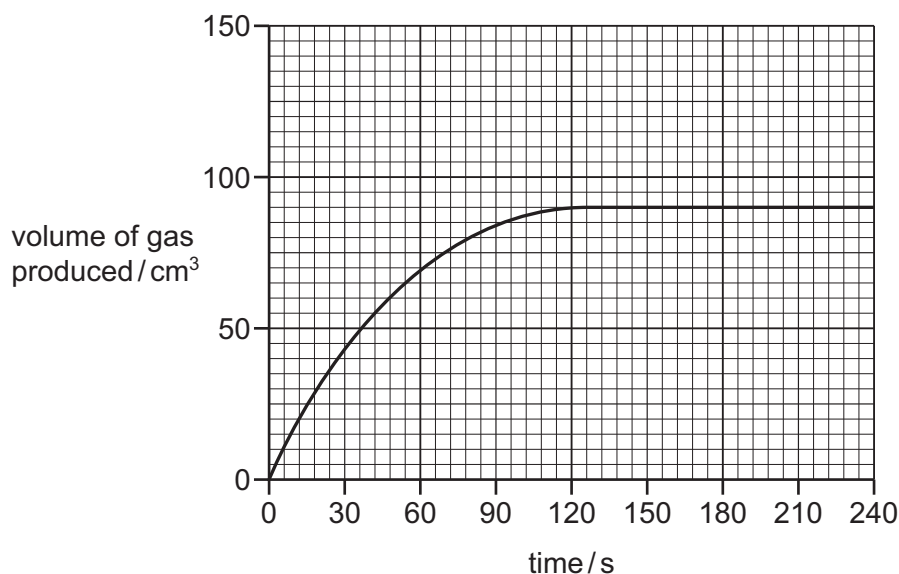
[Total: 26]



- 4 A student investigated the progress of the reaction between dilute hydrochloric acid,  $\text{HCl}$ , and an excess of large pieces of marble,  $\text{CaCO}_3$ , using the apparatus shown.



- (a) A graph of the volume of gas produced against time is shown.



- (i) How does the shape of the graph show that the rate of reaction decreased as the reaction progressed?

.....  
 ..... [1]

- (ii) Why did the rate of reaction decrease as the reaction progressed?

..... [1]

- (iii) After how many seconds did the reaction finish?

..... s [1]

- (b) The experiment was repeated using the same mass of smaller pieces of marble. All other conditions were kept the same.

Draw a graph **on the grid** to show the progress of the reaction using the smaller pieces of marble. [2]



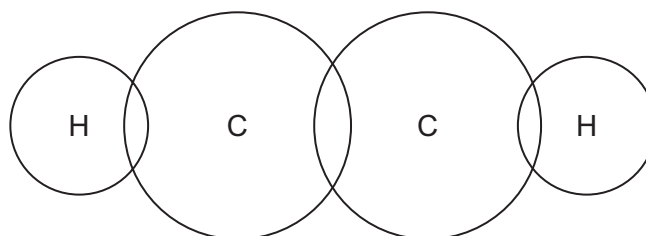
- 5 Alkynes are a homologous series of unsaturated hydrocarbons. All members contain a C≡C triple bond.

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

formula	C <sub>2</sub> H <sub>2</sub>	C <sub>3</sub> H <sub>4</sub>	
structure	H-C≡C-H	H-C≡C-CH <sub>3</sub>	H-C≡C-CH <sub>2</sub> -CH <sub>3</sub>
name	ethyne		butyne

[2]

- (b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethyne, H-C≡C-H. Show outer shell electrons only.



[2]

(c) 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) Use the information in the table in (a) to deduce the general formula of alkynes.

..... [1]

(d) Alkynes are unsaturated.

Describe a test for unsaturation.

test .....

result .....

[2]

(e) (i) Name an oxidising agent which can be used to oxidise ethanol to ethanoic acid.

..... [2]

(ii) Draw the structure of ethanoic acid. Show all of the atoms and all of the bonds.

[1]

(f) Carboxylic acids can be converted into esters.

(i) The ester formed by reacting propanoic acid and methanol has the molecular formula  $C_4H_8O_2$ .

Name this ester and draw its structure. Show all of the atoms and all of the bonds.

name of the ester .....

structure of the ester

[2]

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

..... [1]

(g) Polyesters are polymers.

(i) What type of polymerisation is used in the manufacture of polyesters?

..... [1]

(ii) Name a polyester.

..... [1]

[Total: 17]

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## The Periodic Table of Elements

		Group							
I	II	III	IV	V	VI	VII	VIII		
1	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
<b>Key</b>									
atomic number atomic symbol name relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Na sodium 23	Mg magnesium 24
11	12	13	14	15	16	17	18	19	20
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40	K potassium 39	Ca calcium 40
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Fr francium —	Ra radium —	Ac actinium —	Th thorium 232
91	92	93	94	95	96	97	98	99	100
Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
109	110	111	112	113	114	115	116	117	118
Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessium —	Og oganesson —	Uue unbinilium —	Uuh ununhexium —	Uuo ununoctium —

lanthanoids

actinoids

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

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).