Cambridge IGCSE

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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

7137439209

CHEMISTRY **0971/31**

Paper 3 Theory (Core) **May/June 2019**

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 20.
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 **18** printed pages and **2** blank pages.

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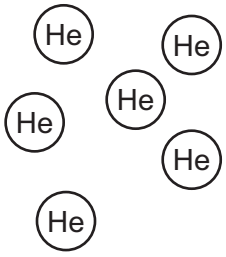
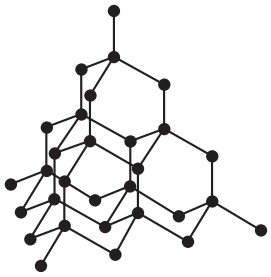
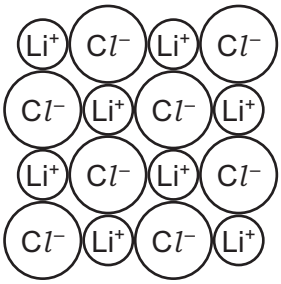
1 The diagrams show part of the structures of five substances, **A**, **B**, **C**, **D** and **E**.



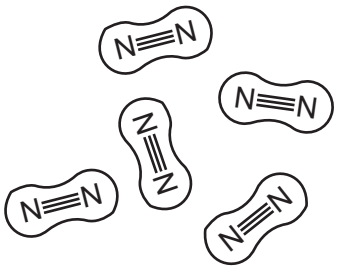
A



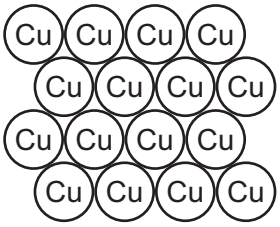
B



C



D



E

(a) Answer the following questions about these structures.
Each structure may be used once, more than once or not at all.

(i) Which **two** of these structures, **A**, **B**, **C**, **D** or **E**, are covalently bonded?

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

(ii) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is a diatomic molecule?

..... [1]

(iii) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is a compound?

..... [1]

(iv) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is very soluble in water?

..... [1]

(v) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is used in cutting tools?

..... [1]

(vi) Which **one** of these structures, **A**, **B**, **C**, **D** or **E**, is used in electrical wiring?

..... [1]

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(b) Substance **B** is an element.

What is meant by the term *element*?

.....

..... [1]

[Total: 8]

2 This question is about iron and iron compounds.

(a) Name the main ore of iron.

..... [1]

(b) In a blast furnace used for the extraction of iron, carbon reacts with oxygen from the air to form carbon monoxide.

Complete the chemical equation for this reaction.

$$....C + ... \rightarrow 2CO$$

[2]

(c) In the hotter parts of the furnace, carbon reacts with the iron(III) oxide present in the iron ore.

$$3C + Fe_2O_3 \rightarrow 3CO + 2Fe$$

How does this equation show that carbon is oxidised?

.....

..... [1]

(d) Limestone is added to the blast furnace. The limestone is converted into calcium oxide and carbon dioxide. The reaction is endothermic.

$$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$$

(i) What type of chemical reaction is this?

..... [1]

(ii) What type of oxide is calcium oxide?
Give a reason for your answer.

.....

..... [2]

(e) Iron is a metal.

Give **three** physical properties that are characteristic of metals.

1 .....

2 .....

3 .....

[3]

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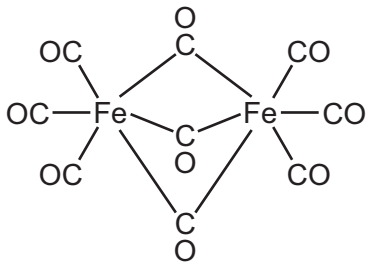
(f) The structure of a compound of iron is shown.



Deduce the molecular formula of this compound to show the number of iron, carbon and oxygen atoms.

..... [1]

[Total: 11]

3 **(a)** The table shows the percentage by mass of the elements on Earth and in the Universe.

element	percentage by mass on Earth	percentage by mass in the Universe
helium	0.0	21.0
hydrogen	0.1	76.0
iron	35.0	1.0
magnesium	14.0	0.1
oxygen	29.0	0.8
silicon	14.0	0.1
sulfur	2.9	0.1
other elements		0.9
total	100.0	100.0

Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of other elements present on Earth.

..... % [1]

(ii) Which non-metallic element is present on Earth in the greatest percentage by mass?

..... [1]

(iii) Give **two** major differences in the percentage by mass of the elements on Earth and in the Universe.

1 .....

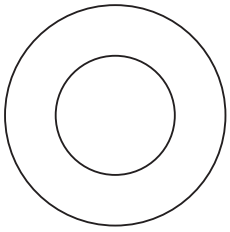
.....

2 .....

.....

[2]

(b) Complete the diagram to show the electron arrangement in an oxygen atom.



[1]

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(c) Helium, neon and argon are noble gases.

(i) Explain, in terms of the electronic structure, why neon is unreactive.

.....

..... [1]

(ii) State **one** use of argon.

..... [1]

[Total: 7]

4 This question is about iodine and compounds of iodine.

(a) Use the kinetic particle model to describe the separation between the molecules and the type of motion of the molecules in:

- solid iodine .....

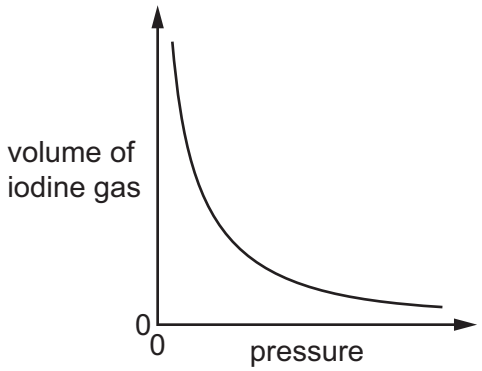
.....

- iodine gas. .....

.....

[4]

(b) The graph shows how the volume of iodine gas changes with pressure. The temperature is kept constant.



Describe how the volume of iodine gas changes with pressure.

.....

..... [1]

(c) **(i)** Complete the word equation to show the halogen and halide compound which react to form the products iodine and potassium bromide.

.....	+	....	→	iodine	+	potassium bromide

[2]

(ii) Explain, in terms of the reactivity of the halogens, why aqueous iodine does **not** react with aqueous potassium chloride.

.....

..... [1]

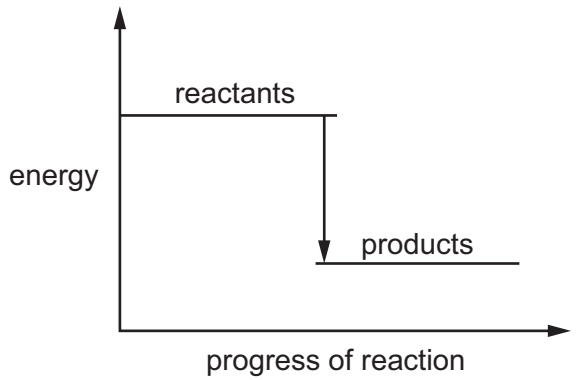
(d) Iodine reacts with aqueous sodium thiosulfate, $Na_2S_2O_3$.

(i) Balance the chemical equation for this reaction.

$$.....Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + ...NaI$$

[2]

(ii) The energy level diagram for this reaction is shown.



Explain how this diagram shows that the reaction is exothermic.

.....

..... [1]

(e) Describe a test for iodide ions.

test .....

observations .....

[2]

(f) Molten sodium iodide is electrolysed.

Predict the product at the positive electrode.

..... [1]

[Total: 14]

5 Coal gas is made by heating coal in the absence of air.
The list shows the main gases present in coal gas.

carbon dioxide
carbon monoxide
ethene
hydrogen
methane
nitrogen

(a) (i) Which **one** of these gases is an alkane?

..... [1]

(ii) Draw the structure of a molecule of ethene. Show all of the atoms and all of the bonds.

[1]

(iii) Describe how aqueous bromine can be used to tell the difference between methane and ethene.

.....

.....

..... [2]

(b) Ethene molecules react with each other to form poly(ethene).

(i) What is the name given to this type of chemical reaction?

..... [1]

(ii) Which **one** of the following words describes the ethene molecules in this reaction?
Draw a circle around the correct answer.

elements **mixtures** **monomers** **polymers**

[1]

(iii) Poly(ethene) is a non-biodegradable plastic.

What is meant by the term *non-biodegradable*?

.....

..... [1]

(iv) Describe **one** pollution problem caused by non-biodegradable plastics.

.....

..... [1]

(c) Ethanol can be made from ethene and one other reactant.

- Name the other reactant.

.....

- State the conditions needed to make ethanol from ethene.

.....

.....

[3]

[Total: 11]

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[Turn over

6 This question is about copper and copper compounds.

(a) Describe how you could prepare a pure sample of crystals of hydrated copper(II) sulfate using dilute sulfuric acid and an excess of copper(II) oxide.

.....

.....

.....

.....

..... [3]

(b) Anhydrous copper(II) sulfate is used to test for water.

$$\underset{\text{anhydrous copper(II) sulfate}}{CuSO_4} + 5H_2O \rightleftharpoons \underset{\text{hydrated copper(II) sulfate}}{CuSO_4.5H_2O}$$

(i) What is meant by the symbol $\rightleftharpoons$?

..... [1]

(ii) How can hydrated copper(II) sulfate be changed into anhydrous copper(II) sulfate?

..... [1]

(c) Complete the table to calculate the relative formula mass of anhydrous copper(II) sulfate, $CuSO_4$.
Use your Periodic Table to help you.

type of atom	number of atoms	relative atomic mass	
copper	1	64	1 × 64 = 64
sulfur			
oxygen			

relative formula mass = ...
[2]

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(d) Complete the table to show the number of electrons, protons and neutrons in the sulfur atom and copper ion shown.

	number of electrons	number of neutrons	number of protons
$^{34}_{16}S$			
$^{63}_{29}Cu^{2+}$			29

[4]

(e) Alloys of copper are used to make coins.

(i) What is meant by the term *alloy*?

.....

..... [1]

(ii) Suggest why an alloy of copper is used to make coins instead of using pure copper.

..... [1]

[Total: 13]

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[Turn over

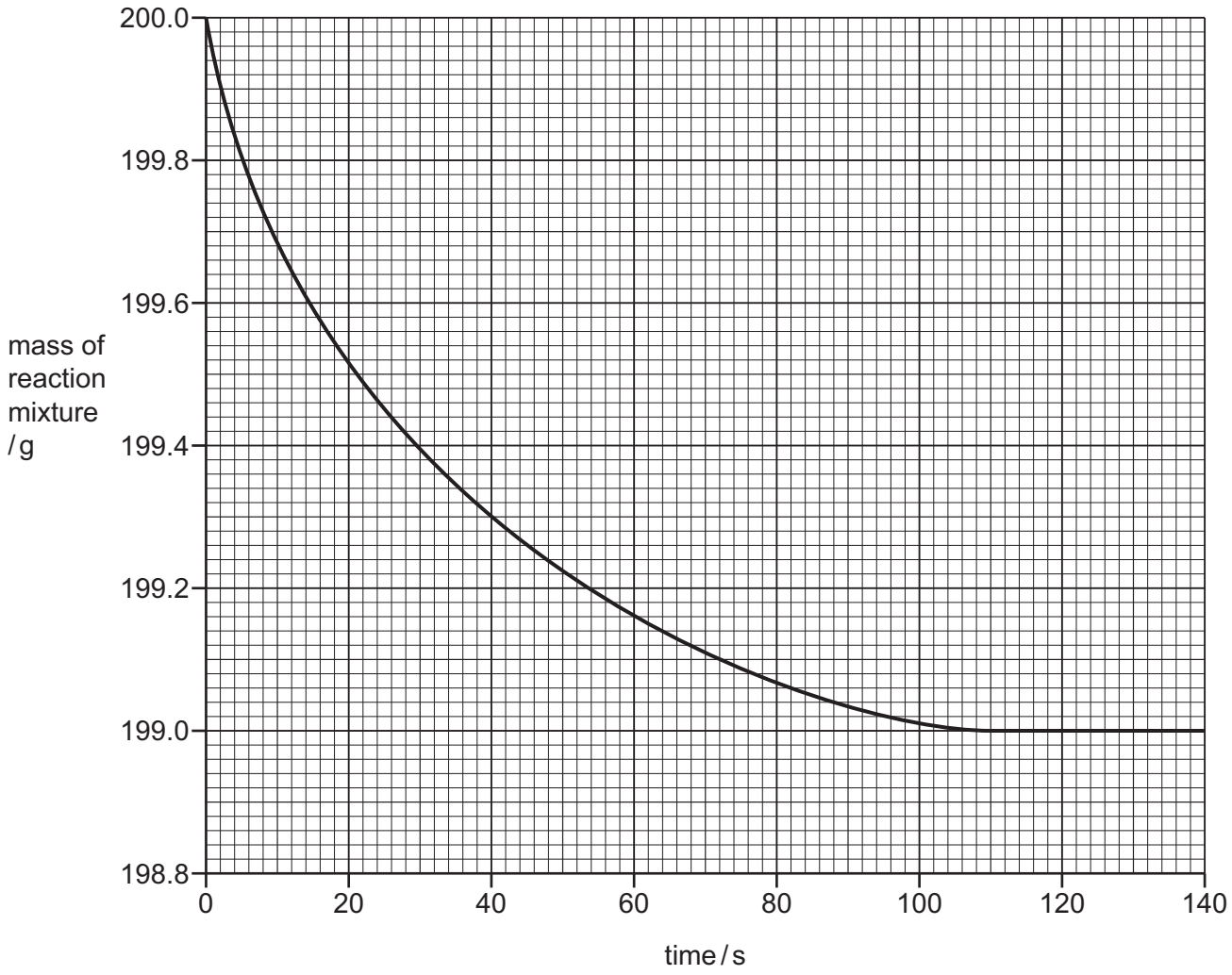
7 A student investigates the rate of reaction of small pieces of calcium carbonate with an excess of hydrochloric acid of concentration 1 mol / dm^3.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) Name the salt formed when calcium carbonate reacts with hydrochloric acid.

..... [1]

(b) The graph shows how the mass of the reaction mixture changes with time.



(i) State why the reaction mixture decreases in mass.

..... [1]

(ii) Calculate the loss in mass during the first 40 seconds of the experiment.

..... g [1]

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(iii) The experiment is repeated using hydrochloric acid of concentration 2 mol / dm^3.
All other conditions are kept the same.

Draw a line **on the grid** for the experiment using hydrochloric acid of concentration 2 mol / dm^3. [2]

(iv) In the experiment, when 2.00 g of calcium carbonate is used, the loss in mass of the reaction mixture is 0.88 g.
All other conditions are kept the same.

Calculate the loss in mass when 0.50 g of calcium carbonate is used.

loss in mass = ... g [1]

(v) The experiment is repeated using the same mass of different sized pieces of calcium carbonate.
All other conditions are kept the same.

The sizes of the pieces of calcium carbonate are:

- powder
- small pieces
- large pieces.

Complete the table by writing the sizes of the pieces of calcium carbonate in the first column.

size of pieces of calcium carbonate	initial rate of loss in mass in g / s
	0.005
	0.030
	0.100

[1]

[Total: 7]

8 **(a)** Sulfur dioxide is a pollutant in the air.

(i) State **one** source of sulfur dioxide in the air.

..... [1]

(ii) Sulfur dioxide is oxidised to sulfur trioxide in the air.
Oxides of nitrogen act as catalysts for this reaction.

What is meant by the term *catalyst*?

.....

..... [1]

(iii) Sulfur trioxide dissolves in rainwater to form acid rain.

Which **one** of the following pH values could be the pH of acid rain?
Draw a circle around the correct answer.

pH 4 pH 7 pH 9 pH 13

[1]

(iv) State **one** adverse effect of acid rain on buildings.

..... [1]

(b) Sulfur dioxide melts at –73 °C and boils at –10 °C.

What is the physical state of sulfur dioxide at –20 °C?
Explain your answer.

.....

..... [2]

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(c) Excess sulfuric acid reacts with ammonia to make a salt which can be used as a fertiliser.

State the name of the salt formed when excess sulfuric acid reacts with ammonia.

..... [1]

(d) The table shows some observations about the reactivity of four metals with dilute sulfuric acid.

metal	reaction with sulfuric acid
iron	a slow stream of bubbles is seen
magnesium	a rapid stream of bubbles is seen
nickel	a few bubbles slowly form
tungsten	no bubbles are seen

Use the information in the table to put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive

[2]

[Total: 9]

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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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).