Cambridge IGCSE

**Cambridge Assessment International Education**
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*7118832773*

**CHEMISTRY** **0620/31**

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.

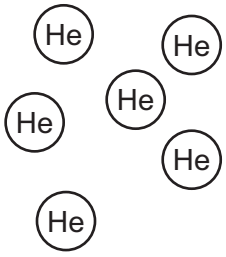
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

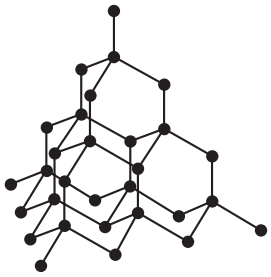
This document consists of **18** printed pages and **2** blank pages.


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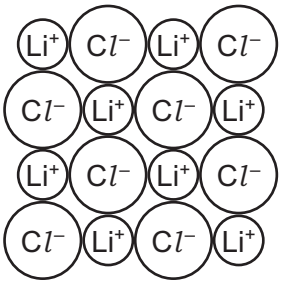
**1** The diagrams show part of the structures of five substances, **A**, **B**, **C**, **D** and **E**.



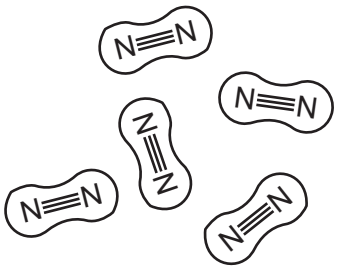

**A**



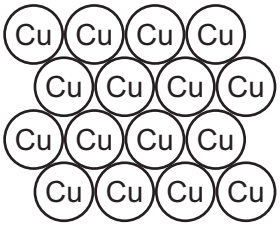
**B**




**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.

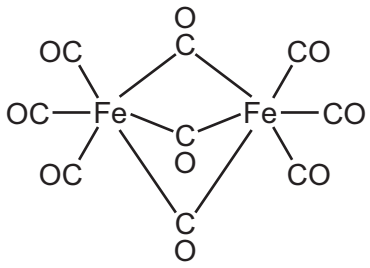
1 .....

2 .....

3 .....

[3]

**(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 .....

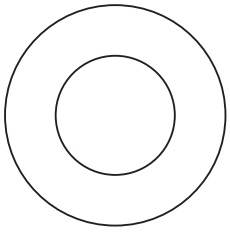
.....

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 .....

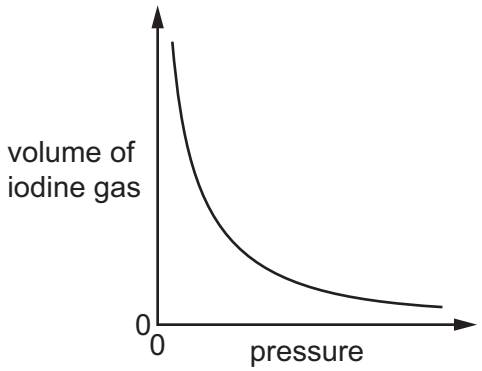
.....

- 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]

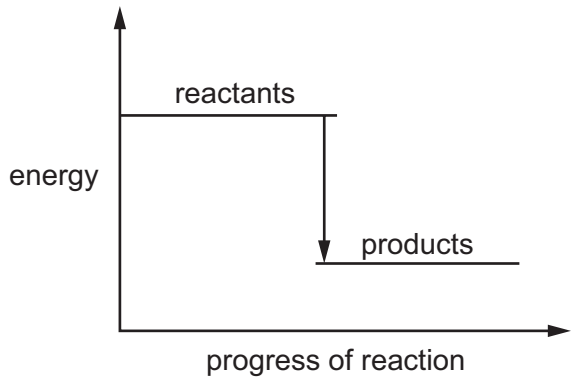
**(d)** Iodine reacts with aqueous sodium thiosulfate, $Na_2S_2O_3$.

**(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**

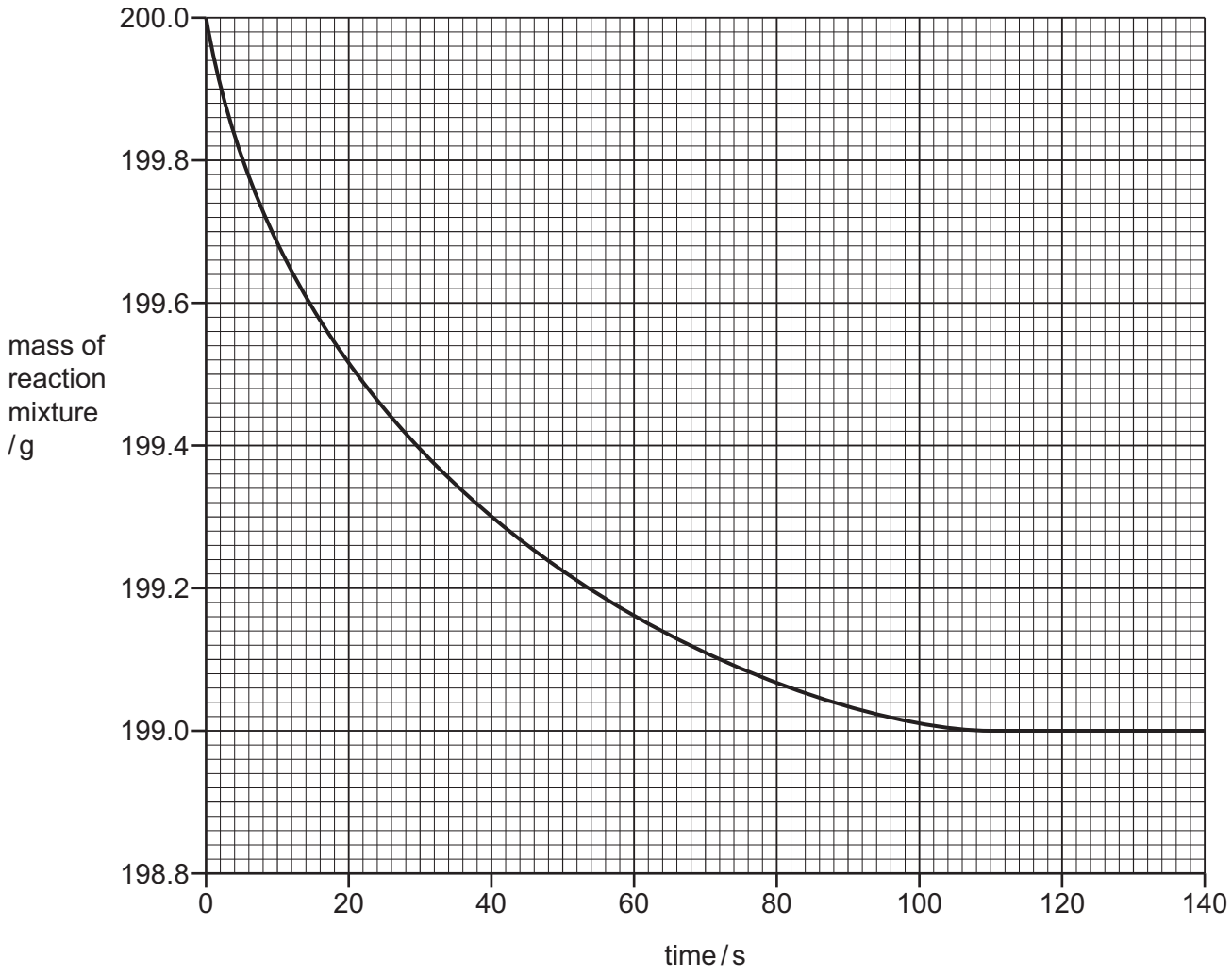
**7** A student investigates the rate of reaction of small pieces of calcium carbonate with an excess of hydrochloric acid of concentration 1 mol / $dm^3$.

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

**(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.).