Cambridge Assessment International Education

# Cambridge IGCSE™ (9–1)

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*5454471593*

**CHEMISTRY** **0971/32**

Paper 3 Theory (Core) **October/November 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 **20** pages. Any blank pages are indicated.




[Turn over

**1** A list of compounds is shown.

**ammonia**
**carbon dioxide**
**carbon monoxide**
**cobalt(II) chloride**
**ethane**
**ethene**
**glucose**
**methane**
**potassium sulfate**
**sodium phosphate**
**sulfur dioxide**

Answer the following questions using only the compounds from the list.
Each compound may be used once, more than once or not at all.

Give the name of the compound that:

**(a)** is an unsaturated hydrocarbon

..... [1]

**(b)** leads to the deoxygenation of water in rivers

..... [1]

**(c)** is a gas which turns damp red litmus paper blue

..... [1]

**(d)** is the main constituent of natural gas

..... [1]

**(e)** is a product of photosynthesis

..... [1]

**(f)** is a compound of a transition element.

..... [1]

[Total: 6]

**2** Petroleum is a mixture of hydrocarbons.

**(a)** Describe **two** characteristics of a mixture.

1 .....

.....

2 .....

.....
[2]

**(b)** Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

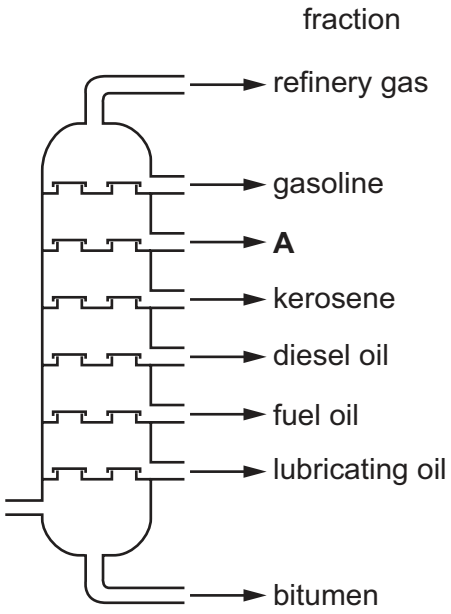


**Fig. 2.1**

**(i)** On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the lowest volatility collects. [1]

**(ii)** Name the fraction labelled **A** in Fig. 2.1.

..... [1]

**(iii)** State the name of the fraction which has hydrocarbons with the longest chain length.

..... [1]

**(iv)** State **one** use of the fuel oil fraction.

..... [1]

[Total: 6]

**3** **(a)** Table 3.1 shows the average concentrations, in ng / 1000 $cm^3$, of air pollutants in four different years.

**Table 3.1**

| year | concentration of air pollutant in ng / 1000 $cm^3$ | | | | |
|---|---|---|---|---|---|
| | carbon monoxide | hydrocarbons | oxides of nitrogen | particulates | sulfur dioxide |
| 2019 | 2.5 | 12.0 | 19.6 | 28.0 | 30.0 |
| 2020 | 2.0 | 13.5 | 21.8 | 30.1 | 21.7 |
| 2021 | 1.8 | 14.8 | 18.5 | 27.5 | 23.8 |
| 2022 | 1.6 | 16.0 | 22.7 | 26.2 | 25.0 |

**(i)** Name the oxide pollutant that has the highest concentration in 2021.

..... [1]

**(ii)** Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.

..... [1]

**(iii)** Calculate the average mass, in ng, of particulates in a 250 $cm^3$ sample of polluted air in 2019.

mass = ..... ng [1]

**(b)** **(i)** State **one** adverse effect of particulates on health.

..... [1]

**(ii)** Particulates are formed by the incomplete combustion of hydrocarbons.

State the meaning of the term incomplete combustion.

.....

..... [1]

**(c) (i)** Oxides of nitrogen contribute to acid rain.

Choose from the list the pH value for an acidic solution.

Draw a circle around your chosen answer.

**pH 5** **pH 7** **pH 9** **pH 13** [1]

**(ii)** Complete the sentence about removing oxides of nitrogen from car exhausts by choosing **two** words from the list.

**agent** **catalytic** **compound** **converter**

**distillation** **filter** **oxidising** **pump**

The emission of oxides of nitrogen from car exhausts is reduced by using a

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

**(iii)** Oxides of nitrogen can be formed by the action of bacteria on nitrates.

Name the aqueous solution and the metal used in the test for nitrate ions.

aqueous solution .....

metal .....
[2]

**(d)** Nitrogen dioxide decomposes when heated. Nitric oxide and oxygen are produced.

**(i)** Complete the symbol equation for this reaction.

$$.....NO_2 \rightleftharpoons 2NO + .....$$ [2]

**(ii)** State the meaning of the symbol $\rightleftharpoons$.

..... [1]

[Total: 12]



**[Turn over**

**4** Tin is a solid at room temperature.

**(a)** State **two** general properties of a solid.

1 .....

.....

2 .....

.....

[2]

**(b)** Fig. 4.1 shows the physical states of tin.

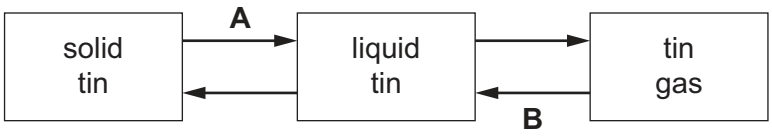


**Fig. 4.1**

Name the changes of physical states **A** and **B**.

**A** .....

**B** .....

[2]

**(c)** Describe solid and liquid tin in terms of the separation and motion of the particles.

solid tin

separation .....

.....

motion .....

.....

liquid tin

separation .....

.....

motion .....

.....

[4]

**(d)** A sealed gas syringe contains 80 $cm^3$ of carbon dioxide gas.

State how decreasing the temperature affects the volume of carbon dioxide gas in the gas syringe when the pressure remains constant.

..... [1]

[Total: 9]

**5** This question is about metals.

**(a)** Table 5.1 shows some properties of some Group I metals.

**Table 5.1**

| metal | melting point in °C | boiling point in °C | atomic volume in $cm^3$ / mol | observations on reaction with water |
|---|---|---|---|---|
| lithium | 181 | 1342 | 12.9 | |
| sodium | 98 | | 23.7 | bubbles form rapidly but no flame |
| potassium | 63 | 760 | 45.4 | bubbles form rapidly and flame seen |
| rubidium | 39 | 686 | | explodes |

Use the information in Table 5.1 to predict:

**(i)** the boiling point of sodium ..... [1]

**(ii)** the atomic volume of rubidium ..... [1]

**(iii)** the observations when lithium reacts with water .....

..... [1]

**(iv)** the physical state of lithium at 1300 °C. Give a reason for your answer.

physical state .....

reason .....

.....

[2]

**(b)** Iron is extracted in a blast furnace by reduction of iron(III) oxide, $Fe_2O_3$, with carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

**(i)** Explain how this equation shows that iron(III) oxide is reduced.

.....

..... [1]

**(ii)** Choose the phrase which describes the meaning of (III) in iron(III) oxide.

Tick (✓) **one** box.

| | |
|---|---|
| the number of oxygen atoms in iron(III) oxide | ☐ |
| the oxidation number of iron in iron(III) oxide | ☐ |
| the number of CO molecules which react with iron(III) oxide | ☐ |
| the number of electrons in one atom of iron | ☐ |

[1]

**(iii)** Calcium carbonate is added to the blast furnace.

The calcium carbonate undergoes thermal decomposition.

Complete the word equation for the thermal decomposition of calcium carbonate.

calcium carbonate → ..... + .....
..... .....

[2]

**(c)** Stainless steel is an alloy.

**(i)** Choose the diagram, **A**, **B**, **C** or **D**, in Fig. 5.1 that best shows the structure of an alloy.

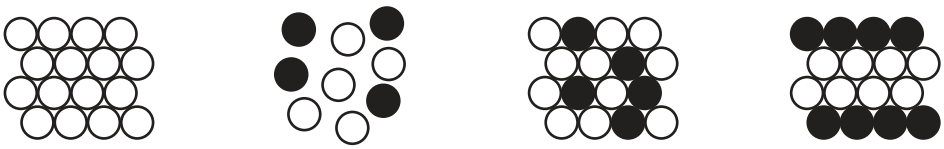


**Fig. 5.1**

diagram ..... [1]

**(ii)** Give **one** reason for using stainless steel instead of pure iron for cutlery.

..... [1]

**(d)** Table 5.2 gives the observations when four different metals react with dilute hydrochloric acid.

**Table 5.2**

| metal | observations |
|---|---|
| iron | bubbles form slowly |
| mercury | no bubbles seen |
| strontium | bubbles form very quickly |
| tin | 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: 13]

**6** A student investigates the reaction of large pieces of magnesium with dilute hydrochloric acid at 20 °C. The magnesium is in excess.

**(a)** Fig. 6.1 shows the volume of hydrogen gas released as the reaction proceeds.

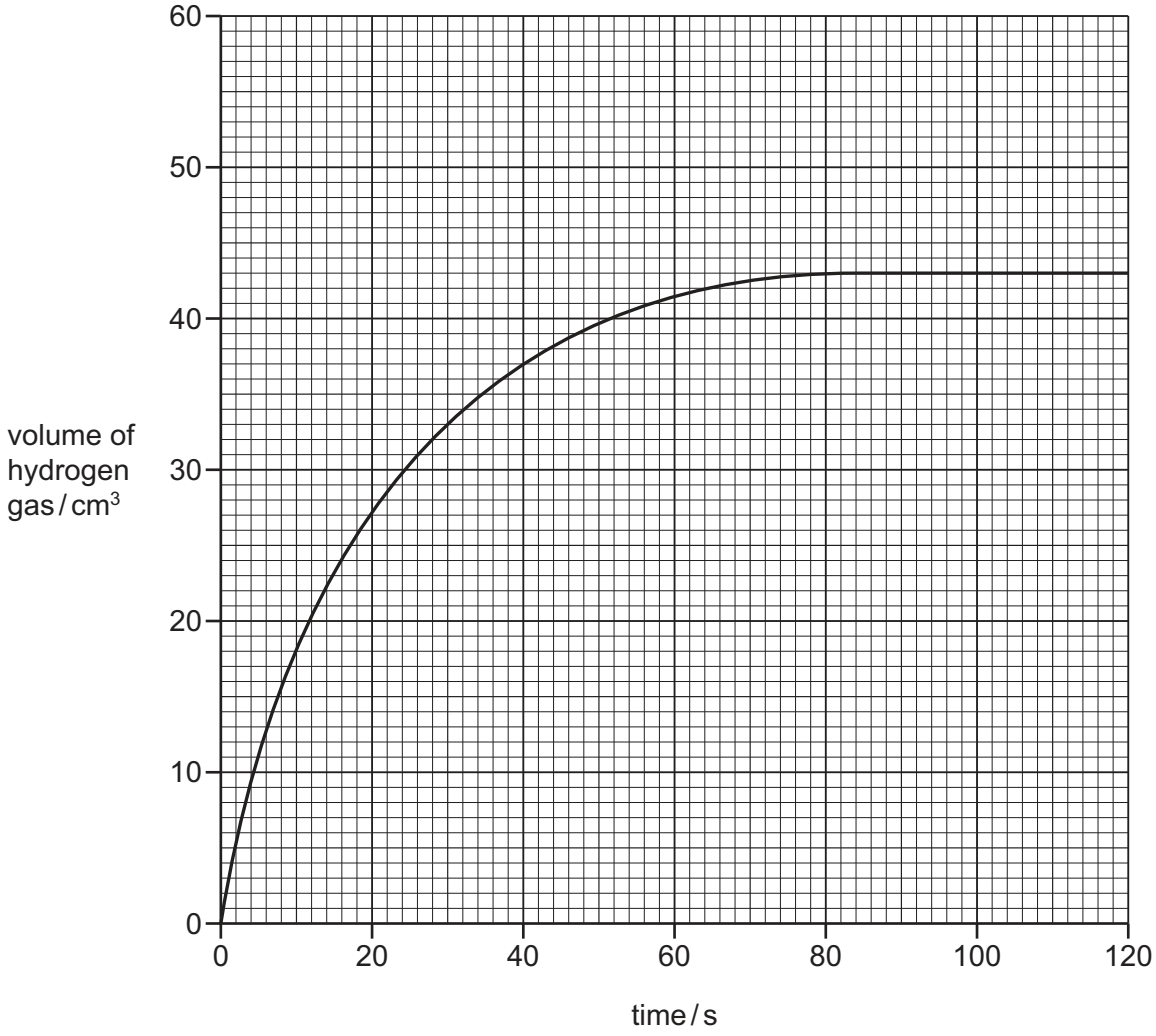


**Fig. 6.1**

**(i)** Deduce the volume of hydrogen gas released after 30 seconds.

volume of hydrogen = ..... $cm^3$ [1]

**(ii)** The student repeats the experiment using smaller pieces of magnesium. The mass of magnesium used remains the same. The magnesium is still in excess.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show the volume of hydrogen gas released when smaller pieces of magnesium are used. [2]



[Turn over

**(b) (i)** The student repeats the experiment at a higher temperature of 35 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when a temperature of 35 °C is used.

..... [1]

**(ii)** The student repeats the experiment using a lower concentration of acid.

All other conditions stay the same.

Describe how the rate of reaction differs when a lower concentration of acid is used.

..... [1]

**(c)** Hydrochloric acid reacts with lithium hydroxide.

**(i)** Complete the word equation for this reaction.

| | | | | | | |
|---|---|---|---|---|---|---|
| hydrochloric acid | + | lithium hydroxide | → | ..... ..... | + | ..... |

[2]

**(ii)** Choose from the list the word that best describes this reaction.

Draw a circle around your chosen answer.

**addition** **decomposition** **neutralisation** **oxidation** [1]

**(iii)** State the colour of a solution of thymolphthalein dissolved in aqueous sodium hydroxide.

..... [1]

[Total: 9]

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

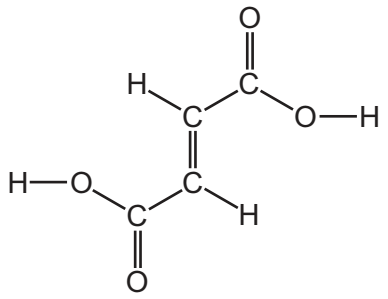


**Fig. 7.1**

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

**(ii)** Deduce the molecular formula of fumaric acid.

..... [1]

**(iii)** Fumaric acid is a colourless compound.

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

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

**(b)** Fumaric acid can be oxidised to produce a compound with the molecular formula $C_4H_6O_6$.

Complete Table 7.1 to calculate the relative molecular mass of $C_4H_6O_6$.

**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]

**(c)** Ethanoic acid is a carboxylic acid.

Complete the word equation for the reaction of ethanoic acid with sodium carbonate.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ethanoic acid | + | sodium carbonate | → | ..... ..... | + | ..... ..... | + | ..... |

[3]

**(d)** Ethanoic acid can be produced by the oxidation of ethanol.

**(i)** State **one** use of ethanol.

..... [1]

**(ii)** Ethanol, $C_2H_5OH$, is an alcohol.

Choose from the list the general formula for the alcohol homologous series.

Draw a circle around your chosen answer.

$C_nH_nOH$ $C_nH_{2n+1}OH$ $C_nH_{2n+2}OH$ $C_{2n}H_{2n}OH$ [1]

**(iii)** Ethanol can be manufactured by the addition of steam to ethene.

State **two** conditions for this reaction.

1 .....

2 .....

[2]

[Total: 13]

**8** Zinc chloride is an ionic compound.

**(a)** Ionic compounds are good electrical conductors when molten or in aqueous solution.

Describe one **other** physical property of ionic compounds.

..... [1]

**(b)** Complete Fig. 8.1 to show:

- the electronic configuration of a chloride ion
- the charge on the ion.

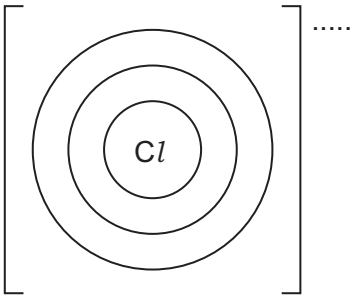


**Fig. 8.1**

[2]

**(c) (i)** Deduce the number of protons and neutrons in the zinc ion shown.

$^{67}_{30}Zn^{2+}$

number of protons .....

number of neutrons .....

[2]

**(ii)** Complete this sentence about positive ions.

Positive ions are known as ..... . [1]

**(d)** Molten zinc chloride is electrolysed using graphite electrodes.

State the names of the products at each electrode and give the observations at the positive electrode.

product at the negative electrode .....

product at the positive electrode .....

observations at the positive electrode

.....

[3]

**(e)** Graphite electrodes conduct electricity.

**(i)** State one **other** property that the electrode should have.

..... [1]

**(ii)** Choose the correct statement about the structure and bonding in graphite.

Tick (✓) **one** box.

| | |
|---|---|
| simple ionic | ☐ |
| simple covalent | ☐ |
| giant ionic | ☐ |
| giant covalent | ☐ |

[1]

**(iii)** State **one** use of graphite other than as an electrode.

..... [1]

[Total: 12]

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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 – | 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.).