



Cambridge IGCSE™ (9–1)

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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.

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.

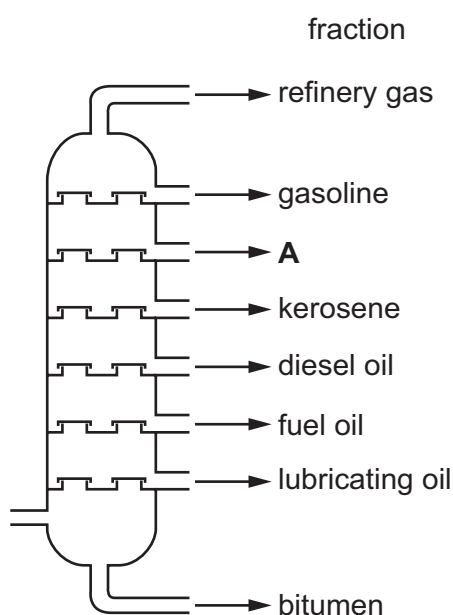


Fig. 2.1

(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 $\text{ng}/1000\text{cm}^3$, of air pollutants in four different years.

Table 3.1

year	concentration of air pollutant in $\text{ng}/1000\text{cm}^3$				
	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 250cm^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.

pH5 pH7 pH9 pH13 [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.



- (ii) State the meaning of the symbol \rightleftharpoons .

..... [1]

[Total: 12]

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.

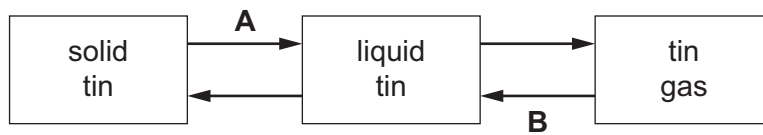


Fig. 4.1

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.

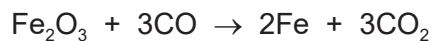
Table 5.1

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, Fe₂O₃, with carbon monoxide.



- (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.

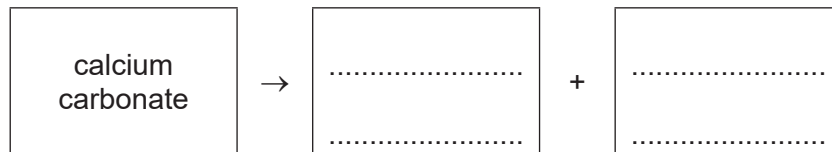
- the number of oxygen atoms in iron(III) oxide
- the oxidation number of iron in iron(III) oxide
- the number of CO molecules which react with iron(III) oxide
- the number of electrons in one atom of iron

[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.



[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.

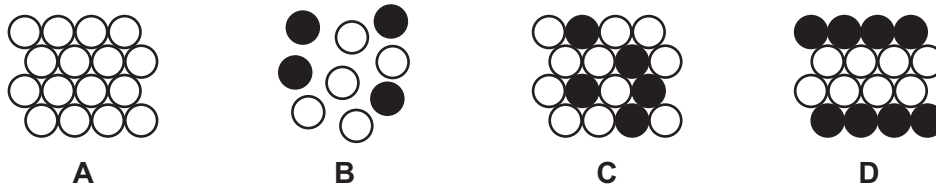


Fig. 5.1

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 \longrightarrow 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.

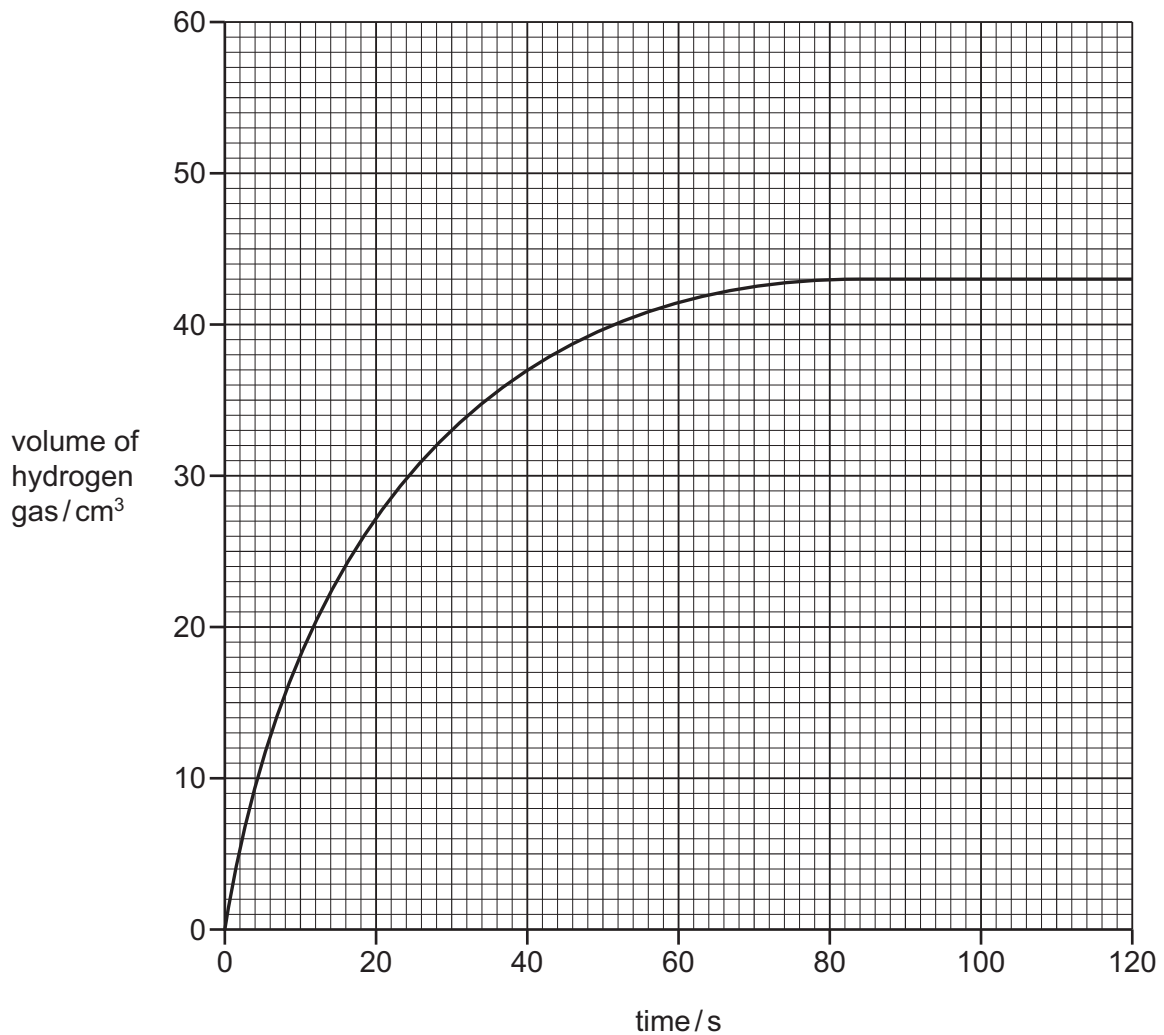


Fig. 6.1

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

volume of hydrogen = cm³ [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]

- (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.

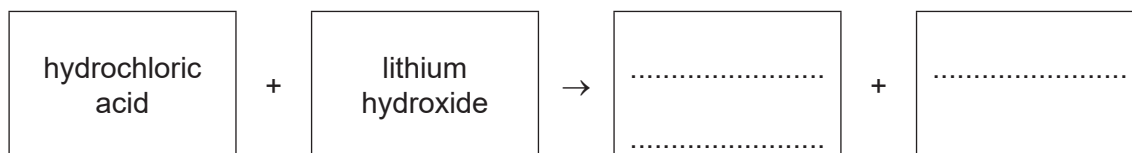
All other conditions stay the same.

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.



[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.

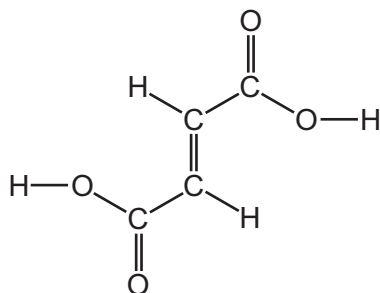


Fig. 7.1

(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 $C_4H_6O_6$.

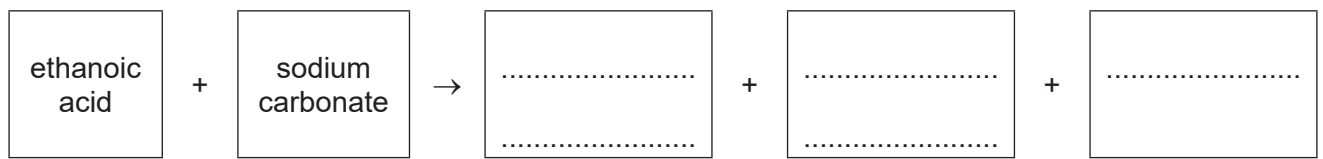
Table 7.1

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.



[3]

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

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

..... [1]

(ii) Ethanol, C₂H₅OH, 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.

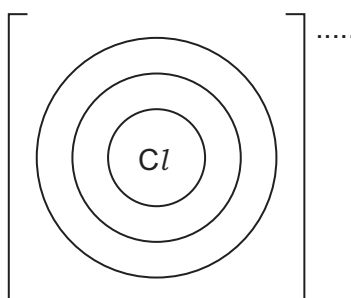


Fig. 8.1

[2]

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



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		
3 Li lithium 7	4 Be beryllium 9	1 H hydrogen 1	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20	2
11 Na sodium 23	12 Mg magnesium 24	Key atomic number atomic symbol name relative atomic mass							
19 K potassium 39	20 Ca calcium 40	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	36 Kr krypton 84	36
37 Rb rubidium 85	38 Sr strontium 88	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	54 Xe xenon 131	54
55 Cs caesium 133	56 Ba barium 137	49 In indium 115	48 Cd cadmium 112	47 Ag silver 108	46 Pd palladium 106	45 Rh rhodium 103	44 Ru ruthenium 101	86 Rn radon —	86
87 Fr francium —	88 Ra radium —	81 Tl thallium 204	80 Hg mercury 201	79 Au gold 197	78 Pt platinum 195	77 Ir iridium 192	76 Os osmium 190	118 Og oganesson —	118
		113 Nh nihonium —	112 Cn copernicium —	111 Rg roentgenium —	110 Ds darmstadtium —	109 Mt meitnerium —	108 Hs hassium —	116 Lv livermorium —	116
		114 Fl flerovium —	112 Cn copernicium —	111 Rg roentgenium —	110 Ds darmstadtium —	109 Mt meitnerium —	108 Hs hassium —	117 Ts tennessine —	117
		115 Mc moscovium —	112 Cn copernicium —	111 Rg roentgenium —	110 Ds darmstadtium —	109 Mt meitnerium —	108 Hs hassium —	118 Og oganesson —	118

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
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 —

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).