Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **0971/32**

Paper 3 Theory (Core) **May/June 2024**

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 Fig. 1.1 shows the structures of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

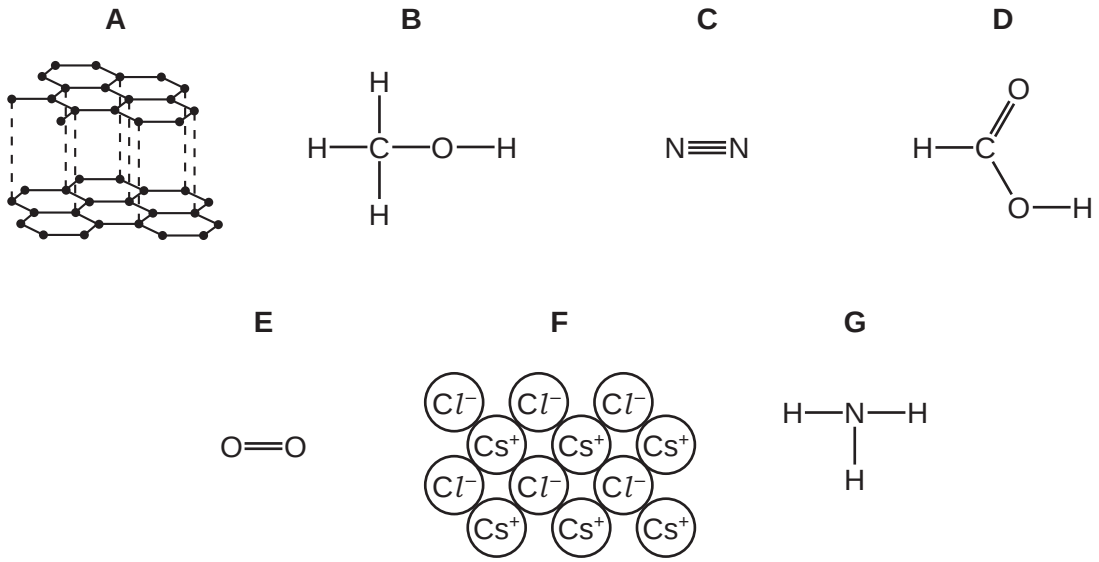


Fig. 1.1

(a) Answer the following questions using only the structures in Fig. 1.1.
Each structure may be used once, more than once or not at all.

State which structure represents:

(i) a gas that forms 78% by volume of clean, dry air

..... [1]

(ii) a compound with a high melting point

..... [1]

(iii) a giant covalent structure

..... [1]

(iv) a compound in the same homologous series as ethanol

..... [1]

(v) a product of photosynthesis

..... [1]

(vi) a non-metallic element that conducts electricity.

..... [1]

(b) Complete Fig. 1.2 to show the dot-and-cross diagram for structure **G**.
Show the outer electron shells only.

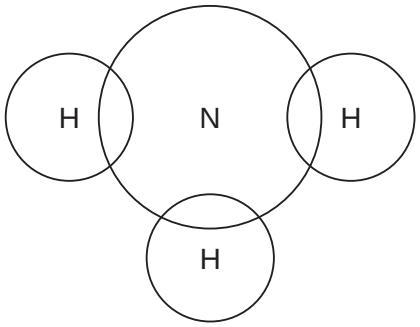


Fig. 1.2

[2]

[Total: 8]

2 **(a)** Blood plasma is the liquid part of blood.
Table 2.1 shows the mass, in mg, of some ions present in 100 cm^3 of blood plasma.

Table 2.1

name of ion	formula of ion	mass of ion in 100 cm^3 of blood plasma / mg
calcium	Ca^{2+}	10.0
chloride	Cl^-	365.6
hydrogencarbonate	HCO_3^-	164.7
hydrogen phosphate	HPO_4^{2-}	9.6
magnesium	Mg^{2+}	3.6
potassium	K^+	19.5
sodium	Na^+	326.6
	SO_4^{2-}	4.8

Answer these questions using information from Table 2.1.

(i) Name the positive ion in Table 2.1 that is present in the lowest concentration in blood plasma.

..... [1]

(ii) Name the ion in Table 2.1 that contains an element in Group V of the Periodic Table.

..... [1]

(b) Name the compound containing Na^+ ions and SO_4^{2-} ions.

..... [1]

(c) Describe a test for chloride ions.

test .....

.....

observations .....

.....
[2]

(d) Choose from the list the salt that is insoluble in water.

Tick (✓) **one** box.

calcium sulfate	☐
magnesium chloride	☐
potassium sulfate	☐
sodium chloride	☐

[1]

(e) Table 2.2 shows some properties of the Group I metals.

Table 2.2

metal	density in g / cm^3	observations on reaction with water
lithium	0.53	bubbles form very slowly and no flame
sodium	0.97	
potassium	0.86	bubbles form very rapidly and flame
rubidium		explodes

Use the information in Table 2.2 to:

- suggest why it is difficult to predict the density of rubidium

.....

- describe the observations when sodium reacts with water.

.....

[2]

(f) State how the melting point of the Group I elements changes down the Group.

..... [1]

(g) Sodium oxide, Na_2O, can be made by heating sodium in a limited supply of oxygen.

Complete the symbol equation for this reaction.

$$.....Na + O_2 \rightarrow .....Na_2O$$ [2]

[Total: 11]

3 **(a)** Fig. 3.1 shows the apparatus used to electrolyse molten magnesium chloride.

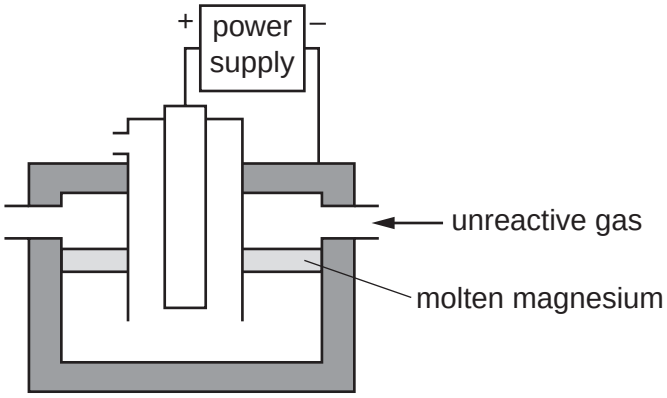


Fig. 3.1

(i) Label the anode in Fig. 3.1. [1]

(ii) Name a non-metal that can be used as the anode.

..... [1]

(iii) Name the product formed at each electrode.

positive electrode .....

negative electrode .....
[2]

(b) Use your knowledge of the reactivity of magnesium to suggest why an unreactive gas is blown into the electrolysis cell.

.....

..... [1]

(c) Alloys of magnesium and aluminium are used to make aircraft.

State the meaning of the term alloy.

.....

..... [1]

(d) Magnesium reacts with hydrochloric acid.

(i) Write the formula of the ion that is present in all acids.

..... [1]

(ii) Name the gas produced when hydrochloric acid reacts with magnesium.

..... [1]

(iii) Dilute hydrochloric acid is added to a solution of thymolphthalein in aqueous sodium hydroxide until the acid is in excess.

State the colour change of the thymolphthalein.

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

(iv) Name the indicator that can be used to determine the pH of a sample of dilute hydrochloric acid.

..... [1]

[Total: 11]

4 Some plants produce ethene gas.

(a) (i) Draw the displayed formula for a molecule of ethene.

[1]

(ii) The incomplete combustion of ethene produces a small amount of carbon dioxide.

Name two **other** products of the incomplete combustion of ethene.

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

(b) A student extracts a mixture of coloured compounds from a plant.

Fig. 4.1 shows the results of chromatography of this mixture.

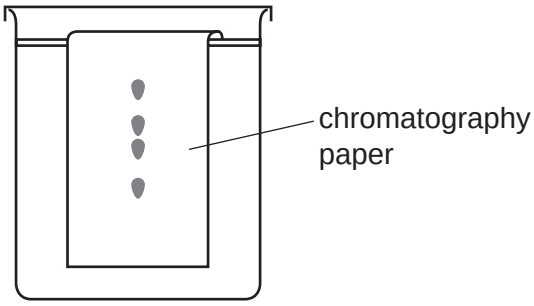


Fig. 4.1

(i) Complete Fig. 4.1, to show:

- where the mixture of coloured compounds is placed on the chromatography paper at the start of the chromatography
- the level of the solvent at the start of the chromatography.

[2]

(ii) State **two** characteristics of a mixture.

1 .....

.....

2 .....

.....

[2]

[Total: 7]

5 **(a)** An atom of sulfur is represented by the symbol shown.

$^{34}_{16}S$

Describe this atom of sulfur in terms of:

- the position of the electrons, neutrons and protons in the atom

.....

.....

- the number of neutrons and number of protons

.....

.....

- the electronic configuration.

.....

[5]

(b) Sulfur burns to produce sulfur dioxide.

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

..... [1]

(ii) Complete the symbol equation for the reaction of sulfur dioxide with magnesium.

..... + 2Mg → .....MgO + S [2]

(c) Fig. 5.1 shows the displayed formula of a compound of sulfur.

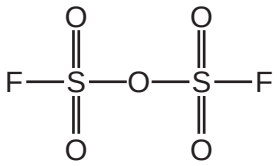


Fig. 5.1

Deduce the molecular formula of this compound.

..... [1]

(d) Another compound of sulfur has the formula $Na_2S_2O_7$.

Complete Table 5.1 to calculate the relative formula mass of $Na_2S_2O_7$.

Table 5.1

type of atom	number of atoms	relative atomic mass	
sodium	2	23	$2 \times 23 = 46$
sulfur		32	
oxygen		16	

relative formula mass = ... [2]

[Total: 11]

6 Solid nitrogen pentoxide, N_2O_5, decomposes to produce nitrogen dioxide gas and oxygen gas.

(a) Complete the equation by adding the missing state symbols.

$$2N_2O_5(s) \rightarrow 4NO_2(.....) + O_2(.....)$$ [1]

(b) Fig. 6.1 shows how the mass of nitrogen pentoxide changes as the reaction proceeds.

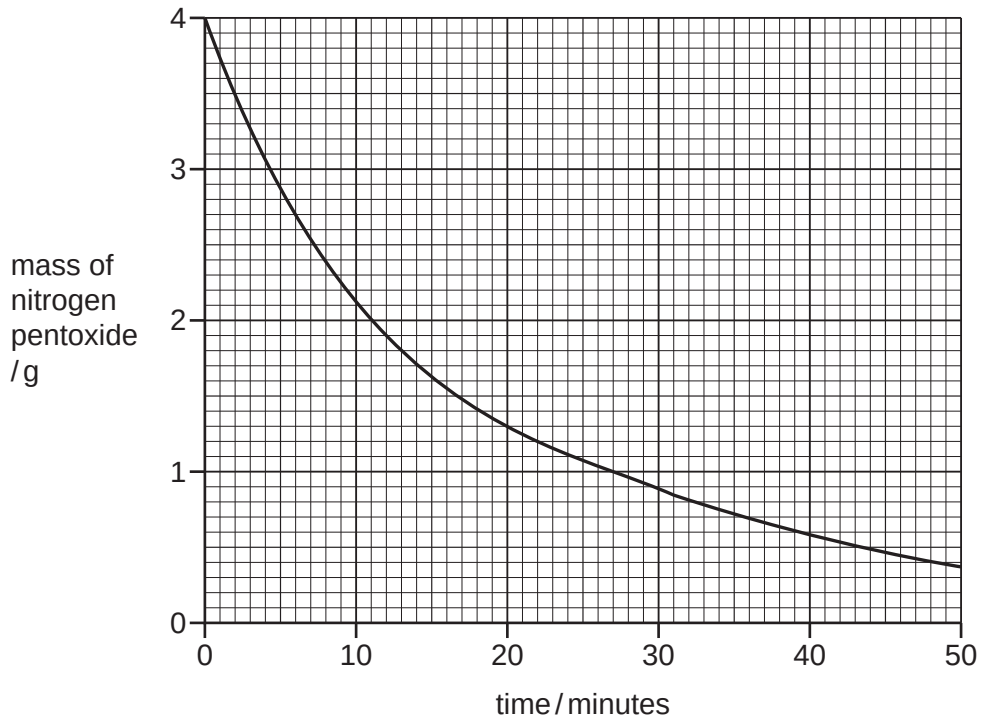


Fig. 6.1

(i) On Fig. 6.1, draw an **X** to show where the rate of reaction is fastest. [1]

(ii) Deduce the mass of nitrogen pentoxide 12 minutes from the start of the reaction.

..... [1]

(c) At 50 °C, the reactant and products are all gases.

(i) Describe the effect each of the following has on the rate of decomposition of nitrogen pentoxide.

All other conditions stay the same.

- The pressure is decreased.

.....

- A catalyst is added to the reaction mixture.

.....
[2]

(ii) Increasing the concentration of nitrogen pentoxide increases the rate of decomposition.

Choose the correct unit of concentration from the list.

Draw a circle around your chosen answer.

dm^3/g **g/dm** **g/dm^2** **g/dm^3** [1]

(d) Some oxides of nitrogen such as nitrogen dioxide are acidic air pollutants.

(i) Choose the pH value which is acidic.

Draw a circle around your chosen answer.

pH 1 **pH 7** **pH 8** **pH 14** [1]

(ii) State **one** way of reducing the emissions of nitrogen dioxide in cars.

..... [1]

(e) Nitrogen dioxide is a yellow liquid which evaporates to form a brown gas at room temperature.

A long glass tube is set up as shown in Fig. 6.2.

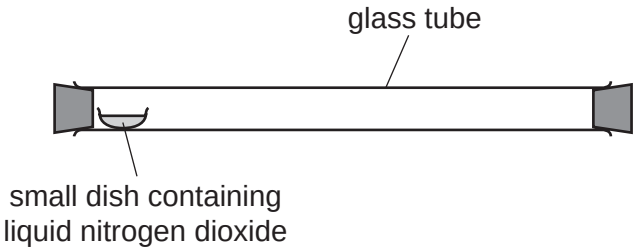


Fig. 6.2

At first, the brown gas can only be seen above the small dish.
After a short time, the brown gas has completely filled the tube.

Explain these results in terms of kinetic particle theory.

.....

.....

.....

..... [3]

[Total: 11]

7 Iron and copper are transition elements. They are malleable and are good thermal and electrical conductors.

(a) State three **other** physical properties of iron.

1 .....

2 .....

3 .....

[3]

(b) Fig. 7.1 shows some clean iron nails placed in four test-tubes, **M**, **N**, **O** and **P**, under different conditions.

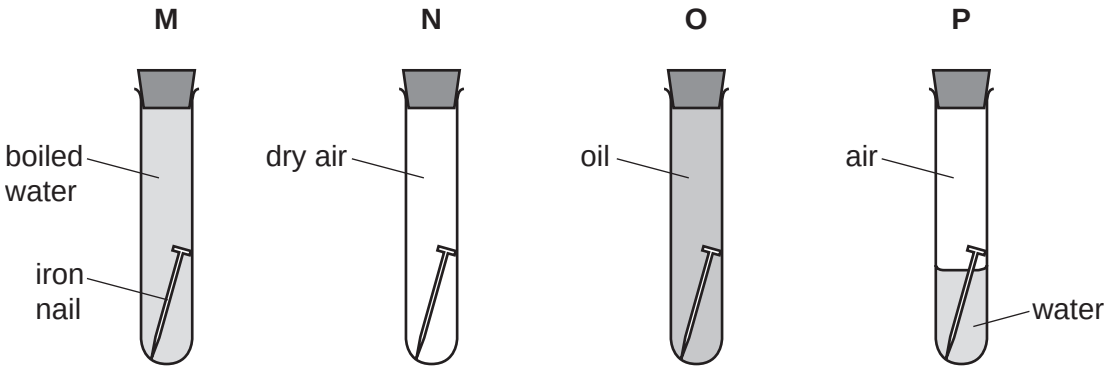


Fig. 7.1

(i) State in which test-tube, **M**, **N**, **O** or **P**, the iron nail is most likely to rust.

..... [1]

(ii) Choose from the list the compound in rust.

Tick (✓) **one** box.

anhydrous iron(III) oxide	☐
anhydrous iron(III) sulfate	☐
hydrated iron(III) chloride	☐
hydrated iron(III) oxide	☐

[1]

(c) Copper is used in electrical wiring because of its good electrical conductivity.

State one **other** reason why copper is used in electrical wiring.

..... [1]

(d) Copper(II) oxide reacts with hydrochloric acid.

Complete the word equation for this reaction.

copper(II) oxide	+	hydrochloric acid	→	....	+	.....

[2]

(e) Copper can be produced by heating copper(II) oxide in hydrogen.

$$CuO + H_2 \rightarrow Cu + H_2O$$

Describe how this equation shows that copper(II) oxide is reduced.

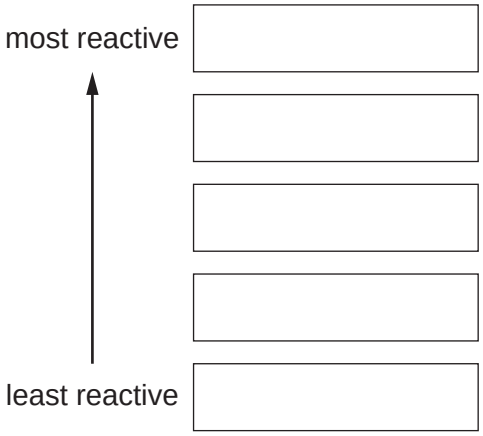
.....

..... [1]

(f) The list shows five metals.

aluminium **copper** **gold** **magnesium** **potassium**

Put these metals in order of their reactivity.
Put the most reactive metal at the top.



[2]

[Total: 11]

8 This question is about carboxylic acids and alkanes.

(a) Table 8.1 shows the names, formulae and boiling points of some carboxylic acids.

Table 8.1

name	formula	boiling point / °C
methanoic acid	HCOOH	101
ethanoic acid	CH_3COOH	118
propanoic acid	C_2H_5COOH	141
butanoic acid	C_3H_7COOH	166

Use the information in Table 8.1 to answer these questions.

(i) State the trend in the boiling points of the carboxylic acids.

..... [1]

(ii) Deduce the general formula for carboxylic acids.

..... [1]

(b) (i) Complete the word equation for the reaction of ethanoic acid with sodium carbonate.

ethanoic acid	+	sodium carbonate	→	sodium ethanoate	+	.....	+	....

[2]

(ii) Choose the correct formula of sodium ethanoate from the list.

Draw a circle around your chosen answer.

CH_3CH_2ONa **CH_3CH_2COONa** **CH_3COONa** **$(CH_3COO)_2Na$** [1]

(c) Methane, ethane and propane belong to the alkane homologous series.

(i) Define the term homologous series.

.....

..... [2]

(ii) State the type of bonding in a methane molecule.

..... [1]

(iii) State **two** types of reaction of the alkanes.

1 .....

2 .....
[2]

[Total: 10]

BLANK PAGE

BLANK PAGE

BLANK PAGE

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.).