Cambridge Assessment International Education

# Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*7941377889*

**CHEMISTRY** **5070/21**

Paper 2 Theory **October/November 2023**

**1 hour 45 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.

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**1** Choose from the list of compounds to answer these questions.

**calcium oxide**

**carbon dioxide**

**carbon monoxide**

**lead chloride**

**propan-1-ol**

**sodium nitrate**

**sodium sulfate**

**sulfur dioxide**

**water**

Each compound may be used once, more than once or not at all.

Identify the compound that:

**(a)** is a toxic gas produced by the incomplete combustion of carbon-containing compounds

..... [1]

**(b)** turns anhydrous copper(II) sulfate blue

..... [1]

**(c)** leads to deoxygenation of water in rivers

..... [1]

**(d)** in aqueous solution, gives a white precipitate on addition of acidified aqueous barium chloride

..... [1]

**(e)** contains an anion with a charge of –1.

..... [1]

[Total: 5]

**2** This question is about metals.

**(a)** Potassium is an element in Group I of the Periodic Table.
Copper is a transition element.

State **two** physical properties of potassium that are different from those of copper.

1 .....

2 .....
[2]

**(b)** Complete the diagram in Fig. 2.1 to show the electronic configuration of a potassium ion.

Include the charge on the ion.

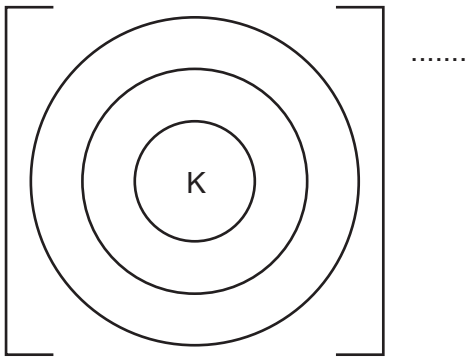


**Fig. 2.1** [2]

**(c)** Table 2.1 shows the observations when four different metals react with cold water.

**Table 2.1**

| metal | observations |
|---|---|
| cerium | bubbles form slowly |
| potassium | bubbles form rapidly |
| uranium | bubbles form very slowly |
| vanadium | no bubbles seen |

Put the four metals in order of their reactivity.
Put the least reactive metal first.

| | | | |
|---|---|---|---|

least reactive ⟶ most reactive

[1]

**(d)** Deduce the number of protons and neutrons in the copper atom shown.

$^{65}_{29}Cu$

number of protons .....

number of neutrons .....
[2]

**(e)** In the presence of oxygen, copper reacts with sulfuric acid, $H_2SO_4$, to form copper(II) sulfate and water.

Construct the symbol equation for this reaction.

..... [2]

**(f)** Copper can be used as a catalyst.

**(i)** State how a catalyst increases the rate of a chemical reaction.

..... [1]

**(ii)** Name the catalyst used in the Contact process.

..... [1]

**(g)** Give **two** reasons why copper is used in electrical wiring.

1 .....

2 .....
[2]

[Total: 13]

**3** A student investigates the reaction of small pieces of zinc with dilute hydrochloric acid at 25 °C. The dilute hydrochloric acid is in excess.

**(a)** Complete the equation for this reaction by adding state symbols.

$$Zn(.....) + 2HCl(.....) \rightarrow ZnCl_2(aq) + H_2(.....)$$ [2]

**(b)** Fig. 3.1 shows the volume of hydrogen released as the reaction proceeds.

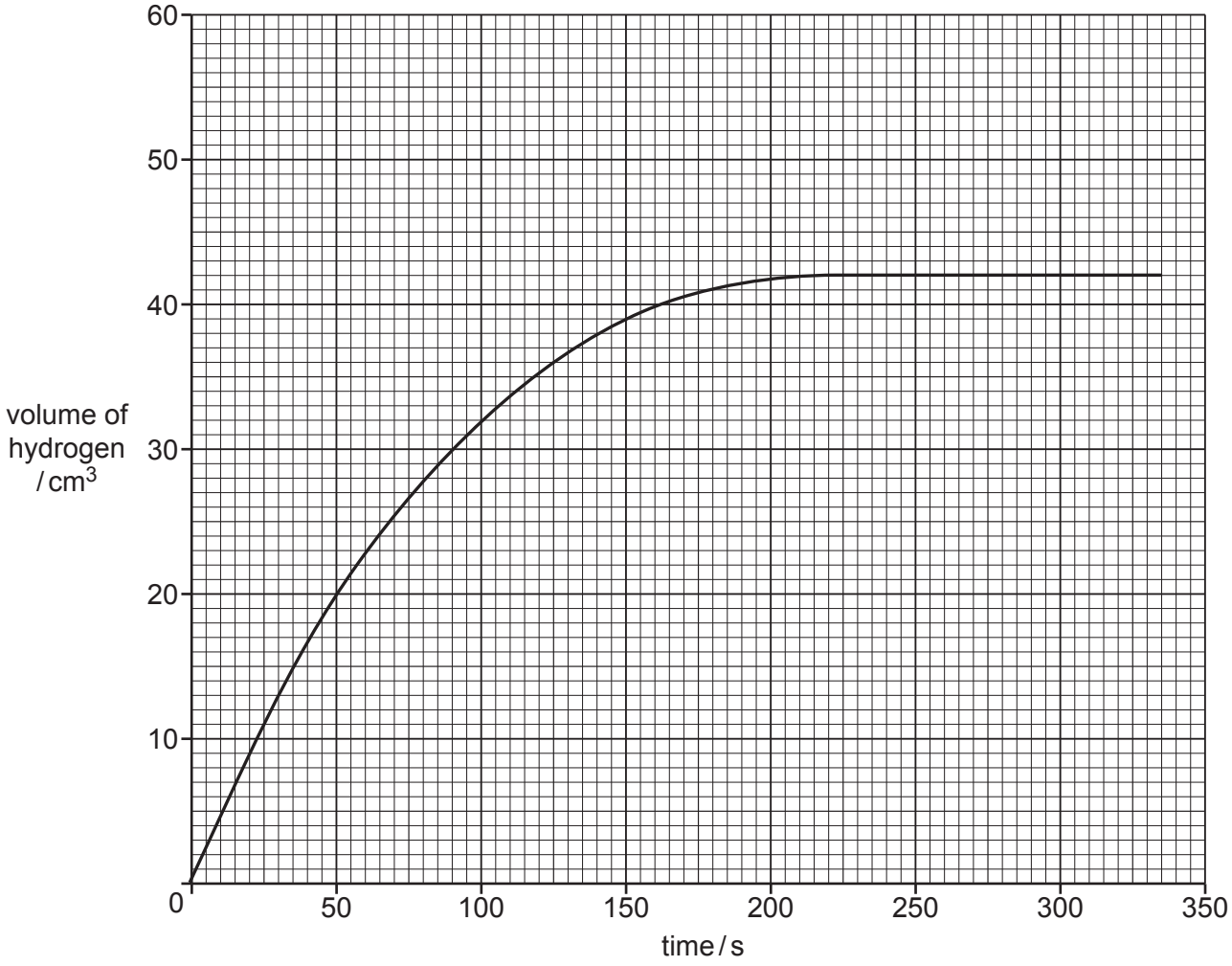


**Fig. 3.1**

**(i)** Deduce the time taken from the beginning of the experiment to collect 39 $cm^3$ of hydrogen.

time ..... s [1]

**(ii)** The student repeats the experiment using dilute hydrochloric acid with a higher concentration.

All other conditions stay the same.

Draw a line on the grid in Fig. 3.1 to show how the volume of hydrogen changes when dilute hydrochloric acid with a higher concentration is used. [2]

**(c)** The student repeats the experiment at 30 °C.

All other conditions stay the same.

Describe and explain, using collision theory, how the rate of reaction differs when a temperature of 30 °C is used.

.....

.....

.....

..... [2]

**(d)** A sample of hydrogen is put into a gas syringe. The end of the gas syringe is then blocked so that no gas can escape.

Explain, using kinetic particle theory, why decreasing the pressure in the gas syringe increases the volume of gas when the temperature stays the same.

.....

..... [1]

[Total: 8]

**4** **(a)** Concentrated aqueous calcium bromide is electrolysed using graphite electrodes.

Predict the product at each electrode.

anode .....

cathode .....
[2]

**(b)** Molten calcium bromide is electrolysed using graphite electrodes.

Construct the ionic half-equation for the reaction at each electrode when molten calcium bromide is electrolysed.

anode .....

cathode .....
[2]

**(c)** Describe a test for aqueous bromide ions. Include the observations for a positive result.

test .....

observations .....
[2]

**(d)** Calcium reduces zinc ions to zinc.

$$Ca + Zn^{2+} \longrightarrow Zn + Ca^{2+}$$

**(i)** Explain, in terms of the movement of electrons, how calcium acts as a reducing agent in this equation.

.....

..... [1]

**(ii)** State the oxidation number of the $Zn^{2+}$ ion.

..... [1]

**(e)** Sulfur dibromide is produced when sulfur reacts with bromine.

Complete Fig. 4.1 to show the dot-and-cross diagram for a molecule of sulfur dibromide.

Show only the outer shell electrons.

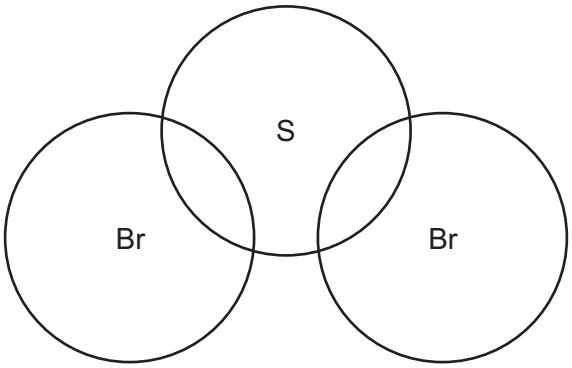


**Fig. 4.1** [2]

[Total: 10]

**5** **(a)** Fig. 5.1 shows the displayed formula of compound **A**.

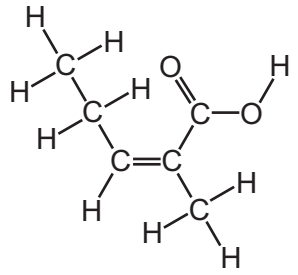

**Fig. 5.1**

**(i)** Draw a circle around the functional group on Fig. 5.1 that is also present in alkenes. [1]

**(ii)** Deduce the molecular formula of compound **A**.

..... [1]

**(iii)** Compound **A** is a solid at 20 °C.

Describe the motion and arrangement of the particles in a solid.

motion .....

arrangement .....
[2]

**(b)** Alkenes react with hydrogen in the presence of a catalyst.

**(i)** Draw a circle around the type of reaction that takes place.

addition condensation neutralisation substitution [1]

**(ii)** Name the catalyst used.

..... [1]

**(c)** Fig. 5.2 shows the structure of compound **B**.

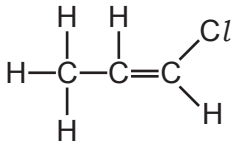


**Fig. 5.2**

Compound **B** can be polymerised.

Draw **two** repeat units of the polymer formed when compound **B** is polymerised.

[2]

**(d)** Fig. 5.3 shows part of the structure of a protein.

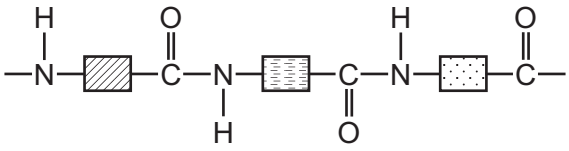


**Fig. 5.3**

**(i)** Name the type of monomer used to make proteins.

..... [1]

**(ii)** Name the linkage in proteins.

..... [1]

[Total: 10]

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**6** The equation for the Haber process used in the production of ammonia is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

**(a) (i)** The nitrogen for this process comes from the air.

State the percentage by volume of nitrogen in clean, dry air.

..... [1]

**(ii)** State a source of hydrogen for the Haber process.

..... [1]

**(b)** The forward reaction in the Haber process is exothermic.

**(i)** Explain, in terms of bond making and bond breaking, why this reaction is exothermic.

.....

.....

.....

..... [2]

**(ii)** The transfer of thermal energy in a chemical reaction is called the enthalpy change.

Write the symbol for an enthalpy change. Include the sign for an exothermic enthalpy change.

..... [1]

**(c)** Aqueous ammonia is an alkali.
Aqueous ammonia reacts with dilute nitric acid to form a salt.

**(i)** Name this salt.

..... [1]

**(ii)** Name the experimental technique used to make a solution of this salt from dilute nitric acid and aqueous ammonia.

..... [1]

[Total: 7]



**[Turn over**

**7** **(a)** Dilute ethanoic acid reacts with aqueous calcium hydroxide.

$$2CH_3COOH + Ca(OH)_2 \rightarrow (CH_3COO)_2Ca + 2H_2O$$

A student reacts 25.0 $cm^3$ of 0.0100 $mol/dm^3$ aqueous calcium hydroxide with dilute ethanoic acid using thymolphthalein as an indicator.

A volume of 12.5 $cm^3$ of dilute ethanoic acid reacts exactly with the 0.0100 $mol/dm^3$ aqueous calcium hydroxide.

Calculate the concentration, in $mol/dm^3$, of the dilute ethanoic acid.

concentration of dilute ethanoic acid ..... $mol/dm^3$ [3]

**(b)** State the colour of thymolphthalein in aqueous calcium hydroxide.

..... [1]

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

**(i)** Define the term weak in the phrase weak acid.

..... [1]

**(ii)** Write the formula of the ion present in aqueous solutions of acids.

..... [1]

**(d)** Dilute ethanoic acid reacts with sodium carbonate.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$

Calculate the volume, measured at r.t.p., of carbon dioxide produced, in $cm^3$, when 3.18 g of sodium carbonate reacts with excess dilute ethanoic acid.

volume of carbon dioxide ..... $cm^3$ [2]

**(e)** Sulfur dioxide contributes to acid rain.

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

..... [1]

**(ii)** Describe **one** method of reducing the amount of sulfur dioxide getting into the air.

..... [1]

**(iii)** In the Contact process, sulfur dioxide reacts with oxygen.

Complete the symbol equation for this reaction.

$$2SO_2 + O_2 \rightleftharpoons .....$$ [1]

[Total: 11]

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**8** **(a)** Ethanoic acid is manufactured from methanol.

$$CH_3OH(g) + CO(g) \rightleftharpoons CH_3COOH(g)$$

The forward reaction is exothermic.

**(i)** Predict and explain the effect, if any, on the position of equilibrium when the pressure is decreased and the temperature remains constant.

.....

.....

..... [2]

**(ii)** Predict and explain the effect, if any, on the position of equilibrium when the temperature is decreased and the pressure remains constant.

.....

..... [1]

**(b)** Ethanoic acid can be produced by bacterial oxidation.

Describe one other method of making ethanoic acid by oxidising an alcohol other than methanol.

name of alcohol .....

name of oxidising agent .....
[2]

**(c)** Ethanoic acid reacts with propan-1-ol, $CH_3CH_2CH_2OH$, to produce an ester.

Name the ester and draw its displayed formula.

name .....

displayed formula

[2]

[Total: 7]

**9** **(a)** Table 9.1 shows the melting points and relative electrical conductivities of three elements.

**Table 9.1**

| | carbon (graphite) | magnesium | phosphorus |
|---|---|---|---|
| melting point / °C | 3652 | 649 | 44 |
| relative electrical conductivity of solid | good | good | poor |

Use ideas about structure and bonding to explain:

**(i)** the difference in the melting points of magnesium and phosphorus

.....

.....

.....

.....

..... [3]

**(ii)** the difference in the electrical conductivities of graphite and phosphorus.

.....

.....

..... [2]

**(b)** Diamond and graphite are different forms of carbon.

Explain, in terms of its structure and bonding, why diamond is used in cutting tools.

.....

.....

..... [2]

**(c)** A compound of phosphorus, oxygen and chlorine contains 20.2% phosphorus, 10.4% oxygen and 69.4% chlorine by mass.

Deduce the empirical formula of this compound.

empirical formula ..... [2]

[Total: 9]

## 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.).