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.

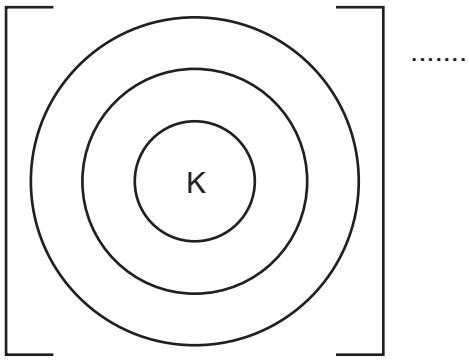

Fig. 2.1 [2]

(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.

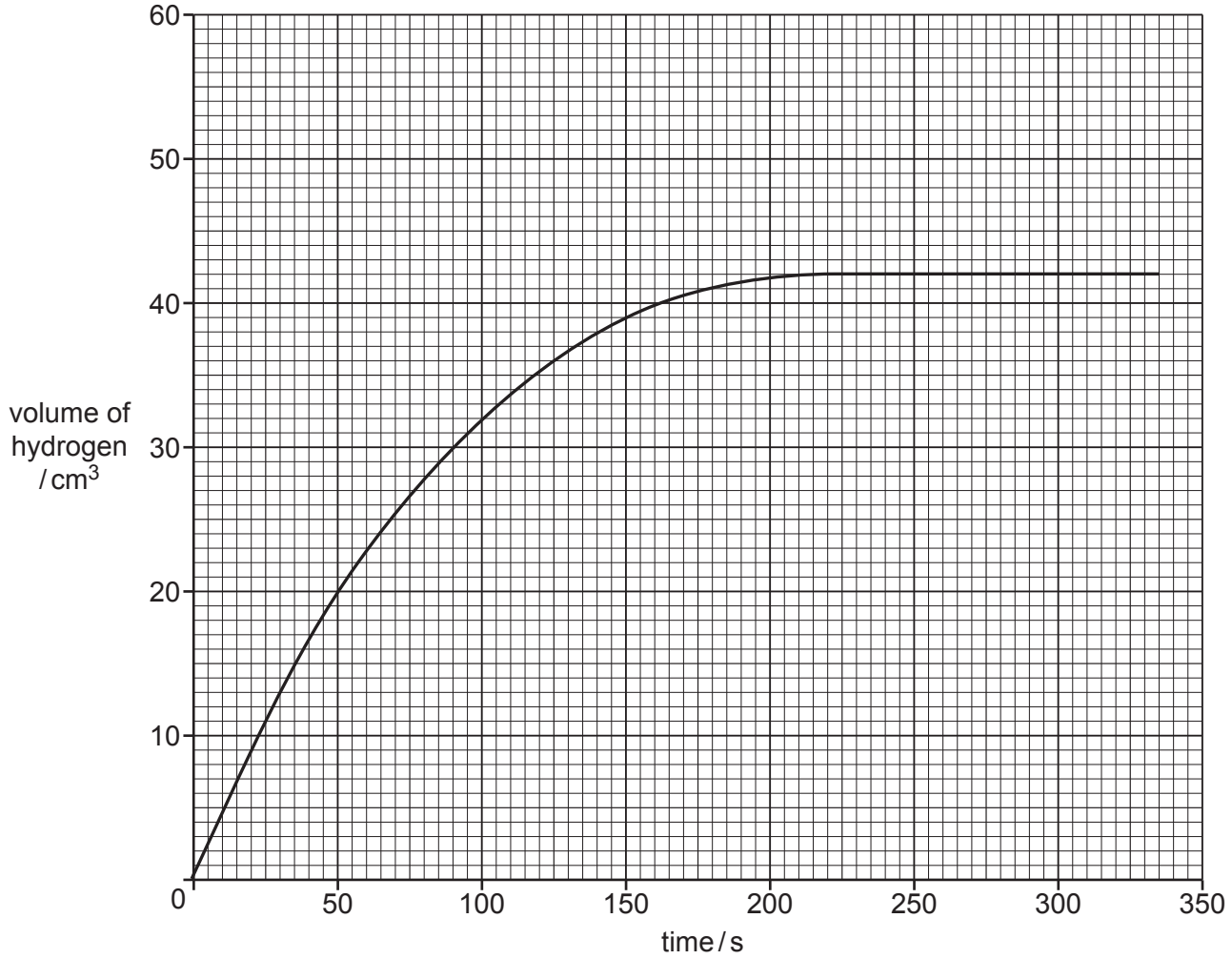

Fig. 3.1

(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.

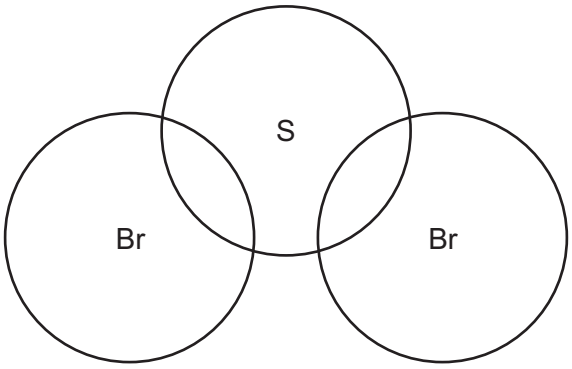

Fig. 4.1 [2]

[Total: 10]

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

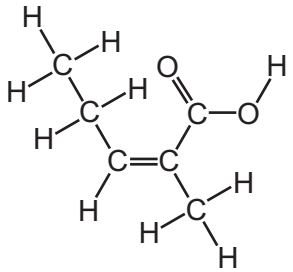

Fig. 5.1

(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**.

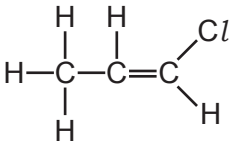

Fig. 5.2

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.

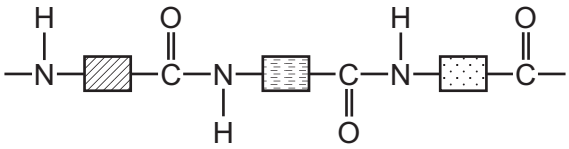

Fig. 5.3

(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]

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.

$$2SO_2 + O_2 \rightleftharpoons \text{.....}$$ [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]

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(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]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

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 –

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.).

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