Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

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.

ammonia

ethanol

glucose

magnesium chloride

magnesium oxide

methane

nitrogen dioxide

phosphorus(V) chloride

poly(ethene)

sodium bromide

water

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

Identify the compound that:

(a) is a waste gas from digestion in animals

..... [1]

(b) turns blue cobalt(II) chloride pink

..... [1]

(c) reacts with ethene above 100 °C to produce ethanol

..... [1]

(d) is a product of photosynthesis

..... [1]

(e) contains an anion with a charge of –2.

..... [1]

[Total: 5]

2 This question is about metals.

(a) Chromium is a transition element.

Sodium is an element in Group I of the Periodic Table.

State **two** physical properties of chromium that are different to those of sodium.

1 .....

2 .....
[2]

(b) Deduce the number of protons and neutrons in the chromium atom shown.

$^{53}_{24}Cr$

number of protons .....

number of neutrons .....
[2]

(c) Chromium(III) oxide, Cr_2O_3, reacts with carbon and chlorine to produce chromium(III) chloride, $CrCl_3$, and carbon monoxide.

Construct the symbol equation for this reaction.

..... [2]

(d) Complete the diagram in Fig. 2.1 to show the electronic configuration of a sodium ion. Include the charge on the ion.

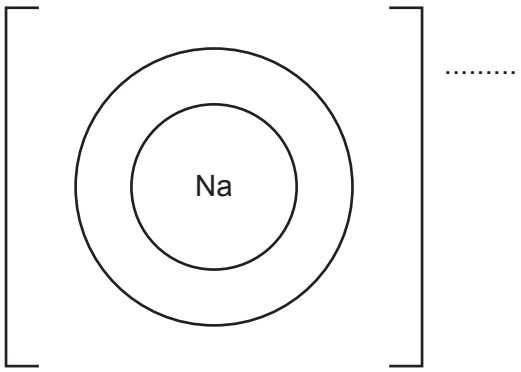


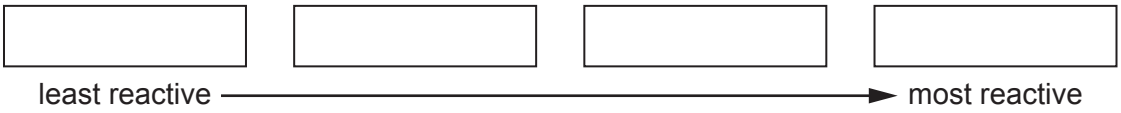
Fig. 2.1 [2]

(e) Table 2.1 shows the observations made when four different metals are heated in oxygen.

Table 2.1

metal	observations
lanthanum	forms a layer of oxide rapidly on the surface but does not burn
mercury	does not form a layer of oxide on the surface
nickel	forms a layer of oxide slowly on the surface but does not burn
sodium	burns rapidly

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



[1]

(f) Aluminium is used in food containers and overhead electrical cables because it is resistant to corrosion.

(i) Explain why aluminium is resistant to corrosion.

.....

..... [2]

(ii) State two **other** reasons why aluminium is used in overhead electrical cables.

1 .....

2 .....

[2]

[Total: 13]

3 A student investigates the reaction of large pieces of calcium carbonate with dilute hydrochloric acid at 25 °C. The hydrochloric acid is in excess.

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

$CaCO_3$(.....) + 2HC*l*(.....) → $CaCl_2$(aq) + H_2O(.....) + CO_2(g) [2]

(b) Fig. 3.1 shows the volume of carbon dioxide gas released as the reaction proceeds.

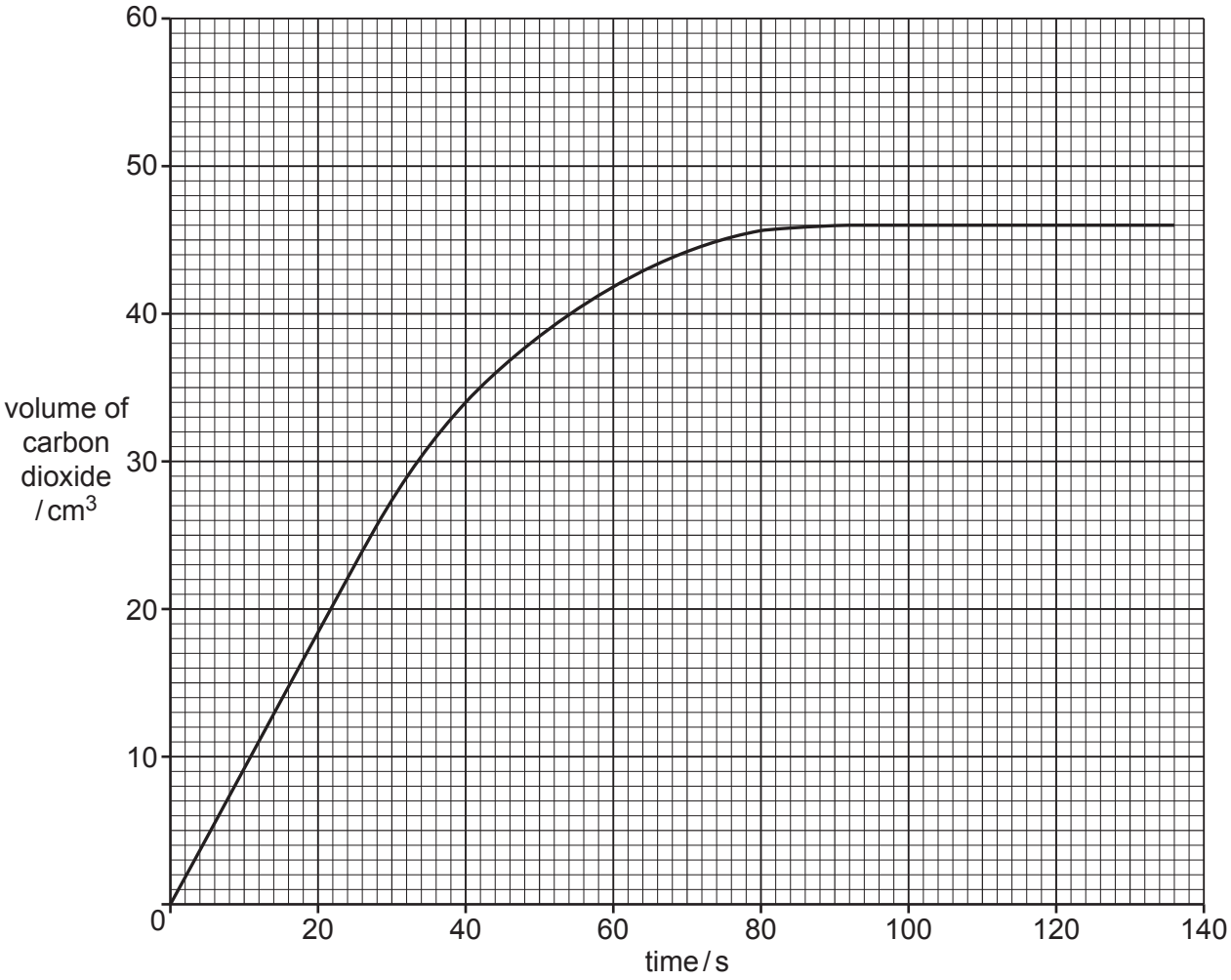


Fig. 3.1

(i) Deduce the volume of carbon dioxide gas released after 40 seconds.

volume ..... cm^3 [1]

(ii) The student repeats the experiment using the same mass of smaller pieces of calcium carbonate.

All other conditions stay the same.

Draw a line on the grid in Fig. 3.1 to show how the volume of carbon dioxide changes when smaller pieces of calcium carbonate are used. [2]

(c) The student repeats the experiment at 20 °C.

All other conditions stay the same.

Describe and explain, using collision theory, how the rate of reaction differs when a temperature of 20 °C is used.

.....

.....

.....

..... [2]

(d) A sample of carbon dioxide 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 increasing the pressure in the gas syringe decreases the volume of gas when the temperature stays the same.

.....

..... [1]

[Total: 8]

4 **(a)** Concentrated aqueous magnesium iodide is electrolysed using graphite electrodes.

Predict the product at each electrode.

anode .....

cathode .....
[2]

(b) Molten magnesium iodide is electrolysed using graphite electrodes.

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

anode .....

cathode .....
[2]

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

test .....

observations .....
[2]

(d) Iodide ions reduce manganese(IV) oxide, MnO_2, to Mn^{2+} ions.

$$2I^- + MnO_2 + 4H^+ \longrightarrow Mn^{2+} + I_2 + 2H_2O$$

(i) Explain, in terms of movement of electrons, how iodide ions act as a reducing agent in this reaction.

.....

..... [1]

(ii) State the name of the type of reaction that involves simultaneous oxidation and reduction.

..... [1]

(e) Phosphorus(III) iodide is produced when phosphorus reacts with iodine.

Complete Fig. 4.1 to show the dot-and-cross diagram for a molecule of phosphorus(III) iodide.

Show only the outer shell electrons.

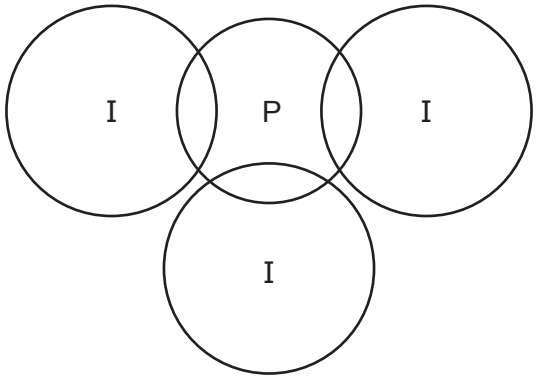


Fig. 4.1 [2]

[Total: 10]

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

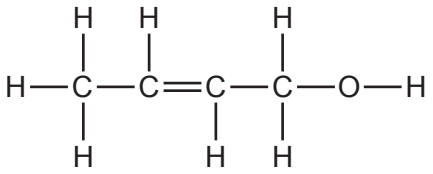


Fig. 5.1

(i) On Fig. 5.1, draw a circle around the functional group that reacts with aqueous bromine. [1]

(ii) Describe the colour change when excess compound **A** is added to a few drops of aqueous bromine in a test tube.

colour of aqueous bromine .....

colour after addition of compound **A** .....
[2]

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

..... [1]

(iv) Compound **A** is a liquid at room temperature.

Describe the motion and separation of the particles in a liquid.

motion .....

separation .....
[2]

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

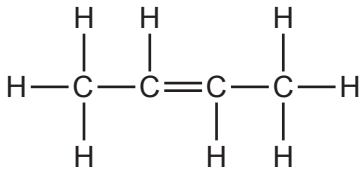


Fig. 5.2

Compound **B** is polymerised.

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

[2]

(c) Describe **two** environmental challenges caused by the disposal of plastics.

1 .....

.....

2 .....

.....

[2]

[Total: 10]

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6 **(a)** Steam reacts with carbon to produce carbon monoxide and hydrogen.

$$\text{steam} + \text{carbon} \rightleftharpoons \text{carbon monoxide} + \text{hydrogen}$$

The forward reaction is endothermic.

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

.....

.....

.....

..... [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 endothermic enthalpy change.

..... [1]

(b) Carbon monoxide, water and carbon dioxide are formed during the incomplete combustion of carbon-containing fuels.

(i) Name **one** other substance formed during the incomplete combustion of carbon-containing fuels.

..... [1]

(ii) State **one** adverse effect of carbon monoxide.

..... [1]

(c) Hydrogen is used in a hydrogen-oxygen fuel cell.

Describe **two** advantages of a hydrogen-oxygen fuel cell compared with a gasoline / petrol engine.

1 .....

.....

2 .....

.....

[2]

[Total: 7]

[Turn over

7 **(a)** Dilute hydrochloric acid reacts with aqueous sodium carbonate.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

A student titrates $20.0\,cm^3$ of $0.0250\,mol/dm^3$ aqueous sodium carbonate with dilute hydrochloric acid using methyl orange as an indicator.

A volume of $15.5\,cm^3$ of dilute hydrochloric acid reacts exactly with the $0.0250\,mol/dm^3$ aqueous sodium carbonate.

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

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

(b) **(i)** State the colour of methyl orange in alkaline solution.

..... [1]

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

..... [1]

(c) Calculate the volume, measured at r.t.p., of carbon dioxide produced, in cm^3, when 2.65 g of sodium carbonate reacts with excess hydrochloric acid.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

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

(d) Hydrochloric acid is a strong acid.

Define the term strong in the phrase strong acid.

..... [1]

(e) Oxides of nitrogen contribute to acid rain.

(i) State **one** other adverse effect of oxides of nitrogen.

..... [1]

(ii) Oxides of nitrogen are removed from car exhausts by catalytic converters.

Complete the symbol equation for the reaction that occurs in catalytic converters.

$$2CO + 2NO \rightarrow \text{.....} + \text{.....}$$ [2]

[Total: 11]

8 **(a)** The equation for the reaction of carbon monoxide with hydrogen at a high temperature in a closed container is shown.

$$CO(g) + 2H_2(g) \rightleftharpoons \underset{\text{methanol}}{CH_3OH(g)}$$

The forward reaction is exothermic.

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

.....

.....

..... [2]

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

.....

..... [1]

(b) Methanol reacts with ethanoic acid, CH_3COOH, to produce an ester.

Name the ester and draw its displayed formula.

name .....

displayed formula

[2]

(c) Methanol is a member of the alcohol homologous series.

Describe **two** general characteristics of a homologous series.

1 .....

.....

2 .....

.....

[2]

[Total: 7]

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

Table 9.1

	calcium	carbon (diamond)	iodine
melting point / °C	839	3550	114
relative electrical conductivity of solid	good	poor	poor

Use ideas about structure and bonding to explain:

(i) the difference in the melting points of diamond and iodine

.....

.....

.....

.....

..... [3]

(ii) the difference in the electrical conductivities of calcium and iodine.

.....

.....

..... [2]

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

Explain, in terms of its structure, why graphite is a lubricant.

.....

.....

..... [2]

(c) A compound of sodium, iodine and oxygen contains 11.62% sodium, 64.14% iodine and 24.24% oxygen 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.).