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Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

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CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2024**

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 **(a)** Fig. 1.1 shows the electronic configurations of five atoms, **A**, **B**, **C**, **D** and **E**.

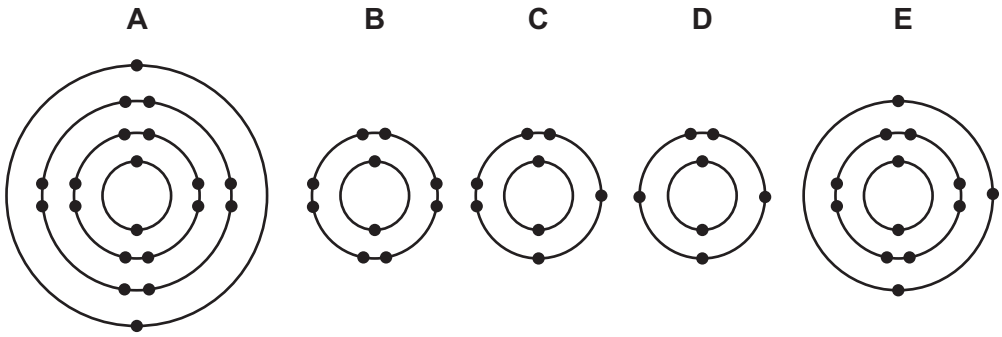

Fig. 1.1

Answer the questions about these electronic configurations.

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

State which electronic configuration, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom of a noble gas

..... [1]

(ii) an atom of an element that is used in food containers because of its resistance to corrosion

..... [1]

(iii) an atom of an element in Group V of the Periodic Table

..... [1]

(iv) an atom of an element in Period 3 of the Periodic Table

..... [1]

(v) an atom that forms a stable ion with a charge of 2–.

..... [1]

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

$^{51}_{23}V$

number of protons .....

number of neutrons .....

[2]

[Total: 7]

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2 Iron is extracted in the blast furnace by the reduction of iron(III) oxide, Fe_2O_3.

This process is made up of three steps.

(a) **(i)** In step 1, carbon burns in air to produce carbon dioxide.

Give one **other** reason why carbon is burned in air in the blast furnace.

..... [1]

(ii) In step 2, carbon monoxide is produced by the reaction of carbon dioxide with carbon.

State **one** adverse effect of carbon monoxide on health.

..... [1]

(iii) In step 3, iron(III) oxide is reduced by carbon monoxide.

Write the symbol equation for this reaction.

..... [1]

(b) Explain why calcium carbonate is added to the blast furnace.

Include any relevant reactions or equations in your answer.

.....

.....

..... [2]

(c) Iron is a transition element.

Transition elements have high melting and boiling points.

State two **other** properties that are typical of transition elements but **not** of Group I metals.

1 .....

2 .....
[2]

(d) Iron is prevented from rusting by galvanising with zinc.

Explain **two** different ways in which zinc prevents rusting.

.....

.....

.....

..... [3]

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(e) The equation shows the reaction of iron with steam in a closed container.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

Predict and explain what happens to the position of equilibrium when the pressure is increased. The temperature remains the same.

prediction .....

explanation .....

.....

[2]

(f) Fe_3O_4 reacts with concentrated hydrochloric acid.

The products are iron(II) chloride, iron(III) chloride and a liquid that turns blue cobalt(II) chloride paper pink.

Construct the symbol equation for this reaction.

..... [2]

[Total: 14]

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3 Fig. 3.1 shows the apparatus used for the electrolysis of dilute sulfuric acid using graphite electrodes.

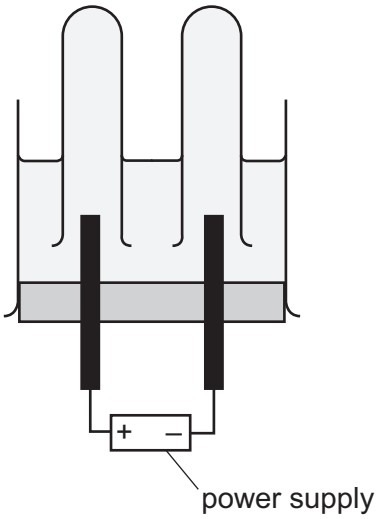

Fig. 3.1

(a) Define the term electrolysis.

.....

..... [2]

(b) Label the anode on Fig. 3.1. [1]

(c) **(i)** Name the product at the cathode.

..... [1]

(ii) Oxygen is formed at the anode.

Construct the ionic half-equation for the reaction at the anode.

..... [1]

(d) Name a suitable element other than graphite that is used for the electrodes in this electrolysis.

..... [1]

[Total: 6]

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4 This question is about alkanes and alkenes.

(a) Butane belongs to the alkane homologous series.

Members of the same homologous series have the same functional group and the same general formula.

State two **other** characteristics of a homologous series.

1 .....

2 .....
[2]

(b) Fig. 4.1 shows the displayed formula of butane.

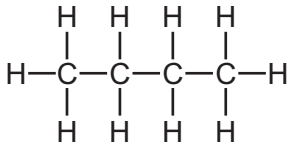

Fig. 4.1

(i) Explain how Fig. 4.1 shows that butane is a saturated compound.

..... [1]

(ii) Give the structural formula of butane.

..... [1]

(c) Nonane, C_9H_{20}, is present in the naphtha fraction from the distillation of petroleum.

(i) State **one** use of the naphtha fraction.

..... [1]

(ii) When nonane is cracked, shorter hydrocarbon molecules are formed.

Construct the symbol equation for a reaction in which nonane is cracked and the only products are propane and ethene.

..... [2]

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(d) Propane reacts with chlorine in the presence of ultraviolet light.

Fig. 4.2 shows the displayed formulae of the reactants and products.

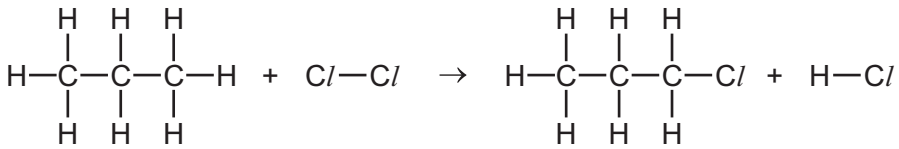

Fig. 4.2

(i) Name the type of chemical reaction that takes place.

..... [1]

(ii) State the purpose of the ultraviolet light in this reaction.

..... [1]

(iii) Calculate the enthalpy change of this reaction in kJ / mol.

Use the bond energies in Table 4.1.

Table 4.1

type of bond	C–C	C–H	C*l*–C*l*	C–C*l*	H–C*l*
bond energy in kJ / mol	347	413	243	346	432

enthalpy change = ... kJ / mol
[3]

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(e) The equation shows the reaction of ethene with chlorine.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

Explain how this equation shows that this reaction is an addition reaction.

.....

..... [1]

[Total: 13]

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5 A student adds large pieces of zinc to dilute hydrochloric acid. The zinc is in excess.

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

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(....) + H_2(....)$$ [1]

(b) Fig. 5.1 shows how the volume of hydrogen changes with time as the reaction proceeds.

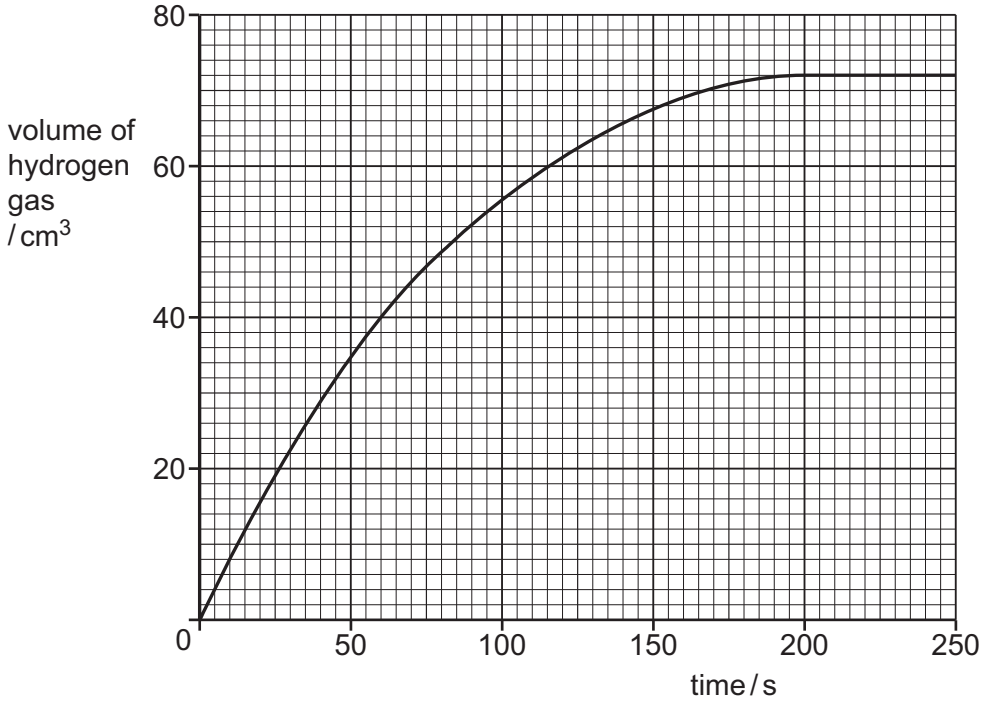

Fig. 5.1

(i) Describe how the shape of the curve in Fig. 5.1 shows that the rate of reaction decreases with time.

.....

.....

..... [1]

(ii) Explain in terms of collision theory why the rate of reaction decreases with time.

.....

.....

..... [2]

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(iii) The student repeats the experiment using the same mass of powdered zinc instead of large pieces of zinc. All other conditions stay the same.

Describe and explain the difference in rate of reaction when powdered zinc is used.

.....

.....

..... [2]

(c) Excess zinc is added to 16.0 cm^3 of 0.400 mol / dm^3 hydrochloric acid.

Calculate the volume of hydrogen gas released measured at room temperature and pressure.

Give your answer to **two** significant figures.

volume of hydrogen gas = ... dm^3 [3]

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(d) The reaction of zinc with hydrochloric acid is exothermic.

Complete the reaction pathway diagram in Fig. 5.2 to show:

- the reactants and products
- a labelled arrow for the activation energy, E_a
- a labelled arrow for the enthalpy change, ΔH.

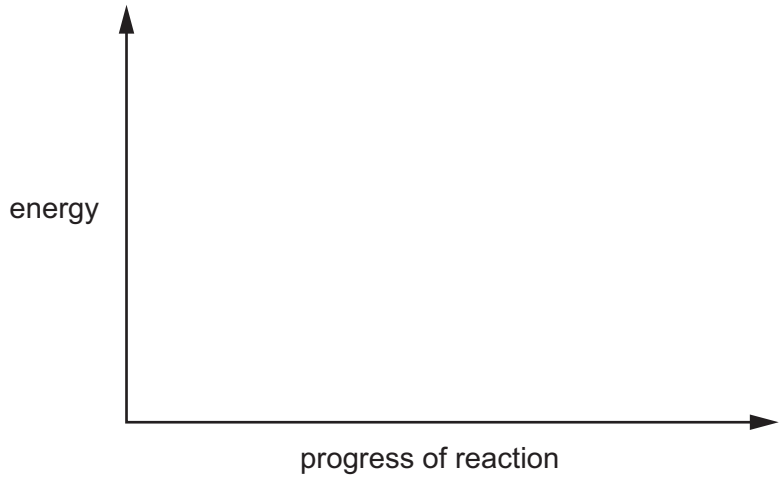

Fig. 5.2

[3]

(e) Describe the observations made when:

- a few drops of aqueous ammonia are added to an aqueous solution containing zinc ions

  .....

- excess aqueous ammonia is added to an aqueous solution containing zinc ions.

  .....

[2]

(f) Describe how to prepare pure, dry crystals of zinc chloride after reacting excess zinc with dilute hydrochloric acid.

.....

.....

.....

.....

..... [3]

[Total: 17]

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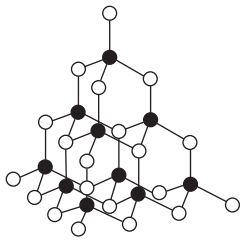
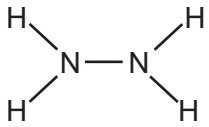
Question 6 starts on page 14.

6 Fig. 6.1 shows the structures of boron nitride and hydrazine.

Boron nitride has a structure similar to diamond.



boron nitride



hydrazine

Key : ● boron atoms
○ nitrogen atoms

Fig. 6.1

(a) Explain why boron nitride has a high melting point.

Use the information in Fig. 6.1.

.....

.....

..... [2]

(b) Explain why hydrazine is a poor electrical conductor.

Use the information in Fig. 6.1.

..... [1]

(c) Complete Fig. 6.2 to show the dot-and-cross diagram for the electronic configuration of hydrazine.

Show only the outer shell electrons.

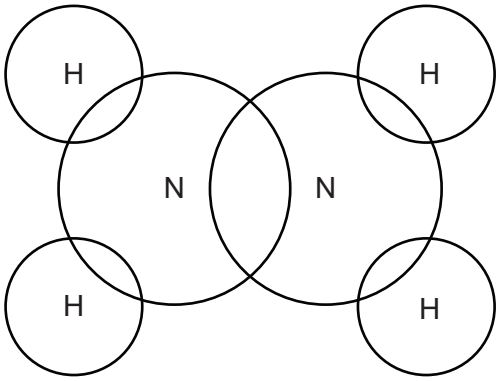


Fig. 6.2

[1]

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(d) The ionic equation for the reaction of nitride ions with water is shown.

$$N^{3-} + 3H_2O \rightarrow NH_3 + 3OH^-$$

(i) The oxidation number of hydrogen in NH_3 is +1.

Deduce the oxidation number of nitrogen in NH_3.

..... [1]

(ii) Explain why this is **not** a redox reaction by referring to the oxidation number of nitrogen.

.....

..... [1]

(e) Boron oxide reacts with magnesium as shown.

$$B_2O_3 + 3Mg \rightarrow 2B + 3MgO$$

8.0 g of boron oxide is reacted with 7.2 g of magnesium.

Show by calculation that boron oxide is in excess.

[3]

[Total: 9]

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7 Esters are represented by the formula $C_nH_{2n}O_2$.

(a) **(i)** State the name given to a formula such as $C_nH_{2n}O_2$.

..... [1]

(ii) Deduce the value of n in the ester propyl ethanoate.

..... [1]

(b) The ester ethyl butanoate is produced by reacting ethanol with butanoic acid.

Draw the displayed formula of ethyl butanoate.

[1]

(c) Fig. 7.1 shows the simplified structures of two molecules that combine to form a polyester.

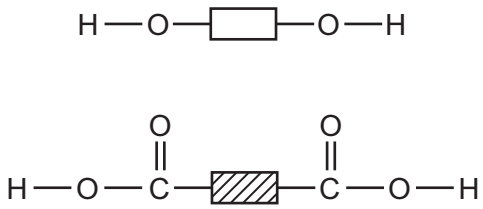

Fig. 7.1

(i) Complete the diagram in Fig. 7.2 to show the structure of two repeat units of this polyester.

Show all of the atoms and all of the bonds in the linkages.

Fig. 7.2

[3]

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(ii) Name the type of polymerisation in this reaction.

..... [1]

(d) PET is a plastic.

Describe the chemical processes involved in converting used PET into a new plastic.

.....

..... [2]

(e) Ethanoic acid reacts with sodium carbonate.

(i) Name the three products of this reaction.

1 .....

2 .....

3 .....
[3]

(ii) Ethanoic acid is a liquid at room temperature.

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

arrangement .....

.....

motion .....

.....
[2]

[Total: 14]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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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