Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/21**

Paper 2 Theory **May/June 2025**

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 **16** pages. Any blank pages are indicated.

DC (KS/CT) 341461/4

[Turn over

1 Choose from the following salts to answer the questions.

aluminium chloride

barium sulfate

calcium chloride

copper(II) sulfate

magnesium chloride

potassium iodide

potassium manganate(VII)

silver nitrate

sodium bromide

sodium sulfite

Each salt can be used once, more than once or not at all.

State which salt:

(a) is prepared using a precipitation reaction

..... [1]

(b) in aqueous solution, reacts with an excess of aqueous ammonia to give a dark blue solution

..... [1]

(c) reacts with warm aqueous sodium hydroxide and aluminium foil to give a gas that turns damp red litmus paper blue

..... [1]

(d) has an aqueous solution that is used to test for an oxidising agent

..... [1]

(e) has an aqueous solution that reacts with copper metal.

..... [1]

[Total: 5]

2 A concentrated aqueous solution of copper(II) bromide is electrolysed using graphite electrodes.

(a) Graphite has good electrical conductivity.

(i) Explain why graphite has good electrical conductivity.

Use ideas about structure and bonding.

.....

.....

.....

..... [2]

(ii) State one **other** property of graphite that makes it suitable for use as an electrode during electrolysis.

..... [1]

(b) Predict the products of the electrolysis of concentrated aqueous copper(II) bromide with graphite electrodes.

product at anode .....

product at cathode .....
[2]

(c) Dilute sulfuric acid is electrolysed using graphite electrodes to form oxygen and hydrogen.

Construct the ionic half-equation for the reaction at each electrode.

reaction at anode .....

reaction at cathode .....
[2]

(d) Hydrogen and oxygen are used in a fuel cell to produce electricity.

(i) Name the only chemical product formed in a fuel cell.

..... [1]

(ii) Describe **one** disadvantage of using hydrogen–oxygen fuel cells in vehicles compared to gasoline or petrol engines.

.....

..... [1]

[Total: 9]

3 The equation for the reaction between methane and chlorine is shown in Fig. 3.1.

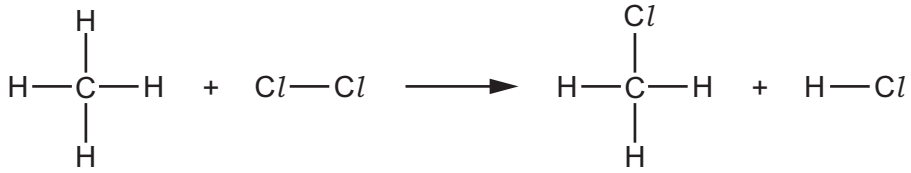

Fig. 3.1

(a) State **one** condition for this reaction.

..... [1]

(b) Explain why this reaction is an example of substitution.

.....

..... [1]

(c) Table 3.1 shows some bond energies.

Table 3.1

bond	bond energy in kJ/mol
C—H	410
C—C*l*	340
C*l*—C*l*	242
H—C*l*	431

Show by calculation that the enthalpy change of the reaction between methane and chlorine, ΔH, is $-119\,kJ/mol$.

[3]

(d) Complete the reaction pathway diagram in Fig. 3.2 for the reaction between methane and chlorine.

Label the:

- reactants
- products
- enthalpy change of the reaction, ΔH
- activation energy, E_a.

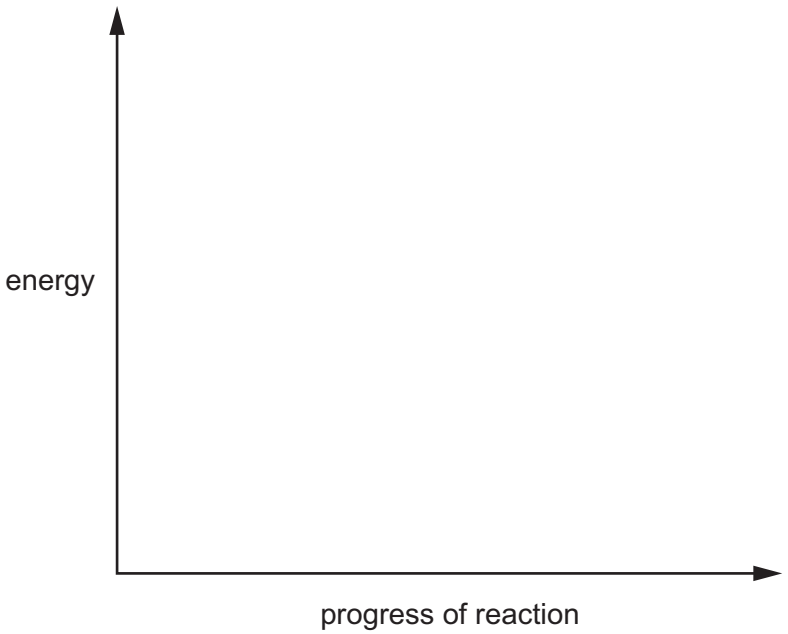

Fig. 3.2

[3]

(e) Draw a dot-and-cross diagram to show the electronic configuration in a molecule of methane.

Show only the outer shell electrons.

[1]

[Total: 9]

4 Ethanol, C_2H_5OH, is a member of the homologous series of alcohols.

(a) Give the general formula of the homologous series of alcohols.

..... [1]

(b) Members of a homologous series have the same general formula and share similar chemical properties.

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

1 .....

2 .....
[2]

(c) The equation for the reaction between ethanol and sodium is shown.

$$2Na + 2C_2H_5OH \rightarrow H_2 + 2C_2H_5ONa$$

A sample of 1.35 g of sodium is added to excess ethanol.

(i) Calculate the volume of hydrogen formed measured at room temperature and pressure.

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

volume = ... dm^3 [3]

(ii) Water is added to the reaction mixture to make an aqueous solution.

A few drops of litmus are then added. The litmus changes colour to blue.

Suggest the name of the ion present in the aqueous solution responsible for the colour change.

..... [1]

(d) State **two** uses for ethanol.

1 .....

2 .....
[2]

(e) Describe the manufacture of ethanol from ethene.

Include the other reactant and the conditions for the manufacture.

.....

.....

.....

.....

..... [3]

[Total: 12]

5 Vehicles that use petrol as a fuel produce several air pollutants.

(a) Petrol is a mixture of hydrocarbons which includes octane, C_8H_{18}.

Explain why octane is a hydrocarbon.

.....

..... [1]

(b) Two of the air pollutants produced are carbon monoxide and nitrogen monoxide.

(i) Explain how carbon monoxide, CO, is formed in a petrol engine.

Include a symbol equation.

.....

.....

..... [2]

(ii) Explain how nitrogen monoxide, NO, is formed in a petrol engine.

Include a symbol equation.

.....

.....

..... [2]

(c) A catalytic converter removes most of the CO and NO formed in a petrol engine.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

(i) Explain why this reaction involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

(ii) The reaction is catalysed using platinum metal.

Explain how a catalyst increases the rate of a reaction.

.....

..... [1]

(iii) State and explain the effect of increasing the temperature on the rate of this reaction.

.....

.....

..... [2]

(iv) State and explain the effect of decreasing the pressure on the rate of this reaction.

.....

.....

..... [2]

[Total: 12]

6 Chlorine, Cl_2, is in Group VII of the Periodic Table.

(a) The melting point of chlorine is –101 °C and the boiling point is –35 °C.

(i) Explain why chlorine is a liquid at –50 °C.

.....

..... [1]

(ii) Describe the arrangement and motion of chlorine molecules at –50 °C.

.....

.....

.....

..... [3]

(b) A sample of chlorine gas contains 1.204×10^{20} molecules.

One mole of chlorine gas contains 6.02×10^{23} molecules.

Calculate the mass of this sample of chlorine gas.

mass of chlorine = ... g [2]

(c) The ionic equation for the reaction of chlorine with cold dilute aqueous sodium hydroxide is shown.

$$Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$$

(i) State the oxidation number of chlorine in Cl_2 and in Cl^-.

Cl_2 .....

Cl^- .....

[2]

(ii) During the reaction chlorine is reduced.

Explain why, using ideas about electrons.

.....

..... [1]

(d) Chlorine reacts with cold water to form an equilibrium mixture containing the acids HCl(aq) and HOCl(aq).

The forward reaction releases thermal energy into the surroundings.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HCl(aq) + HOCl(aq)$$

(i) The temperature of the equilibrium mixture is increased.

State and explain what happens to the acidity of the equilibrium mixture.

statement .....

explanation .....

.....

.....

[2]

(ii) HCl(aq) is a strong acid and HOCl(aq) is a weak acid.

Describe the difference between a strong acid and a weak acid.

.....

.....

..... [2]

(e) A chloride of iron contains 34.5% iron by mass.

Calculate the empirical formula of this chloride.

Show your working.

empirical formula ..... [3]

[Total: 16]

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7 Aluminium is used in the manufacture of aircraft and food containers.

Aluminium is resistant to corrosion by water and oxygen.

(a) Give one **other** reason why aluminium is used in the manufacture of aircraft.

..... [1]

(b) Explain why aluminium is resistant to corrosion by water and oxygen.

.....

.....

..... [2]

(c) Aluminium metal reacts with hot dilute sulfuric acid to form hydrogen and aqueous aluminium sulfate as the only products.

Construct the symbol equation for this reaction.

Include state symbols.

..... [2]

(d) Aluminium oxide reacts with sulfuric acid and with the alkali aqueous sodium hydroxide.

State the name of the type of oxide that reacts with both acids and alkalis.

..... [1]

[Total: 6]

8 Fig. 8.1 shows the displayed formula of methylbut-2-enoate.

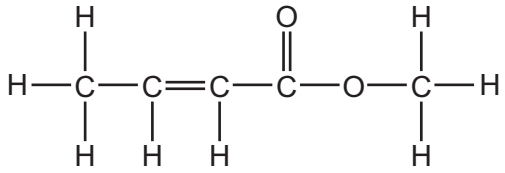

Fig. 8.1

(a) Methylbut-2-enoate is an unsaturated ester.

(i) Explain why methylbut-2-enoate is unsaturated.

.....

..... [1]

(ii) Describe a chemical test to show that methylbut-2-enoate is unsaturated.

.....

.....

..... [2]

(b) Methylbut-2-enoate is made by the reaction of an alcohol and a carboxylic acid in the presence of a catalyst.

(i) State the name of the type of catalyst used in this reaction.

..... [1]

(ii) State the name of the alcohol used in this reaction.

..... [1]

(iii) Draw the displayed formula of the carboxylic acid used in this reaction.

[1]

(c) Methylbut-2-enoate is a monomer used to make an addition polymer.

(i) Draw the structure of this addition polymer.

Include at least **two** repeat units.

[2]

(ii) A sample of 80 g of methylbut-2-enoate is reacted to make the addition polymer.

There is a 100% yield.

State the mass of addition polymer made.

Explain your answer.

mass of addition polymer = ... g

explanation .....

.....

[2]

(d) Fig. 8.2 shows compound **B**.

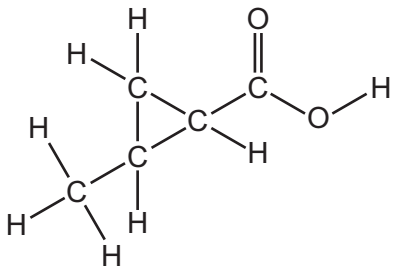

Fig. 8.2

Explain why methylbut-2-enoate and compound **B** are a pair of structural isomers.

.....

..... [1]

[Total: 11]

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.).