International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8153300647

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 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.

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[Turn over

1 Choose from the following compounds to answer the questions.

compound A CH_3OH

compound B $CH_3—CH_2OH$

compound C



compound D $CH_3—CH=CH_2$

compound E $CH_3—CH_2—COOCH_3$

compound F $CH_3—CH_2—CH_2—CH_2—COOH$

compound G $CH_3—CH=CH—COOCH_3$

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

(a) State which compound:

(i) is methanol

..... [1]

(ii) is manufactured by the fermentation of aqueous glucose

..... [1]

(iii) is a carboxylic acid

..... [1]

(iv) is a saturated hydrocarbon

..... [1]

(v) is formed by the reaction between methanol and propanoic acid.

..... [1]

(b) State which **two** compounds have the same molecular formula.

..... and ..... [1]

[Total: 6]

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2 A sample of sulfur found on the planet Mars contains four isotopes.

Table 2.1 shows the percentage abundances of these four isotopes.

Table 2.1

isotope	percentage abundance
$^{32}_{16}S$	95.04
$^{33}_{16}S$	0.75
$^{34}_{16}S$	4.20
$^{36}_{16}S$	0.01

(a) Describe **one** difference between the isotopes $^{32}_{16}S$ and $^{33}_{16}S$.

..... [1]

(b) Explain why all the isotopes of sulfur have the same chemical properties.

.....

..... [1]

(c) Show by calculation that the relative atomic mass of sulfur for this sample is 32.09.

[2]

[Total: 4]

3 Sodium hydrogencarbonate decomposes when heated.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(a) Fig. 3.1 shows the reaction pathway diagram for the decomposition of sodium hydrogencarbonate.

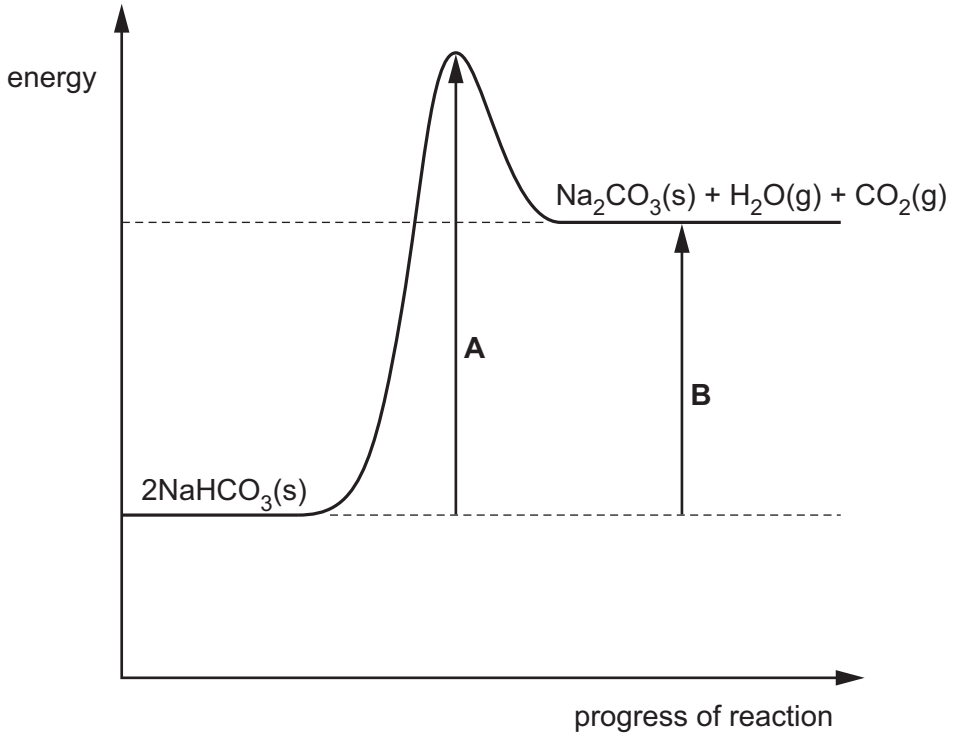


Fig. 3.1

(i) Identify the energy changes labelled **A** and **B**.

energy change **A** .....

energy change **B** .....

[2]

(ii) Use the reaction pathway diagram to explain why the decomposition of sodium hydrogencarbonate is endothermic.

.....

..... [1]

(b) Describe a chemical test for carbon dioxide.

test .....

observation if carbon dioxide present .....

.....

[1]

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(c) A sample of sodium hydrogencarbonate is completely decomposed.

A total volume of 230 cm^3 of carbon dioxide, measured at r.t.p., is produced.

Calculate the mass of the sample of sodium hydrogencarbonate.

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

mass of sodium hydrogencarbonate = ... g [3]

[Total: 7]

4 Fluorine, chlorine, bromine and iodine are elements in Group VII.

(a) Bromine has a low boiling point. It is a liquid at room temperature.

(i) Describe the arrangement and motion of molecules in liquid bromine.

.....

.....

.....

..... [2]

(ii) Explain why bromine has a low boiling point.

Use ideas about structure and bonding.

.....

..... [1]

(b) Fluorine reacts with potassium to make the ionic compound potassium fluoride.

(i) Suggest **two** physical properties of potassium fluoride.

1. .....

2. .....
[2]

(ii) Construct the ionic half-equation to show the formation of potassium ions from potassium atoms.

..... [1]

(iii) Construct the ionic half-equation to show the formation of fluoride ions from fluorine molecules.

..... [1]

(c) Chlorine gas is bubbled into aqueous potassium iodide. A reaction takes place.

Chlorine is an oxidising agent.

(i) Name the **two** products of this reaction.

..... [1]

(ii) Describe the observations made during the reaction.

..... [1]

[Total: 9]

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5 Nickel is a transition element.

(a) Nickel has good electrical conductivity and good thermal conductivity.

Nickel is also ductile and malleable.

State two **other** physical properties of nickel that are typical of a transition element.

1. .....

2. .....
[2]

(b) The physical properties of nickel can be explained using ideas about structure and bonding.

(i) Explain why nickel has good electrical conductivity.

.....

..... [1]

(ii) Explain why nickel is ductile.

.....

..... [1]

(c) Compound **X** contains nickel, carbon and oxygen only.

X contains 28.1% by mass carbon and 37.4% by mass oxygen.

Calculate the empirical formula of compound **X**.

empirical formula = ... [3]

(d) Nickel reacts slowly with dilute hydrochloric acid to form aqueous nickel(II) ions and hydrogen.

(i) Construct the ionic equation for this reaction.

Include state symbols in your answer.

..... [2]

(ii) Predict if nickel reacts with aqueous copper(II) ions.

Explain your answer.

prediction .....

explanation .....

.....

[1]

[Total: 10]

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6 This question is about an unsaturated hydrocarbon called ethyne.

Fig. 6.1 shows the displayed formula of ethyne.

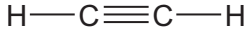


Fig. 6.1

(a) Draw a dot-and-cross diagram to show the electronic arrangement in a molecule of ethyne.

Include only the outer shell electrons of each atom.

[2]

(b) A sample of ethyne gas has a mass of 0.130 g.

(i) Calculate the number of molecules of ethyne in this sample.

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

number of molecules = ... [2]

(ii) Calculate the total number of atoms in this sample of ethyne.

number of atoms = ... [1]

(c) Explain why ethyne is a hydrocarbon.

.....

..... [1]

(d) Suggest the observations when ethyne gas is bubbled into aqueous bromine.

.....

..... [2]

(e) Ethyne is formed when calcium carbide reacts with water.

Calcium carbide contains the ions Ca^{2+} and C_2^{2-} only.

Deduce the formula of calcium carbide.

..... [1]

[Total: 9]

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7 Ethene is used to make ethanol and poly(ethene).

Fig. 7.1 shows the displayed formula of ethene.

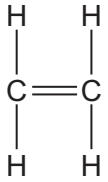


Fig. 7.1

(a) Alkenes such as ethene are manufactured from hydrocarbons such as $C_{12}H_{26}$.

(i) Name this process.

..... [1]

(ii) Describe the conditions used in this process.

.....

..... [2]

(b) Ethene reacts with steam to make ethanol.

This is a reversible reaction.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

(i) Describe and explain the effect of increasing the temperature on the **rate** of the forward reaction.

.....

.....

.....

..... [2]

(ii) Describe and explain the effect of increasing the pressure on the **position of equilibrium** while keeping the temperature constant.

.....

.....

.....

..... [2]

(c) Ethene is used to make the polymer poly(ethene).

This polymer is used to make plastics.

(i) Draw the structure of poly(ethene).

Your structure should show **two** repeat units.

[2]

(ii) State **two** environmental challenges caused by the disposal of poly(ethene).

1 .....

.....

2 .....

.....

[2]

(d) Ethene reacts with hydrogen in the presence of a nickel catalyst.

(i) Explain why this is an example of an addition reaction.

.....

..... [1]

(ii) Draw the displayed formula of the product of this reaction.

[1]

[Total: 13]

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8 Petroleum is a mixture of hydrocarbons most of which are alkanes.

Table 8.1 shows some of the unbranched alkanes present in petroleum and the number of carbon atoms in one molecule of the alkane.

Table 8.1

name	number of carbon atoms in one molecule of the alkane
decane	10
ethane	2
methane	1
pentane	5
tetradecane	14

(a) Deduce the molecular formula of tetradecane.

..... [1]

(b) State the name of the alkane in Table 8.1 that has the highest viscosity.

..... [1]

(c) Petroleum is separated into useful fractions by fractional distillation.

(i) Explain how petroleum is separated by fractional distillation.

.....

.....

.....

.....

..... [3]

(ii) Methane and ethane are both in the refinery gas fraction.

State **one** use for the refinery gas fraction.

..... [1]

(iii) Decane is in the naphtha fraction.

State **one** use for the naphtha fraction.

..... [1]

[Total: 7]

9 Anhydrous copper(II) sulfate is a white solid.

(a) State the meaning of the term anhydrous.

.....

..... [1]

(b) Anhydrous copper(II) sulfate is added to water.

State the colour of the solution formed.

..... [1]

(c) Aqueous ammonia is added dropwise until in excess to a small volume of aqueous copper(II) sulfate.

Describe the observations during this addition.

.....

..... [2]

(d) Describe the observations when aqueous barium nitrate is added to aqueous copper(II) sulfate.

..... [1]

(e) Aqueous copper(II) sulfate is electrolysed separately with carbon electrodes and with copper electrodes.

Complete Table 9.1.

Table 9.1

	electrolysis of aqueous copper(II) sulfate	
	carbon electrodes	copper electrodes
observations at anode		
observations at cathode		

[4]

(f) Explain why aqueous copper(II) sulfate conducts electricity but solid copper(II) sulfate does **not** conduct electricity.

.....

.....

..... [1]

[Total: 10]

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10 Air is a mixture of gases.

(a) State the percentage by volume of oxygen in clean, dry air.

..... [1]

(b) The percentage of carbon dioxide in air is increasing.

(i) State **one** adverse effect of this increasing percentage of carbon dioxide.

..... [1]

(ii) State **one** strategy to reduce this increase in the percentage of carbon dioxide.

..... [1]

(c) Some air pollutants such as sulfur dioxide cause acid rain.

(i) Name one **other** air pollutant that causes acid rain.

..... [1]

(ii) The burning of fossil fuels containing sulfur in power stations produces sulfur dioxide emissions.

Describe **one** way these sulfur dioxide emissions are reduced.

..... [1]

[Total: 5]

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The Periodic Table of Elements

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 –

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.).

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