

**Cambridge IGCSE™**CANDIDATE
NAMECENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY**0620/41**

Paper 4 Theory (Extended)

May/June 2025**1 hour 15 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.





1 A list of substances is shown.

bauxite	calcium oxide	ethanol	graphite	methane
nitrogen	oxygen	propane	propene	sulfur dioxide

Answer the questions using the list of substances.

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

State which of the substances:

(a) is a basic oxide

..... [1]

(b) contains carbon atoms only

..... [1]

(c) is manufactured by fermentation

..... [1]

(d) is produced by the decomposition of vegetation

..... [1]

(e) contains aluminium oxide

..... [1]

(f) causes acid rain

..... [1]

(g) is a simple molecule with 11 atoms

..... [1]

(h) is produced when limestone thermally decomposes in the blast furnace

..... [1]

(i) is a gas that is approximately 21% of clean, dry air

..... [1]

(j) is a monomer in addition polymerisation.

..... [1]

[Total: 10]



2 Atoms are made of electrons, neutrons and protons.

(a) Complete Table 2.1.

Table 2.1

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron	0	
proton		

[2]

(b) Atoms of the same element are known as isotopes.

${}_{19}^{39}\text{K}$ and ${}_{19}^{41}\text{K}$ are isotopes of potassium.

(i) Complete Table 2.2 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.2

isotope	electrons	neutrons	protons
${}_{19}^{39}\text{K}$			
${}_{19}^{41}\text{K}^{+}$			

[3]

(ii) Table 2.3 shows the relative masses and the percentage abundances of the two isotopes in a sample of potassium.

Table 2.3

relative mass of isotope	percentage abundance of isotope
39	90
41	10

Calculate the relative atomic mass of this sample of potassium to **one** decimal place.

relative atomic mass = ... [2]





(iii) An isotope of aluminium has a nucleon number of 27.

Aluminium has a relative atomic mass of 27.

State what conclusion can be made from this information.

.....
 [1]

(c) A calcium atom has the electronic configuration of 2,8,8,2.

Give the formula of one atom and one negative ion that has the same electronic configuration as Ca^{2+} .

- atom
- negative ion [2]

[Total: 10]





3 This question is about copper and compounds of copper.

(a) (i) Describe the bonding in a metallic element such as copper.

.....

.....

.....

.....

..... [3]

(ii) Explain how solid copper conducts electricity.

..... [1]

(b) Copper is in alloys such as brass.

(i) State **one** reason why alloys are more useful than pure metals.

..... [1]

(ii) Name the substance that is present in brass, other than copper.

..... [1]

(c) Copper(II) sulfate crystals are made by the reaction between copper(II) carbonate and dilute sulfuric acid, using the following steps.

The sulfuric acid has a concentration of 0.100 mol/dm^3 .

step 1 Powdered copper(II) carbonate is added to dilute sulfuric acid. The mixture is stirred. A reaction occurs.

step 2 More copper(II) carbonate is added, with stirring, until the reaction stops.

step 3 Unreacted copper(II) carbonate is separated from aqueous copper(II) sulfate by filtration.

step 4 Aqueous copper(II) sulfate is heated until some of the water evaporates.

step 5 The remaining solution is allowed to cool and crystallise.

step 6 The crystals are removed and dried.

(i) Give **two** observations in **step 1**.

1

2 [2]



(ii) State why the reaction stops in **step 2**.

..... [1]

(iii) Name the residue in **step 3**.

..... [1]

(iv) Name a substance, other than copper(II) carbonate, that can be added to dilute sulfuric acid to produce aqueous copper(II) sulfate.

..... [1]

(v) The solution at the end of **step 4** contains the maximum amount of copper(II) sulfate that will dissolve at that temperature.

State the term used to describe this type of solution.

..... [1]

(vi) **Step 1** is repeated using sulfuric acid of concentration 0.200 mol/dm^3 instead of 0.100 mol/dm^3 .

All other conditions are the same.

The rate of reaction increases.

Explain why the rate of reaction increases. Give your answer in terms of particles.

.....

 [2]

(vii) Copper(II) sulfate crystals have the formula $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

State the term used to describe a substance that is chemically combined with water.

..... [1]

[Total: 15]



- 4 This question is about nitrogen and its compounds.

Nitrogen contains molecules with the formula N_2 .

- (a) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in a nitrogen molecule. Show outer-shell electrons only.

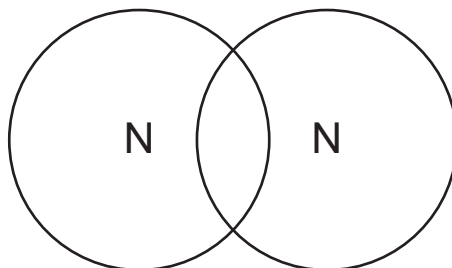


Fig. 4.1

[2]

- (b) Ammonia, NH_3 , is manufactured by reacting nitrogen with hydrogen, H_2 , in the Haber process.

- (i) State **three** typical conditions for the reaction between nitrogen and hydrogen in the Haber process.

- 1
 2
 3

[3]

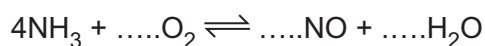
- (ii) Write the symbol equation for the chemical reaction in the Haber process.

..... [1]

- (c) Ammonia is converted into nitric acid in a two-step process.

In step 1, ammonia and oxygen are passed over a catalyst.

- (i) Balance the symbol equation for this reaction.



[1]

- (ii) Give the oxidation number of nitrogen in:

- NH_3
- NO

[2]





(iii) Define oxidation in terms of oxidation number.

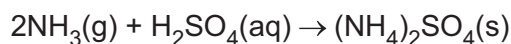
..... [1]

(iv) In step 2, oxygen and water react with NO to produce nitric acid as the only product.

Write a symbol equation for this chemical reaction.

..... [2]

(d) Ammonia is converted into ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$.



360 dm³ of ammonia gas, measured at r.t.p., reacts with excess sulfuric acid.

Calculate the mass of ammonium sulfate produced, using the following steps.

- Calculate the number of moles of $\text{NH}_3(\text{g})$ in 360 dm³.

One mole of any gas occupies 24 dm³ at r.t.p.

..... mol

- Calculate the number of moles of $(\text{NH}_4)_2\text{SO}_4$ produced.

..... mol

- Calculate the mass of $(\text{NH}_4)_2\text{SO}_4$ produced.

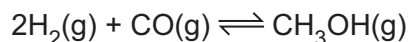
The M_r of $(\text{NH}_4)_2\text{SO}_4$ is 132.

..... g
[3]

[Total: 15]



- 5 Methanol, CH_3OH , is manufactured by the reaction between hydrogen and carbon monoxide. An equilibrium mixture is produced.



- (a) State what happens to the concentration of CH_3OH when the reaction is at equilibrium.

Explain your answer in terms of rate of forward and reverse reactions.

.....

 [2]

- (b) The reaction is carried out at a pressure of 75 atmospheres and a temperature of 250°C .

- (i) State **two** disadvantages of using a pressure **below** 75 atmospheres.

1
 2 [2]

- (ii) Complete Table 5.1 using **only** the words **increases**, **decreases** or **no change**.

Table 5.1

	effect on the concentration of $\text{CH}_3\text{OH}(\text{g})$ at equilibrium	effect on the rate of the reverse reaction
catalyst is added		

[2]

- (iii) If a temperature of more than 250°C is used, the yield of methanol decreases.

State what can be deduced about the forward reaction.

..... [1]

- (iv) Suggest which of the elements from the list is a suitable catalyst for the reaction. Give a reason for your answer.

barium carbon copper potassium sulfur

catalyst

reason

[2]





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

(i) State **two** characteristics of all members of a homologous series.

1

2 [2]

(ii) State the molecular formula of an alcohol that contains five carbon atoms.

..... [1]

(d) Carboxylic acids react with alcohols to form esters.

(i) Draw the displayed formula of an ester which contains three carbon atoms.

[2]

(ii) Butyl ethanoate is an ester.

Name the alcohol and the carboxylic acid that react to produce butyl ethanoate.

alcohol

carboxylic acid [2]

(e) An organic compound has the following composition by mass:

C, 64.87%; H, 13.51%; O, 21.62%.

Calculate the empirical formula of the compound.

empirical formula = ... [2]

[Total: 18]

[Turn over]





6 This question is about the Periodic Table.

(a) State the name given to Group VII elements.

..... [1]

(b) State which Group VII element is most reactive.

..... [1]

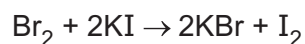
(c) Give the physical state and colour of iodine at room temperature and pressure.

state

colour [2]

(d) When bromine is added to aqueous potassium iodide a displacement reaction occurs.

The equation for the reaction is shown.



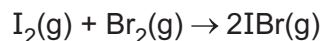
(i) Write an ionic equation for the reaction.

..... [2]



- (ii) Iodine and bromine react at high temperatures to form iodine monobromide, IBr.

The equation is shown.



The structures of the molecules involved in the reaction are I–I, Br–Br and I–Br.

Table 6.1

bond	bond energy in kJ/mol
I–I	150
Br–Br	193
I–Br	175

Calculate the enthalpy change, ΔH , for the reaction using the bond energies in Table 6.1.

Use the following steps.

- Calculate the **total** amount of energy required to break the bonds in 1 mol of $\text{I}_2(\text{g})$ and 1 mol of $\text{Br}_2(\text{g})$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 mol of IBr(g) are formed.

..... kJ

- Calculate the enthalpy change, ΔH , for the reaction.
Your answer should include a sign.

..... kJ/mol
[3]





(e) Sodium is in Group I of the Periodic Table.

When sodium is added to water a chemical reaction occurs.

(i) Give **two** observations when sodium is added to water.

1

2

[2]

(ii) Thymolphthalein is added to the solution when the reaction has finished.

State the final colour of the thymolphthalein in the solution.

..... [1]

[Total: 12]





Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.



The Periodic Table of Elements

Group																					
I	II		1 H hydrogen 1												III	IV	V	VI	VII	VIII	
3 Li lithium 7	4 Be beryllium 9		atomic number atomic symbol name relative atomic mass												5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20	2
	He helium 4																				
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 oganeson —		

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).



CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

0620/42

May/June 2025

1 hour 15 minutes

No additional materials are needed.

- 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.

- 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.

BLANK PAGE

1 Using numbers only, state the:

(a) percentage of nitrogen in clean, dry air

..... [1]

(b) typical operating temperature of the Contact process in °C

..... [1]

(c) number of metals in Period 3 of the Periodic Table

..... [1]

(d) number of halogens which are gases at r.t.p.

..... [1]

(e) typical temperature for the fermentation of aqueous glucose in °C

..... [1]

(f) number of unbranched structural isomers of C_4H_8 which decolourise aqueous bromine

..... [1]

(g) number of covalent bonds in one molecule of ethanol

..... [1]

(h) number of carbon atoms in one molecule of propyl butanoate.

..... [1]

[Total: 8]

2 This question is about covalent compounds.

(a) State what is meant by a covalent bond.

.....
 [2]

(b) Chlorine(I) oxide, Cl_2O , is a simple molecule with covalent bonds.

(i) State what is meant by (I) in the name chlorine(I) oxide.

..... [2]

(ii) Complete the dot-and-cross diagram in Fig. 2.1 of a molecule of chlorine(I) oxide.

Show outer electrons only.

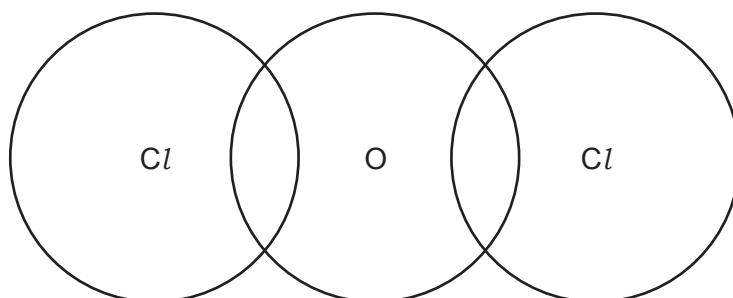


Fig. 2.1

[3]

(iii) Explain, in terms of structure and bonding, why Cl_2O boils at a low temperature and does **not** thermally decompose into its constituent elements, Cl_2 and O_2 .

.....

 [3]

(iv) Give **two** reasons why liquid Cl_2O is a poor conductor of electricity.

1
 2 [2]

(c) Carbon and silicon(IV) oxide both exist as giant covalent structures.

(i) Name a giant covalent structure of carbon which conducts electricity.

..... [1]

(ii) Identify the particles responsible for the conduction of electricity in this covalent structure of carbon.

..... [1]

(iii) Silicon(IV) oxide contains silicon atoms, Si, and oxygen atoms, O.

Fig. 2.2 shows part of the giant covalent structure of silicon(IV) oxide.

Complete the diagram in Fig. 2.2 by adding the symbol for each of the 9 atoms shown.

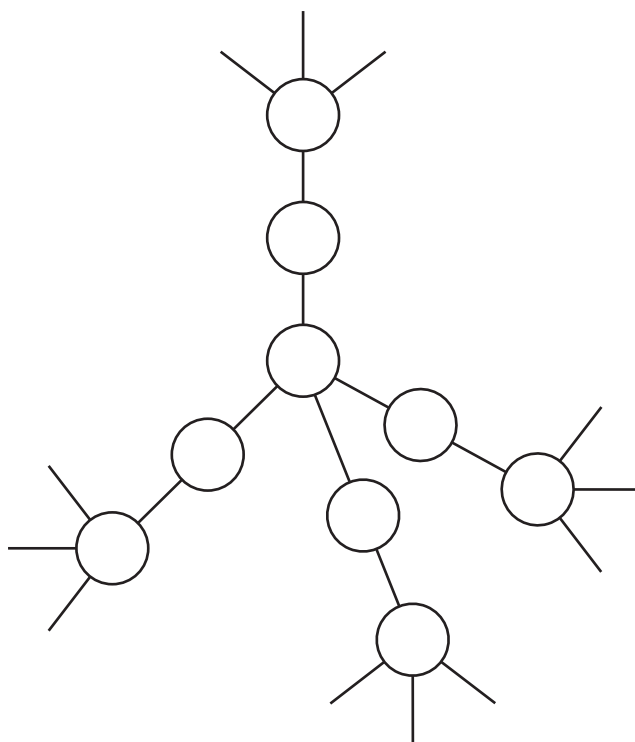


Fig. 2.2

[2]

[Total: 16]

3 This question is about electrolysis.

(a) Complete the definition of electrolysis by filling in the missing words.

The decomposition of compounds when
or by the passage of an electric current.

[3]

(b) Electrolysis of aqueous copper(II) sulfate is carried out using the apparatus shown in Fig. 3.1. The electrodes are made of platinum.

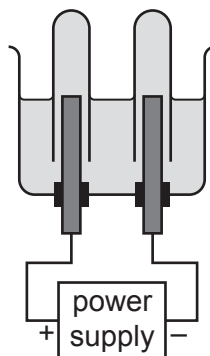


Fig. 3.1

(i) State whether the mass of the cathode increases, decreases or remains the same when platinum electrodes are used.

..... [1]

(ii) Describe the change in appearance, if any, of the electrolyte when platinum electrodes are used.

..... [1]

(iii) Describe what is seen at the anode when platinum electrodes are used.

..... [1]

(iv) Write the ionic half-equation for the reaction at the anode.

..... [3]

(c) The electrolysis is repeated using copper electrodes.

(i) State whether the mass of the cathode increases, decreases or remains the same when copper electrodes are used.

..... [1]

(ii) Describe the change in appearance, if any, of the electrolyte when copper electrodes are used.

.....[1]

(d) Aluminium is extracted from its purified ore by electrolysis.

(i) Name this ore of aluminium.

..... [1]

(ii) Name the substance added to this process to reduce the operating temperature.

..... [1]

(iii) Explain why the anodes need to be continually replaced during this process.

.....

..... [2]

[Total: 15]

4 Chromium is the element with atomic number 24 in the Periodic Table.

(a) The main ore of chromium is chromite. Chromite contains FeCr_2O_4 .

FeCr_2O_4 reacts with carbon.

(i) Complete the equation for this reaction.



(ii) Suggest **one** disadvantage of extracting chromium by reacting chromite with carbon.

..... [1]

(b) Chromium can be mixed with nickel and other elements to form stainless steel.

Name the type of substance formed when a metal is mixed with other elements.

..... [1]

(c) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is a compound containing chromium.

The negative ion in $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is $\text{Cr}_2\text{O}_7^{2-}$.

(i) State the sum of the oxidation numbers in the $\text{Cr}_2\text{O}_7^{2-}$ ion.

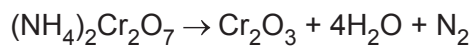
..... [1]

(ii) The oxidation number of each O in $\text{Cr}_2\text{O}_7^{2-}$ ions is -2 .

Determine the oxidation number of each Cr in $\text{Cr}_2\text{O}_7^{2-}$ ions. Show your working.

..... [2]

(iii) When $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is heated the following reaction occurs.



Calculate the volume of nitrogen gas produced at r.t.p., in cm^3 , when 1.26 g of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is heated using the following steps.

The M_r of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ is 252.

- Calculate the number of moles of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ used.

..... mol

- Determine the number of moles of N_2 formed.

..... mol

- Calculate the volume of N_2 formed at r.t.p. in cm^3 .

..... cm^3
[3]

[Total: 9]

5 Alkali metals are reactive elements.

(a) State the group number of the alkali metals.

..... [1]

(b) Identify the alkali metal which:

(i) has the highest melting point

..... [1]

(ii) has the highest density

..... [1]

(iii) has the lowest reactivity

..... [1]

(iv) burns with a lilac flame

..... [1]

(v) is found in fertilisers to improve plant growth.

..... [1]

(c) Sodium sulfide, Na_2S , is an ionic compound.

Complete Fig. 5.1 to show the electronic configurations of the ions in sodium sulfide.

Show the charges on the ions.

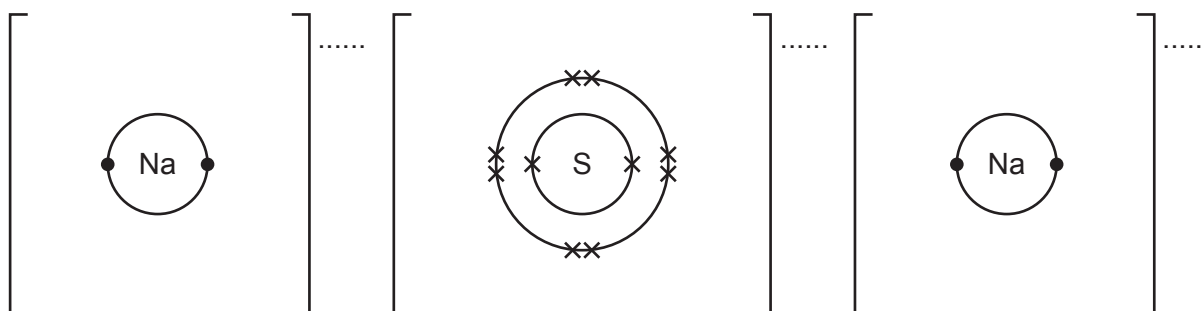


Fig. 5.1

[3]

(d) Rubidium has only two naturally occurring atoms, ^{85}Rb and ^{87}Rb .

(i) State the term given to these naturally occurring atoms of rubidium.

..... [1]

(ii) Complete Table 5.1 to show the number of protons, neutrons and electrons in the atom and ion of rubidium shown.

Table 5.1

	^{85}Rb	$^{87}\text{Rb}^+$
protons		
neutrons		
electrons		

[3]

(iii) The relative atomic mass of rubidium to one decimal place is 85.5.

Determine the relative abundance of ^{85}Rb in rubidium. Express your answer as a percentage.

.....% [1]

[Total: 14]

- 6 Ethene, C_2H_4 , is the first member of a family of similar compounds which contains the alkene functional group.

(a) State the term for a family of similar compounds which contain the same functional group.

..... [1]

(b) Determine the difference in relative molecular mass between C_2H_4 and the next member in this family of similar compounds.

..... [1]

(c) Write the symbol equation for the complete combustion of C_2H_4 .

..... [2]

(d) C_2H_4 reacts with steam to form ethanol.



The process happens in a closed system and the reaction reaches an equilibrium.

The conditions for this process are 300°C and 60 atm pressure. H_3PO_4 is used as a catalyst.

(i) Complete Table 6.1 to show the effect, if any, on the concentration of $\text{C}_2\text{H}_4(\text{g})$ when the following changes to the conditions are applied.

Only use the words **increases**, **decreases** or **no change**.

Table 6.1

change to condition	effect on the concentration of $\text{C}_2\text{H}_4(\text{g})$ at equilibrium
temperature is decreased	
some $\text{C}_2\text{H}_5\text{OH}(\text{g})$ is removed	
pressure is increased	
a more effective catalyst is used	

[4]

(ii) Explain, in terms of collision theory, why the rate of the forward reaction increases if the temperature increases.

.....

.....

.....

.....

..... [3]

(e) Compound **B** has the displayed formula shown in Fig. 6.1.

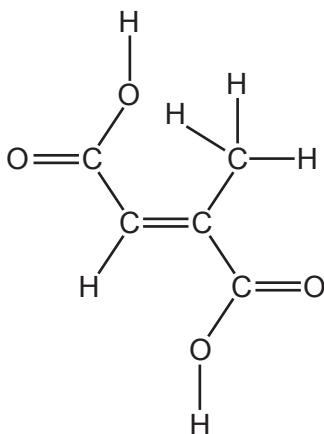


Fig. 6.1

(i) Deduce the molecular formula of compound **B**.

..... [1]

(ii) State why compound **B** is unsaturated.

..... [1]

(iii) Draw the structure of **one** repeat unit of the polymer formed when compound **B** undergoes addition polymerisation.

[2]

(iv) Explain why 1 mol of compound **B** reacts with 2 mol of sodium hydroxide, NaOH.

.....
 [1]

(v) Calculate the volume, in cm^3 , of 0.250 mol/dm^3 NaOH that reacts with 0.100 mol of compound **B**.

volume = ... cm^3 [2]

[Total: 18]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

The Periodic Table of Elements

Group																		
I	II	Key										III	IV	V	VI	VII	VIII	
		atomic number atomic symbol name relative atomic mass																
3 Li lithium 7	4 Be beryllium 9											1 H hydrogen 1	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 dm³ at room temperature and pressure (r.t.p.).

**Cambridge IGCSE™**CANDIDATE
NAMECENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY**0620/43**

Paper 4 Theory (Extended)

May/June 2025**1 hour 15 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.





1 A list of substances is shown.

aluminium oxide calcium oxide chlorine ethanol graphite
nitrogen oxygen propane propene silicon(IV) oxide

Answer the questions using the list of substances.

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

State which of the substances:

(a) is a compound with a giant covalent structure

..... [1]

(b) is an unsaturated hydrocarbon

..... [1]

(c) is an amphoteric oxide

..... [1]

(d) is a good conductor of electricity when solid

..... [1]

(e) contains simple molecules with 9 atoms

..... [1]

(f) react together to form slag in the blast furnace

..... and [2]

(g) belongs to a homologous series whose general formula is C_nH_{2n+2}

..... [1]

(h) is manufactured by the catalytic addition of steam to ethene

..... [1]

(i) is a gas that is approximately 78% of clean, dry air.

..... [1]

[Total: 10]



2 Atoms are made of electrons, neutrons and protons.

(a) State which of these particles are found in the nucleus of an atom.

..... [1]

(b) Atoms of the same element are known as isotopes.

$^{32}_{16}\text{S}$ and $^{34}_{16}\text{S}$ are isotopes of sulfur.

(i) Complete Table 2.1 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.1

isotope	electrons	neutrons	protons
$^{34}_{16}\text{S}$			
$^{32}_{16}\text{S}^{2-}$			

[3]

(ii) Table 2.2 shows the relative masses and the percentage abundances of the two isotopes in a sample of sulfur.

Table 2.2

relative mass of isotope	percentage abundance of isotope
32	95
34	5

Calculate the relative atomic mass of this sample of sulfur to **one** decimal place.

relative atomic mass = ... [2]

(iii) The relative atomic masses of all elements are compared to one atom of an isotope.

Identify this isotope.

..... [1]





(c) Ions are atoms or groups of atoms that have gained or lost one or more electrons.

An oxygen atom has the electronic configuration of 2,6.

Give the formula of **one** atom and **one** positive ion that has the same electronic configuration as O^{2-} .

- atom
- positive ion

[2]

[Total: 9]





3 This question is about zinc and compounds of zinc.

(a) Zinc is held together by electrostatic forces of attraction between particles.

(i) Name the type of bonding in zinc.

..... [1]

(ii) Name the **two** types of particles held together by the bonding in (a)(i).

1

2 [2]

(iii) Name the type of particle whose movement allows zinc to conduct electricity.

..... [1]

(b) Zinc is present in alloys such as brass.

(i) State the meaning of the term alloy.

..... [1]

(ii) Name the substance that is present in brass, other than zinc.

..... [1]

(c) Zinc sulfate crystals are made by the reaction between zinc carbonate and dilute sulfuric acid, using the following steps.

step 1 An excess of powdered zinc carbonate is added to dilute sulfuric acid.

step 2 Excess zinc carbonate is separated from aqueous zinc sulfate by filtration.

step 3 Aqueous zinc sulfate is heated until a saturated solution is formed.

step 4 The saturated solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(i) Give **two** observations which show that the zinc carbonate is in excess in **step 1**.

1

2 [2]

(ii) Name the filtrate in **step 2**.

..... [1]





- (iii) Name a compound, other than zinc carbonate, that can be added to dilute sulfuric acid to produce aqueous zinc sulfate in **step 1**.

..... [1]

- (iv) State what is meant by the term saturated solution.

..... [2]

- (v) **Step 1** is repeated using large pieces of zinc carbonate instead of powdered zinc carbonate.

All other conditions are the same.

The rate of reaction decreases.

Explain why the rate of reaction decreases. Give your answer in terms of particles.

..... [2]

- (vi) Hydrated crystals form in **step 4**.

State what is meant by the term hydrated.

..... [1]

[Total: 15]





4 This question is about compounds of sulfur.

(a) Sulfuric acid is manufactured in a four-stage process.

stage 1 Sulfur dioxide is produced from ores containing sulfur.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

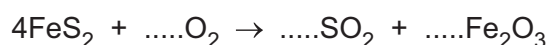
stage 3 Sulfur trioxide reacts with concentrated sulfuric acid to form oleum, $\text{H}_2\text{S}_2\text{O}_7$.

stage 4 Oleum reacts with water to form concentrated sulfuric acid.

(i) Iron pyrite is an ore containing sulfur. The ore contains a compound with the formula FeS_2 .

FeS_2 reacts with oxygen in the air to produce sulfur dioxide.

Balance the symbol equation for this reaction.



[1]

(ii) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in an oxygen molecule, O_2 . Show outer-shell electrons only.

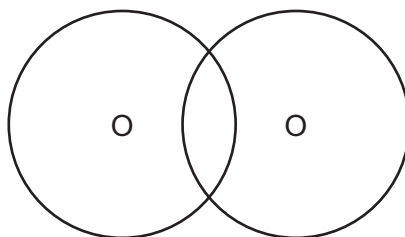


Fig. 4.1

[2]

(b) (i) State **three** typical conditions for the reaction between sulfur dioxide and oxygen in **stage 2**.

1

2

3

[3]



(ii) Write a symbol equation for the reaction that occurs in **stage 2**.

..... [1]

(iii) Write the symbol equation for the reaction in **stage 3**.

..... [1]

(c) Sulfuric acid reacts with carbon. The equation for the reaction is shown.



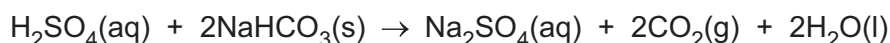
Give the oxidation number of carbon in:

• C

• CO_2

[2]

(d) Dilute sulfuric acid reacts with sodium hydrogencarbonate, NaHCO_3 , to produce carbon dioxide gas, CO_2 .



4.20 g of NaHCO_3 is added to excess dilute sulfuric acid.

Calculate the volume of $\text{CO}_2(\text{g})$, measured at r.t.p., produced using the following steps.

- Calculate the number of moles of NaHCO_3 in 4.20 g.

The M_r of NaHCO_3 is 84.

..... mol

- Deduce the number of moles of $\text{CO}_2(\text{g})$ that are produced.

..... mol

- Calculate the volume of $\text{CO}_2(\text{g})$ produced in cm^3 .

One mole of any gas occupies $24\,000\text{ cm}^3$ at r.t.p.

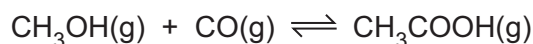
..... cm^3
[3]

[Total: 13]



- 5 Ethanoic acid is manufactured in the reaction between methanol and carbon monoxide.

An equilibrium mixture is produced.



- (a) State **two** characteristics of an equilibrium.

1

2 [2]

- (b) Both a high yield of ethanoic acid and a high rate of reaction are needed.

The reaction is carried out at 300 °C.

The forward reaction is exothermic.

- (i) State the disadvantage of using a temperature:

- below 300 °C

.....

- above 300 °C.

..... [2]

- (ii) Complete Table 5.1 using **only** the words **increases**, **decreases** or **no change**.

Table 5.1

	effect on the equilibrium concentration of $\text{CH}_3\text{COOH}(\text{g})$	effect on the rate of the forward reaction
catalyst is added		increases
pressure is increased		

[3]

- (iii) Suggest which element from the list is a suitable catalyst for the reaction.

Give a reason for your answer.

aluminium

carbon

cobalt

magnesium

sodium

catalyst

reason [2]





(c) Ethanoic acid is a member of the carboxylic acid homologous series.

(i) Name the carboxylic acid that contains only one carbon atom.

..... [1]

(ii) State the molecular formula of a carboxylic acid that contains four carbon atoms.

..... [1]

(d) Carboxylic acids react with alcohols to form esters.

(i) Draw the displayed formula of the ester which contains two carbon atoms.

[2]

(ii) Propyl butanoate is an ester.

Name the carboxylic acid and alcohol that react to produce propyl butanoate.

carboxylic acid

alcohol

[2]

(e) An organic compound has the following composition by mass:

C, 58.82%; H, 9.80%; O, 31.38%.

Calculate the empirical formula of the compound.

empirical formula = ... [3]

[Total: 18]



6 This question is about the Periodic Table.

(a) State the name given to Group I elements.

..... [1]

(b) State which Group I element is least reactive.

..... [1]

(c) Lithium is in Group I of the Periodic Table.

When lithium is added to water a chemical reaction occurs.

(i) Give **two** observations when lithium is added to water.

1

2 [2]

(ii) Write a symbol equation for this reaction.

..... [2]

(d) Group I elements have lower melting points and lower boiling points than transition elements.

Describe **two other** physical properties of Group I elements that are different from transition elements.

1

2 [2]

(e) The Group VII elements are known as the halogens.

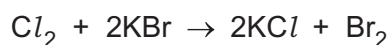
(i) Give the physical state and colour of chlorine at room temperature and pressure.

state

colour [2]

(ii) When chlorine is passed through aqueous potassium bromide, a displacement reaction occurs.

The equation for the reaction is shown.



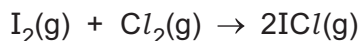
Write an ionic equation for the reaction.

..... [2]



(iii) Iodine and chlorine react at high temperatures to form iodine monochloride, ICl .

The equation for the reaction is shown.



The structures of the molecules involved in the reaction are $\text{I}-\text{I}$, $\text{Cl}-\text{Cl}$ and $\text{I}-\text{Cl}$.

Table 6.1

bond	bond energy in kJ/mol
$\text{I}-\text{I}$	150
$\text{Cl}-\text{Cl}$	242
$\text{I}-\text{Cl}$	218

Calculate the enthalpy change, ΔH , for the reaction using the bond energies in Table 6.1.

Use the following steps.

- Calculate the **total** amount of energy required to break the bonds in 1 mol of $\text{I}_2(\text{g})$ and 1 mol of $\text{Cl}_2(\text{g})$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 mol of $\text{ICl}(\text{g})$ are formed.

..... kJ

- Calculate the enthalpy change, ΔH , for the reaction.
Your answer should include a sign.

..... kJ/mol
[3]

[Total: 15]







Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.



The Periodic Table of Elements

Group																				
I	II											III	IV	V	VI	VII	VIII			
		1 H hydrogen 1																		
		Key atomic number atomic symbol name relative atomic mass																		
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	lanthanoids 57–71				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 —	actinoids 89–103		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 dm³ at room temperature and pressure (r.t.p.).

