



# Cambridge International AS & A Level

**CHEMISTRY**

**9701/12**

Paper 1 Multiple Choice

**October/November 2024**

**1 hour 15 minutes**

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet  
Soft clean eraser  
Soft pencil (type B or HB is recommended)

## INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

## INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages.



1 Which species contains a different number of electrons from the other three?

- A**  $\text{ClO}_4^-$       **B**  $\text{H}_2\text{SO}_4$       **C**  $\text{SO}_4^{2-}$       **D**  $\text{Te}^{2-}$

2 Which factor causes helium to have a higher first ionisation energy than hydrogen?

- A** In the 1s orbital in helium, electrons are paired.  
**B** The lowest energy level in helium is filled.  
**C** The nuclear charge in helium is higher than in hydrogen.  
**D** There is less shielding of the outer shell in helium.

3 A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas. This is the only carbon-containing product formed in the reaction. This methane gas burns completely in  $\text{O}_2$  to form  $\text{H}_2\text{O}$  and  $\text{CO}_2$  only. The volume of  $\text{CO}_2$  produced at room temperature and pressure is  $108 \text{ cm}^3$ .

What is the formula of aluminium carbide?

- A**  $\text{Al}_2\text{C}_3$       **B**  $\text{Al}_3\text{C}_2$       **C**  $\text{Al}_3\text{C}_4$       **D**  $\text{Al}_4\text{C}_3$

4 A reaction between two gases takes place on the surface of the catalytic converter of a petrol-engined car.

In this reaction, four reactant molecules produce three product molecules.

What could be the two reactant gases in this reaction?

- A** nitrogen and carbon dioxide  
**B** nitrogen monoxide and carbon dioxide  
**C** nitrogen monoxide and carbon monoxide  
**D** nitrogen dioxide and carbon monoxide

5 An ion contains 1 nitrogen atom and 2 hydrogen atoms. It has an H–N–H bond angle of approximately  $105^\circ$ .

Which row is correct?

	number of lone pairs around N in ion	overall charge on ion
<b>A</b>	1	+1
<b>B</b>	2	+1
<b>C</b>	1	-1
<b>D</b>	2	-1

- 6 Why does  $ICl$  have a higher boiling point than  $Br_2$ ?
- A because of the difference in the bond energies of the covalent bonds within  $ICl$  and  $Br_2$
- B because of the difference in the polar nature of  $ICl$  and  $Br_2$
- C because of the difference in the number of electrons contained within  $ICl$  and  $Br_2$
- D because of the difference in the relative molecular mass of  $ICl$  and  $Br_2$
- 7 In this question you may assume that nitrogen behaves as an ideal gas. One atmosphere pressure = 101 kPa.

Which volume does 1.0 g of nitrogen occupy at  $50^\circ C$  and a pressure of 2.0 atmospheres?

- A  $70\text{ cm}^3$       B  $150\text{ cm}^3$       C  $470\text{ cm}^3$       D  $950\text{ cm}^3$
- 8 Which statement about the properties associated with the different types of bonding involved is correct?
- A Any covalent compound that contains both oxygen and hydrogen in its molecule forms hydrogen bonds.
- B Ionic bonds and covalent bonds cannot both occur in the same compound.
- C Ionic compounds differ from metals in that ionic compounds do not conduct electricity in the solid state.
- D The only covalent compounds with high melting points are those in which hydrogen bonds occur.
- 9 For which reaction is the enthalpy change an enthalpy change of formation?
- A  $C(g) + 2H_2(g) \rightarrow CH_4(g)$
- B  $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g)$
- C  $Na_2O(s) + SO_3(g) \rightarrow Na_2SO_4(s)$
- D  $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$

- 10 Two standard enthalpy change of formation values are given.

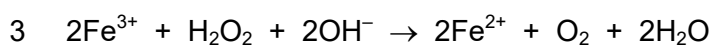
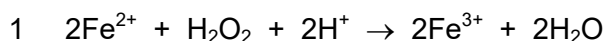
$$\Delta H_f^\ominus [VCl_2] = -452\text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [VCl_3] = -573\text{ kJ mol}^{-1}$$

What is the enthalpy change for the reaction  $3VCl_2 \rightarrow 2VCl_3 + V$ ?

- A  $-210\text{ kJ mol}^{-1}$     B  $-121\text{ kJ mol}^{-1}$     C  $+121\text{ kJ mol}^{-1}$     D  $+210\text{ kJ mol}^{-1}$

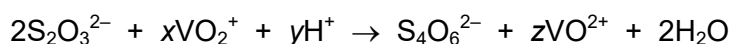
11 Equations for some reactions of hydrogen peroxide are given.



In which reactions is hydrogen peroxide acting as a reducing agent?

- A** 1 and 3      **B** 1 only      **C** 2 and 3      **D** 2 only

12 The equation for the reaction of aqueous thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ , and aqueous dioxo-vanadium ions,  $\text{VO}_2^+$ , is shown.



Which row shows two correct statements about the equation for this reaction?

	comparison of $x$ and $y$ to $z$	change in oxidation number of vanadium
<b>A</b>	$x$ and $z$ are the same value and quarter the value of $y$	from +4 to +5
<b>B</b>	$x$ and $z$ are the same value and quarter the value of $y$	from +5 to +4
<b>C</b>	$x$ and $z$ are the same value and half the value of $y$	from +5 to +4
<b>D</b>	$x$ and $z$ are the same value and half the value of $y$	from +4 to +5

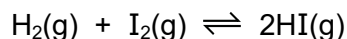
13 When some solid  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  is added to a beaker of water, an equilibrium is set up.



Which compound, when added to the equilibrium mixture, increases the amount of  $\text{Ca}_5(\text{PO}_4)_3\text{OH}(\text{s})$  present?

- A**  $\text{NH}_3$       **B**  $\text{NH}_4\text{Cl}$       **C**  $\text{CH}_3\text{CO}_2\text{H}$       **D**  $\text{NaCl}$

14 Gaseous hydrogen and gaseous iodine react to form gaseous hydrogen iodide.



In an experiment, 2.0 mol of hydrogen and 2.0 mol of iodine are placed in a sealed container of volume  $1.0 \text{ dm}^3$ .

The  $K_c$  value for this reaction under the conditions used is 9.0.

How many moles of hydrogen iodide are present at equilibrium?

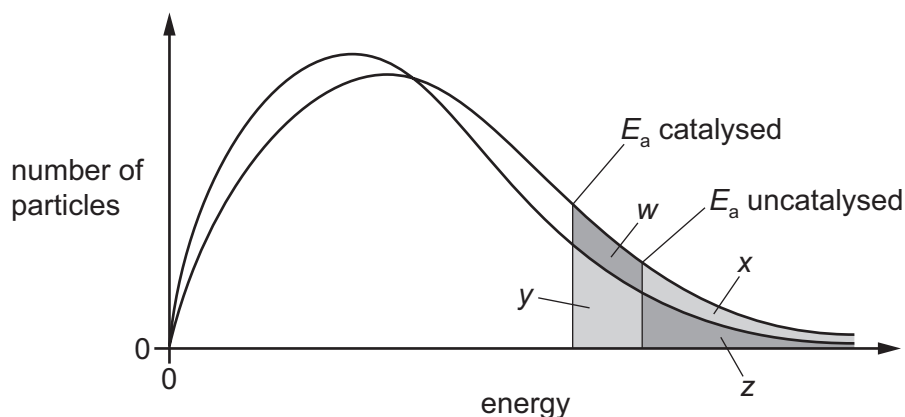
- A** 0.57 mol      **B** 1.2 mol      **C** 1.5 mol      **D** 2.4 mol

15 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

- A** More particles have energy that exceeds the activation energy.  
**B** The particles have more space in which to move.  
**C** The particles move faster.  
**D** There are more frequent collisions between particles.

16 The Boltzmann distribution for a mixture of gases capable of reaction is shown.

The two curves represent the mixture of gases at  $25^\circ\text{C}$  and at  $35^\circ\text{C}$ . The activation energies for the catalysed and uncatalysed reactions are shown.



Which row is correct?

	number of particles with enough energy to react at $25^\circ\text{C}$ in the catalysed reaction	number of particles with enough energy to react at $35^\circ\text{C}$ in the uncatalysed reaction
<b>A</b>	$w + x + y + z$	$z$
<b>B</b>	$w + x + y + z$	$x + z$
<b>C</b>	$y + z$	$z$
<b>D</b>	$y + z$	$x + z$

17 Which oxide is insoluble in aqueous sodium hydroxide?

- A MgO                      B  $Al_2O_3$                       C  $P_4O_{10}$                       D  $SO_2$

18 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O <sub>2</sub>	S + O <sub>2</sub>
<b>A</b>	white flame	blue flame
<b>B</b>	white flame	yellow flame
<b>C</b>	yellow flame	blue flame
<b>D</b>	yellow flame	yellow flame

19 X and Y are elements in Period 3 of the Periodic Table.

Y has a greater atomic number than X.

The stable ion formed by Y has a greater radius than the stable ion formed by X.

The stable ion formed by Y has 18 electrons.

Which row is correct?

	number of electrons in the stable ion of X	element with the greater atomic radius
<b>A</b>	10	X
<b>B</b>	10	Y
<b>C</b>	18	X
<b>D</b>	18	Y

- 20 X is a Group 2 element in either Period 3 or Period 5.  $X(OH)_2$  is less soluble in water than  $Ca(OH)_2$ .

When  $X(NO_3)_2$  is heated, it decomposes.

Which row is correct?

	identity of X	equation describing decomposition of $X(NO_3)_2$
<b>A</b>	Mg	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
<b>B</b>	Mg	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$
<b>C</b>	Sr	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
<b>D</b>	Sr	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$

- 21 Which statement comparing magnesium and barium, or their compounds, is correct?

- A** Magnesium reacts with dilute hydrochloric acid more rapidly than barium does.
- B** One mole of magnesium carbonate gives off a greater amount of gas when it reacts with an excess of dilute hydrochloric acid than one mole of barium carbonate does.
- C** The solubility of magnesium sulfate in water is greater than the solubility of barium sulfate in water.
- D** Magnesium carbonate undergoes thermal decomposition **less** readily than barium carbonate does.

- 22 The colours of the silver halides  $AgCl$ ,  $AgBr$  and  $AgI$  differ.

The solubilities of these halides in aqueous ammonia also differ.

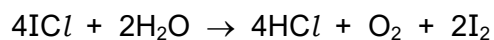
Which row is correct?

	colour of $AgBr$	silver halide that is most soluble in $NH_3(aq)$
<b>A</b>	cream	$AgCl$
<b>B</b>	cream	$AgI$
<b>C</b>	yellow	$AgCl$
<b>D</b>	yellow	$AgI$

23 The name 'chlorate' is used for an anion consisting of chlorine and oxygen only.

In a molecule of  $ICl$ , the iodine atom has oxidation number  $x$  and the chlorine atom has oxidation number  $y$ .

When  $ICl$  is added to  $H_2O$ , iodine is reduced.



Which statement about the value of  $x$  or  $y$  is correct?

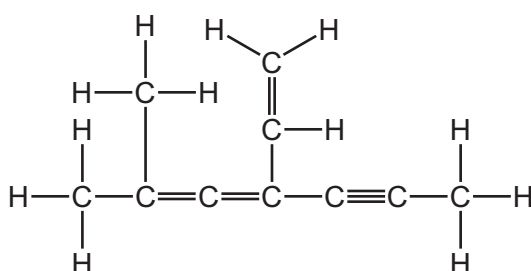
- A  $x$  is the same as the oxidation number of  $Cl$  in the chlorate ion formed when  $Cl_2(aq)$  is added to cold  $NaOH(aq)$ .
- B  $x$  is the same as the oxidation number of  $Cl$  in the chlorate ion formed when  $Cl_2(aq)$  is added to hot  $NaOH(aq)$ .
- C  $y$  is the same as the oxidation number of  $Cl$  in the chlorate ion formed when  $Cl_2(aq)$  is added to cold  $NaOH(aq)$ .
- D  $y$  is the same as the oxidation number of  $Cl$  in the chlorate ion formed when  $Cl_2(aq)$  is added to hot  $NaOH(aq)$ .

24 Which statement is correct?

- A An ammonium ion is basic due to a lone pair of electrons on the nitrogen atom.
- B Nitrogen monoxide,  $NO$ , reacts with peroxyacetyl nitrate to produce a component of photochemical smog.
- C Nitrogen dioxide catalyses the oxidation of atmospheric sulfur dioxide.
- D Nitrogen is very unreactive due to the very strong permanent dipole–permanent dipole attractions between the nitrogen atoms.

25 The diagram shows the structural formula of a hydrocarbon molecule Q.

molecule Q



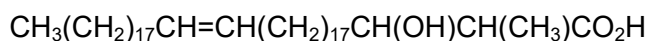
How many of the carbon atoms in molecule Q are  $sp^2$  hybridised?

- A 3
- B 4
- C 7
- D 10



26 Compound X is found in cell walls of some bacteria. Its structural formula is shown.

compound X



How many stereoisomers are there with this structural formula?

- A 2                      B 4                      C 6                      D 8

27 Structural isomerism **only** should be considered when answering this question.

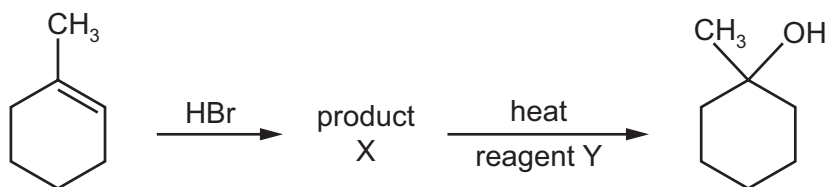
How many straight-chain isomers are there with molecular formula  $\text{C}_4\text{H}_8\text{Cl}_2$ ?

- A 6                      B 7                      C 8                      D 9

28 What is true of **every** nucleophile?

- A It attacks a double bond.  
 B It donates a lone pair of electrons.  
 C It is a single atom.  
 D It is negatively charged.

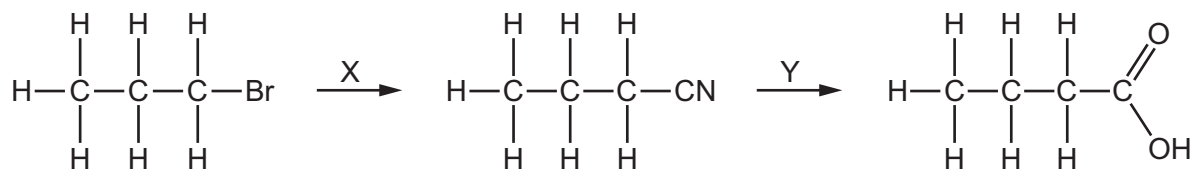
29 The diagram shows a synthetic route to produce 1-methylcyclohexanol.



What is reagent Y?

- A aqueous NaOH  
 B cold dilute  $\text{KMnO}_4$   
 C ethanolic NaOH  
 D hot concentrated  $\text{KMnO}_4$

30 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of reagents X and Y?

	X	Y
<b>A</b>	NH <sub>3</sub>	HCl(aq)
<b>B</b>	KCN in C <sub>2</sub> H <sub>5</sub> OH	NaOH(aq)
<b>C</b>	KCN in C <sub>2</sub> H <sub>5</sub> OH	HCl(aq)
<b>D</b>	HCN	NaOH(aq)

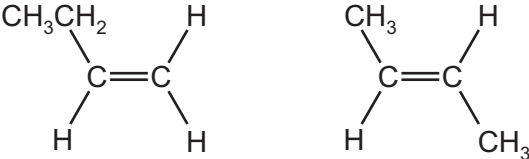
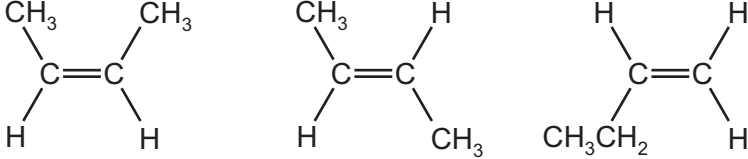
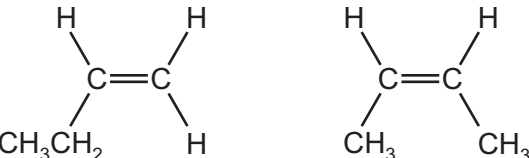
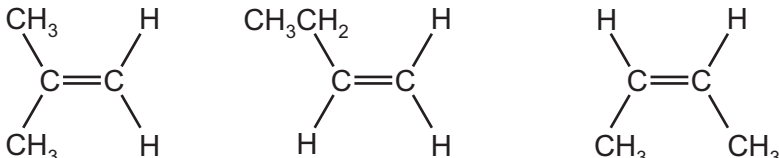
31 The table shows three sets of reagents and reaction conditions.

	reagents	reaction conditions
1	CH <sub>2</sub> C(CH <sub>3</sub> )CH <sub>3</sub> and HCl(g)	room temperature
2	CH <sub>3</sub> C(CH <sub>3</sub> )(OH)CH <sub>3</sub> and SOCl <sub>2</sub>	room temperature
3	CH <sub>3</sub> CH(CH <sub>3</sub> )CH <sub>3</sub> and Cl <sub>2</sub>	the presence of ultraviolet light

Which sets of reagents and conditions can be used to produce 2-chloro-2-methylpropane as one of the organic products?

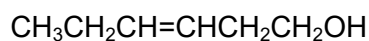
- A** 1, 2 and 3      **B** 1 and 2 only      **C** 1 and 3 only      **D** 2 and 3 only

32 What are the **only** structures formed when butan-2-ol is heated with concentrated  $\text{H}_2\text{SO}_4$ ?

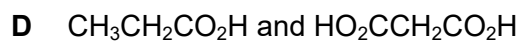
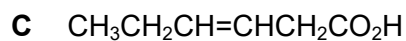
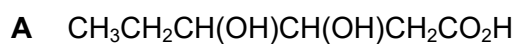
<b>A</b>	
<b>B</b>	
<b>C</b>	
<b>D</b>	

33 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

leaf alcohol



What will be formed when 'leaf alcohol' is oxidised using an excess of hot acidified  $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ ?



34 Compound X:

- does **not** react with Tollens' reagent
- forms a yellow precipitate with alkaline  $I_2(aq)$
- does **not** react with sodium.

What could be the identity of X?

- A  $CH_3CHO$
- B  $C_2H_5COCH_3$
- C  $CH_3COOC_2H_5$
- D  $CH_3CHOHCH_3$

35 Which compound can undergo nucleophilic addition?

- A bromoethane,  $C_2H_5Br$
- B ethanal,  $CH_3CHO$
- C ethane,  $C_2H_6$
- D ethene,  $C_2H_4$

36  $C_2H_5COOCH_3$  is reacted with aqueous acid.

The products from this reaction are reacted with  $LiAlH_4$  to form two molecules Y and Z.

What are the identities of molecules Y and Z?

- A both molecules are  $C_2H_5OH$
- B  $CH_3OH$  and  $CH_3CHOHCH_3$
- C  $CH_3OH$  and  $C_2H_5OH$
- D  $CH_3OH$  and  $C_2H_5CH_2OH$

37 A sample of propanoic acid of mass 3.70 g reacts with an excess of magnesium.

A second sample of propanoic acid of mass 3.70 g reacts with an excess of sodium.

Both reactions go to completion forming a gas.

Which row is correct?

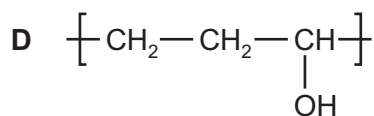
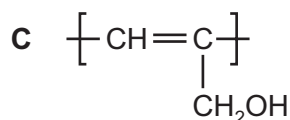
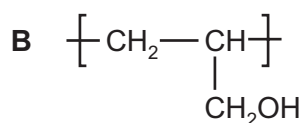
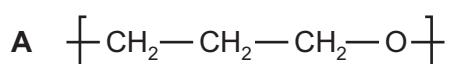
	volume of gas formed with magnesium at s.t.p. / cm <sup>3</sup>	volume of gas formed with sodium at s.t.p. / cm <sup>3</sup>
<b>A</b>	560	560
<b>B</b>	560	1120
<b>C</b>	1120	560
<b>D</b>	1120	1120

38 Which statement about  $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{CH}_3$  is correct?

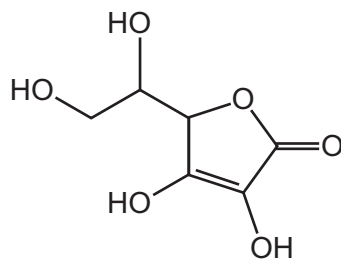
- A** It can be hydrolysed to a secondary alcohol.
- B** It can be made using ethanoic acid and a suitable alcohol.
- C** It gives a positive test with alkaline  $\text{I}_2(\text{aq})$ .
- D** When treated with hot concentrated acidified  $\text{KMnO}_4$  it gives  $\text{CH}_3\text{COCH}_2\text{COOH}$  as one product.

39 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol,  $\text{CH}_2=\text{CHCH}_2\text{OH}$ .

Which structure represents the repeat unit in the polymer poly(prop-2-en-1-ol)?



40 Vitamin C has the structure shown.



The mass spectrum of vitamin C has a molecular ion peak with an  $m/e$  value of 176 and a relative abundance of 7.0%.

What is the abundance of the  $M + 1$  peak?

- A** 0.462%      **B** 0.539%      **C** 0.616%      **D** 0.693%

### Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 $\text{J g}^{-1} \text{ K}^{-1}$ )

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