



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** ClO_4^- **B** H_2SO_4 **C** SO_4^{2-} **D** 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 O_2 to form H_2O and CO_2 only. The volume of CO_2 produced at room temperature and pressure is 108 cm^3 .

What is the formula of aluminium carbide?

- A** Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_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° .

Which row is correct?

	number of lone pairs around N in ion	overall charge on ion
A	1	+1
B	2	+1
C	1	–1
D	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°C and a pressure of 2.0 atmospheres?

- A 70 cm^3 B 150 cm^3 C 470 cm^3 D 950 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 $\text{C(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$
- B $\frac{1}{2}\text{N}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NO(g)}$
- C $\text{Na}_2\text{O(s)} + \text{SO}_3\text{(g)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)}$
- D $\text{PCl}_3\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow \text{PCl}_5\text{(g)}$
- 10 Two standard enthalpy change of formation values are given.

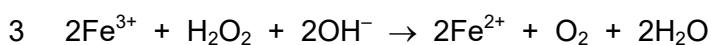
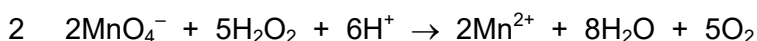
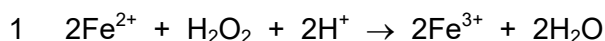
$$\Delta H_f^\ominus [\text{VCl}_2] = -452\text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{VCl}_3] = -573\text{ kJ mol}^{-1}$$

What is the enthalpy change for the reaction $3\text{VCl}_2 \rightarrow 2\text{VCl}_3 + \text{V}$?

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

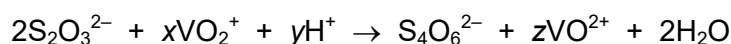
11 Equations for some reactions of hydrogen peroxide are given.



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, 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
A	x and z are the same value and quarter the value of y	from +4 to +5
B	x and z are the same value and quarter the value of y	from +5 to +4
C	x and z are the same value and half the value of y	from +5 to +4
D	x and z are the same value and half the value of y	from +4 to +5

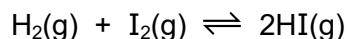
13 When some solid $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ is added to a beaker of water, an equilibrium is set up.



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** NH_3 **B** NH_4Cl **C** $\text{CH}_3\text{CO}_2\text{H}$ **D** 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 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?

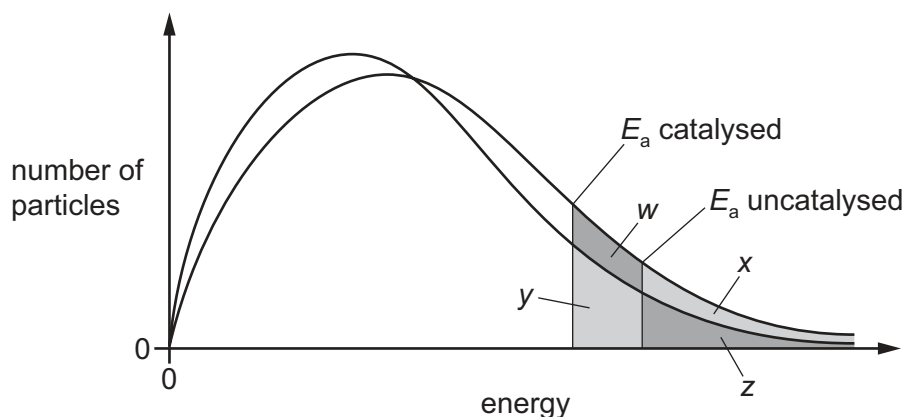
- A** 0.57 mol **B** 1.2 mol **C** 1.5 mol **D** 2.4 mol

- 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°C and at 35°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°C in the catalysed reaction	number of particles with enough energy to react at 35°C in the uncatalysed reaction
A	$w + x + y + z$	z
B	$w + x + y + z$	$x + z$
C	$y + z$	z
D	$y + z$	$x + z$

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 ₂	S + O ₂
A	white flame	blue flame
B	white flame	yellow flame
C	yellow flame	blue flame
D	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
A	10	X
B	10	Y
C	18	X
D	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 $X(NO_3)_2$
A	Mg	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
B	Mg	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$
C	Sr	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
D	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 $NH_3(aq)$
A	cream	$AgCl$
B	cream	AgI
C	yellow	$AgCl$
D	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.

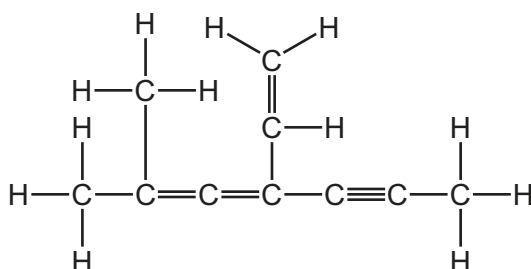


Which statement about the value of x or y is correct?

- 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

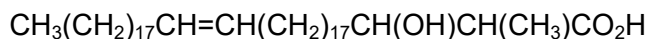


How many of the carbon atoms in molecule Q are sp^2 hybridised?

- 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?

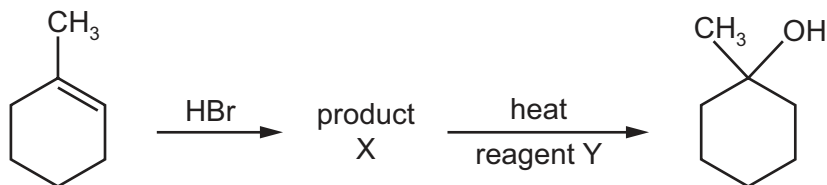
- A 2 B 4 C 6 D 8
- 27 Structural isomerism **only** should be considered when answering this question.

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.

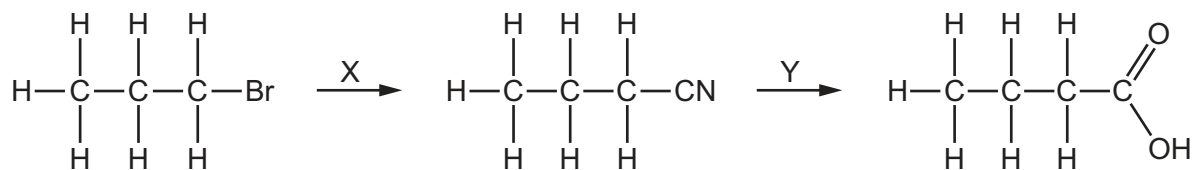
- 29 The diagram shows a synthetic route to produce 1-methylcyclohexanol.



What is reagent Y?

- A aqueous NaOH
 B cold dilute KMnO_4
 C ethanolic NaOH
 D hot concentrated 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
A	NH ₃	HCl(aq)
B	KCN in C ₂ H ₅ OH	NaOH(aq)
C	KCN in C ₂ H ₅ OH	HCl(aq)
D	HCN	NaOH(aq)

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

	reagents	reaction conditions
1	CH ₂ C(CH ₃)CH ₃ and HCl(g)	room temperature
2	CH ₃ C(CH ₃)(OH)CH ₃ and SOCl ₂	room temperature
3	CH ₃ CH(CH ₃)CH ₃ and Cl ₂	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?

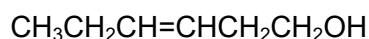
- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

32 What are the **only** structures formed when butan-2-ol is heated with concentrated H_2SO_4 ?

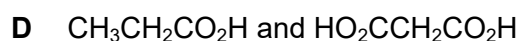
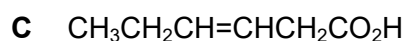
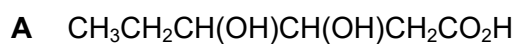
A	$\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{CH}_3 \end{array}$
B	$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{CH}_3 \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3\text{CH}_2 \quad \text{H} \end{array}$
C	$\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3\text{CH}_2 \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$
D	$\begin{array}{c} \text{CH}_3 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{H} \end{array}$ $\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$

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?

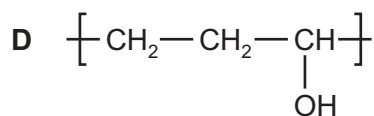
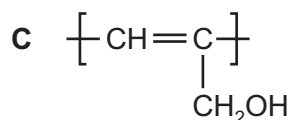
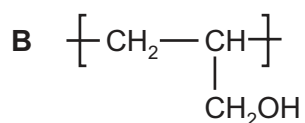
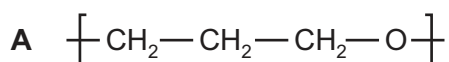
	volume of gas formed with magnesium at s.t.p. / cm ³	volume of gas formed with sodium at s.t.p. / cm ³
A	560	560
B	560	1120
C	1120	560
D	1120	1120

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?

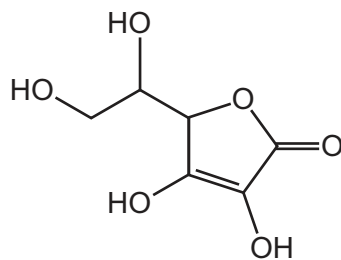
- A** It can be hydrolysed to a secondary alcohol.
- B** It can be made using ethanoic acid and a suitable alcohol.
- C** It gives a positive test with alkaline $\text{I}_2(\text{aq})$.
- D** When treated with hot concentrated acidified KMnO_4 it gives $\text{CH}_3\text{COCH}_2\text{COOH}$ as one product.

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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The Periodic Table of Elements

Group																						
1	2													13	14	15	16	17	18			
																		1 H hydrogen 1.0				2 He helium 4.0