



Cambridge Pre-U

CHEMISTRY

9791/01

Paper 1 Multiple Choice

May/June 2022

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet Data booklet
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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document has **16** pages. Any blank pages are indicated.



- 1 The first five successive ionisation energies for element Q are shown.

738 kJ mol⁻¹

1451 kJ mol⁻¹

7733 kJ mol⁻¹

10 541 kJ mol⁻¹

13 629 kJ mol⁻¹

In which group of the Periodic Table is Q?

- A** 1 **B** 2 **C** 13 **D** 14

- 2 Beams of protons, neutrons and electrons are passed between two oppositely charged plates. All the particles travel at the same speed.

Three statements about the behaviour of the protons, neutrons and electrons are given.

- 1 The protons, neutrons and electrons travel in a curved path.
- 2 The electrons are deflected more than the protons.
- 3 The electrons are deflected towards the positive plate.

Which statements are correct?

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

- 3 The electronegativity values of five elements are shown.

element	H	C	N	O	F
electronegativity value	2.1	2.5	3.0	3.5	4.0

Which molecules will have the strongest intermolecular forces between them?

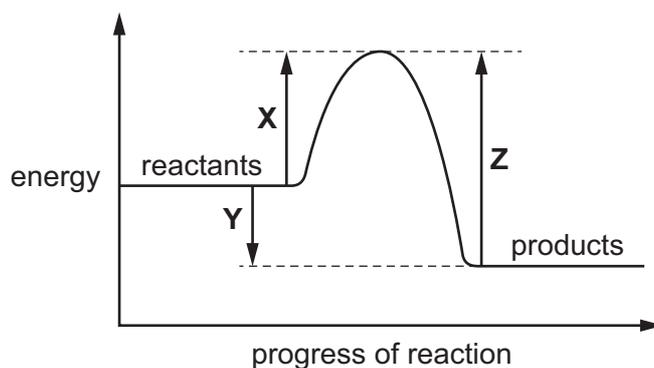
- A** CO **B** F₂ **C** HF **D** NO

- 4 Data relevant to the enthalpy change of hydration of $\text{Na}^+(\text{g})$ is given.

	$\Delta H^\ominus / \text{kJ mol}^{-1}$
$\Delta_{\text{hyd}}H \text{ Cl}^-(\text{g})$	-364
$\Delta_{\text{sol}}H \text{ NaCl}(\text{s})$	+10
$\Delta_{\text{latt}}H \text{ NaCl}(\text{s})$	-780

What is the enthalpy change of hydration of $\text{Na}^+(\text{g})$?

- A $-1134 \text{ kJ mol}^{-1}$
 B -406 kJ mol^{-1}
 C $+406 \text{ kJ mol}^{-1}$
 D $+1134 \text{ kJ mol}^{-1}$
- 5 The diagram shows a reaction profile for an uncatalysed, reversible reaction.

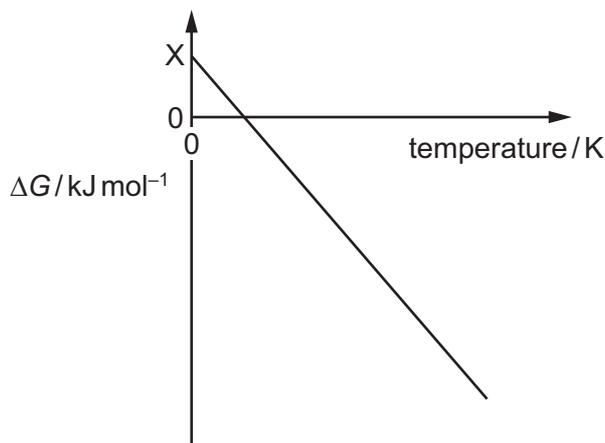


How would the values of **X**, **Y** and **Z** for a catalysed reaction compare with the values of **X**, **Y** and **Z** for the uncatalysed reaction?

	X	Y	Z
A	bigger	more negative	the same
B	bigger	the same	bigger
C	smaller	less negative	smaller
D	smaller	the same	smaller

- 6 Which value is essential to calculate the lattice energy of the compound NaH ?
- A electron affinity of hydrogen
 B electron affinity of sodium
 C first ionisation energy of hydrogen
 D second ionisation energy of sodium

- 7 The sketch graph shows how ΔG varies with temperature for a reaction.



What is the gradient of the line and what is the intercept?

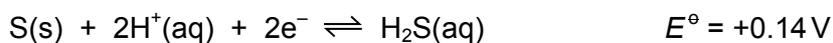
	gradient	intercept, X
A	ΔH	ΔS
B	ΔS	ΔH
C	$-\Delta H$	ΔS
D	$-\Delta S$	ΔH

- 8 The same current passes through two electrolytic cells for the same amount of time. The first cell contains $XSO_4(aq)$ while the second cell contains $Y_2SO_4(aq)$. The relative atomic masses of X and Y are in the ratio 1 : 2.

What is the ratio mass of X liberated : mass of Y liberated?

- A** 1 : 1 **B** 1 : 2 **C** 1 : 4 **D** 2 : 1

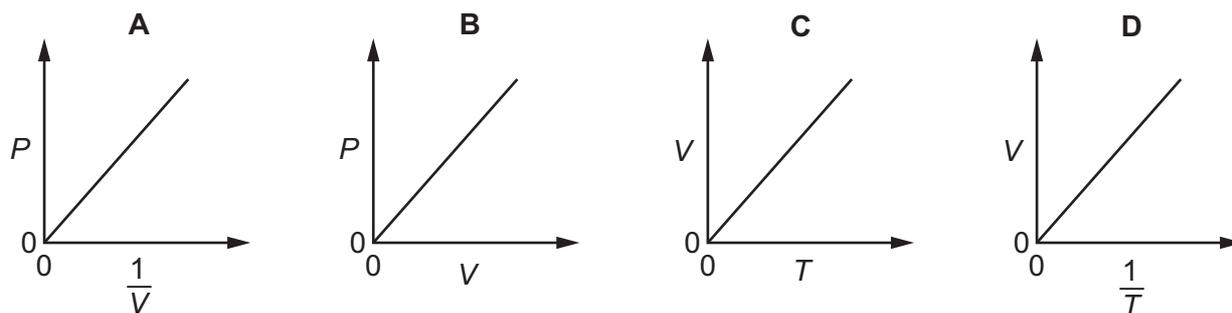
- 9 Two electrode potentials are shown.



What is the cell diagram for a cell with a standard cell potential of +0.03 V?

- A** $H_2S(aq) | S(s) | 2H^+(aq) || SO_4^{2-}(aq) + 4H^+(aq), SO_2(aq) + 2H_2O(l)$
B $Pt | H_2S(aq) | S(s) | 2H^+(aq) || SO_4^{2-}(aq) + 4H^+(aq), SO_2(aq) + 2H_2O(l) | Pt$
C $Pt | SO_2(aq) + 2H_2O(l), SO_4^{2-}(aq) + 4H^+(aq) || 2H^+(aq) | S(s) | H_2S(aq) | Pt$
D $SO_2(aq) + 2H_2O(l), SO_4^{2-}(aq) + 4H^+(aq) || 2H^+(aq) | S(s) | H_2S(aq)$

10 Which graph is a correct representation of Boyle's Law?



11 The theoretical lattice energy of MgI_2 is $-1944 \text{ kJ mol}^{-1}$, whereas it is found by experiment to be $-2327 \text{ kJ mol}^{-1}$.

Which statement best explains the difference in the two values?

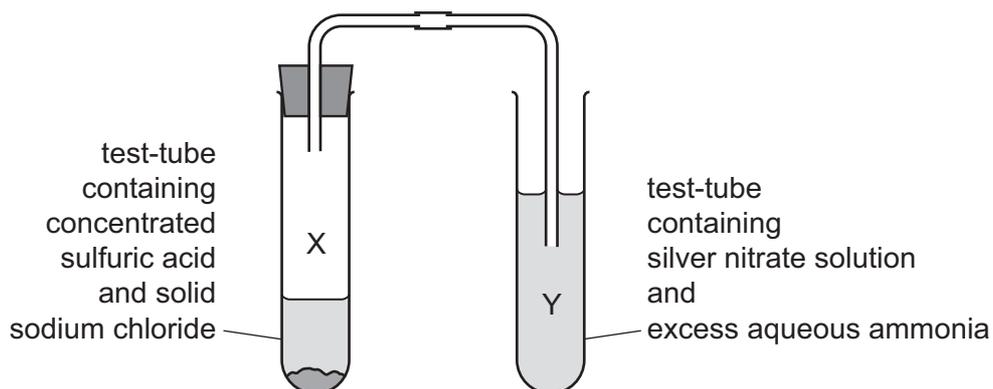
- A Magnesium iodide decomposes quickly in air at room temperature.
- B The experimental lattice energy cannot be measured directly.
- C The theoretical lattice energy is calculated assuming the bonding is purely ionic.
- D The theoretical lattice energy is calculated assuming all ions have the same charge.

12 Elements are stored under different conditions depending on their reactivity.

Which row correctly describes the environment in which each element is stored?

	white phosphorus, P_4	sodium, Na
A	air	oil
B	air	water
C	water	air
D	water	oil

13 The diagram shows an experiment.



What is seen **just after** the two tubes are connected?

	colour of gas in tube X	observation in tube Y
A	colourless	no precipitate
B	colourless	white precipitate
C	green	no precipitate
D	green	white precipitate

14 Which statement about the elements in Group 14 and their compounds is correct?

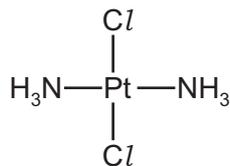
- A** Carbon is a metalloid.
- B** Lead(II) oxide is more stable than lead(IV) oxide.
- C** Silicon is a better conductor of electricity than tin.
- D** Tin(IV) oxide has more covalent nature than germanium(IV) oxide.

15 Carbon and silicon are in Group 14 of the Periodic Table. They both form dioxides.

Which statement about the Group 14 dioxides is correct?

- A** The shape around both the carbon and the silicon atoms is linear.
- B** Both carbon and silicon form double bonds with oxygen.
- C** Silicon and oxygen form a stable π bond.
- D** Silicon-oxygen bonds are longer than carbon-oxygen bonds.

16 Which statement about the transition metal complex shown is correct?



- A** It has tetrahedral geometry around the platinum atom.
B It has no overall dipole moment.
C It is a complex of platinum(IV).
D It is a *cis* isomer.

17 Geometric isomers and optical isomers are both types of stereoisomers.

How many stereoisomers will the octahedral complex ion $[\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Cl}_2]^+$ have?

- A** 0 **B** 2 **C** 3 **D** 4

18 Solution X is added to a warm mixture of an organic compound Y and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$.

A reaction occurs producing $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ ions.

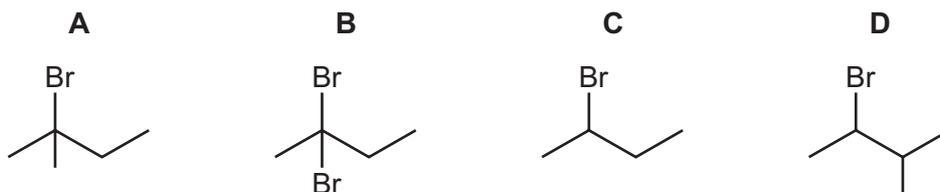
What are X and Y?

	X	Y
A	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{C}_2\text{H}_5\text{OH}$
B	$\text{H}_2\text{SO}_4(\text{aq})$	CH_3COOH
C	$\text{NaOH}(\text{aq})$	$\text{C}_2\text{H}_5\text{OH}$
D	$\text{NaOH}(\text{aq})$	CH_3CHO

19 Which row describes a cubic close-packed metal structure?

	arrangement of the close-packed layers	coordination number of atoms
A	ABAB	8
B	ABAB	12
C	ABCABC	8
D	ABCABC	12

20 Which skeletal formula shows the structure of 2-bromo-2-methylbutane?



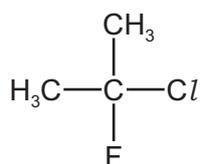
21 The equation shows the change brought about by reaction of but-1-ene with hot potassium manganate(VII).



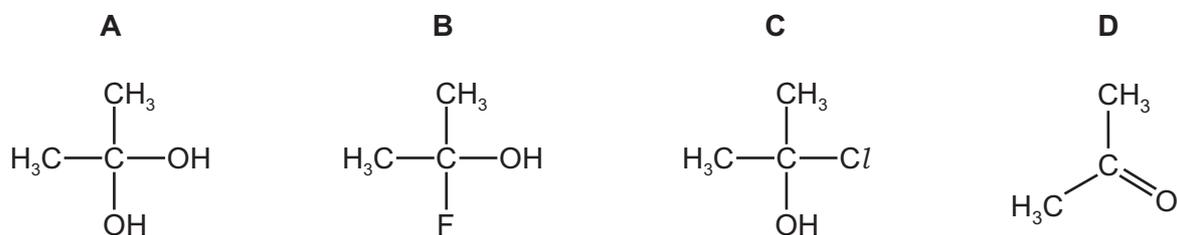
What is the total number of functional group levels moved up by carbon atoms in this reaction?

- A 4 B 5 C 6 D 7

22 The diagram shows 2-chloro-2-fluoropropane.

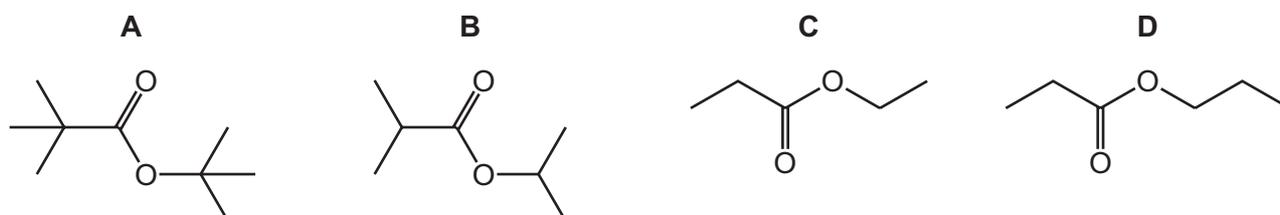


What is the hydrolysis product of 2-chloro-2-fluoropropane under mild conditions?



23 Four different esters undergo acid hydrolysis. The products of each hydrolysis are then heated under reflux with an acidified aqueous solution of potassium dichromate(VI).

Which ester would give **two different** carboxylic acids as the products of this reaction sequence?

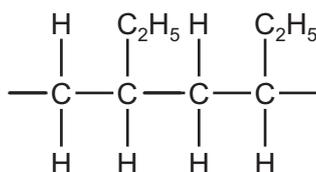


24 Which equation represents moving within a functional group level?

- A $\text{CH}_3\text{COCH}_3 + \text{CH}_3\text{CH}_2\text{MgBr} \rightarrow \text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{OMgBr}$
 B $(\text{CH}_3)_2\text{CO} + \text{HCN} \rightarrow (\text{CH}_3)_2\text{C}(\text{OH})\text{CN}$
 C $\text{CH}_3\text{C}(\text{O})\text{OC}(\text{O})\text{CH}_3 + \text{H}_2\text{O} \rightarrow 2\text{CH}_3\text{COOH}$
 D $3\text{CH}_3\text{CHO} + \text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ \rightarrow 3\text{CH}_3\text{COOH} + 2\text{Cr}^{3+} + 4\text{H}_2\text{O}$

25 An alcohol, X, can be dehydrated producing a hydrocarbon.

Polymerisation of this hydrocarbon gives the polymer shown.



What is X?

- A 2-methylpropan-1-ol
 B butan-1-ol
 C ethanol
 D propan-1-ol
- 26 Propene reacts with HBr in a polar solvent to give a mixture of products.

Which statement about this reaction is correct?

- A One of the hydrogen atoms involved behaves as an electrophile.
 B The first step involves a nucleophilic attack on an alkene functional group.
 C The first step involves homolytic fission of a π bond.
 D The major product is 1-bromopropane.
- 27 Which reaction **must** have an atom economy of 100%?
- A an addition reaction
 B a neutralisation reaction
 C a redox reaction
 D a substitution reaction

28 Which compound will undergo hydrolysis to produce carbon dioxide as a product?

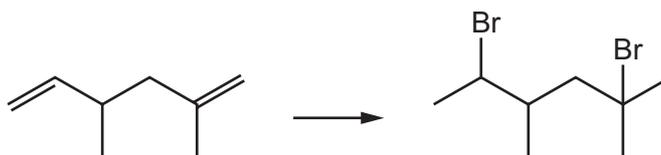
- A CH_3COCl B H_2CO C HCOOCH_3 D $(\text{H}_2\text{N})_2\text{CO}$

29 A single enantiomer, X, is hydrolysed with aqueous sodium hydroxide. The product of the hydrolysis is racemic.

Which row could be correct?

	structural formula of X	mechanism of hydrolysis
A	$\text{CH}(\text{CH}_3)(\text{C}_2\text{H}_5)\text{Br}$	$\text{S}_{\text{N}}1$
B	$\text{CH}(\text{CH}_3)(\text{C}_2\text{H}_5)\text{Br}$	$\text{S}_{\text{N}}2$
C	$\text{C}_2\text{H}_5\text{CHBrC}_2\text{H}_5$	$\text{S}_{\text{N}}1$
D	$\text{C}_2\text{H}_5\text{CHBrC}_2\text{H}_5$	$\text{S}_{\text{N}}2$

30 The molecule shown can react with two molecules of hydrogen bromide.



Which statement explains why the bromine atoms are found in the positions shown?

- A The bromine atom is added before the hydrogen atom.
 B The hydrogen atom is added before the bromine atom.
 C The intermediate carbocations are higher in energy when they are more substituted.
 D The intermediate carbocations are lower in energy when they are more substituted.

31 Nitrobenzene can be reduced to phenylamine using tin and hydrochloric acid. The final step of this process is addition of excess sodium hydroxide to the reaction mixture.

Why is the sodium hydroxide added?

- A to decompose any remaining starting material
 B to dry the product
 C to hydrolyse the intermediate
 D to react with phenylammonium chloride

- 32 The table contains statements about the relative acidity of water and phenol, and about the relative basicity of water and propylamine.

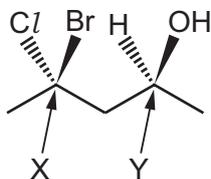
Which row is correct?

	relative acidity of water and phenol	relative basicity of water and propylamine
A	phenol > water	propylamine > water
B	phenol > water	water > propylamine
C	water > phenol	propylamine > water
D	water > phenol	water > propylamine

- 33 Which statement about aminoethanoic acid is correct?

- A** It can form an addition polymer.
B It contains a chiral carbon atom.
C It forms zwitterions by the donation of a proton from an amine group.
D It is soluble in water.

- 34 Compound Q has two chiral centres, marked as X and Y on the diagram.



What is the R/S assignment for each chiral centre?

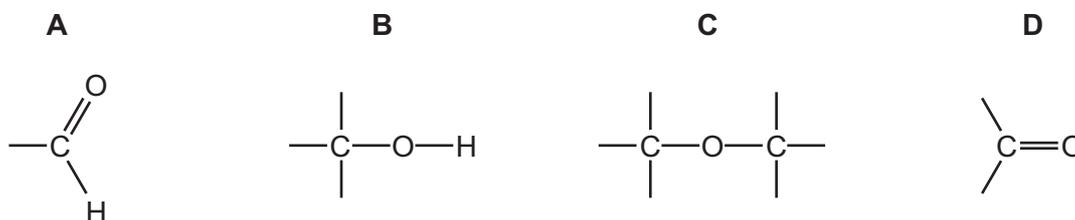
	X	Y
A	R	R
B	R	S
C	S	R
D	S	S

- 35 A large **excess** of aqueous silver nitrate is added to aqueous barium chloride and the precipitate removed by filtration.

What are the most abundant ions in the filtrate?

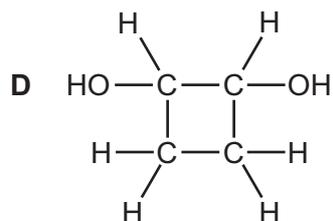
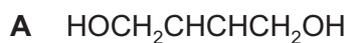
- A Ag^+ , Ba^{2+} and NO_3^-
 B Ag^+ and NO_3^- only
 C Ba^{2+} , NO_3^- and Cl^-
 D Ba^{2+} and NO_3^- only
- 36 What is shown on the mass spectra of the compounds 1-chloropropane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$, and 2-chloropropane, $\text{CH}_3\text{CHClCH}_3$?
- A Both spectra have a single molecular ion peak at 78.5.
 B Both spectra have molecular ion peaks at 78 and 80 with integration heights in the ratio 1 : 1.
 C Both spectra have molecular ion peaks at 78 and 80 with integration heights in the ratio 3 : 1.
 D The two spectra have molecular ion peaks which are different from each other.
- 37 Why do the emission lines in the visible spectrum of hydrogen converge at high frequency?
- A Emission lines represent transitions from excited states to the ground state.
 B The energies of photons are quantised.
 C The energy levels of the excited hydrogen atom get closer together at high energy.
 D The photons in the visible region have a higher energy than those in the infra-red region.
- 38 An organic compound contains only one oxygen atom. The infra-red spectrum of the compound has a broad peak at wavelength 3350 cm^{-1} .

What is the arrangement of the oxygen atom in the molecule?



- 39 The ^{13}C NMR spectrum of a compound with formula $\text{C}_4\text{H}_8\text{O}_2$ shows peaks at 15 ppm, 20 ppm, 60 ppm and 175 ppm.

What is the structure of the compound?



- 40 How many possible orientations does a magnetic dipole of a spin $\frac{1}{2}$ nucleus adopt in an external magnetic field?

A 1

B 2

C 4

D ∞ (infinity)

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