



# Cambridge International AS & A Level

**CHEMISTRY**

**9701/12**

Paper 1 Multiple Choice

**May/June 2021**

**1 hour**

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)  
Data booklet

## 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.

This document has **16** pages.



## Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

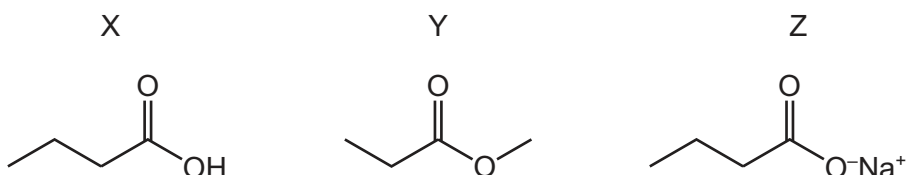
1 Which statement about the Avogadro constant is correct?

- A It is the mass of one mole of any element.
- B It is the mass of  $6.02 \times 10^{23}$  atoms of any element.
- C It is the number of atoms in one mole of neon.
- D It is the number of atoms in 12 g of any element.

2 Which equation represents the first ionisation energy of iodine?

- A  $\frac{1}{2} \text{I}_2(\text{g}) + \text{e}^- \rightarrow \text{I}^-(\text{g})$
- B  $\text{I}(\text{g}) + \text{e}^- \rightarrow \text{I}^-(\text{g})$
- C  $\frac{1}{2} \text{I}_2(\text{g}) \rightarrow \text{I}^+(\text{g}) + \text{e}^-$
- D  $\text{I}(\text{g}) \rightarrow \text{I}^+(\text{g}) + \text{e}^-$

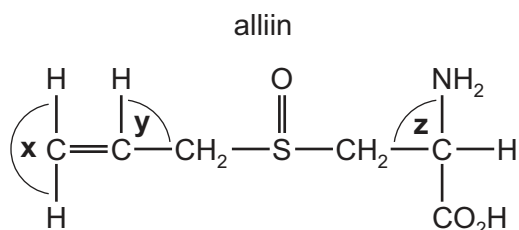
3 The structures represent three compounds, each with four carbon atoms per molecule.



Which row is correct?

	lowest boiling point	→	highest boiling point
<b>A</b>	X	Y	Z
<b>B</b>	Y	X	Z
<b>C</b>	Z	X	Y
<b>D</b>	Z	Y	X

- 4 The structural formula of alliin is shown.



What are the approximate bond angles **x**, **y** and **z** in a molecule of alliin?

	<b>x</b>	<b>y</b>	<b>z</b>
<b>A</b>	90°	90°	109°
<b>B</b>	120°	109°	90°
<b>C</b>	120°	120°	109°
<b>D</b>	180°	109°	109°

- 5 Flask Q contains 5 dm<sup>3</sup> of helium at 12 kPa pressure. Flask R contains 10 dm<sup>3</sup> of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

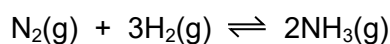
- A** 8 kPa      **B** 9 kPa      **C** 10 kPa      **D** 11 kPa

- 6 Sodium chloride, water and air represent three states of matter – solid, liquid and gas.

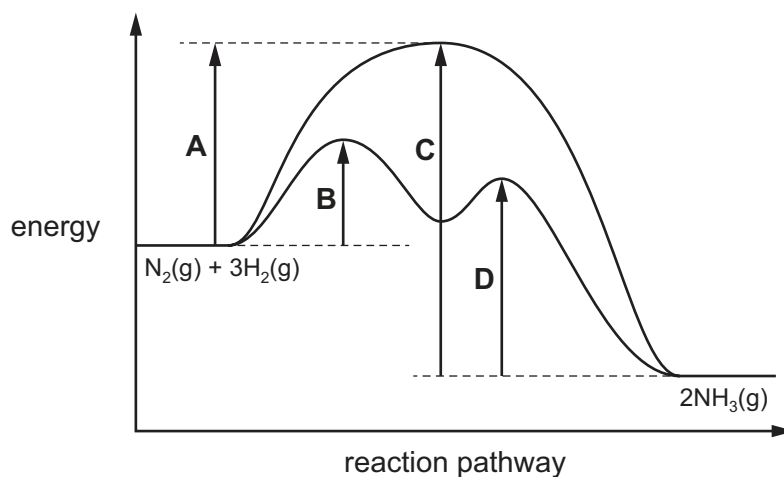
Which row is correct?

	sodium chloride	water	air
<b>A</b>	particles held in rigid structure	can easily be compressed	can easily be compressed
<b>B</b>	particles stationary	particles move	cannot easily be compressed
<b>C</b>	particles stationary	particles stationary	particles move
<b>D</b>	resistant to change of shape	cannot easily be compressed	can easily be compressed

- 7 The reaction pathway diagram for the catalysed reaction and the uncatalysed reaction between  $\text{N}_2$  and  $\text{H}_2$  is shown.



Which letter represents the activation energy for the first step in the decomposition of  $\text{NH}_3$  in the presence of a catalyst?

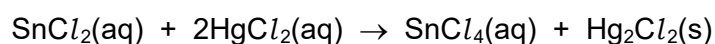


- 8 Nitrogen and oxygen can react together to form nitrogen monoxide,  $\text{NO}$ .



What is the bond energy of the bond between the atoms in  $\text{NO}$ ?

- A**  $630 \text{ kJ mol}^{-1}$     **B**  $810 \text{ kJ mol}^{-1}$     **C**  $1260 \text{ kJ mol}^{-1}$     **D**  $1620 \text{ kJ mol}^{-1}$
- 9 The equation for a redox reaction is shown.

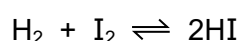


Which species is being oxidised in this reaction?

- A**  $\text{Sn}^{2+}$     **B**  $\text{Cl}^-$     **C**  $\text{Hg}^+$     **D**  $\text{Hg}^{2+}$

- 10 3.60 moles of hydrogen gas and 2.00 moles of iodine vapour are placed in a reaction vessel which is then sealed and maintained at a constant temperature.

The equation for the reaction is shown.



At equilibrium, 3.20 moles of hydrogen remain. All reactants and products are gaseous.

What is the value of  $K_p$  under these conditions?

- A** 0.0313    **B** 0.125    **C** 0.156    **D** 8.00

11 Two chemicals, X and Y, react together in solution to give product Z.

The rate of formation of product Z at the start of the reaction was measured in five experiments, 1–5, using various concentrations of X and Y. The results are shown.

experiment number	starting concentration of X / mol dm <sup>-3</sup>	starting concentration of Y / mol dm <sup>-3</sup>	rate of formation of Z at the start / mol dm <sup>-3</sup> s <sup>-1</sup>
1	0.10	0.10	0.0001
2	0.10	0.20	0.0004
3	0.10	0.40	0.0016
4	0.20	0.10	0.0001
5	0.40	0.10	0.0001

Which statement is correct?

- A The rate of the reaction is directly proportional to the concentration of reagent X.
- B The rate of the reaction is directly proportional to the concentration of reagent Y.
- C The rate of the reaction is **not** affected by the concentration of reagent X.
- D The rate of the reaction is **not** affected by the concentration of reagent Y.

12 A sample of SiCl<sub>4</sub> is added to cold water.

Which statement describes the mixture formed at the end of the reaction?

- A acidic solution with no precipitate
- B acidic solution with white precipitate
- C neutral solution with no precipitate
- D neutral solution with white precipitate

13 L and M are elements in Period 3 of the Periodic Table.

- The oxide of L is a solid at room temperature. This oxide has a giant structure.
- The chloride of L does not react with water.
- Argon is the only element in Period 3 with a lower melting point than M.

Which formula represents a compound of elements L and M?

- A Al<sub>2</sub>S<sub>3</sub>      B MgS      C NaCl      D PCl<sub>5</sub>

14 A farmer requires a solid compound to raise the pH of the soil in a field from 5.5 to above 6.0.

Which compound could the farmer use?

- A (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>      B NH<sub>4</sub>NO<sub>3</sub>      C Ca(OH)<sub>2</sub>      D Ca(NO<sub>3</sub>)<sub>2</sub>

- 15 Z is an anhydrous compound of a Group 2 element. When it is heated, Z undergoes thermal decomposition to produce two different gases. Z has relatively low thermal stability compared to other Group 2 compounds containing the same anion as Z.

What is compound Z?

- A barium carbonate
- B barium nitrate
- C magnesium carbonate
- D magnesium nitrate

- 16 Which row gives mixtures that **both** result in the oxidation of a halide ion?

	mixture 1	mixture 2
<b>A</b>	$\text{AgNO}_3(\text{aq})$ and $\text{NaCl}(\text{aq})$	concentrated $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{HI}(\text{aq})$
<b>B</b>	$\text{Br}_2(\text{aq})$ and $\text{NaCl}(\text{aq})$	concentrated $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{HCl}(\text{aq})$
<b>C</b>	$\text{Cl}_2(\text{aq})$ and $\text{NaBr}(\text{aq})$	$\text{CH}_3\text{CHBrCH}_3(\text{l}) + \text{NaOH}$ (ethanolic)
<b>D</b>	$\text{Br}_2(\text{aq})$ and $\text{NaI}(\text{aq})$	concentrated $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{NaBr}(\text{s})$

- 17 Chlorine gas is widely used to treat contaminated water.

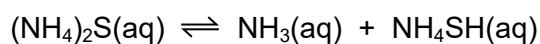
When chlorine is added to water, which chemical species present is responsible for killing bacteria?

- A  $\text{ClO}_2^-$
- B  $\text{Cl}^-$
- C  $\text{HCl}$
- D  $\text{ClO}^-$

- 18 What is an environmental consequence of the uncontrolled use of nitrate fertilisers?

- A acid rain
- B low oxygen levels in streams
- C ozone depletion
- D the greenhouse effect

- 19 Ammonia gas,  $\text{NH}_3$ , and hydrogen sulfide gas,  $\text{H}_2\text{S}$ , react together to form the salt ammonium sulfide,  $(\text{NH}_4)_2\text{S}$ . Ammonium sulfide dissolves in water to produce an orange alkaline solution.



The addition of  $\text{NaOH}(\text{aq})$  to this solution produces a gas, X.

The addition of  $\text{HCl}(\text{aq})$  to a separate portion of this solution produces a gas, Y.

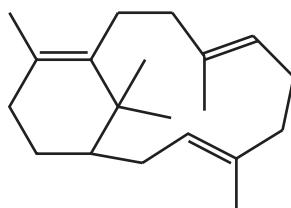
X and Y could represent different gases or identical gases.

What are the identities of X and Y?

	X	Y
<b>A</b>	$\text{H}_2\text{S}$	$\text{H}_2\text{S}$
<b>B</b>	$\text{H}_2\text{S}$	$\text{NH}_3$
<b>C</b>	$\text{NH}_3$	$\text{H}_2\text{S}$
<b>D</b>	$\text{NH}_3$	$\text{NH}_3$

- 20 Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

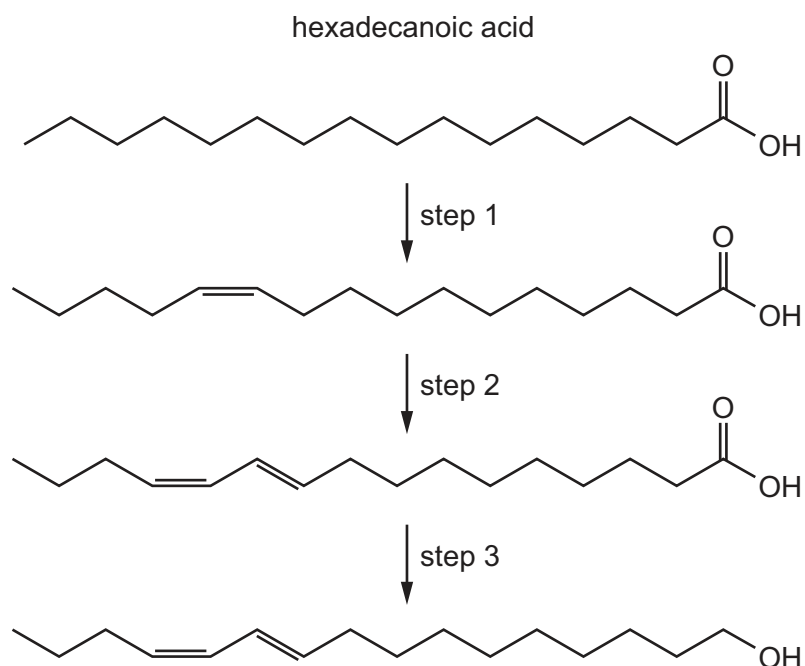
compound P



What is the number of chiral carbon atoms in the product Q?

- A** 4                      **B** 5                      **C** 6                      **D** 7

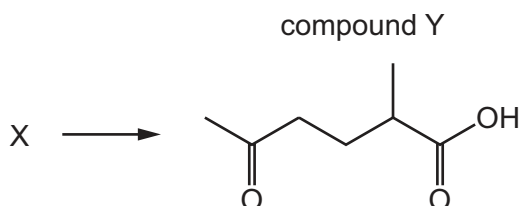
- 21 Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



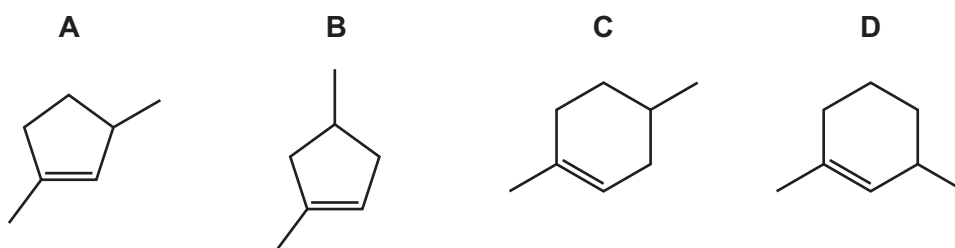
Which row contains correct descriptions of the three steps?

	step 1	step 2	step 3
<b>A</b>	elimination	elimination	dehydration
<b>B</b>	elimination	reduction	reduction
<b>C</b>	oxidation	elimination	oxidation
<b>D</b>	oxidation	oxidation	reduction

- 22 Compound X can be converted into compound Y in a single step.



What could be the identity of X?





23 Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

**A** Br and H      **B** Br and CH<sub>3</sub>      **C** Br and C<sub>2</sub>H<sub>6</sub>      **D** CH<sub>3</sub> and CH<sub>3</sub>Br

24 A few drops of 2-bromopropane were placed in a test-tube. An equal volume of aqueous silver nitrate was added. A precipitate was formed.

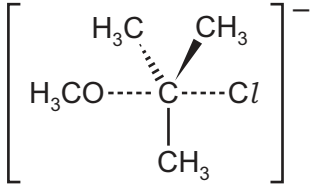
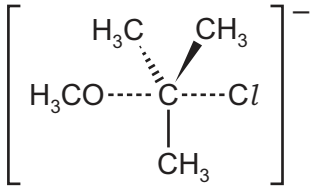
The experiment was repeated with 2-iodopropane.

Which row is correct?

	colour of precipitate from <b>2-bromopropane</b> + AgNO <sub>3</sub> (aq)	faster rate of reaction
<b>A</b>	cream	2-bromopropane + AgNO <sub>3</sub> (aq)
<b>B</b>	yellow	2-bromopropane + AgNO <sub>3</sub> (aq)
<b>C</b>	cream	2-iodopropane + AgNO <sub>3</sub> (aq)
<b>D</b>	yellow	2-iodopropane + AgNO <sub>3</sub> (aq)

- 25 Sodium methoxide,  $\text{Na}^+\text{CH}_3\text{O}^-$ , reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the  $\text{CH}_3\text{O}^-$  ion.

Which row is correct?

	intermediate or transition state	product
<b>A</b>	$(\text{CH}_3)_3\text{C}^+$	$(\text{CH}_3)_3\text{COCH}_3$
<b>B</b>	$(\text{CH}_3)_3\text{C}^+$	$(\text{CH}_3)_3\text{CCH}_2\text{OH}$
<b>C</b>		$\text{HOCH}_2\text{C}(\text{CH}_3)_3$
<b>D</b>		$\text{H}_3\text{COC}(\text{CH}_3)_3$

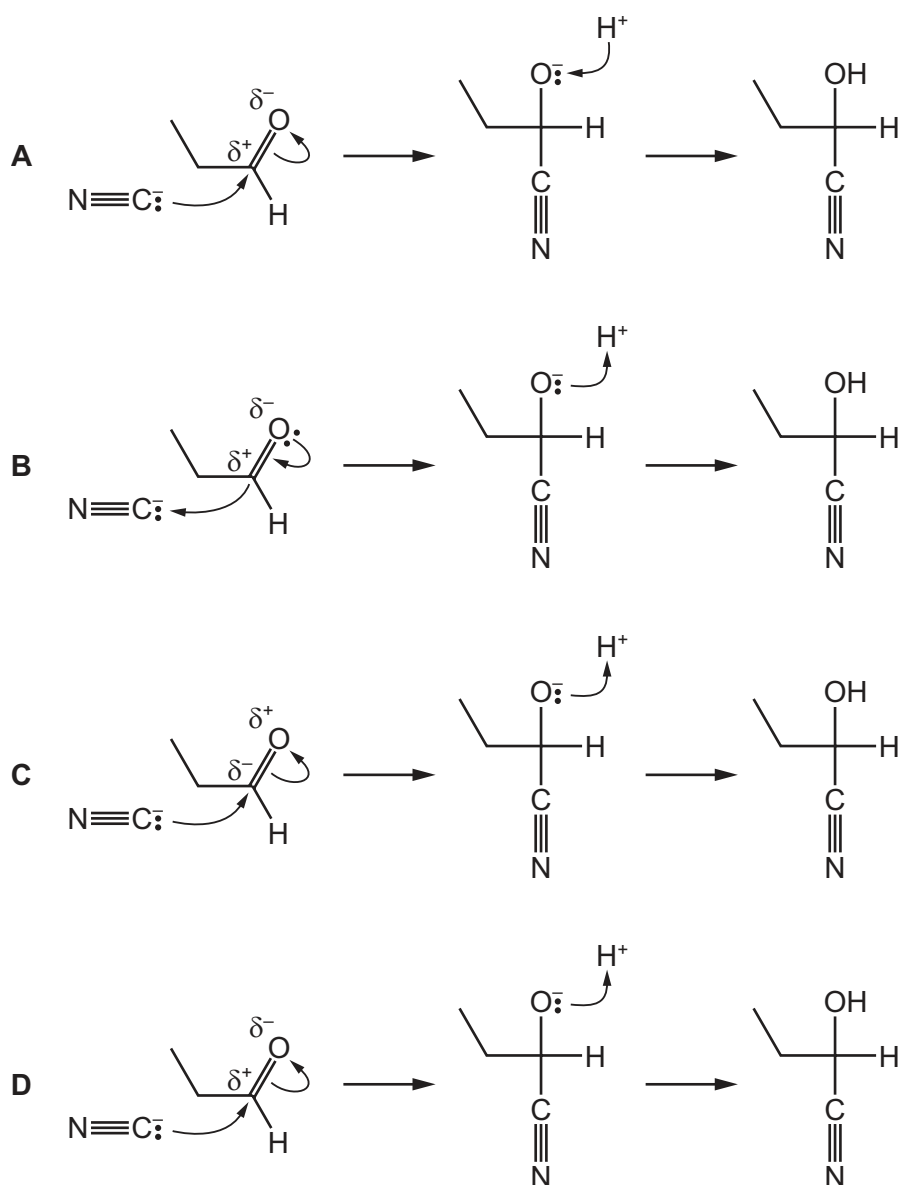
- 26 Alcohol X reacts with concentrated sulfuric acid to produce a mixture of products.

Two of the products are structural isomers of each other.

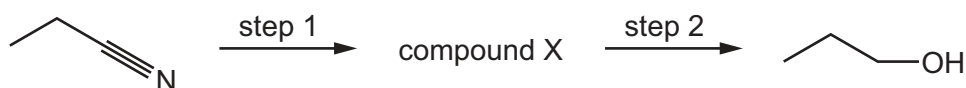
What could be X?

- A** hexan-2-ol  
**B** pentan-1-ol  
**C** pentan-3-ol  
**D** propan-2-ol
- 27 Which reaction will form a strong organic base?
- A** ethanol and acidified sodium dichromate  
**B** ethanol and hot aluminium oxide  
**C** ethanol and sodium  
**D** ethanol and hydrogen chloride

28 Which reaction mechanism for the formation of  $\text{C}_2\text{H}_5\text{CH}(\text{OH})(\text{CN})$  is correct?



29 The synthesis shown may be used for the production of propan-1-ol.

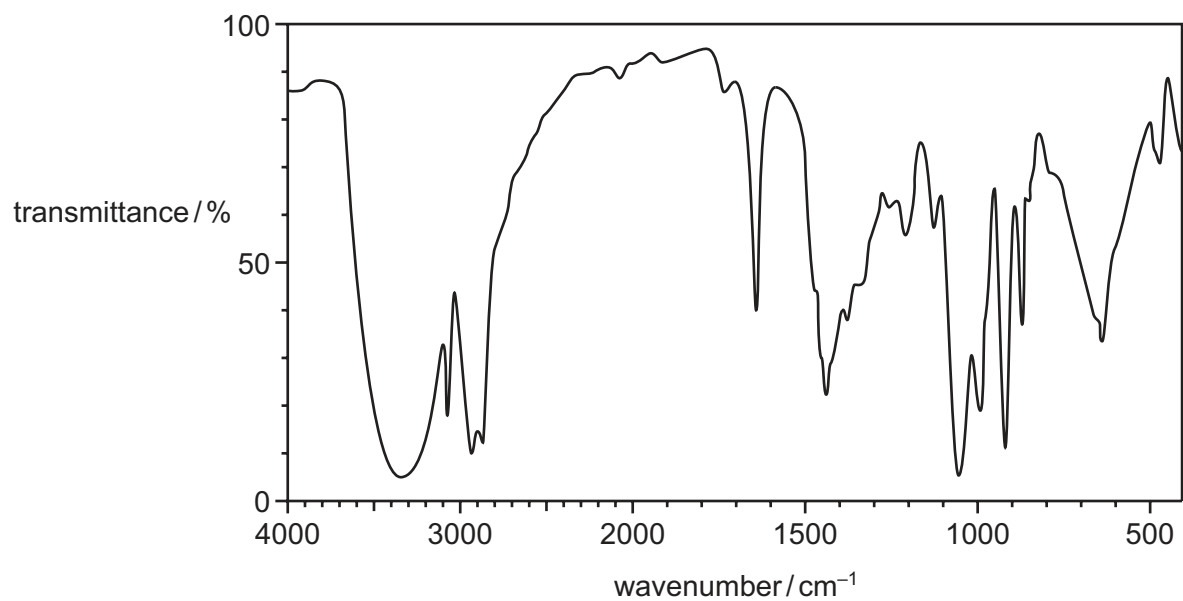


Which row gives the correct reagents for steps 1 and 2?

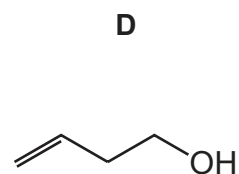
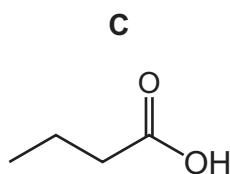
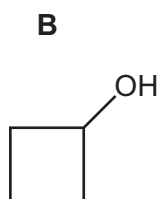
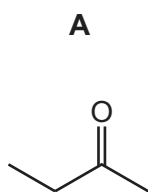
	step 1	step 2
<b>A</b>	$\text{HCl}(\text{aq})$	$\text{H}_2 + \text{Ni}$
<b>B</b>	$\text{HCl}(\text{aq})$	$\text{LiAlH}_4$
<b>C</b>	$\text{NaOH}(\text{aq})$	$\text{H}_2 + \text{Ni}$
<b>D</b>	$\text{NaOH}(\text{aq})$	$\text{NaBH}_4$

30 The molecular formula of Z is  $C_4H_8O$ .

The infra-red spectrum of Z is shown.



What could be Z?



## Section B

For each of the questions in this section, one or more of the three numbered statements 1 to 3 may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

**31** In which ions are the number of electrons equal to the number of neutrons?

- 1  ${}_{9}^{19}\text{F}^{-}$
- 2  ${}_{15}^{31}\text{P}^{-}$
- 3  ${}_{11}^{23}\text{Na}^{+}$

**32** Compound X is a straight chain hydrocarbon with an  $M_r$  of 84.

What can be determined about X?

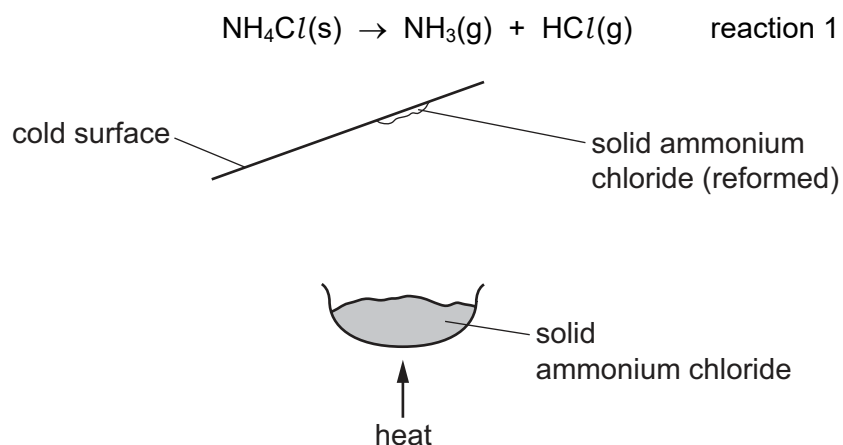
- 1 empirical formula
- 2 molecular formula
- 3 whether X contains a C=C bond or not

The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

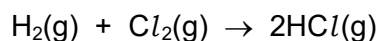
- 33** When a sample of ammonium chloride is warmed it decomposes into ammonia and hydrogen chloride gas.



When the mixture of hot ammonia and hydrogen chloride gases hit a cold surface, a white solid of ammonium chloride reforms.

Which statements are correct?

- 1 Reaction 1 is in dynamic equilibrium.
  - 2 Reaction 1 is reversible.
  - 3 Reaction 1 is an endothermic reaction.
- 34** Hydrogen chloride gas is formed by the reaction shown.



What will change the average kinetic energy of the reacting gas particles?

- 1 increasing the temperature and increasing the concentration of hydrogen
- 2 cooling the reaction mixture and adding a catalyst
- 3 adding a catalyst and increasing the concentration of chlorine

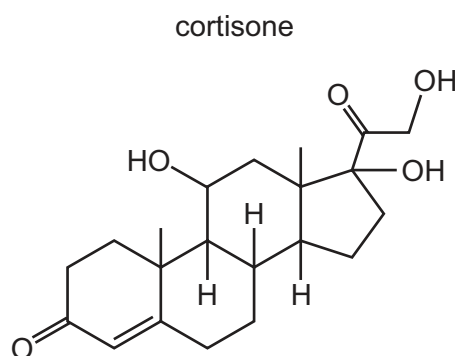
35 Which oxides will cause a change in pH when added to water?

- 1 CaO
- 2  $Al_2O_3$
- 3  $SiO_2$

36 Which reaction routes can be used to make a pure sample of barium sulfate?

- 1 Ba  $\xrightarrow[\text{in } O_2]{\text{heat}}$  product  $\xrightarrow[HCl]{\text{dilute}}$  product  $\xrightarrow[H_2SO_4]{\text{dilute}}$  product  $\xrightarrow[\text{and dry}]{\text{filter, wash}}$
- 2  $Ba(NO_3)_2 \xrightarrow[\text{heat in air}]{\text{strong}}$  solid product  $\xrightarrow[\text{of water}]{\text{an excess}}$  product  $\xrightarrow[H_2SO_4]{\text{dilute}}$  product  $\xrightarrow[\text{and dry}]{\text{filter, wash}}$
- 3  $Ba(OH)_2 \xrightarrow[HNO_3]{\text{dilute}}$  product  $\xrightarrow[H_2SO_4]{\text{dilute}}$  product  $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

37 Cortisone is a synthetic hormone.



Which classes of alcohol does this molecule contain?

- 1 primary alcohol
- 2 secondary alcohol
- 3 tertiary alcohol

38 Which changes are commonly involved in the formation of an addition polymer?

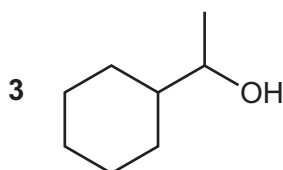
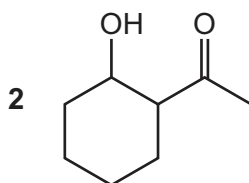
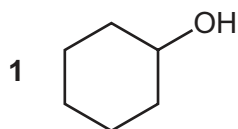
- 1 the formation of a  $\sigma$ -bond
- 2 the breaking of a  $\pi$ -bond
- 3 the change in hybridisation of the orbitals of a carbon atom from  $sp^2$  to  $sp^3$

The responses **A** to **D** should be selected on the basis of

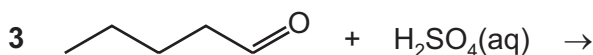
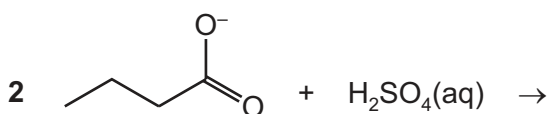
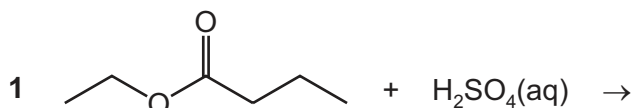
<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

**39** Which alcohols can be oxidised to form an organic compound which will give coloured precipitates with both 2,4-dinitrophenylhydrazine reagent and alkaline aqueous iodine?



**40** Which mixtures form a carboxylic acid as one of the products?



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