



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.

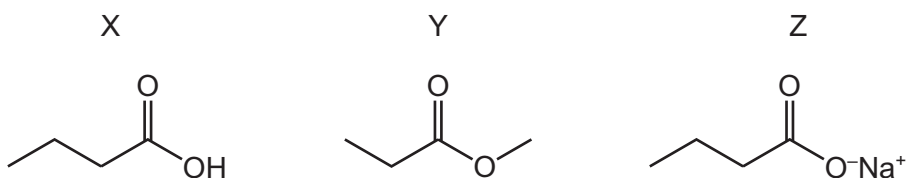
1 Which statement about the Avogadro constant is correct?

- A** It is the mass of one mole of any element.
- B** It is the mass of 6.02×10^{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** $\text{I}(\text{g}) \rightarrow \text{I}^+(\text{g}) + \text{e}^-$

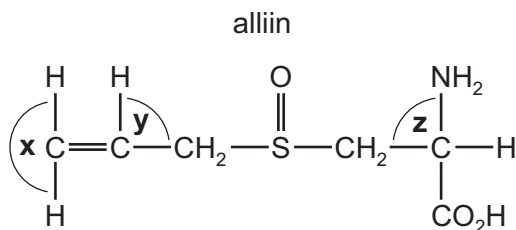
3 The structures represent three compounds, each with four carbon atoms per molecule.



Which row is correct?

	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	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?

	x	y	z
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

- 5 Flask Q contains 5 dm³ of helium at 12 kPa pressure. Flask R contains 10 dm³ of neon at 6 kPa pressure.

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

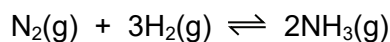
- A** 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

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

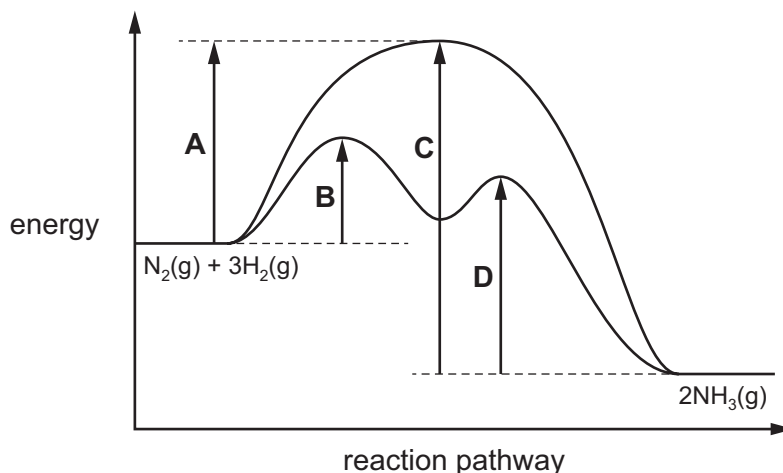
Which row is correct?

	sodium chloride	water	air
A	particles held in rigid structure	can easily be compressed	can easily be compressed
B	particles stationary	particles move	cannot easily be compressed
C	particles stationary	particles stationary	particles move
D	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 N_2 and H_2 is shown.



Which letter represents the activation energy for the first step in the decomposition of NH_3 in the presence of a catalyst?



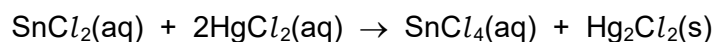
- 8 Nitrogen and oxygen can react together to form nitrogen monoxide, NO .



What is the bond energy of the bond between the atoms in NO ?

- A** 630 kJ mol^{-1} **B** 810 kJ mol^{-1} **C** 1260 kJ mol^{-1} **D** 1620 kJ mol^{-1}

- 9 The equation for a redox reaction is shown.

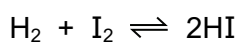


Which species is being oxidised in this reaction?

- A** Sn^{2+} **B** Cl^- **C** Hg^+ **D** 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 ⁻³	starting concentration of Y / mol dm ⁻³	rate of formation of Z at the start / mol dm ⁻³ s ⁻¹
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 SiCl₄ 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 Al₂S₃ B MgS C NaCl D PCl₅

- 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 (NH₄)₂SO₄ B NH₄NO₃ C Ca(OH)₂ D Ca(NO₃)₂

- 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
A	$\text{AgNO}_3(\text{aq})$ and $\text{NaCl}(\text{aq})$	concentrated $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{HI}(\text{aq})$
B	$\text{Br}_2(\text{aq})$ and $\text{NaCl}(\text{aq})$	concentrated $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{HCl}(\text{aq})$
C	$\text{Cl}_2(\text{aq})$ and $\text{NaBr}(\text{aq})$	$\text{CH}_3\text{CHBrCH}_3(\text{l}) + \text{NaOH}$ (ethanolic)
D	$\text{Br}_2(\text{aq})$ 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.

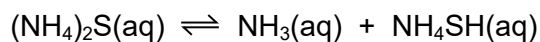
When chlorine is added to water, which chemical species present is responsible for killing bacteria?

- A ClO_2^-
- B Cl^-
- C HCl
- D 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, NH_3 , and hydrogen sulfide gas, H_2S , 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.

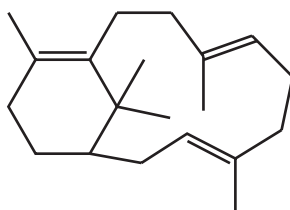
X and Y could represent different gases or identical gases.

What are the identities of X and Y?

	X	Y
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	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.

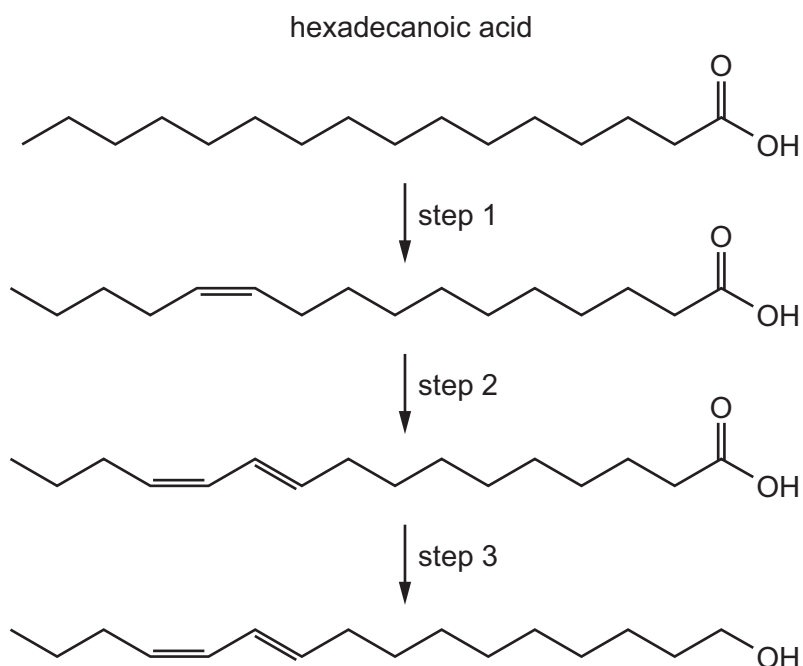
compound P



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

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

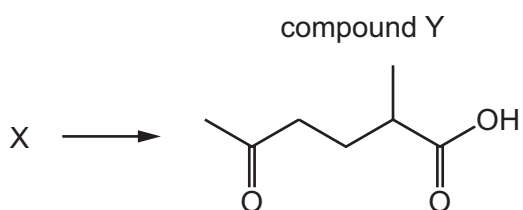
- 21 Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



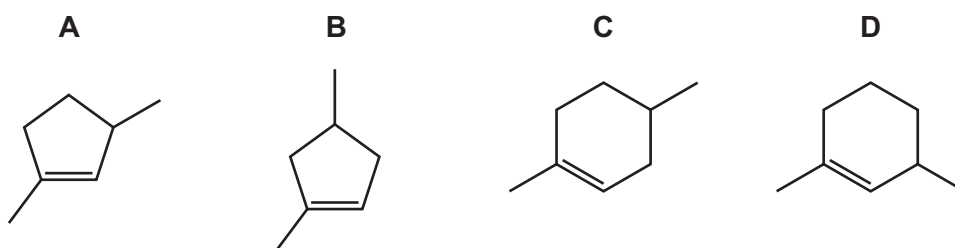
Which row contains correct descriptions of the three steps?

	step 1	step 2	step 3
A	elimination	elimination	dehydration
B	elimination	reduction	reduction
C	oxidation	elimination	oxidation
D	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 CH₃ **C** Br and C₂H₆ **D** CH₃ and CH₃Br

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.

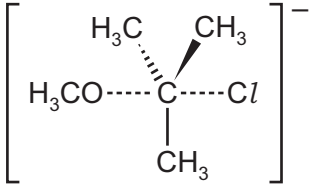
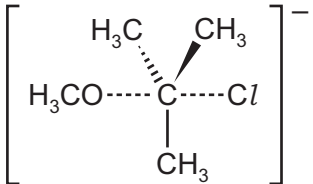
The experiment was repeated with 2-iodopropane.

Which row is correct?

	colour of precipitate from 2-bromopropane + AgNO ₃ (aq)	faster rate of reaction
A	cream	2-bromopropane + AgNO ₃ (aq)
B	yellow	2-bromopropane + AgNO ₃ (aq)
C	cream	2-iodopropane + AgNO ₃ (aq)
D	yellow	2-iodopropane + AgNO ₃ (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 CH_3O^- ion.

Which row is correct?

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

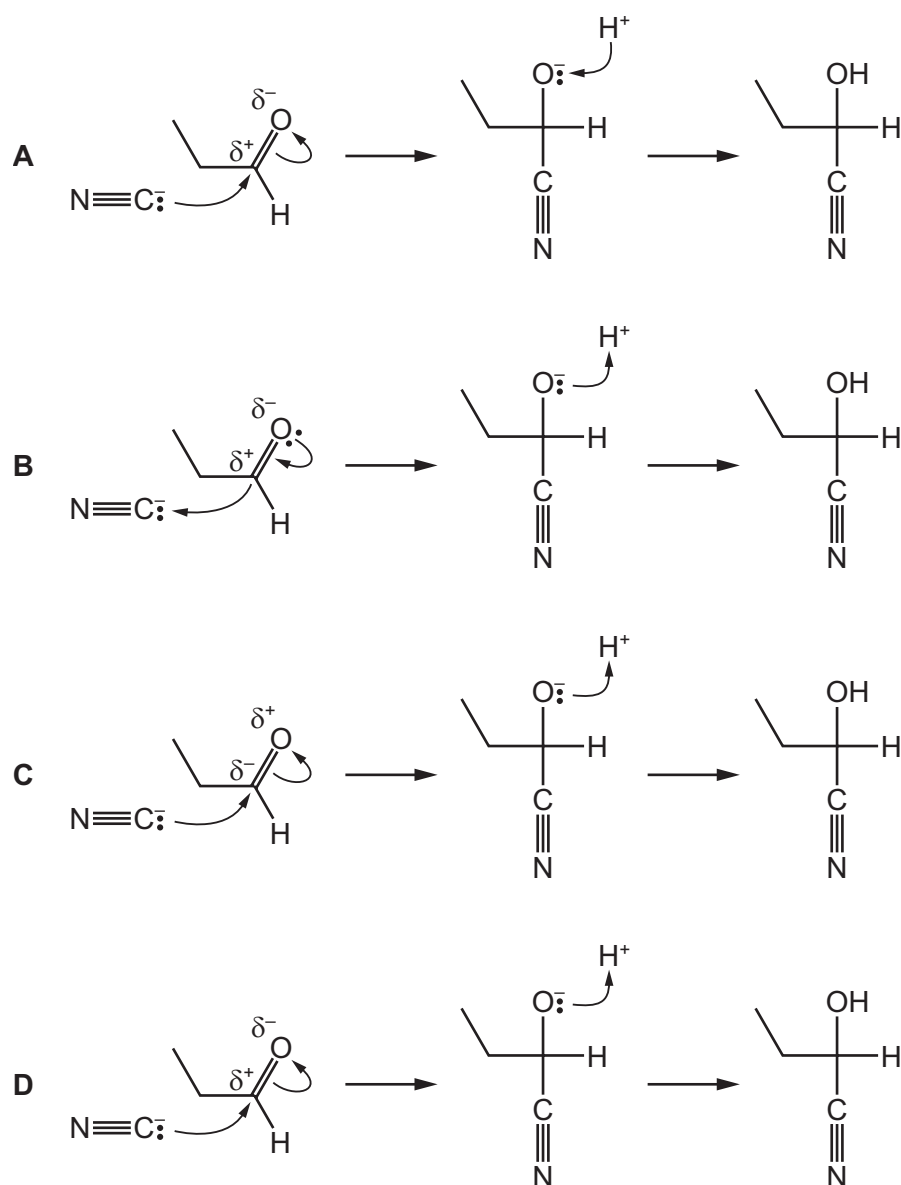
- 26** Alcohol X reacts with concentrated sulfuric acid to produce a mixture of products.

Two of the products are structural isomers of each other.

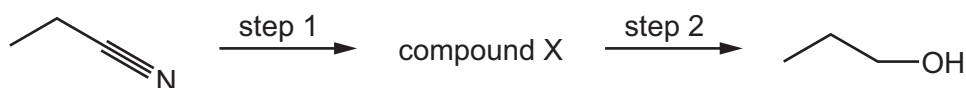
What could be X?

- 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.

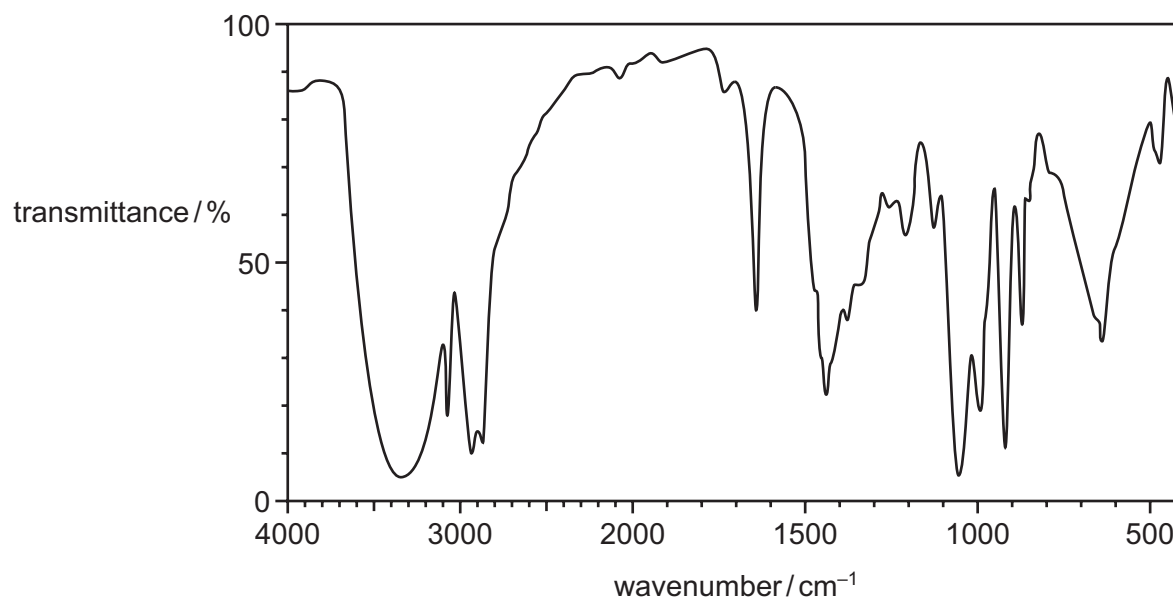


Which row gives the correct reagents for steps 1 and 2?

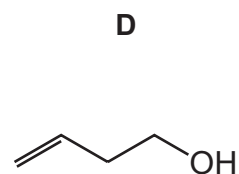
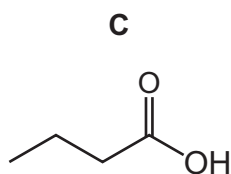
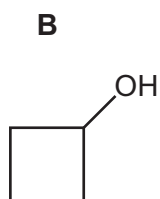
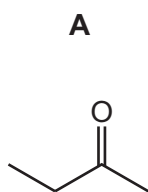
	step 1	step 2
A	$\text{HCl}(\text{aq})$	$\text{H}_2 + \text{Ni}$
B	$\text{HCl}(\text{aq})$	LiAlH_4
C	$\text{NaOH}(\text{aq})$	$\text{H}_2 + \text{Ni}$
D	$\text{NaOH}(\text{aq})$	NaBH_4

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

A	B	C	D
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** ${}^{19}_{9}\text{F}^{-}$
- 2** ${}^{31}_{15}\text{P}^{-}$
- 3** ${}^{23}_{11}\text{Na}^{+}$

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

What can be determined about X?

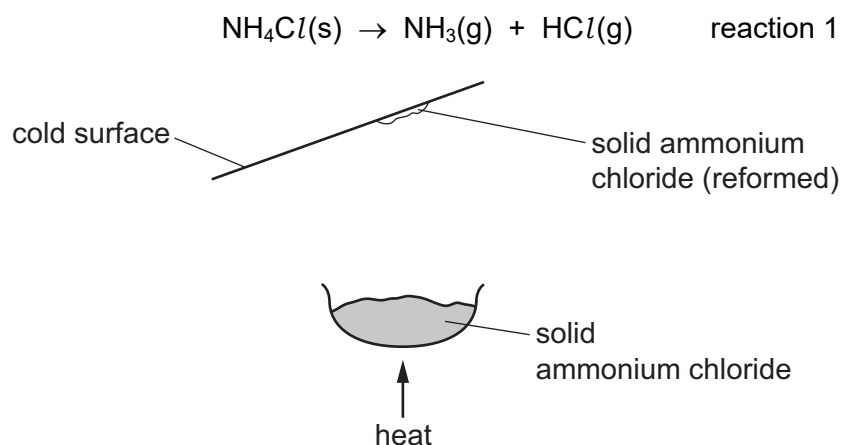
- 1** empirical formula
- 2** molecular formula
- 3** whether X contains a C=C bond or not

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

A	B	C	D
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.

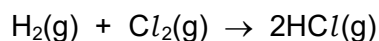
- 33** When a sample of ammonium chloride is warmed it decomposes into ammonia and hydrogen chloride gas.



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

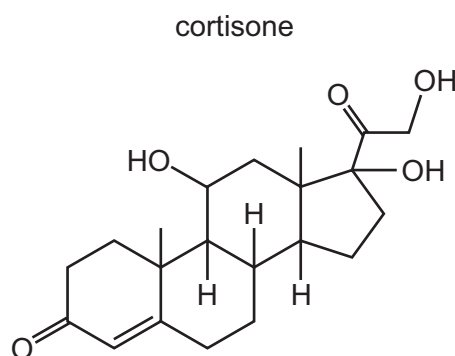
35 Which oxides will cause a change in pH when added to water?

- 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?

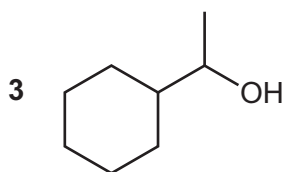
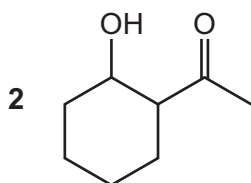
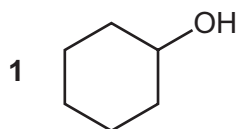
- 1 the formation of a σ -bond
- 2 the breaking of a π -bond
- 3 the change in hybridisation of the orbitals of a carbon atom from sp^2 to sp^3

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

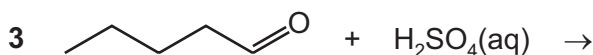
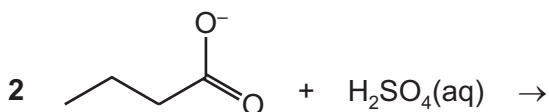
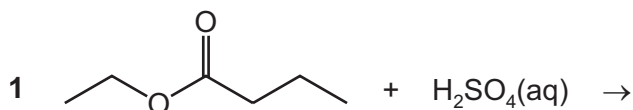
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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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