Cambridge Assessment International Education

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 $\frac{1}{2}I_2(g) + e^- \rightarrow I^-(g)$

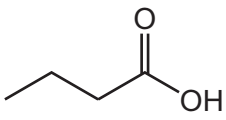
B $I(g) + e^- \rightarrow I^-(g)$

C $\frac{1}{2}I_2(g) \rightarrow I^+(g) + e^-$

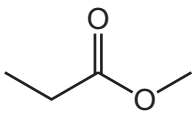
D $I(g) \rightarrow I^+(g) + e^-$

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

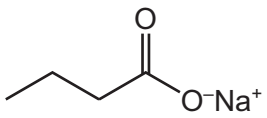
X



Y



Z

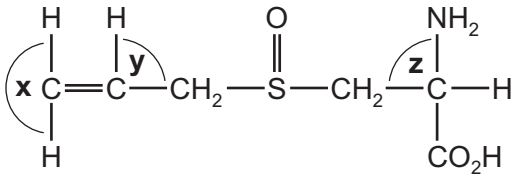


Which row is correct?

	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.

alliin



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 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 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.

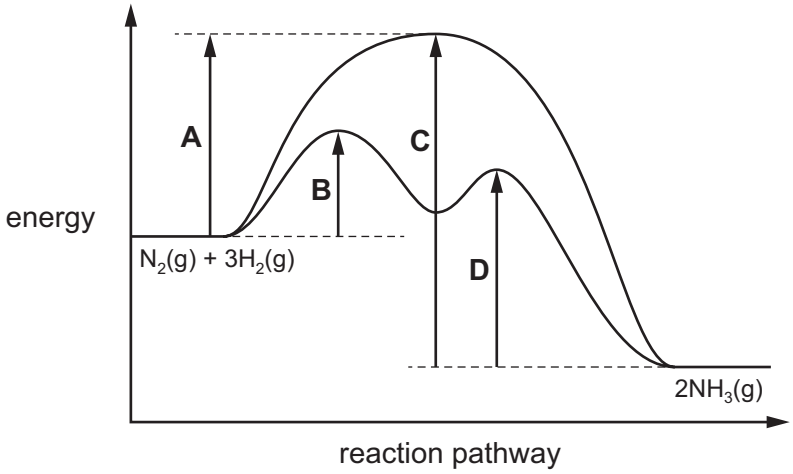
Which row is correct?

	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.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

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.

$$N_2 + O_2 \rightarrow 2NO \qquad \Delta H = +180\,kJ\,mol^{-1}$$

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.

$$SnCl_2(aq) + 2HgCl_2(aq) \rightarrow SnCl_4(aq) + Hg_2Cl_2(s)$$

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.

$$H_2 + I_2 \rightleftharpoons 2HI$$

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 $SiCl_4$ 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_2S_3 **B** MgS **C** $NaCl$ **D** PCl_5

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 $(NH_4)_2SO_4$ **B** NH_4NO_3 **C** $Ca(OH)_2$ **D** $Ca(NO_3)_2$

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	$AgNO_3$(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HI(aq)
B	Br_2(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HCl(aq)
C	Cl_2(aq) and NaBr(aq)	$CH_3CHBrCH_3$(l) + NaOH (ethanolic)
D	Br_2(aq) and NaI(aq)	concentrated H_2SO_4(aq) and NaBr(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, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, X.
The addition of HCl(aq) to a separate portion of this solution produces a gas, Y.

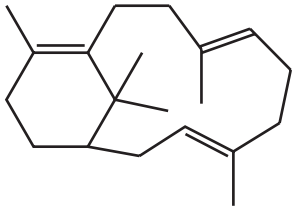
X and Y could represent different gases or identical gases.

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.

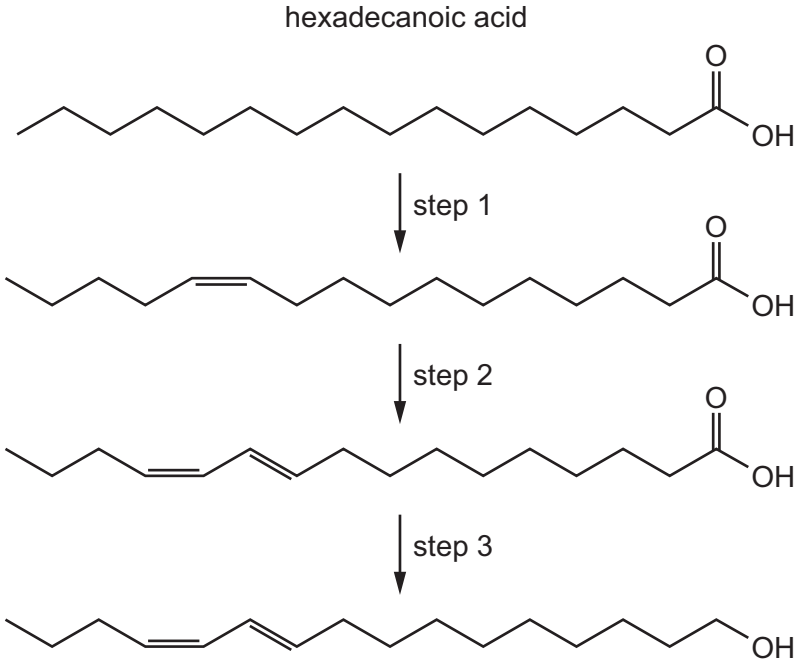
compound P



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

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

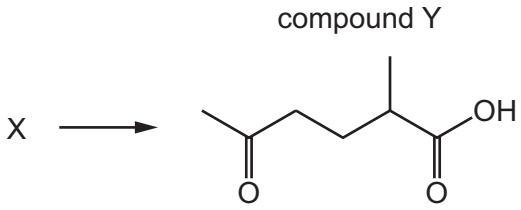
21 Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



Which row contains correct descriptions of the three steps?

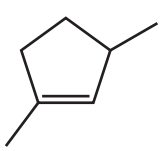
	step 1	step 2	step 3
A	elimination	elimination	dehydration
B	elimination	reduction	reduction
C	oxidation	elimination	oxidation
D	oxidation	oxidation	reduction

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

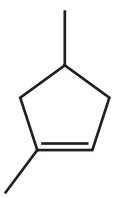


What could be the identity of X?

A



B



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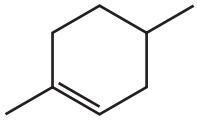
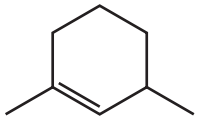


D



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_3 **C** Br and C_2H_6 **D** CH_3 and CH_3Br

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.

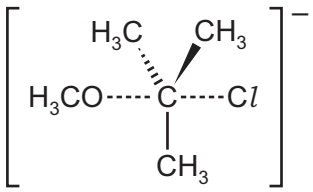
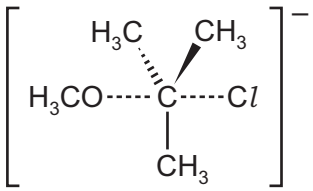
The experiment was repeated with 2-iodopropane.

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, $Na^+CH_3O^-$, 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	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C		$HOCH_2C(CH_3)_3$
D		$H_3COC(CH_3)_3$

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

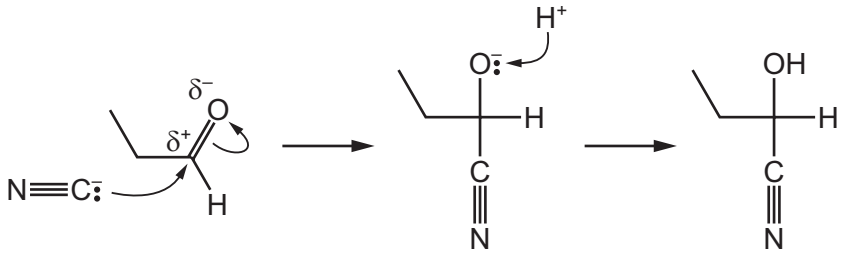
B ethanol and hot aluminium oxide

C ethanol and sodium

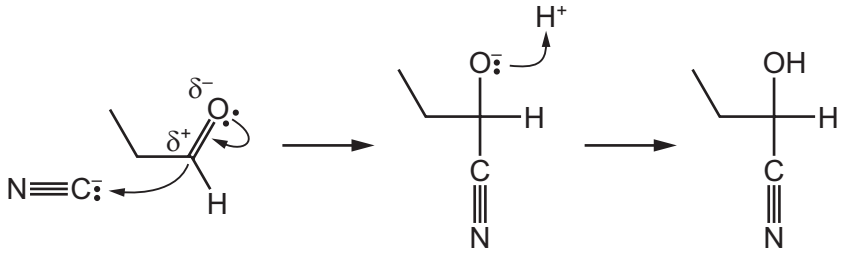
D ethanol and hydrogen chloride

28 Which reaction mechanism for the formation of $C_2H_5CH(OH)(CN)$ is correct?

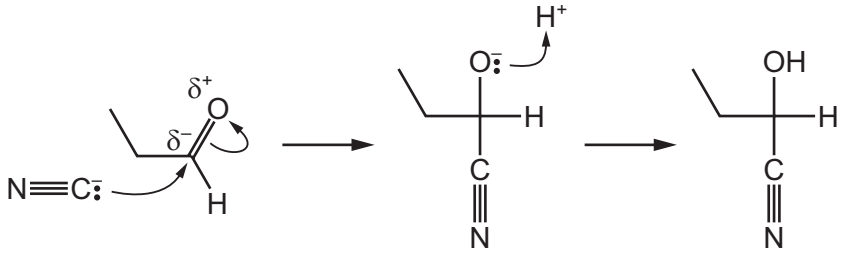
A



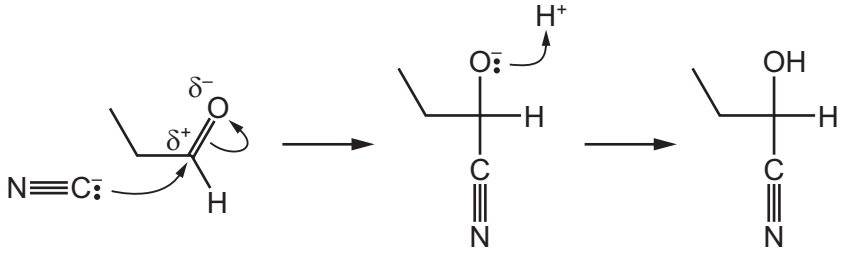
B



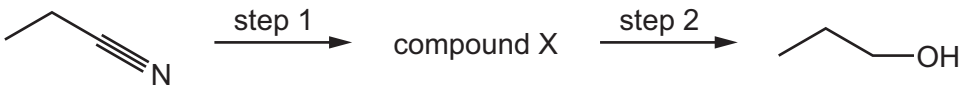
C



D



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

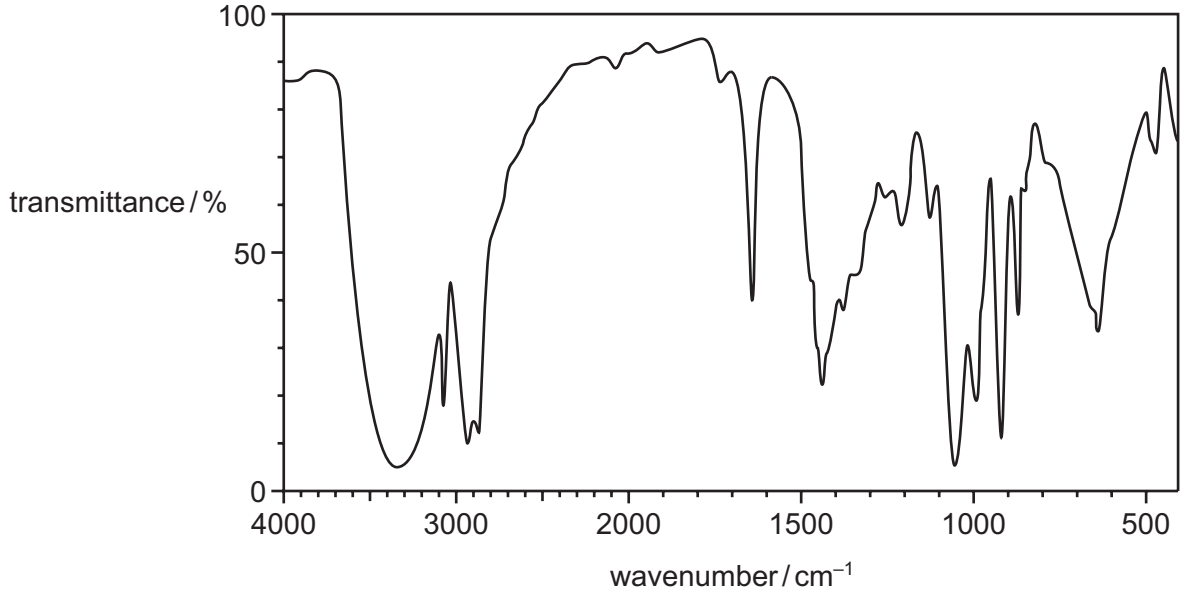


Which row gives the correct reagents for steps 1 and 2?

	step 1	step 2
A	HCl(aq)	H_2 + Ni
B	HCl(aq)	LiA$l$$H_4$
C	NaOH(aq)	H_2 + Ni
D	NaOH(aq)	$NaBH_4$

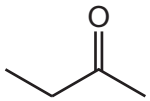
30 The molecular formula of Z is C_4H_8O.

The infra-red spectrum of Z is shown.

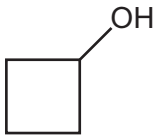


What could be Z?

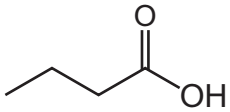
A



B



C



D

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 $^{19}_{9}F^{-}$

2 $^{31}_{15}P^{-}$

3 $^{23}_{11}Na^{+}$

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

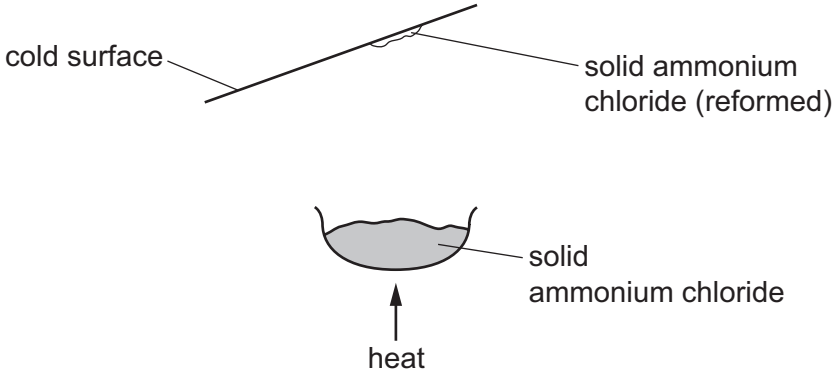
The responses **A** to **D** should be selected on the basis of

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.

$$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g) \qquad \text{reaction 1}$$



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.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

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?

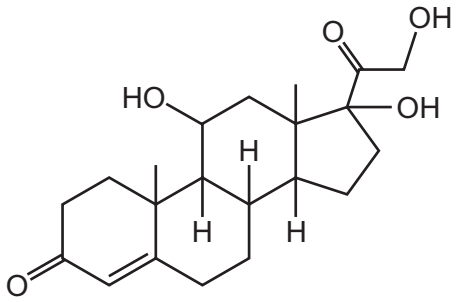
1 Ba $\xrightarrow[\text{in } O_2]{\text{heat}}$ product $\xrightarrow[HCl]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

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.

cortisone



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

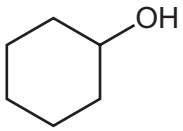
The responses **A** to **D** should be selected on the basis of

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

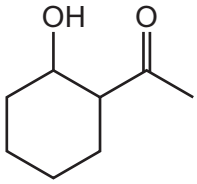
No other combination of statements is used as a correct response.

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?

1



2



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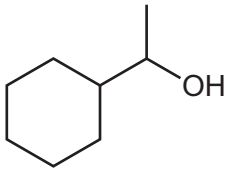
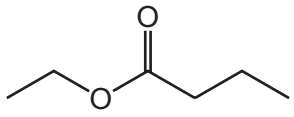


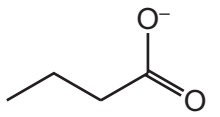
40 Which mixtures form a carboxylic acid as one of the products?

1



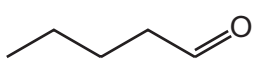
+ $H_2SO_4(aq)$ →

2



+ $H_2SO_4(aq)$ →

3



+ $H_2SO_4(aq)$ →