Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

2230209778

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **16** printed pages.

CAMBRIDGE International Examinations

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 The first four ionisation energies for element X are shown in the table.

ionisation energy	1st	2nd	3rd	4th
value / kJ mol^{-1}	577	1980	2960	6190

Which ion of X is produced by removing an electron from a filled shell?

A X^{+} **B** X^{2+} **C** X^{3+} **D** X^{4+}

2 What is a basic assumption of the kinetic theory, as applied to an ideal gas?

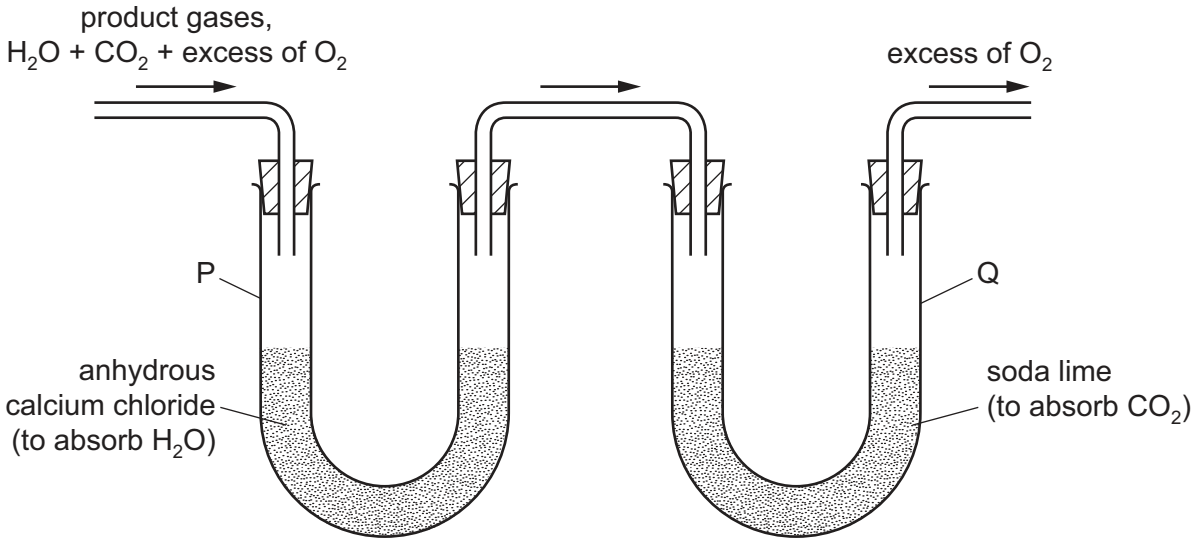
A Collisions between gas molecules are elastic.

B Each gas molecule occupies a finite volume.

C Gases consist of particles that experience the force of gravity.

D Gas molecules attract each other with weak intermolecular forces.

3 A sample of the hydrocarbon C_6H_{12} is completely burned in dry oxygen and the product gases are collected as shown.



The increases in mass of the collecting vessels P and Q are M_P and M_Q, respectively.

What is the ratio M_P / M_Q?

A 0.41 **B** 0.82 **C** 1.2 **D** 2.4

4 5.0 g samples of the carbonates of barium, copper, lithium and magnesium are decomposed to the metal oxides and carbon dioxide.

For which compound is there the greatest loss in mass?

A barium carbonate

B copper(II) carbonate

C lithium carbonate

D magnesium carbonate

5 In this question you should assume methane behaves as an ideal gas.

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

The volume of a sample of methane is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is 5.37×10^{-3} m^3.

What is the mass of the sample of methane, given to two significant figures?

A 0.0032 g **B** 0.018 g **C** 3.2 g **D** 18 g

6 A butane burner is used to heat water. The M_r of butane is 58.

- $\Delta H_c^{\ominus}$ of butane is –2877 kJ mol^{-1}.
- 250 g of water is heated from 12 °C to 100 °C.
- The burner transfers 47% of the heat released from the burning fuel to the water.

Assume that the butane undergoes complete combustion and none of the water evaporates.

What is the minimum mass of butane that must be burnt?

A 0.068 g **B** 1.85 g **C** 3.94 g **D** 4.48 g

7 Nitric acid is known to take part in the oxidation of atmospheric sulfur dioxide. One possible reaction is shown.

$$SO_2 + HNO_3 \rightarrow NO^+ + HSO_4^-$$

Which row shows the correct changes in oxidation numbers of nitrogen and sulfur?

	nitrogen	sulfur
A	–3	+3
B	–2	+2
C	–2	+3
D	–1	+2

8 A transition metal ion, M^{2+}, reacts with acidified dichromate(VI) ions to form M^{4+} ions, Cr^{3+} ions, and H_2O.

Which equation correctly represents this reaction?

A $Cr_2O_7^{2-} + 14H^+ + M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + M^{4+}$

B $Cr_2O_7^{2-} + 14H^+ + 2M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 2M^{4+}$

C $Cr_2O_7^{2-} + 14H^+ + 3M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 3M^{4+}$

D $Cr_2O_7^{2-} + 14H^+ + 6M^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6M^{4+}$

9 In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.5\,kJ\,mol^{-1}$$

Which statement **must** be true for the K_p of this equilibrium to be constant?

A The partial pressures of H_2, I_2 and HI are equal.

B The external pressure is constant.

C The forward and reverse reactions have stopped.

D The temperature is constant.

10 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c?

A 0.150 $mol\,dm^{-3}$

B 0.800 $mol\,dm^{-3}$

C 1.25 $mol^{-1}\,dm^3$

D 6.67 $mol^{-1}\,dm^3$

11 Two reactions are shown.

reaction 1 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

reaction 2 $2O_3(g) \rightleftharpoons 3O_2(g)$

In reaction 1, a finely powdered iron catalyst is used.

In reaction 2, a vaporised tetrachloromethane catalyst in ultraviolet light is used.

Which statement about the catalysts used is correct?

A Both reaction 1 and reaction 2 use a heterogeneous catalyst.

B Both reaction 1 and reaction 2 use a homogeneous catalyst.

C Reaction 1 uses a heterogeneous catalyst and reaction 2 uses a homogeneous catalyst.

D Reaction 1 uses a homogeneous catalyst and reaction 2 uses a heterogeneous catalyst.

12 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	blue
B	white	yellow
C	yellow	blue
D	yellow	yellow

[Turn over

13 X and Y are elements in Period 3 of the Periodic Table.

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

What could be the formula of a compound formed between elements X and Y?

A Al_2S_3 **B** MgS **C** NaCl **D** PCl_5

14 Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	bonding	structure	bonding	structure
A	covalent	giant	covalent	giant
B	covalent	giant	covalent	simple
C	ionic	giant	covalent	giant
D	ionic	giant	covalent	simple

15 A sample of anhydrous calcium nitrate is placed in a test-tube and heated in a roaring Bunsen flame until it decomposes. The description of the gas in the test-tube is then noted. A glowing splint is then put into the test-tube and any changes are noted.

Which observations are correct?

	description of the gas in the test-tube	result of glowing splint test
A	brown	the splint goes out
B	brown	the splint relights
C	colourless	the splint goes out
D	colourless	the splint relights

16 Which row correctly describes the properties of the halogens as Group 17 is descended from chlorine to iodine?

	volatility	strength as oxidising agent
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

17 Reaction 1: chlorine reacts with cold aqueous sodium hydroxide to form solution Z.

Reaction 2: solution Z is heated and forms ClO_3^-(aq) and Cl^-(aq).

Which equations represent reaction 1 and reaction 2?

A reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO_2^- \rightarrow 2ClO_3^- + Cl^-$

B reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

C reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $2ClO^- + 2OH^- \rightarrow ClO_3^- + Cl^- + H_2O$

D reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

18 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

19 Transition elements and their compounds are widely used as catalysts.

What is the identity and what is the oxidation number of the element present in the catalyst used in the Contact process?

	element	oxidation number
A	iron	0
B	iron	+3
C	vanadium	0
D	vanadium	+5

20 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.

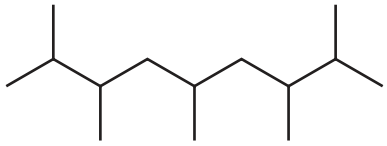
D It is negatively charged.

21 X has the molecular formula $C_5H_{12}O$. X has a branched carbon skeleton and a secondary alcohol functional group.

How many **structural** isomers fit this description of X?

A 1 **B** 2 **C** 3 **D** 4

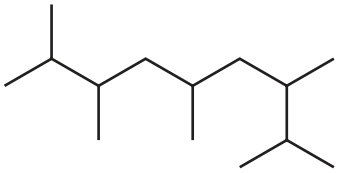
22 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



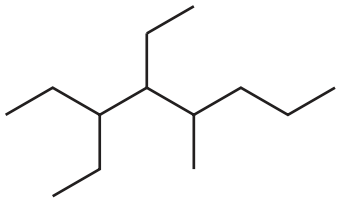
Q

Which skeletal formula represents a **structural isomer** of Q?

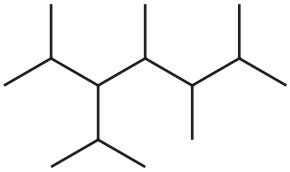
A



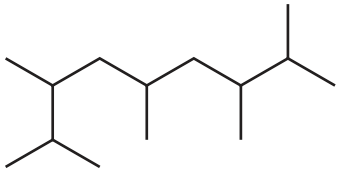
B



C



D



23 The conversion of propene to propan-2-ol can be carried out in two stages represented by the equations shown.

reaction 1 $CH_3CH{=}CH_2(g) + HI(g) \rightarrow CH_3CHICH_3(l)$

reaction 2 $CH_3CHICH_3(l) + KOH(aq) \rightarrow CH_3CH(OH)CH_3(aq) + K^+(aq) + I^-(aq)$

How can these two reactions be described?

	reaction 1	reaction 2
A	addition	elimination
B	addition	substitution
C	elimination	substitution
D	substitution	elimination

24 An organic molecule W contains 3 carbon atoms. It requires 4.5 molecules of oxygen for complete combustion.

What could W be?

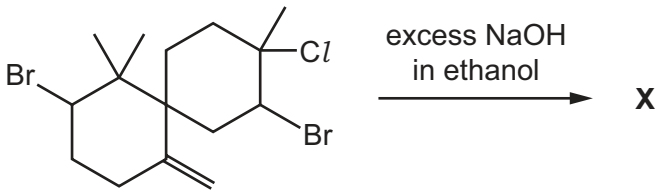
A propane

B propanoic acid

C propanone

D propan-1-ol

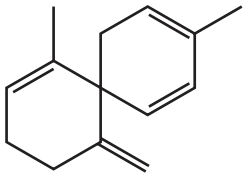
25 Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is **X**.



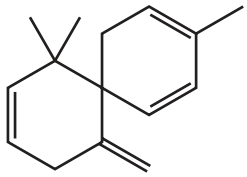
compound J

What could be the skeletal formula of **X**?

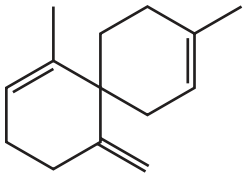
A



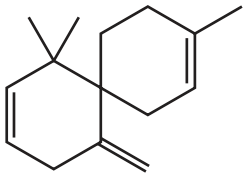
B



C



D



26 Sodium reacts with 1 mol of compound Y to produce 1 mol of $H_2(g)$.

Which compound could Y be?

A $CH_3CH_2CH_2CH_2OH$

B $(CH_3)_3COH$

C $CH_3CH_2CH_2CO_2H$

D $CH_3CH(OH)CO_2H$

27 Which compound shows optical isomerism and gives a positive test with alkaline aqueous iodine?

A $CH_3COCH(OH)CH_3$

B $CH_3COCH_2CH_2OH$

C $HOCH_2CH(CH_3)CHO$

D $(CH_3)_2C(OH)CHO$

28 Ethanedioic acid, HO_2CCO_2H, is reduced using an excess of lithium aluminium hydride, $LiAlH_4$.

What is the organic product of the reaction?

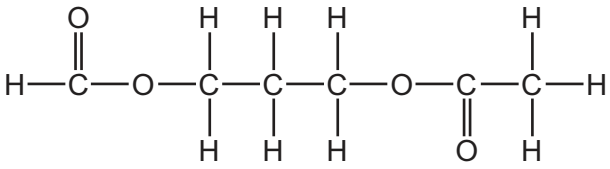
A ethanol

B ethane-1,2-diol

C ethanedial, OHCCHO

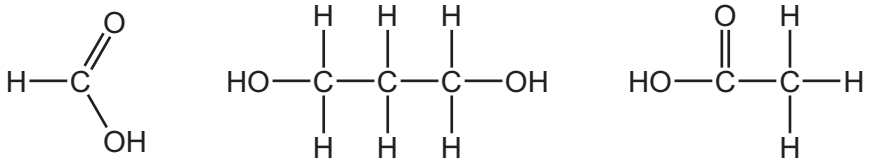
D methane

29 The diester shown can be hydrolysed by heating with an excess of aqueous sodium hydroxide.

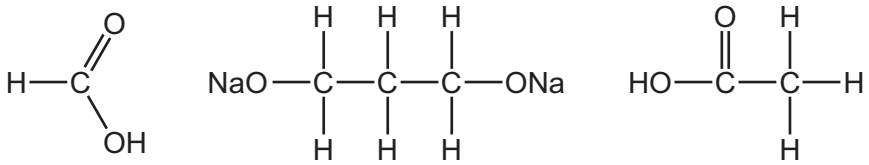


What would the products of this reaction be?

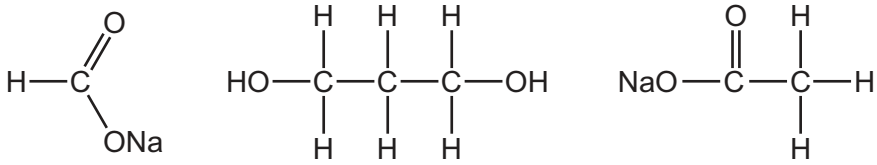
A



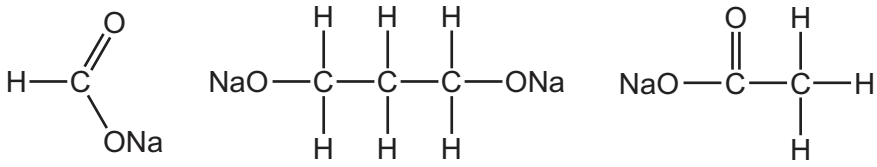
B



C

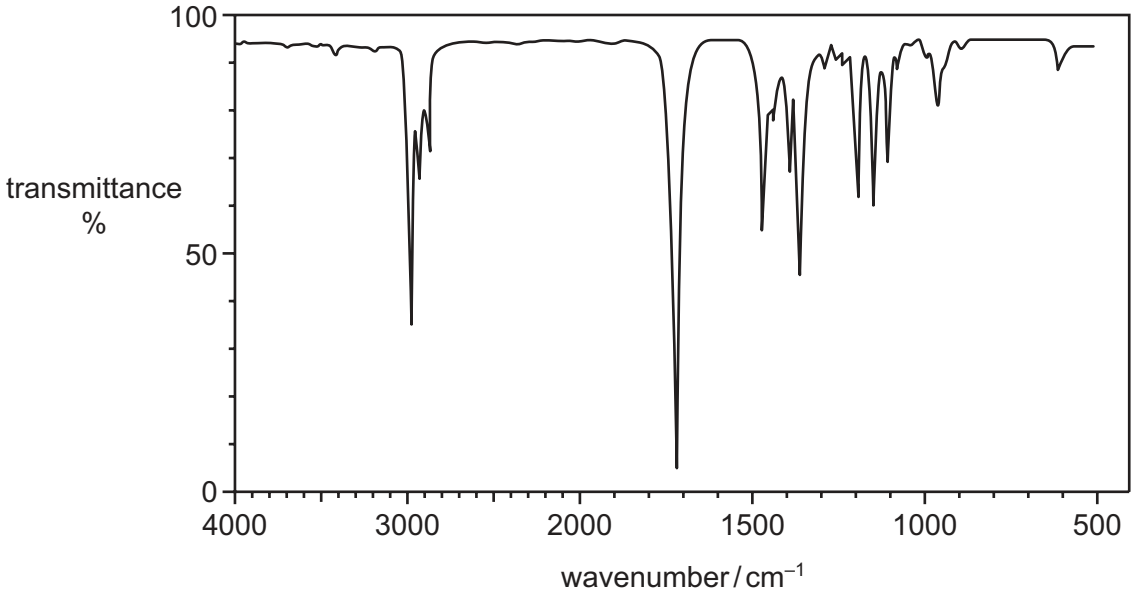


D



30 **J** is a branched-chain alcohol, $C_5H_{12}O$. **J** is heated under reflux with an excess of $Cr_2O_7^{2-}/H^+$ until no further reaction occurs. An organic compound **K** is formed in good yield.

The infra-red spectrum of **K** is shown.



What are the structures of the branched-chain alcohol **J** and compound **K**?

	J	**K**
A	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2CHO$
B	$CH_3CH_2CH(OH)CH_2CH_3$	$CH_3CH_2COCH_2CH_3$
C	$CH_3CH(CH_3)CH(OH)CH_3$	$CH_3CH(CH_3)COCH_3$
D	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2COOH$

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 Which ions contain one or more unpaired electrons?

1 Cu^{2+}

2 Mn^{3+}

3 V^{3+}

32 Which molecules and ions have a bond angle of 120°?

1 BF_3

2 CH_3^-

3 NH_3

33 Which statements are correct for **all** exothermic reactions?

1 ΔH for the reaction is negative.

2 On a reaction pathway diagram the products are shown lower than the reactants.

3 The reaction will occur without heating.

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.

34 The factors affecting the rate of reaction between aqueous sodium thiosulfate and hydrochloric acid can be investigated. The ionic equation for the reaction is shown.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + S(s) + SO_2(aq)$$

Which of the following can be used to investigate the rate of this reaction?

1 change of mass

2 change of appearance caused by formation of a precipitate

3 change of electrical conductivity

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

1 Ba metal $\xrightarrow[\text{in } O_2]{\text{heat}}$ product $\xrightarrow[HCl]{\text{dilute}}$ product 2 $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 3 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

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

3 $Ba(OH)_2$ $\xrightarrow[HNO_3]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product 2 $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

36 Which properties increase from magnesium to barium?

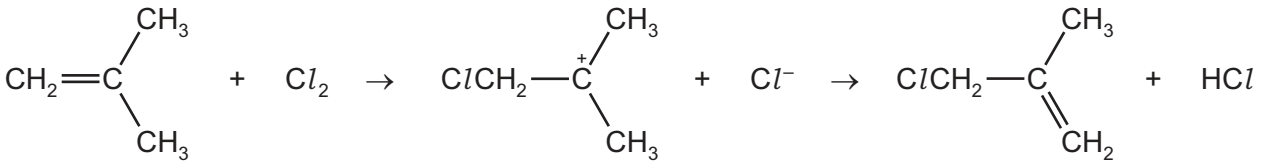
1 ionic radius of the cation M^{2+}

2 screening of outermost electrons by inner shells

3 solubility of the hydroxides, $M(OH)_2$, in water

37 2-methylpropene can react in more than one way with chlorine.

One of the reactions follows the pathway shown.



2-methylpropene intermediate product

Which statements about this mechanism are correct?

1 The intermediate has all carbon atoms in the same plane.

2 There is an electrophilic attack on the double bond.

3 It is a free radical mechanism.

38 The halogenoalkanes listed below all react with NaOH(aq).

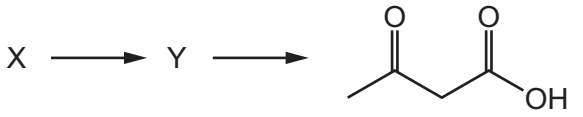
Which reactions proceed mainly by an S_N1 mechanism?

1 1-iodopropane

2 2-iodo-2-methylpropane

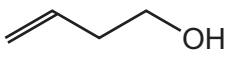
3 2-bromo-2-methylbutane

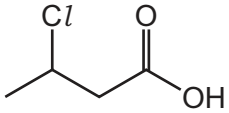
39 3-oxobutanoic acid can be synthesised in a two-step process.

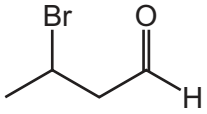


3-oxobutanoic acid

What could be the structure of X?

1 

2 

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.

40 Ethanal reacts with HCN in the presence of KCN.

Which changes in bonding occur during this reaction?

1 A carbon-carbon bond is formed.

2 A carbon-hydrogen bond is broken.

3 A carbon-nitrogen bond is broken.