

CHEMISTRY

9701/11

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

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.



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

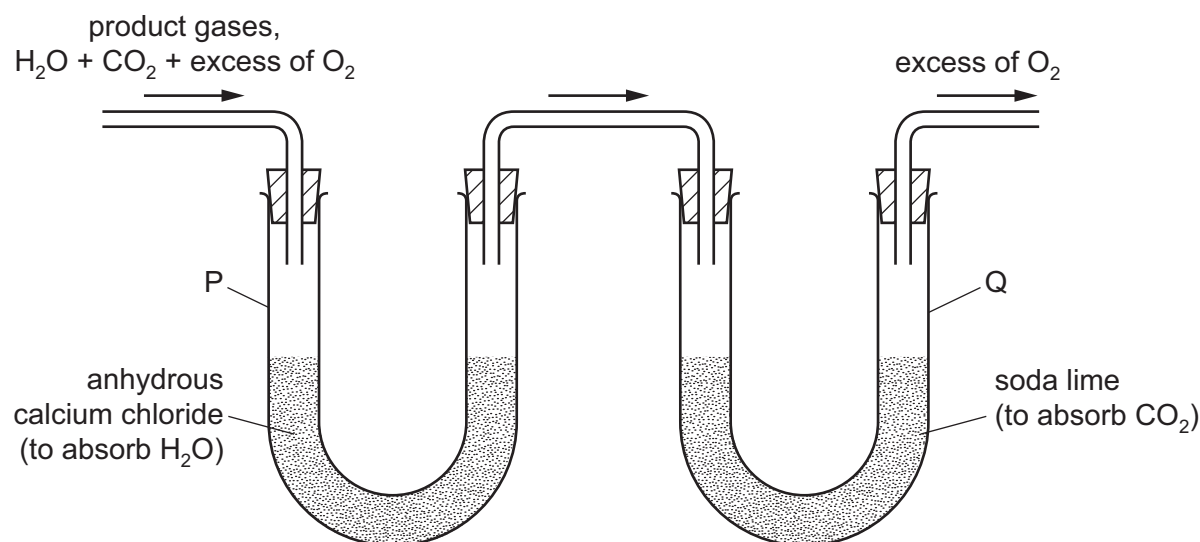
Which ion of X is produced by removing an electron from a filled shell?

- 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 $5.37 \times 10^{-3} \text{ m}^3$.

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.

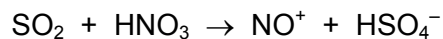
- $\Delta H_c^\ominus$ of butane is $-2877 \text{ kJ mol}^{-1}$.
- 250 g of water is heated from 12 °C to 100 °C.
- The burner transfers 47% of the heat released from the burning fuel to the water.

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.



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

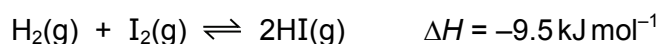
- 8 A transition metal ion, M^{2+} , reacts with acidified dichromate(VI) ions to form M^{4+} ions, Cr^{3+} ions, and H_2O .

Which equation correctly represents this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + \text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + \text{M}^{4+}$
- B** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 2\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 2\text{M}^{4+}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{M}^{4+}$
- D** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{M}^{4+}$

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

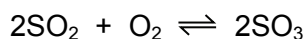
Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.



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.

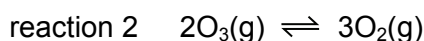
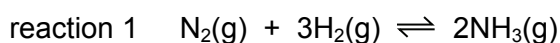
- 10 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm³ sealed container. The gases are allowed to react until equilibrium is reached.



At equilibrium there is 0.100 mol of SO₃ 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 dm³
 - D 6.67 mol⁻¹ dm³
- 11 Two reactions are shown.



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

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 $\text{ClO}_3^-(\text{aq})$ and $\text{Cl}^-(\text{aq})$.

Which equations represent reaction 1 and reaction 2?

- A** reaction 1 $2\text{Cl}_2 + 4\text{OH}^- \rightarrow \text{ClO}_2^- + 3\text{Cl}^- + 2\text{H}_2\text{O}$
 reaction 2 $3\text{ClO}_2^- \rightarrow 2\text{ClO}_3^- + \text{Cl}^-$
- B** reaction 1 $2\text{Cl}_2 + 4\text{OH}^- \rightarrow \text{ClO}_2^- + 3\text{Cl}^- + 2\text{H}_2\text{O}$
 reaction 2 $3\text{ClO}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$
- C** reaction 1 $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$
 reaction 2 $2\text{ClO}^- + 2\text{OH}^- \rightarrow \text{ClO}_3^- + \text{Cl}^- + \text{H}_2\text{O}$
- D** reaction 1 $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$
 reaction 2 $3\text{ClO}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$

- 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?

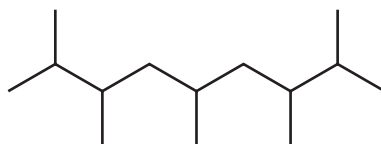
- A** It attacks a double bond.
- B** It donates a lone pair of electrons.
- C** It is a single atom.
- D** It is negatively charged.

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

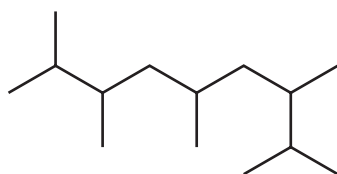
- 22 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



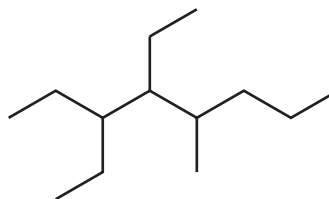
Q

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

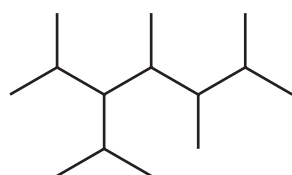
A



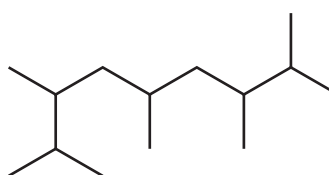
B



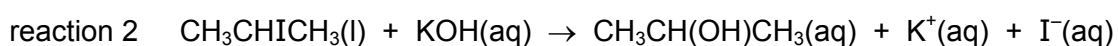
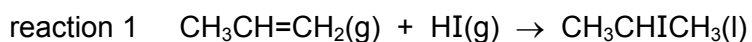
C



D



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



How can these two reactions be described?

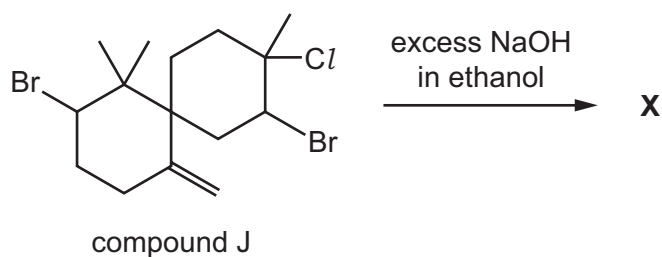
	reaction 1	reaction 2
A	addition	elimination
B	addition	substitution
C	elimination	substitution
D	substitution	elimination

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

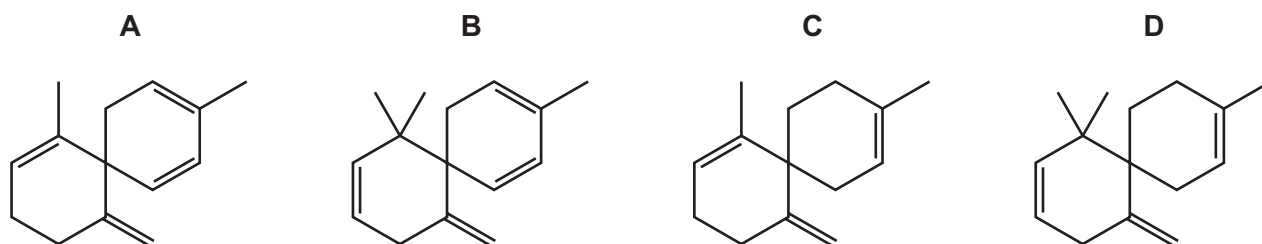
What could W be?

- 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.



What could be the skeletal formula of X?



- 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?

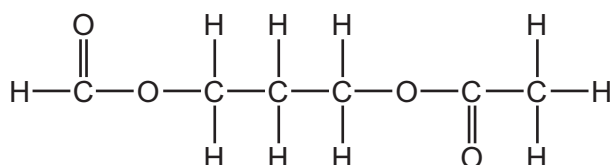
- A $CH_3COCH(OH)CH_3$
- B $CH_3COCH_2CH_2OH$
- C $HOCH_2CH(CH_3)CHO$
- D $(CH_3)_2C(OH)CHO$

- 28 Ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, is reduced using an excess of lithium aluminium hydride, LiAlH_4 .

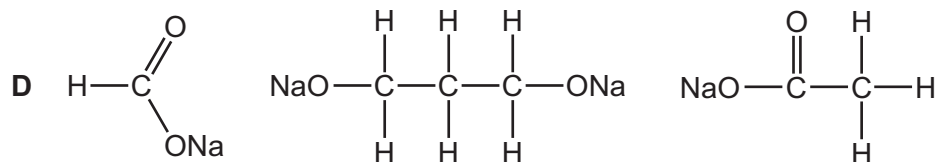
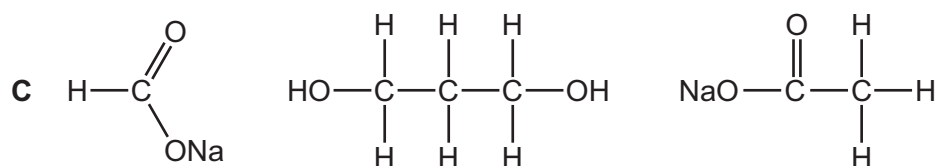
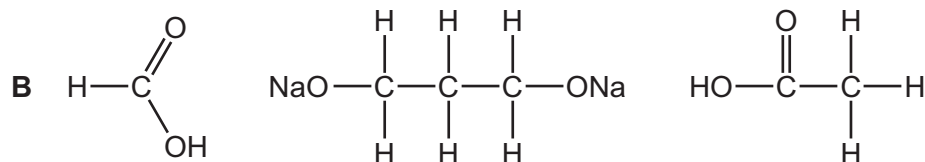
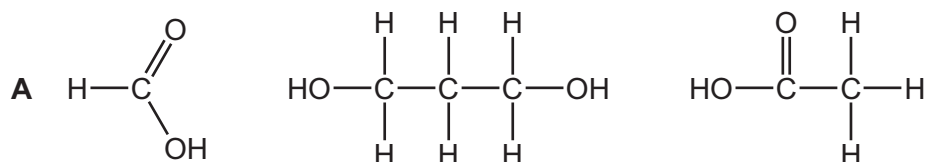
What is the organic product of the reaction?

- 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.

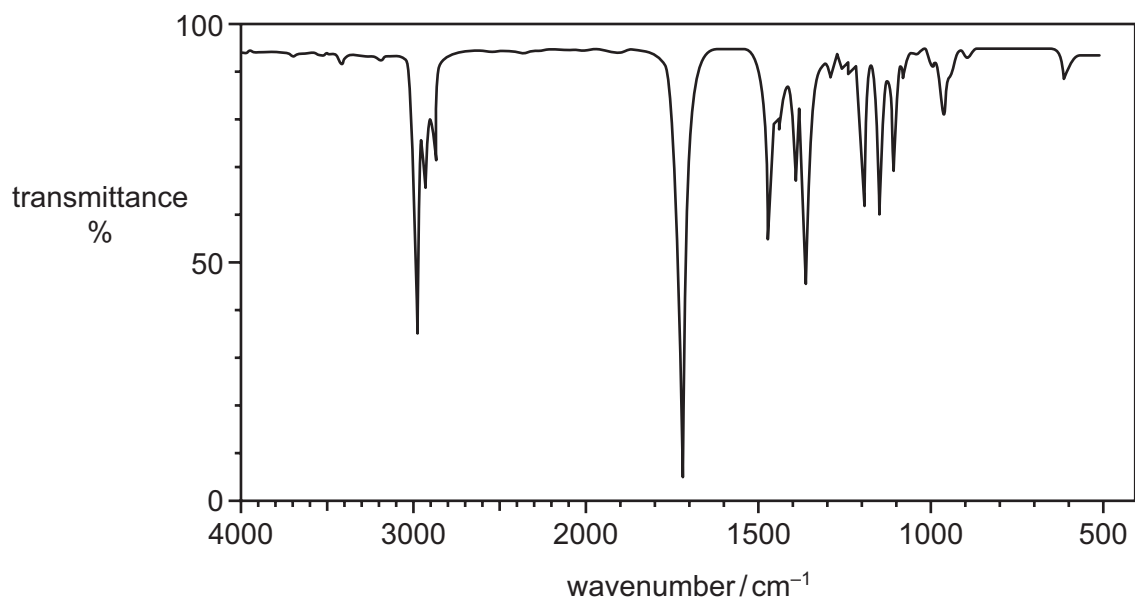


What would the products of this reaction be?



- 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?

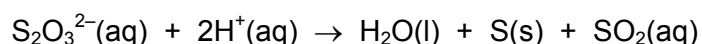
- 1** ΔH for the reaction is negative.
- 2** On a reaction pathway diagram the products are shown lower than the reactants.
- 3** The reaction will occur without heating.

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.



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?

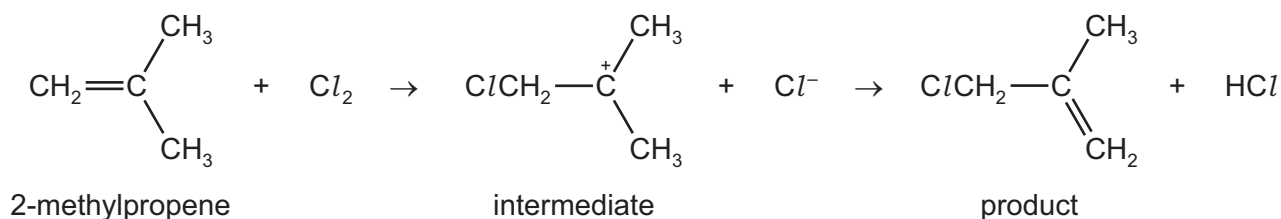
- 1** Ba metal $\xrightarrow[\text{in O}_2]{\text{heat}}$ product $\xrightarrow[\text{HCl}]{\text{dilute}}$ product 2 $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 3 $\xrightarrow{\text{filter, wash and dry}}$
- 2** $\text{Ba}(\text{NO}_3)_2 \xrightarrow[\text{heat in air}]{\text{strong}}$ solid product $\xrightarrow[\text{of water}]{\text{an excess}}$ product 2 $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 3 $\xrightarrow{\text{filter, wash and dry}}$
- 3** $\text{Ba}(\text{OH})_2 \xrightarrow[\text{HNO}_3]{\text{dilute}}$ product $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 2 $\xrightarrow{\text{filter, wash and dry}}$

- 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, $\text{M}(\text{OH})_2$, in water

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

One of the reactions follows the pathway shown.



Which statements about this mechanism are correct?

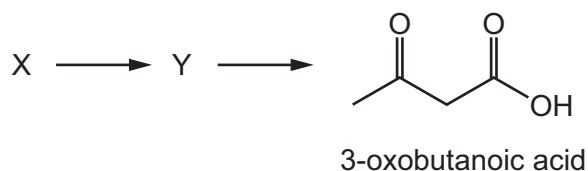
- 1 The intermediate has all carbon atoms in the same plane.
- 2 There is an electrophilic attack on the double bond.
- 3 It is a free radical mechanism.

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.



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.

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CHEMISTRY

9701/12

Paper 1 Multiple Choice

October/November 2018

1 hour

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Data Booklet

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Electronic calculators may be used.

This document consists of **14** printed pages and **2** blank 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 enthalpy changes is correct?

- A** Enthalpy changes of atomisation are always negative.
- B** Enthalpy changes of combustion are always positive.
- C** Enthalpy changes of formation are always positive.
- D** Enthalpy changes of neutralisation are always negative.

2 Beams of charged particles are deflected by an electrical field. The angle of deflection of a particle is proportional to its charge/mass ratio.

In an experiment protons are deflected by an angle of $+15^\circ$. In another experiment under identical conditions $^2\text{H}^+$ ions are deflected by an angle of Y° .

What is the value of Y?

- A** -30.0
- B** -7.5
- C** $+7.5$
- D** $+30.0$

3 Rubidium and bromine form ions that are isoelectronic. Each ion has 36 electrons.

Which row is correct?

	rubidium radii	bromine / bromide radii
A	atomic < ionic	atomic < ionic
B	atomic < ionic	atomic > ionic
C	atomic > ionic	atomic < ionic
D	atomic > ionic	atomic > ionic

4 In which set do all the molecules have all their atoms arranged in one plane?

- A** AlCl_3 , BF_3 , PH_3
- B** AlCl_3 , CO_2 , NH_3
- C** BF_3 , C_2H_4 , C_3H_6
- D** C_2H_4 , CO_2 , H_2O

- 5 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y 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 Exactly 1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.

The volume of one mole of gas at this temperature and pressure is 24.0 dm^3 .

What could be the identity of the metal?

- A calcium
B magnesium
C potassium
D sodium

- 7 Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is -393 kJ mol^{-1} .

The standard enthalpy change of formation of water is -286 kJ mol^{-1} .

The standard enthalpy change of formation of ethanol is -277 kJ mol^{-1} .

What is the standard enthalpy change of combustion of ethanol?

- A -1921 kJ mol^{-1}
B -1367 kJ mol^{-1}
C -956 kJ mol^{-1}
D -402 kJ mol^{-1}

- 8 Ammonium metavanadate, NH_4VO_3 , can be used to make a solution containing VO_2Cl , which contains chloride ions.

What is the **change** in the oxidation number of vanadium in this reaction?

- A -1 B 0 C +1 D +2

- 9 In this question, all pressures are measured in atm.

The equation represents the equilibrium between three gaseous substances X, Y and Z.



At temperature T_1 , the numerical value of K_p , the equilibrium constant, is 2.

At a higher temperature T_2 , the partial pressures at equilibrium are as shown.

X	Y	Z
2	3	5

Which row is correct?

	the numerical value of K_p at T_2	the forward reaction is
A	54/25	endothermic
B	54/25	exothermic
C	25/54	endothermic
D	25/54	exothermic

- 10 In a chemical system the particles involved have a range of energies. This can be shown on a graph called the Boltzmann distribution.

Which statement correctly explains the effect of a catalyst on the particles in a chemical system?

- A** A catalyst enables particles with a lower energy to collide successfully.
- B** A catalyst increases the number of particles with higher energies.
- C** A catalyst increases the number of particles with the most probable energy value.
- D** A catalyst increases the value of the most probable particle energy.

- 11 Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture **and** increasing the temperature?

	adding iron	increasing the temperature
A	has no effect on the equilibrium yield	reduces the equilibrium yield
B	increases the equilibrium yield	increases the equilibrium yield
C	increases the equilibrium yield	increases the rate
D	increases the rate	has no effect on the equilibrium yield

- 12 The melting points of the Period 3 elements phosphorus to argon are shown in the table.

element	P	S	Cl	Ar
mp/K	317	392	172	84

Which factor explains the changes in melting points from phosphorus to argon?

- A** the changes in electronegativity from phosphorus to argon
- B** the changes in first ionisation energy from phosphorus to argon
- C** the increase in the number of electrons in each atom from phosphorus to argon
- D** the number of atoms in each molecule of the element from phosphorus to argon
- 13 Which observations are made when a sample of silicon chloride, SiCl_4 , is added to a beaker of water?
- A** No visible change is observed.
- B** Steamy fumes and a precipitate are both observed.
- C** The appearance of a precipitate is the only observation.
- D** The appearance of steamy fumes is the only observation.

- 14** A 4.00 g sample of an anhydrous Group 2 metal nitrate is heated strongly until there is no further change. A solid residue of mass 1.37 g is formed.

Which metal is present?

- A** barium
- B** calcium
- C** magnesium
- D** strontium

- 15** In which row are all statements comparing magnesium and barium correct?

	fourth ionisation energy		reaction with water	
	magnesium	barium	magnesium	barium
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

- 16** Which statement about the halogens is correct?

- A** Iodine cannot behave as an oxidising agent.
- B** The volatility of the elements increases from chlorine to iodine because of the increase in molecular size down the group.
- C** When an equimolar mixture of chlorine and hydrogen is exploded, only one product is formed.
- D** When concentrated sulfuric acid is added to solid sodium bromide, hydrogen sulfide is one of the products.

- 17** Chlorine reacts with both hot and cold sodium hydroxide to form products containing chlorine.

Cold sodium hydroxide forms sodium chlorate(X) and hot sodium hydroxide forms sodium chlorate(Y). X and Y are oxidation numbers.

Which equation is correct?

- A** $Y = X - 6$
- B** $Y = X - 4$
- C** $Y = X + 4$
- D** $Y = X + 6$

- 18 The product of the Contact process is Z.

Which reaction or process leads to the formation of a gas that can neutralise an aqueous solution of Z?

- A atmospheric lightning
- B combustion of fuel in an internal combustion engine
- C the Haber process
- D thermal decomposition of Group 2 nitrates

- 19 If ammonium cyanate is heated in the absence of air, the only product of the reaction is urea, $\text{CO}(\text{NH}_2)_2$. No other products are formed in the reaction.

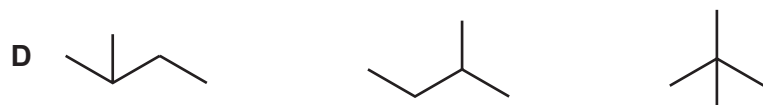
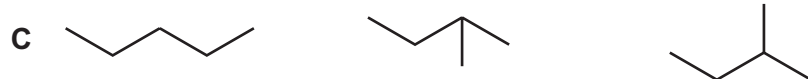
What is the formula of the cyanate ion present in ammonium cyanate?

- A CON_2^- B CON_2^{2-} C OCN^- D OCN^{2-}

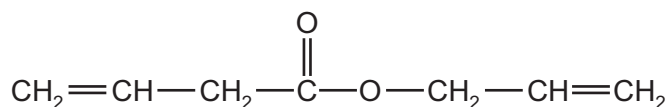
- 20 There are three structural isomers with the formula C_5H_{12} .

Which formulae correctly represent these three structural isomers?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ $\text{C}(\text{CH}_3)_4$
 B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$



- 21 The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

- A 15 B 17 C 18 D 21

22 Polyethene is made by the polymerisation of ethene.

Which statement is correct?

- A** The monomer and the polymer have different empirical formulae.
- B** The monomer can be oxidised without heat whereas the polymer cannot.
- C** The monomer can be used as a fuel whereas the polymer cannot.
- D** The monomer has greater van der Waals' forces than the polymer.

23 Compound P reacts separately with KOH(aq) and HBr.

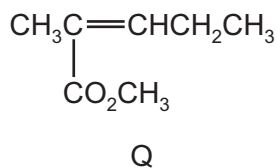


compound P

What are the mechanisms of these two reactions?

	KOH (aq)	HBr
A	nucleophilic addition	electrophilic addition
B	nucleophilic addition	free radical substitution
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	free radical substitution

24 Which statement about compound Q is correct?



- A It could be polymerised to give a polymer with the repeat unit $\begin{array}{c} \text{H} \qquad \text{CH}_3 \\ | \qquad | \\ -\text{C}-\text{C}- \\ | \qquad | \\ \text{CO}_2\text{CH}_3 \quad \text{CH}_2\text{CH}_3 \end{array}$.
- B It reacts with chlorine by a free radical mechanism to give $\begin{array}{c} \text{Cl} \quad \text{Cl} \\ | \quad | \\ \text{CH}_3\text{CH}-\text{C}-\text{CH}-\text{CH}_3 \\ | \quad | \\ \text{CO}_2\text{CH}_3 \quad \text{H} \end{array}$.
- C It reacts with cold, dilute acidified manganate(VII) to give $\begin{array}{c} \text{OH} \quad \text{OH} \\ | \quad | \\ \text{CH}_3\text{C}-\text{C}-\text{CH}_2\text{CH}_3 \\ | \quad | \\ \text{CO}_2\text{CH}_3 \quad \text{H} \end{array}$.
- D It reacts with bromine via a free radical mechanism to give $\begin{array}{c} \text{Br} \quad \text{Br} \\ | \quad | \\ \text{CH}_3-\text{C}-\text{C}-\text{CH}_2\text{CH}_3 \\ | \quad | \\ \text{CO}_2\text{CH}_3 \quad \text{H} \end{array}$.

25 A halogenoalkane has the molecular formula $\text{C}_5\text{H}_{11}\text{Br}$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

- A 1-bromo-2-methylbutane
 B 2-bromo-2-methylbutane
 C 3-bromopentane
 D bromodimethylpropane

26 The reactions of four organic compounds are given in the table.

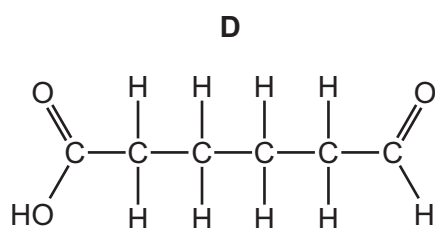
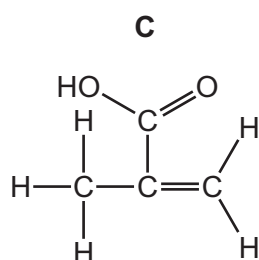
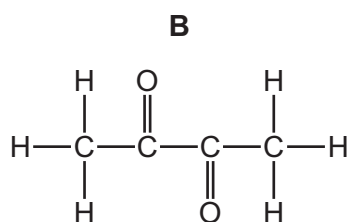
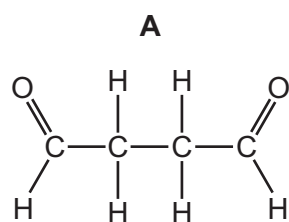
Which compound could be propan-2-ol?

	reagent/ observations	
	when oxidised with $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$, gives an organic product with a boiling point greater than the original compound	when added to ethanoic acid, and a few drops of conc. H_2SO_4 , gives a sweet-smelling compound
A	no	no
B	no	yes
C	yes	no
D	yes	yes

27 Compound X has the empirical formula $\text{C}_2\text{H}_3\text{O}$.

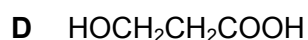
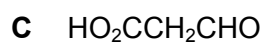
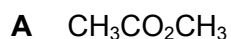
Compound X reacts with 2,4-dinitrophenylhydrazine reagent to give an orange precipitate and also decolourises warmed acidified potassium manganate(VII) solution.

What could be the identity of X?



28 Compound Y gives methanol and sodium ethanoate on treatment with aqueous sodium hydroxide.

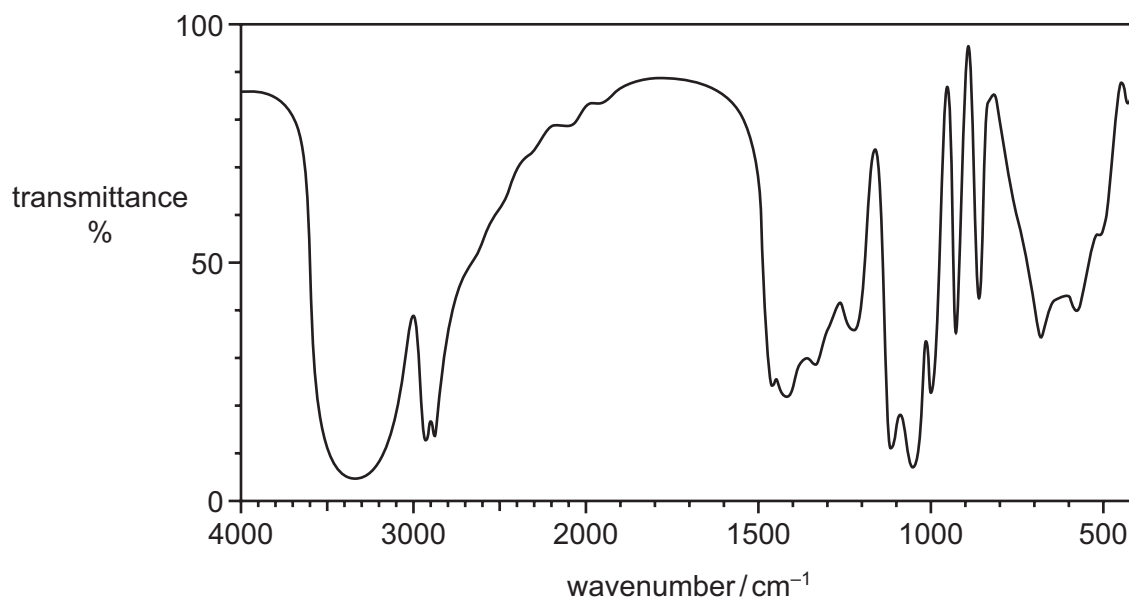
What is the structure of Y?



29 Which compound can be used to make propanoic acid by treatment with a single reagent?

- A $\text{CH}_2=\text{CHCH}_2\text{CH}_3$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
- C $\text{CH}_3\text{CH}(\text{OH})\text{CN}$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

30 The infra-red spectrum of compound **L** is shown.



What could be the structure of **L**?

- A $\text{HOCH}_2\text{COCH}_2\text{OH}$
- B $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$
- C $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$
- D $\text{HOCH}_2\text{CH}_2\text{COOH}$

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).

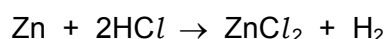
The responses **A** to **D** should be selected on the basis of

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 Zinc reacts with hydrochloric acid according to the following equation.



Which statements are correct?

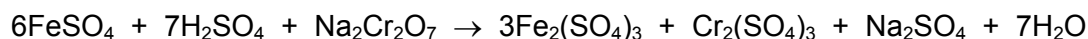
- 1** A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.0500 mol of zinc chloride.
- 2** A 6.54 g sample of zinc reacts completely with exactly 100 cm³ of 1.00 mol dm⁻³ hydrochloric acid.
- 3** A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm³ of hydrogen, measured at room conditions.

32 The melting point of chlorine is lower than the melting point of iodine.

Which statements help to explain this difference?

- 1** Iodine has more electrons than chlorine and so has stronger van der Waals' forces.
- 2** An iodine molecule is more polar than a chlorine molecule.
- 3** The covalent bonds between iodine atoms are stronger than the covalent bonds between chlorine atoms.

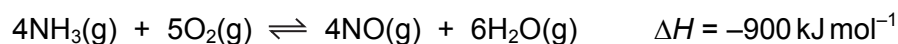
33 Aqueous iron(II) sulfate can take part in redox reactions.



Which redox changes occur during this reaction?

- 1 Fe(II) is oxidised to Fe(III).
- 2 Cr(VI) is reduced to Cr(III).
- 3 Oxygen is reduced to water.

34 The equation represents an equilibrium.



What would increase the concentration of NO at equilibrium?

- 1 a reduction in the reaction temperature
- 2 the use of a suitable catalyst
- 3 an increase in the total pressure

35 A sample containing x mol of Al_2Cl_6 is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, y mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

- 1 the initial pH of solution W is below 7
- 2 $y = 3x$
- 3 Z contains x mol of aluminium

36 Which statements concerning calcium hydroxide are correct?

- 1 It is less soluble in water than strontium hydroxide.
- 2 When it is added to water an alkaline solution is formed.
- 3 It is used in agriculture to lower soil pH.

37 Which bromopropenes would react with cold bromine in the dark to form a product containing a chiral carbon atom?

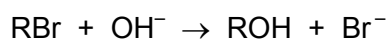
- 1 $\text{CHBr}=\text{CHCH}_3$
- 2 $\text{CH}_2=\text{CHCH}_2\text{Br}$
- 3 $\text{CH}_2=\text{CBrCH}_3$

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.

38 Halogenoalkanes can undergo reaction with hydroxide ions.



The reaction of some halogenoalkanes proceeds by the $\text{S}_{\text{N}}1$ mechanism.

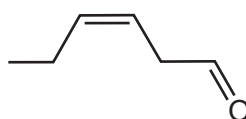
Which statements about the $\text{S}_{\text{N}}1$ mechanism are correct?

- 1 A carbocation is formed which is stabilised by the inductive effect of the alkyl groups present.
- 2 Only tertiary halogenoalkanes are hydrolysed in this way.
- 3 The intermediate formed includes a carbon atom with five bonds attached to it.

39 Which statements about 2-methylbutan-1-ol are correct?

- 1 It can give HCl(g) on reaction with PCl_5 .
- 2 It can be oxidised to give an aldehyde.
- 3 It displays optical isomerism.

40 The compound cis-hex-3-enal is responsible for the characteristic smell of cut grass.



cis-hex-3-enal

Which reagents will react with cis-hex-3-enal?

- 1 sodium
- 2 sodium borohydride
- 3 Fehling's reagent

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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

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.

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

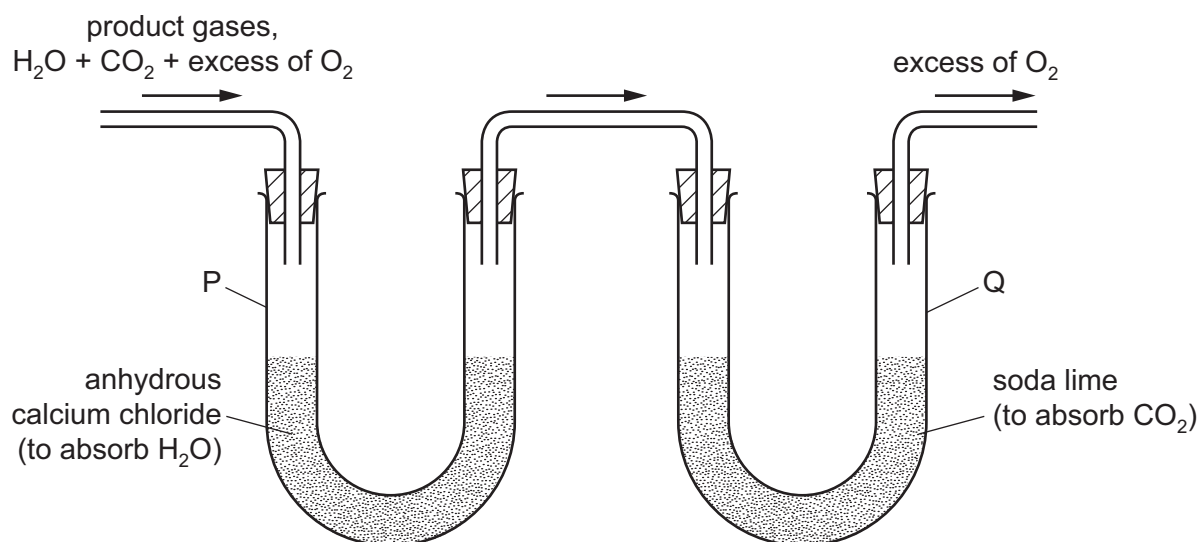
Which ion of X is produced by removing an electron from a filled shell?

- 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 $5.37 \times 10^{-3} \text{ m}^3$.

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.

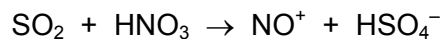
- ΔH_c° of butane is $-2877 \text{ kJ mol}^{-1}$.
- 250 g of water is heated from 12 °C to 100 °C.
- The burner transfers 47% of the heat released from the burning fuel to the water.

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.



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

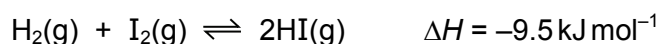
- 8 A transition metal ion, M^{2+} , reacts with acidified dichromate(VI) ions to form M^{4+} ions, Cr^{3+} ions, and H_2O .

Which equation correctly represents this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + \text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + \text{M}^{4+}$
- B** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 2\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 2\text{M}^{4+}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{M}^{4+}$
- D** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{M}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{M}^{4+}$

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

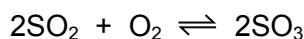
Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.



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.

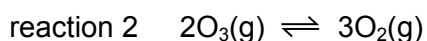
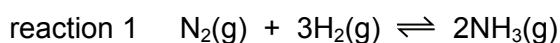
- 10 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm³ sealed container. The gases are allowed to react until equilibrium is reached.



At equilibrium there is 0.100 mol of SO₃ 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 dm³
 - D 6.67 mol⁻¹ dm³
- 11 Two reactions are shown.



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

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 $\text{ClO}_3^-(\text{aq})$ and $\text{Cl}^-(\text{aq})$.

Which equations represent reaction 1 and reaction 2?

- A** reaction 1 $2\text{Cl}_2 + 4\text{OH}^- \rightarrow \text{ClO}_2^- + 3\text{Cl}^- + 2\text{H}_2\text{O}$
 reaction 2 $3\text{ClO}_2^- \rightarrow 2\text{ClO}_3^- + \text{Cl}^-$
- B** reaction 1 $2\text{Cl}_2 + 4\text{OH}^- \rightarrow \text{ClO}_2^- + 3\text{Cl}^- + 2\text{H}_2\text{O}$
 reaction 2 $3\text{ClO}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$
- C** reaction 1 $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$
 reaction 2 $2\text{ClO}^- + 2\text{OH}^- \rightarrow \text{ClO}_3^- + \text{Cl}^- + \text{H}_2\text{O}$
- D** reaction 1 $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$
 reaction 2 $3\text{ClO}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$

- 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?

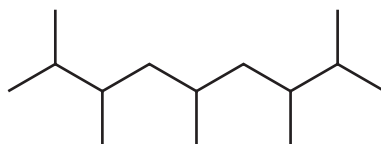
- A** It attacks a double bond.
- B** It donates a lone pair of electrons.
- C** It is a single atom.
- D** It is negatively charged.

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

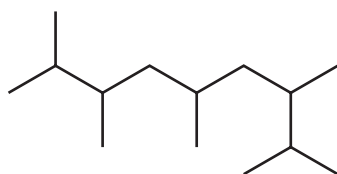
- 22 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



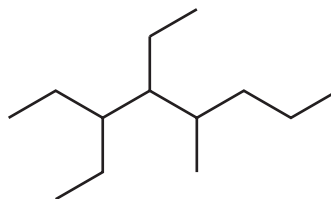
Q

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

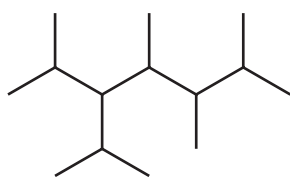
A



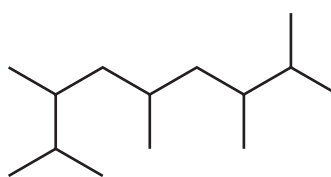
B



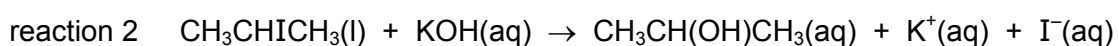
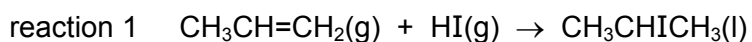
C



D



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



How can these two reactions be described?

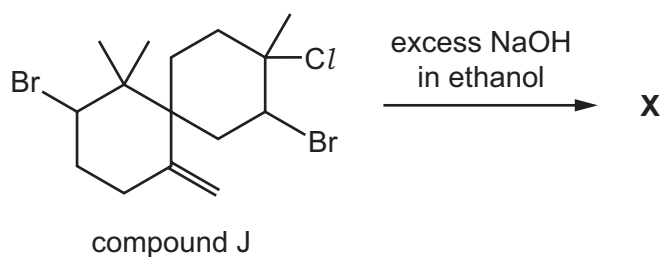
	reaction 1	reaction 2
A	addition	elimination
B	addition	substitution
C	elimination	substitution
D	substitution	elimination

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

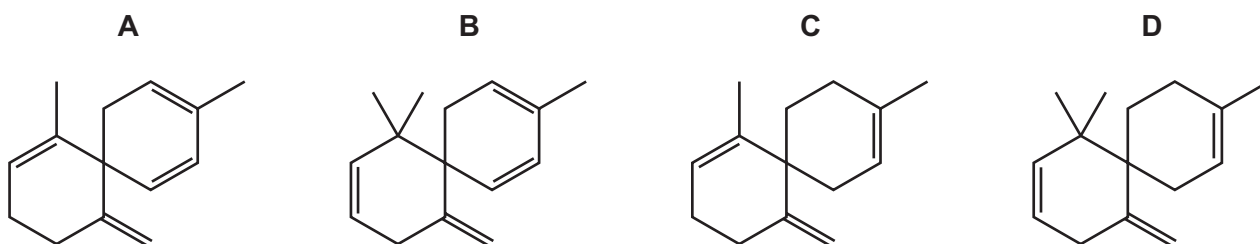
What could W be?

- 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.



What could be the skeletal formula of X?



- 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?

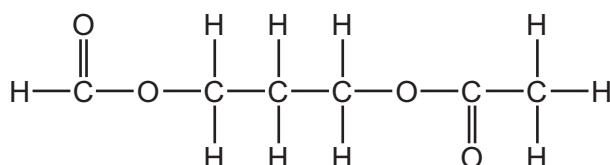
- A $CH_3COCH(OH)CH_3$
- B $CH_3COCH_2CH_2OH$
- C $HOCH_2CH(CH_3)CHO$
- D $(CH_3)_2C(OH)CHO$

- 28 Ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, is reduced using an excess of lithium aluminium hydride, LiAlH_4 .

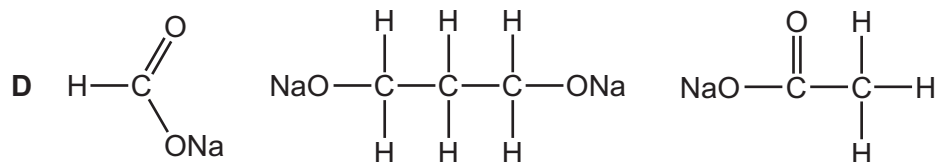
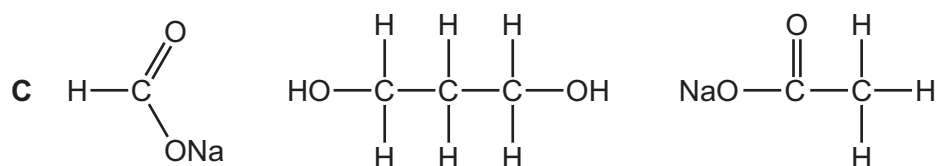
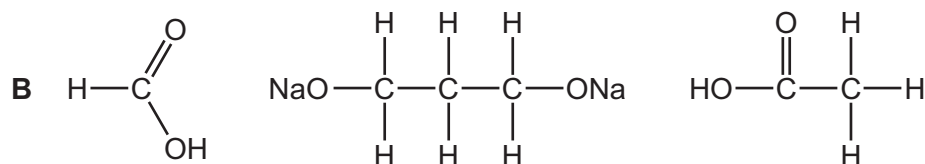
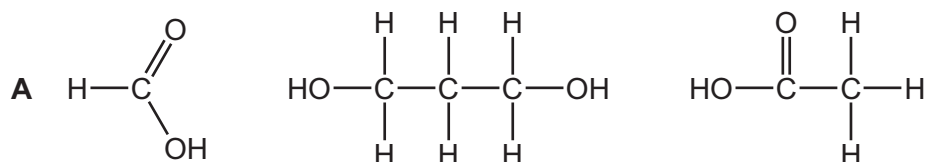
What is the organic product of the reaction?

- 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.

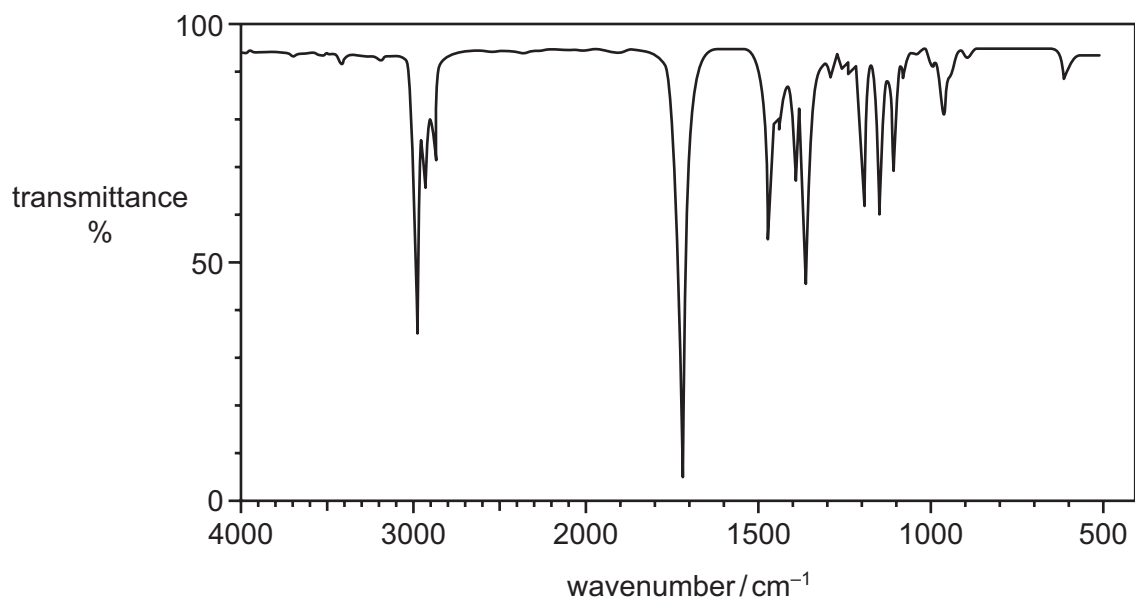


What would the products of this reaction be?



- 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?

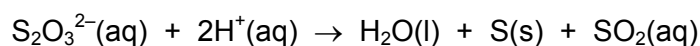
- 1** ΔH for the reaction is negative.
- 2** On a reaction pathway diagram the products are shown lower than the reactants.
- 3** The reaction will occur without heating.

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.



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?

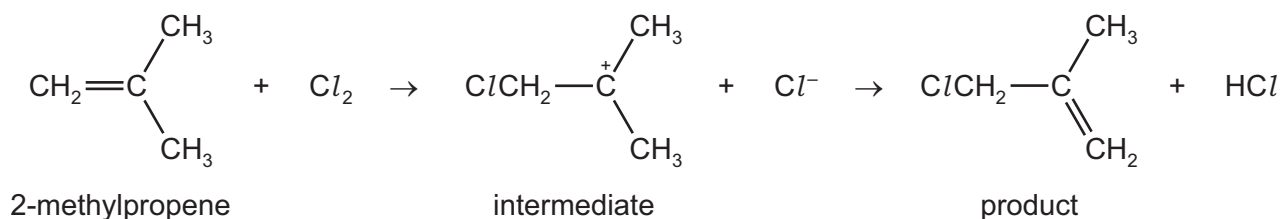
- 1** Ba metal $\xrightarrow[\text{in O}_2]{\text{heat}}$ product $\xrightarrow[\text{HCl}]{\text{dilute}}$ product 2 $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 3 $\xrightarrow{\text{filter, wash and dry}}$
- 2** $\text{Ba}(\text{NO}_3)_2 \xrightarrow[\text{heat in air}]{\text{strong}}$ solid product $\xrightarrow[\text{of water}]{\text{an excess}}$ product 2 $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 3 $\xrightarrow{\text{filter, wash and dry}}$
- 3** $\text{Ba}(\text{OH})_2 \xrightarrow[\text{HNO}_3]{\text{dilute}}$ product $\xrightarrow[\text{H}_2\text{SO}_4]{\text{dilute}}$ product 2 $\xrightarrow{\text{filter, wash and dry}}$

- 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, $\text{M}(\text{OH})_2$, in water

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

One of the reactions follows the pathway shown.



Which statements about this mechanism are correct?

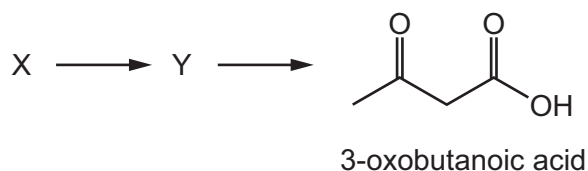
- 1 The intermediate has all carbon atoms in the same plane.
- 2 There is an electrophilic attack on the double bond.
- 3 It is a free radical mechanism.

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.



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.

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