

CHEMISTRY

9701/11

Paper 1 Multiple Choice

May/June 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 **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 This question refers to isolated gaseous atoms.

In which atom are all electrons paired?

- A** Ba **B** Br **C** S **D** Si

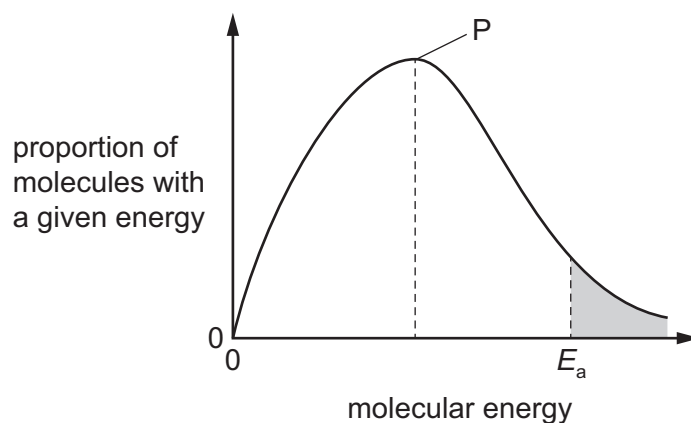
- 2 Which compound has a boiling point that is influenced by hydrogen bonding?

- A** CH_3CHO **B** CH_3OCH_3 **C** HCO_2CH_3 **D** HCO_2H

- 3 Which fuel would produce the largest mass of CO_2 when 10 kg of the fuel undergo complete combustion?

- A** biodiesel, $\text{C}_{17}\text{H}_{34}\text{O}_2$
B ethanol, $\text{C}_2\text{H}_6\text{O}$
C octane, C_8H_{18}
D propane, C_3H_8

- 4 The diagram shows the Boltzmann distribution of energies in a gas. The gas can take part in a reaction with an activation energy, E_a . The gas is maintained at a constant temperature.



Which statement is correct?

- A** If a catalyst is added, peak P will be lower and E_a will move to the left.
B If a catalyst is added, peak P will be lower and E_a will move to the right.
C If a catalyst is added, peak P will be the same and E_a will move to the left.
D If a catalyst is added, peak P will be the same and E_a will move to the right.

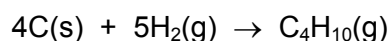
5 Which molecule has no overall dipole?

- A CH_3Cl B CH_2Cl_2 C CHCl_3 D CCl_4

6 Which solid contains more than one type of bonding?

- A iodine
B silicon dioxide
C sodium chloride
D zinc

7 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

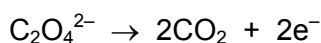


By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^\ominus$, of butane?

substance	$\Delta H_c^\ominus / \text{kJ mol}^{-1}$
C(s)	-394
H ₂ (g)	-286
C ₄ H ₁₀ (g)	-2877

- A $-5883 \text{ kJ mol}^{-1}$
B -129 kJ mol^{-1}
C $+129 \text{ kJ mol}^{-1}$
D $+2197 \text{ kJ mol}^{-1}$

8 Ethanedioate ions, $\text{C}_2\text{O}_4^{2-}$, react with a suitable reagent to form CO_2 . A half-equation for this reaction is shown.



Which row is correct?

	oxidation state of carbon in $\text{C}_2\text{O}_4^{2-}$	type of reaction
A	+3	oxidation
B	+3	reduction
C	+5	oxidation
D	+5	reduction

- 9 Oxidation numbers should be used to answer this question.

A redox reaction takes place between hydroxylammonium ions, $[\text{NH}_3\text{OH}]^+$, and acidified iron(III) ions, Fe^{3+} . The products are iron(II) ions, Fe^{2+} , H^+ ions, water and a compound of nitrogen.

The mole ratio of reacting hydroxylammonium ions to reacting iron(III) ions is 1 : 2.

Which nitrogen-containing compound could be formed in the reaction?

- A NH_3 B N_2O C NO D NO_2

- 10 Element X has a higher first ionisation energy than element Y.

Two students state what they believe is one factor that helps to explain this.

student 1 "X has a higher first ionisation energy than Y because an atom of X has more protons in its nucleus than an atom of Y."

student 2 "X has a higher first ionisation energy than Y because X has a smaller atomic radius than Y."

Only **one** of the two students is correct.

What could X and Y be?

	X	Y
A	carbon	boron
B	magnesium	aluminium
C	oxygen	nitrogen
D	oxygen	sulfur

- 11 Hydrogen ions catalyse the hydrolysis of esters.

Which statement is correct?

- A The hydrogen ions act as a heterogeneous catalyst.
 B The hydrogen ions are in the same phase as the reactants.
 C The hydrogen ions are used up in the reaction.
 D The hydrogen ions have no effect on the activation energy of the reaction.

- 12 Silicon is heated in an excess of chlorine, producing compound J.

Excess water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

- 13 Which element has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

- A** boron
B calcium
C magnesium
D sodium

- 14 Chlorine reacts with **cold** aqueous sodium hydroxide to produce sodium chloride, water and compound X.

Chlorine reacts with **hot** aqueous sodium hydroxide to produce sodium chloride, water and compound Y.

What are the oxidation states of chlorine in compound X and compound Y?

	X	Y
A	-1	-5
B	-1	+5
C	+1	-5
D	+1	+5

- 15 In which reaction does ammonia behave as a Brønsted-Lowry base?

- A** $\text{NH}_3 + \text{CH}_3\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HBr}$
B $\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow (\text{NH}_4)\text{HCO}_3$
C $2\text{NH}_3 + 2\text{Na} \rightarrow 2\text{NaNH}_2 + \text{H}_2$
D $4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$

- 16** Aqueous silver nitrate is added to a solution of potassium iodide.

Aqueous ammonia is then added.

What would be observed?

- A** a cream precipitate that dissolves on addition of aqueous ammonia
B a cream precipitate that does not dissolve on addition of aqueous ammonia
C a yellow precipitate that dissolves on addition of aqueous ammonia
D a yellow precipitate that does not dissolve on addition of aqueous ammonia
- 17** Oxides of nitrogen are present in the environment due to natural and man-made sources.
- Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

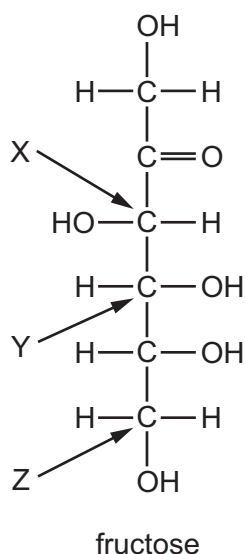
- 18** When 3.00g of an anhydrous nitrate of a Group 2 metal is decomposed, 1.53g of gas is produced.

What is the nitrate compound?

- A** beryllium nitrate
B calcium nitrate
C magnesium nitrate
D strontium nitrate
- 19** Which row correctly describes one property of barium and one property of barium oxide?

	observation when barium metal is added to water	pH of solution obtained when a spatula measure of BaO is added to 100 cm ³ of water
A	a few gas bubbles form on the metal surface	8
B	a few gas bubbles form on the metal surface	13
C	rapid effervescence is seen	8
D	rapid effervescence is seen	13

- 20 Fructose is a sugar with more than one chiral centre. The fructose molecule is shown with X, Y and Z indicating three carbon atoms.



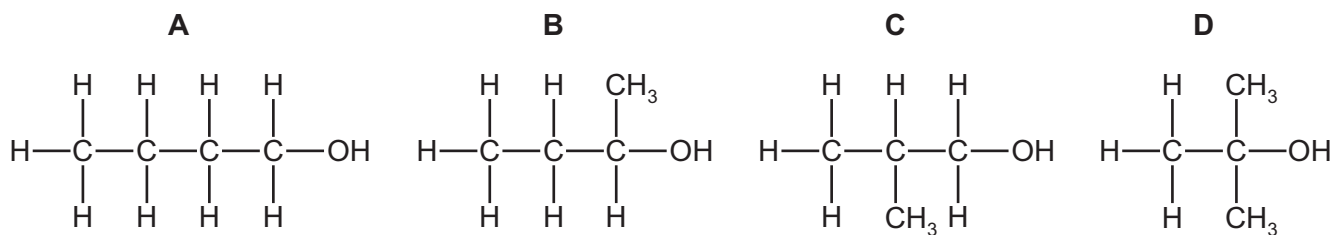
Which carbon atoms are chiral centres?

- A** X, Y and Z **B** X and Y only **C** X only **D** Y only
- 21 Which pair of alcohols are isomers of each other?
- A** butan-1-ol and 2,2-dimethylpropan-1-ol
B butan-2-ol and 2-methylpropan-2-ol
C pentan-1-ol and 2-methylpropan-2-ol
D propan-2-ol and 2-methylpropan-2-ol
- 22 Sodium methoxide, $\text{Na}^+\text{CH}_3\text{O}^-$, reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the CH_3O^- ion.

Which row is correct?

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

23 Which alcohol can be dehydrated to give two products which are structural isomers of each other?



24 Which reagent could detect the presence of alcohol in a mixture consisting mainly of alkanes and alkenes?

- A** Na
- B** Br₂ (in CCl₄)
- C** KMnO₄(aq)
- D** 2,4-dinitrophenylhydrazine

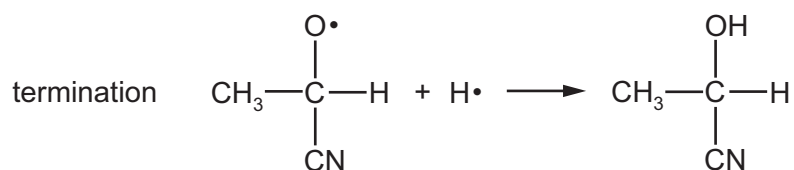
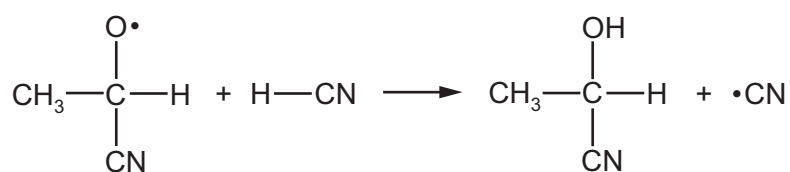
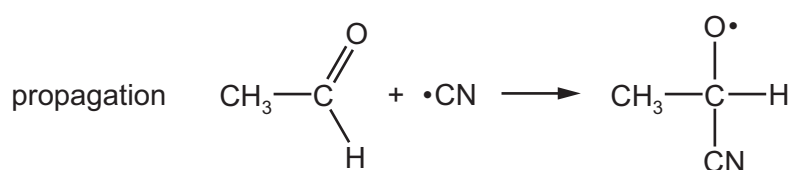
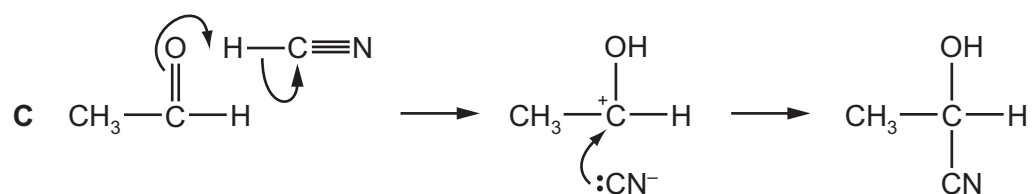
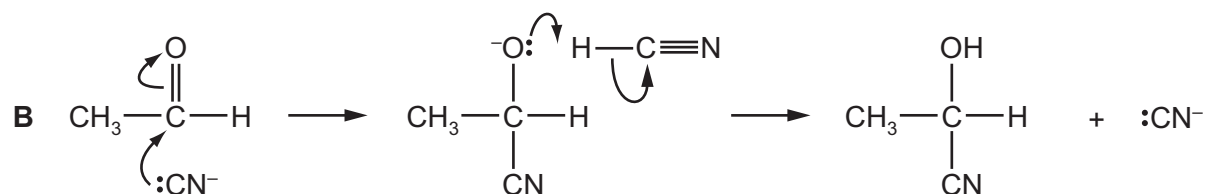
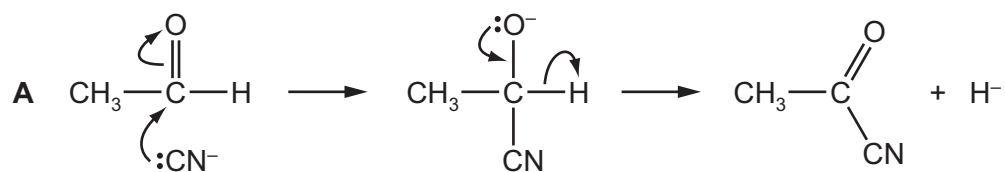
25 Compound Q

- contains a chiral centre,
- gives a positive result with Fehling's reagent,
- gives a positive result with alkaline aqueous iodine.

What could compound Q be?

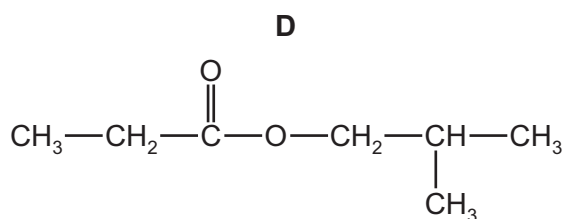
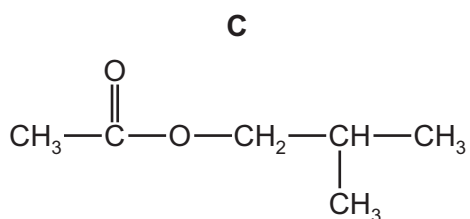
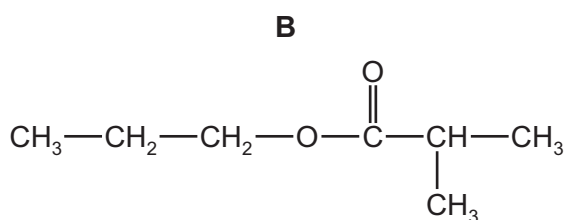
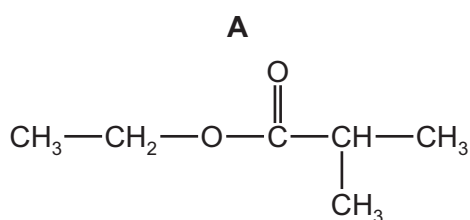
- A** 1-hydroxybutanone
- B** 2-hydroxybutanal
- C** 3-hydroxybutanal
- D** 3-hydroxybutanone

26 What is the mechanism for the reaction of ethanal, CH_3CHO , with hydrogen cyanide, HCN , in the presence of NaCN ?

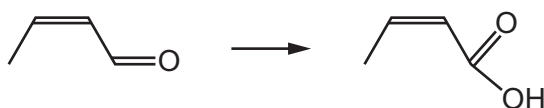


- 27 Ethyl propanoate is refluxed with aqueous sodium hydroxide. The alcohol produced is then reacted with methyl propanoic acid to make a second ester.

What is the structural formula of this second ester?



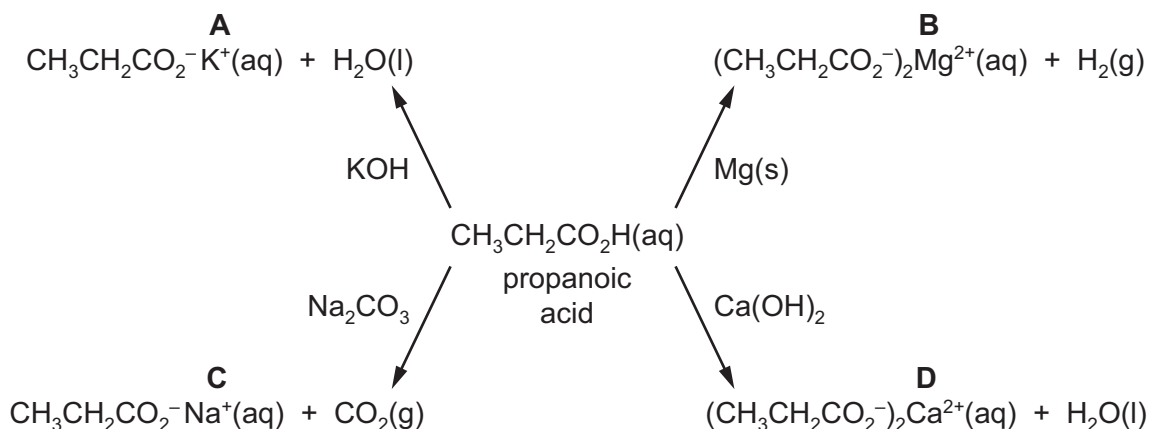
- 28 Which reagent could be used to carry out the following reaction?



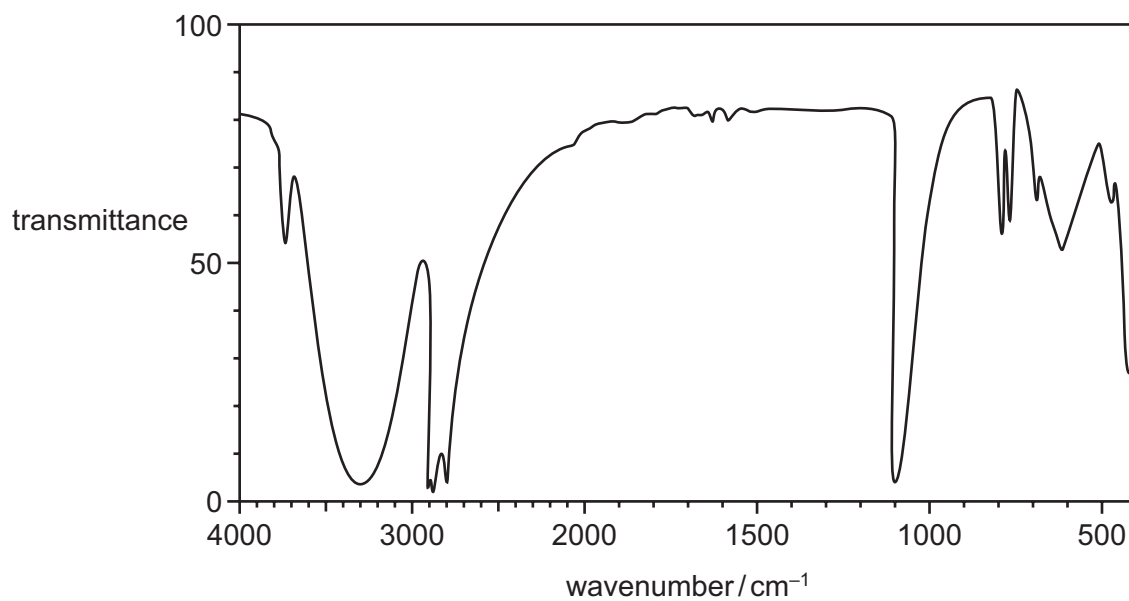
- A** a solution containing acidified dichromate(VI) ions
B a solution containing dilute, acidified manganate(VII) ions
C a solution containing hot, concentrated, acidified manganate(VII) ions
D concentrated sulfuric acid

- 29 Four reactions of propanoic acid to form salts and other products are shown.

Which reaction does **not** show the formulae of **all** the correct products?



- 30 Compound X contains three carbon atoms. Part of a simplified infra-red spectrum of compound X is shown.



Which compound could be X?

- A $\text{CH}_3\text{CH}_2\text{CHO}$
- B $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CO}_2\text{CH}_3$

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** One mole of sulfuric acid is used to make an aqueous solution. The solution contains H_2SO_4 molecules, H^+ ions, SO_4^{2-} ions and HSO_4^- ions.

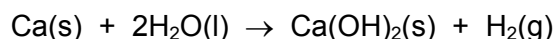
Which statements are correct?

- 1** The solution contains 6.02×10^{23} sulfur atoms.
- 2** The solution contains an exactly equal number of H^+ ions and HSO_4^- ions.
- 3** One mole of SO_4^{2-} ions contains two moles of electrons.

- 32** Which statements are correct?

- 1** The hydrogen bonds in ice are more regularly arranged than in water.
- 2** The solidification of water to form ice is exothermic.
- 3** Pure water is less dense than ice.

- 33** Calcium reacts with water to form calcium hydroxide and hydrogen.



The standard enthalpy change for this reaction is -414 kJ mol^{-1} .

What further information is needed in order to calculate the standard enthalpy change of formation of calcium hydroxide, $\Delta H_f^\ominus \text{Ca(OH)}_2\text{(s)}$?

- 1** $\Delta H_f^\ominus$ for $\text{H}_2\text{O(l)}$
- 2** $\Delta H_f^\ominus$ for $\text{H}_2\text{(g)}$
- 3** first and second ionisation energies of Ca

34 Which statements are correct when a reversible reaction is at equilibrium?

- 1 All species are at equal concentration.
- 2 The concentrations of all species remain constant.
- 3 The rate of the forward reaction equals the rate of the reverse reaction.

35 Each of the three mixtures shown can result in a chemical reaction.

Which mixtures result in a redox reaction?

- 1 bromine + hydrogen
- 2 sodium chloride + concentrated sulfuric acid
- 3 potassium iodide + silver nitrate

36 Which statements correctly describe an oxide of nitrogen acting as an atmospheric pollutant?

- 1 Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide which contributes to acid rain.
- 2 Nitrogen dioxide reacts with sulfur dioxide to form sulfur trioxide which reacts with water to form sulfuric acid.
- 3 Nitrogen oxides react with unburnt hydrocarbons in sunlight to form other pollutants.

37 Polymer Z contains the length of polymer chain shown below.

This short length of chain is found many times within the chains of polymer Z, although it is **not** the repeat unit.



What could be the name of polymer Z?

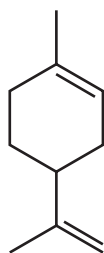
- 1 poly(2-chloropropene)
- 2 poly(chloroethene)
- 3 PVC

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 Limonene is found in lemons.



limonene

Limonene is heated with concentrated acidified potassium manganate(VII).

Which compounds are produced?

- 1** $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}(\text{CH}_2\text{CO}_2\text{H})_2$
- 2** CO_2
- 3** $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}(\text{COCH}_3)\text{CH}_2\text{CO}_2\text{H}$

39 Chlorofluoroalkanes have been used as the refrigerant in refrigerators but care has to be taken in disposing of old refrigerators.

Which statements about chlorofluoroalkanes are correct?

- 1** C–Cl bonds more readily undergo homolytic fission than C–F bonds.
- 2** Care is taken in the disposal of old refrigerators because of possible ozone depletion.
- 3** $\text{C}_2\text{H}_4\text{ClF}$ is more volatile than C_2H_6 .

40 The M_r of compound X is 72. The composition by mass of X is 66.7% carbon, 11.1% hydrogen and 22.2% oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent. X does not react with Fehling's reagent.

What can be deduced from this information?

- 1** X is a carbonyl compound.
- 2** X is a ketone.
- 3** X is butanone.

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9701/12

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Any rough working should be done in this booklet.

Electronic calculators may be used.

This document consists of **12** 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 Which feature is present in both ethene and poly(ethene)?

- A** bond angles of 109°
- B** π covalent bonds
- C** σ covalent bonds
- D** sp^3 orbitals

2 The electronic configuration of an atom of sulfur is $1s^2 2s^2 2p^6 3s^2 3p^4$.

How many valence shell and unpaired electrons are present in one sulfur atom?

	valence shell electrons	unpaired electrons
A	2	1
B	4	2
C	6	0
D	6	2

3 In which pair does the second substance have a **lower** boiling point than the first substance?

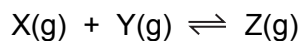
- A** C_2H_6 and C_2H_5Cl
- B** CH_3OCH_3 and C_2H_5OH
- C** Ne and Ar
- D** CH_3NH_2 and C_2H_6

4 Compound J burns in excess oxygen to give carbon dioxide and water only. When a 3.00 g sample of compound J is burnt in excess oxygen, 4.40 g of carbon dioxide and 1.80 g of water are formed.

What is the empirical formula of J?

- A** CH
- B** CHO
- C** CH_2
- D** CH_2O

- 5 The gases X and Y react to form Z.



An equilibrium mixture of these three gases is compressed at constant temperature.

What will be the changes in the mole fraction of Z and in K_p ?

	mole fraction of Z	K_p
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

- 6 Which gas is likely to deviate most from ideal gas behaviour?

A HCl **B** He **C** CH₄ **D** N₂

- 7 The enthalpy change of reaction 1 is -114 kJ mol^{-1} .



By using this information, what is the most likely value for the enthalpy change of reaction 2?



A -57 kJ mol^{-1} **B** -76 kJ mol^{-1} **C** -114 kJ mol^{-1} **D** -228 kJ mol^{-1}

- 8 Sulfur reacts with concentrated nitric acid in a redox reaction.



What are the changes in oxidation number of sulfur and of nitrogen in this reaction?

	sulfur	nitrogen
A	+2	-3
B	+2	-1
C	+4	-3
D	+4	-1

- 9 Materials can be classified by their chemical structures. Four common types of structure are metallic, ionic, simple molecular and giant molecular.

Some physical properties of four substances are shown in the table.

Which substance has a simple molecular structure?

	melting point / °C	effect of adding water	electrical conductivity
A	64	reacts	good when solid
B	113	insoluble	always poor
C	767	soluble	good when solid
D	1600	insoluble	always poor

- 10 In a particular reversible reaction the yield of product is increased

- if the temperature is increased;
- if the pressure is decreased.

Which equation could describe this reversible reaction?

- A** $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{CO}(\text{g}) \quad \Delta H = +206 \text{ kJ mol}^{-1}$
- B** $4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g}) \quad \Delta H = -227 \text{ kJ mol}^{-1}$
- C** $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g}) \quad \Delta H = -58 \text{ kJ mol}^{-1}$
- D** $3\text{O}_2(\text{g}) \rightleftharpoons 2\text{O}_3(\text{g}) \quad \Delta H = +143 \text{ kJ mol}^{-1}$

- 11 A chemical company used a catalyst in a chemical process. The company has now decided not to use the catalyst but to increase the temperature so that the rate of the reaction is the same as it was when the catalyst was used.

Which statement about the new conditions compared to the original conditions is correct?

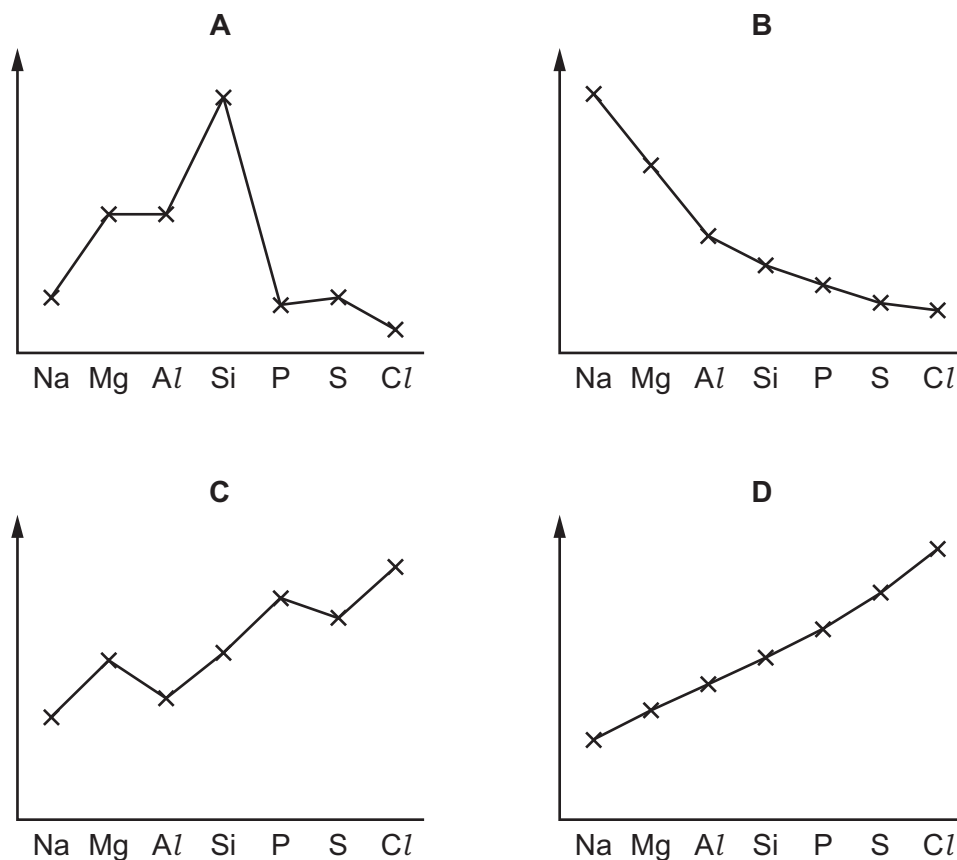
- A** The activation energy has been decreased.
- B** The activation energy has been increased.
- C** There are fewer successful collisions per unit time.
- D** There are more successful collisions per unit time.

- 12 Which oxide does **not** react with cold, dilute sodium hydroxide to produce a salt?

- A** Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

- 13 The graphs show trends in four physical properties of elements in Period 3, excluding argon.

Which graph has electronegativity on the y-axis?



- 14 In this question, X represents an atom of chlorine, bromine or iodine.

Which explanation for the variation in volatility down Group 17 is correct?

- A Instantaneous dipole-induced dipole forces between molecules become stronger.
 - B Permanent dipole-permanent dipole forces between molecules become stronger.
 - C The bond energy of the X_2 molecules decreases.
 - D The first ionisation energy $X(g) \rightarrow X^+(g) + e^-$ decreases.
- 15 To manufacture cement, 1000 million tonnes of limestone are decomposed each year. To manufacture lime for agriculture, 200 million tonnes of limestone are decomposed each year.

What is the total mass of carbon dioxide in million tonnes produced from these two processes in a year?

- A 440 B 528 C 660 D 880

- 16 In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.

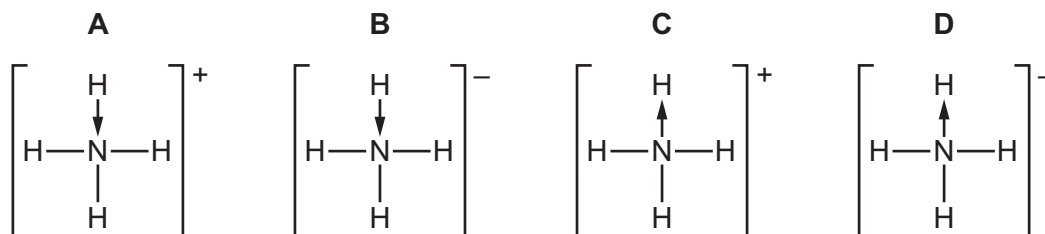
Which property shows a **decrease** from magnesium to barium?

- A the decomposition temperature of the carbonates
 - B the decomposition temperature of the nitrates
 - C the solubility of the hydroxides
 - D the solubility of the sulfates
- 17 When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However when concentrated sulfuric acid is added to solid sodium chloride **only** hydrogen chloride and sodium hydrogensulfate are produced.

What is the reason for this difference?

- A Bromine is less volatile than chlorine.
 - B Hydrochloric acid is a weak acid.
 - C Sulfuric acid is not an oxidising agent.
 - D The bromide ion is a stronger reducing agent than the chloride ion.
- 18 The dative covalent bond can be represented by an arrow, $\rightarrow$. The arrow points towards the atom receiving the lone pair.

Which diagram of an ammonium ion is correct?

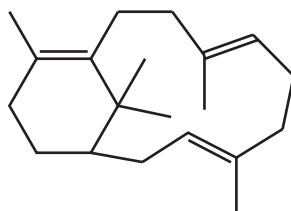


- 19 Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows the regeneration of the catalyst?

- A $\text{N}_2 + 2\text{O}_2 \rightleftharpoons 2\text{NO}_2$
- B $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$
- C $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$
- D $\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$

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



compound Y

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

- A 5 B 6 C 7 D 8
- 21 Which equation represents a valid propagation step in the chlorination of ethane?
- A $\text{C}_2\text{H}_6 + \text{Cl}\bullet \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{H}\bullet$
- B $\text{C}_2\text{H}_5\text{Cl} + \text{Cl}\bullet \rightarrow \text{C}_2\text{H}_4\text{Cl}\bullet + \text{HCl}$
- C $\text{C}_2\text{H}_5\text{Cl} + \text{H}\bullet \rightarrow \text{C}_2\text{H}_5\bullet + \text{HCl}$
- D $\text{C}_2\text{H}_5\bullet + \text{Cl}\bullet \rightarrow \text{C}_2\text{H}_5\text{Cl}$
- 22 Maleic acid is used in the food industry and for stabilising drugs. It is the cis-isomer of butenedioic acid and has the structural formula $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$.

What is the product formed from the reaction of maleic acid with cold, dilute, acidified manganate(VII) ions?

- A $\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$
- B $\text{HO}_2\text{CCO}_2\text{H}$
- C $\text{HO}_2\text{CCH}_2\text{CH}(\text{OH})\text{CO}_2\text{H}$
- D $\text{HO}_2\text{CCOCOCO}_2\text{H}$
- 23 Primary halogenoalkanes undergo hydrolysis reactions.
- Which reaction would occur most rapidly if they are all warmed to the same temperature?
- A $\text{C}_2\text{H}_5\text{Br}$ with H_2O
- B $\text{C}_2\text{H}_5\text{Br}$ with $\text{NaOH}(\text{aq})$
- C $\text{C}_2\text{H}_5\text{Cl}$ with H_2O
- D $\text{C}_2\text{H}_5\text{Cl}$ with $\text{NaOH}(\text{aq})$

- 24 Structural isomerism and stereoisomerism should be considered when answering this question.

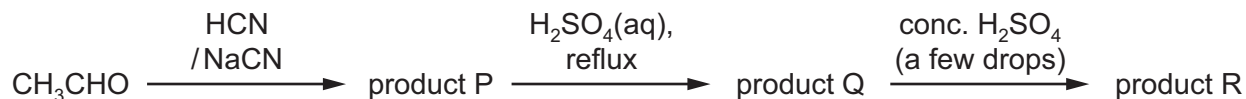
A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only** two alkenes is formed.

What could the colourless liquid be?

- A $(CH_3CH_2)_2CHCl$
 - B $CH_3CH_2CH_2CHClCH_3$
 - C $(CH_3)_2CHCHClCH_3$
 - D $CH_3CH_2CCl(CH_3)_2$
- 25 When warm water is added to halogenoalkane X, an S_N1 reaction occurs.
- $AgNO_3(aq)$ is then added; a yellow precipitate is formed.
- What could be X?
- A 1-chlorobutane
 - B 1-iodobutane
 - C 2-chloro-2-methylpropane
 - D 2-iodo-2-methylpropane
- 26 Which alcohol will react with an acidified solution of potassium dichromate(VI) to produce a ketone containing six carbon atoms?
- A 2,2-dimethylbutan-1-ol
 - B 2-methylpentan-3-ol
 - C 3,3-dimethylpentan-2-ol
 - D 3-methylpentan-3-ol
- 27 Which statement about butanone is correct?
- A Butanone can be dehydrated by concentrated sulfuric acid to give $CH_2=CHCH=CH_2$.
 - B Butanone gives a positive result with Tollens' reagent.
 - C Butanone reacts with HCN by an electrophilic addition mechanism.
 - D Butanone reacts with $NaBH_4$ to give a chiral product.

28 Ethanal, CH_3CHO , is used to make product R in a three-stage synthesis.



Two molecules of Q react to give one molecule of R plus two molecules of water.

R has two ester functional groups in each molecule. R does not react with sodium.

What is the empirical formula of R?

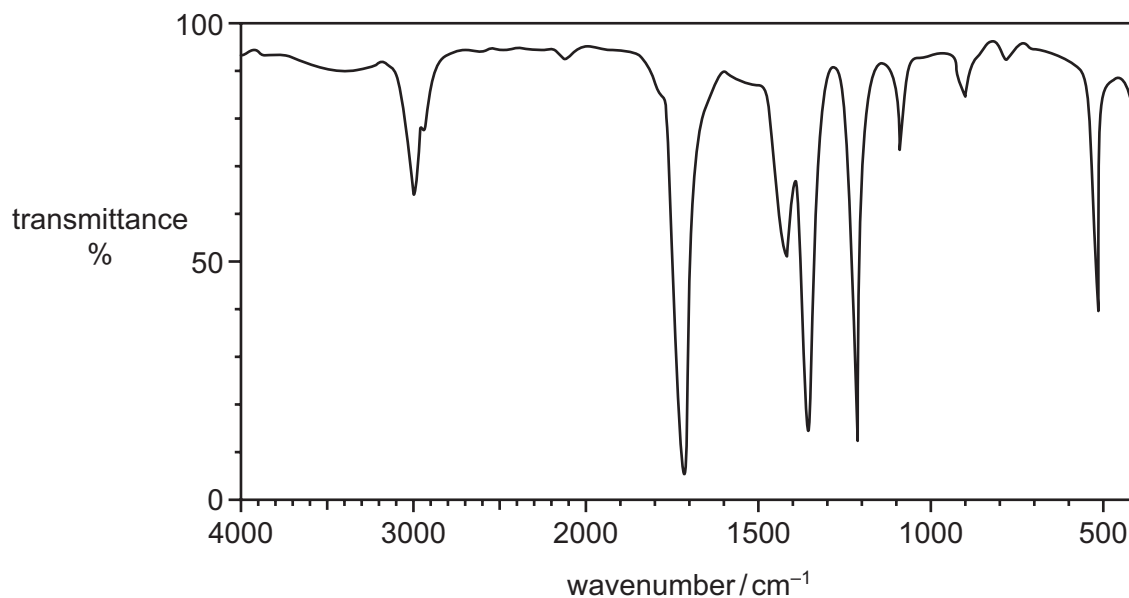
- A** CHO **B** $\text{C}_3\text{H}_4\text{O}_2$ **C** $\text{C}_3\text{H}_5\text{O}_2$ **D** $\text{C}_6\text{H}_{10}\text{O}_5$

29 The ester ethyl butanoate can be hydrolysed using an excess of dilute sodium hydroxide solution.

Which substance is a product of this reaction?

- A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{Na}$
B $\text{CH}_3\text{CO}_2\text{Na}$
C $\text{CH}_3\text{CH}_2\text{ONa}$
D H_2O

30 The infra-red spectrum of an organic compound is shown.



Which compound could give this spectrum?

- A** $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
B $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
C CH_3COCH_3
D $\text{CH}_3\text{COCH}_2\text{OH}$

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 For complete combustion, 1 mol of an organic compound X requires 2.5 mol of O₂.

Which compounds could be X?

1 C₂H₅OH

2 C₂H₂

3 CH₃CHO

32 In which pairs do both species have the same number of electrons?

1 ³⁵Cl and ³⁷Cl

2 ³⁵Cl⁻ and ⁴⁰Ar

3 ⁴⁰Ar and ⁴⁰K⁺

33 For which reactions does the value of $\Delta H^\ominus$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 C(s) + O₂(g) → CO₂(g)

2 2C(s) + O₂(g) → 2CO(g)

3 CO(g) + $\frac{1}{2}$ O₂(g) → CO₂(g)

34 The temperature of a reversible gas phase reaction is increased.

Which statements are **always** correct?

- 1 More product is present at equilibrium.
- 2 The average speed of the particles increases.
- 3 There are more successful collisions per unit time.

35 Three samples of chlorine gas each contain 0.710 g of chlorine. Each sample is reacted with a reagent.

- In the first reaction a sample is reacted completely with hydrogen gas.
- In the second reaction a sample is reacted completely with cold NaOH(aq).
- In the third reaction a sample is reacted completely with hot NaOH(aq).

Which masses of the named products would be formed?

- 1 Exactly 0.730 g of HCl form in the first reaction.
- 2 Exactly 0.585 g of NaCl form in the second reaction.
- 3 Exactly 0.975 g of NaCl form in the third reaction.

36 Solid barium oxide is added to some ammonium sulfate solution in a test-tube and the mixture is warmed. A piece of damp red litmus paper is held over the mouth of the test-tube.

Which observations would be made?

- 1 The damp litmus paper initially turns from red to blue.
- 2 A white precipitate forms in the test-tube.
- 3 A brown gas is evolved with strong heating.

37 Which compounds show geometrical (cis-trans) isomerism?

- 1 $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{C}_2\text{H}_5$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_2\text{CH}_3$
- 3 $\text{C}_2\text{H}_5\text{CH}=\text{CHC}_2\text{H}_5$

38 Which pairs of compounds may be distinguished from each other by testing with alkaline aqueous iodine?

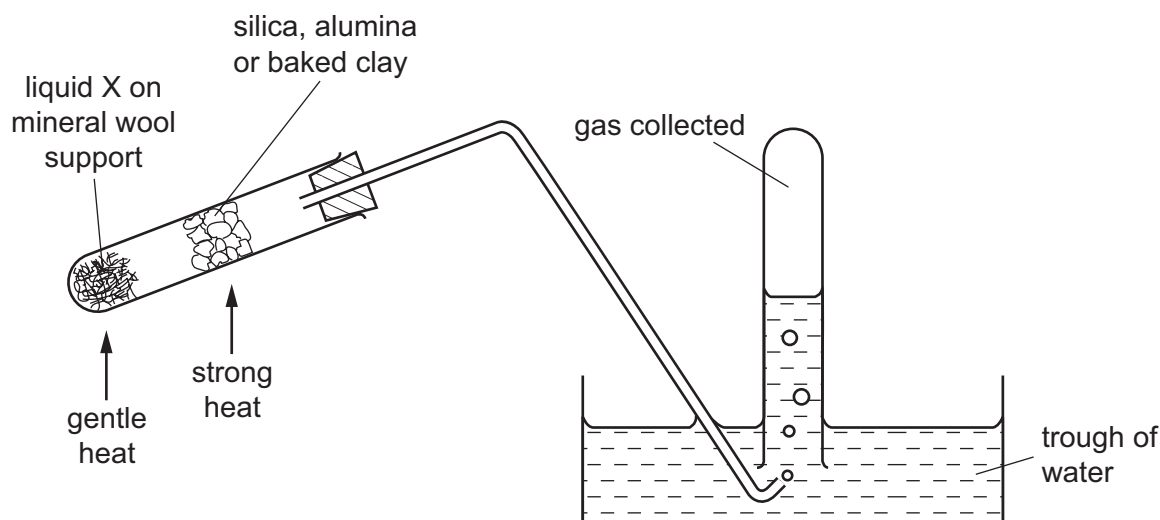
- 1 ethane-1,2-diol and ethanol
- 2 propan-2-ol and methylpropan-2-ol
- 3 ethanol and butan-2-ol

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 The diagram shows an experimental set-up which can be used in several different experiments.



Which processes could be demonstrated by using the above apparatus?

- 1** oxidation of ethanol (liquid X)
- 2** dehydration of ethanol (liquid X)
- 3** cracking of paraffin (liquid X)

40 The ester $\text{C}_2\text{H}_5\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$ can be made in a school or college laboratory by a sequence of four reactions or fewer using compound Z as the **only** organic material.

What might be the identity of compound Z?

- 1** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 2** $\text{CH}_3\text{CH}_2\text{CHO}$
- 3** CH_3COCH_3

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CHEMISTRY

9701/13

Paper 1 Multiple Choice

May/June 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 **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.

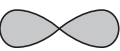
- 1 Why is the boiling point of ammonia, NH_3 , higher than the boiling point of phosphine, PH_3 ?
- A** Ammonia molecules are polar; phosphine molecules are not.
- B** Ammonia molecules have significant hydrogen bonding; phosphine molecules do not.
- C** N–H covalent bonds are stronger than P–H covalent bonds.
- D** There is one lone pair in each ammonia molecule but no lone pair in each phosphine molecule.
- 2 Neutrons are passed through an electric field. The mass of one neutron relative to $\frac{1}{12}$ the mass of a ^{12}C atom and any deflection in the electric field is recorded.

Which row is correct?

	mass of neutron	behaviour of beam of neutrons in an electric field
A	0	deflected
B	1	deflected
C	0	not deflected
D	1	not deflected

- 3 The table refers to the electron distribution in the second shell of an atom with eight protons.

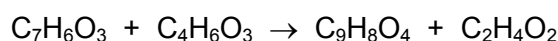
Which row is correct for this atom?

	orbital shape 		orbital shape 	
	orbital type	number of electrons	orbital type	number of electrons
A	p	2	s	4
B	p	4	s	2
C	s	2	p	4
D	s	4	p	2

4 Which statement describes the bond between carbon and hydrogen in an ethene molecule?

- A a π bond between an s orbital and an sp^2 orbital
- B a π bond between an s orbital and an sp^3 orbital
- C a σ bond between an s orbital and an sp^2 orbital
- D a σ bond between an s orbital and an sp^3 orbital

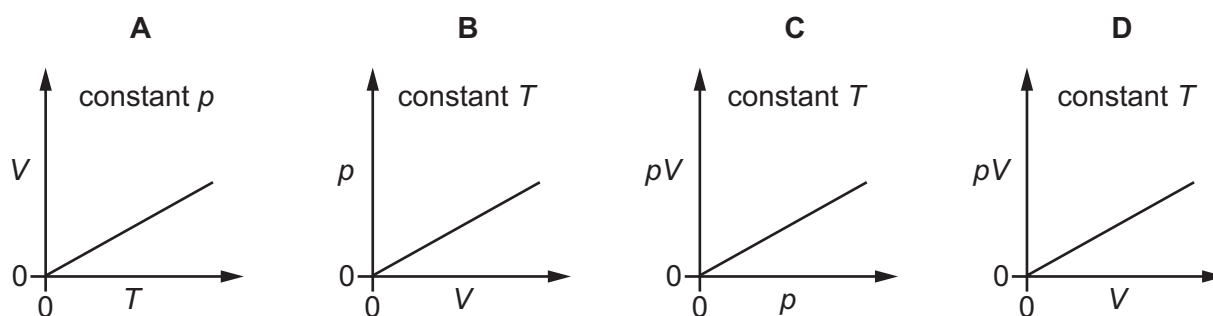
5 Aspirin, $C_9H_8O_4$, $M_r = 180.0$, can be made by a reaction between 2-hydroxybenzoic acid, $C_7H_6O_3$, $M_r = 138.0$, and ethanoic anhydride, $C_4H_6O_3$, $M_r = 102.0$. The balanced equation for the reaction is shown.



If a reaction mixture consists of 10.0g of each of the two reactants, what is the maximum mass of aspirin that can be produced?

- A 5.7g
- B 10.0g
- C 13.0g
- D 17.6g

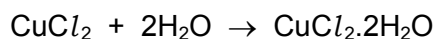
6 Which diagram correctly describes the behaviour of a fixed mass of an ideal gas? (T is measured in K.)



- 7 Anhydrous copper(II) chloride, CuCl_2 , combines with water to form $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$. The standard enthalpy changes of formation for this reaction are shown in the table.

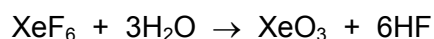
	$\Delta H_f^\circ / \text{kJ mol}^{-1}$
H_2O	-286
CuCl_2	-206
$\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$	-808

What is the standard enthalpy change of the reaction shown?



- A -1586 kJ mol^{-1}
- B -316 kJ mol^{-1}
- C -110 kJ mol^{-1}
- D -30 kJ mol^{-1}

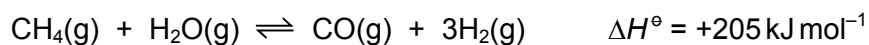
- 8 Xenon hexafluoride, XeF_6 , reacts with water.



Which statement is correct?

- A Hydrogen is reduced in this reaction.
- B Hydrogen is the only element oxidised in this reaction.
- C The only element oxidised in this reaction is xenon.
- D This is not a redox reaction.

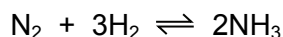
- 9 Hydrogen is produced industrially from methane as shown in the equation.



Which conditions would most favour the formation of hydrogen?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

- 10 The chemical equilibrium shown is formed when ammonia is produced in the Haber process.

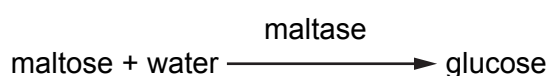


The following concentrations are found to be present at equilibrium under certain conditions.

N_2	H_2	NH_3
$0.200 \text{ mol dm}^{-3}$	$0.300 \text{ mol dm}^{-3}$	$0.600 \text{ mol dm}^{-3}$

What is the numerical value of K_c under these conditions?

- A 0.0150 B 6.0 C 10.0 D 66.7
- 11 The enzyme maltase speeds up the reaction between maltose and water.



Maltase shows **specificity**.

Which statement describes the **specificity** of maltase?

- A Maltase is a biological catalyst and it is a type of protein.
 B Maltase is most effective between pH 6.1 and pH 6.8.
 C Maltase lowers the activation energies of the reactions it catalyses.
 D Maltase only speeds up a small number of chemical reactions.
- 12 Which description of the bonding and acid / base nature of aluminium oxide is correct?

	bonding	acid / base nature
A	simple covalent	amphoteric
B	giant covalent	basic only
C	ionic	amphoteric
D	ionic	basic only

- 13 X and Y are elements of the third period.

X and Y are individually heated in excess chlorine. Each product is purified and then separately added to water, producing two solutions. Both solutions have a pH of less than 5.

What could be X and Y?

- A Na and P B Mg and Al C Mg and Si D Si and P

- 14** An ore contains magnesium carbonate and barium carbonate. A sample of the ore is dissolved in nitric acid.

How could this solution be processed into a magnesium compound and a separate barium compound?

- A** Add $\text{HCl}(\text{aq})$, filter off the solid barium chloride.
 - B** Add $\text{HCl}(\text{aq})$, filter off the solid magnesium chloride.
 - C** Add $\text{H}_2\text{SO}_4(\text{aq})$, filter off the solid barium sulfate.
 - D** Add $\text{H}_2\text{SO}_4(\text{aq})$, filter off the solid magnesium sulfate.
- 15** When calcium and calcium hydride, CaH_2 , react separately with water, they each produce a white solid and a colourless gas. The white solid is the same compound in each reaction.

Which statement is correct?

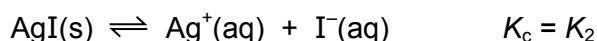
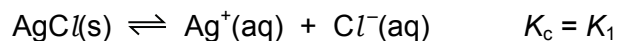
- A** Both Ca and CaH_2 produce H_2 .
 - B** Both Ca and CaH_2 produce O_2 .
 - C** Ca produces H_2 and CaH_2 produces O_2 .
 - D** Ca produces O_2 and CaH_2 produces H_2 .
- 16** When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but not Cl_2 .

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

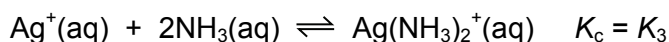
- A** Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised.
- B** Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised.
- C** Sulfuric acid is a reducing agent and chloride ions are more easily reduced.
- D** Sulfuric acid is a reducing agent and iodide ions are more easily reduced.

- 17 Silver chloride and silver iodide form equilibria when added to water.



Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.



The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

A $K_1 > K_2 > K_3$

B $K_2 > K_1 > K_3$

C $K_3 > K_1 > K_2$

D $K_3 > K_2 > K_1$

- 18 Elements and their compounds are important as catalysts.

In which process is a compound used, rather than an element?

A catalytic converters

B Contact process

C Haber process

D hydrogenation of alkenes

- 19 The gaseous products of heating a mixture of $\text{Ca}(\text{OH})_2$ and NH_4Cl are passed through solid CaO . This absorbs water vapour and a gas, **W**, is collected.

A sample of **W** is oxidised by $\text{Cl}_2(\text{g})$ to produce two gases, **X** and **Y**.

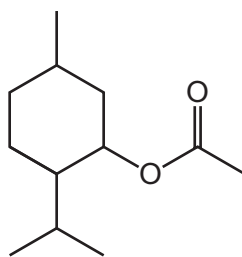
X is an element. **Y** is acidic.

Y reacts with **W** to produce **Z**.

What are **X** and **Z**?

	X	Z
A	N_2	CaCl_2
B	N_2	NH_4Cl
C	O_2	CaCl_2
D	O_2	NH_4Cl

20 Molecule G is shown.



G

How many chiral centres are present in each molecule of G?

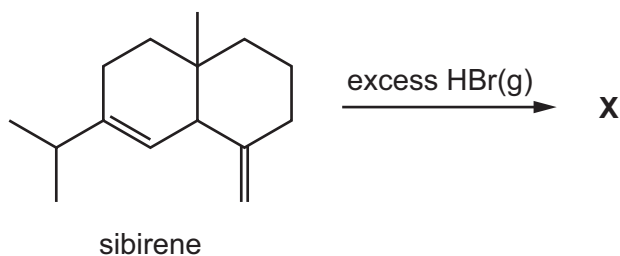
A 1

B 2

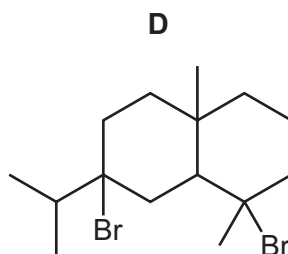
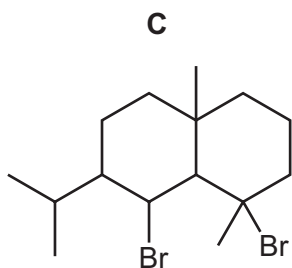
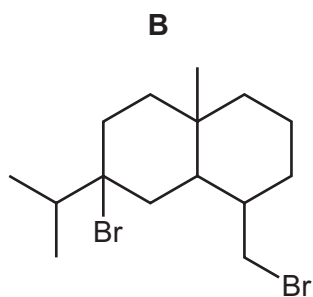
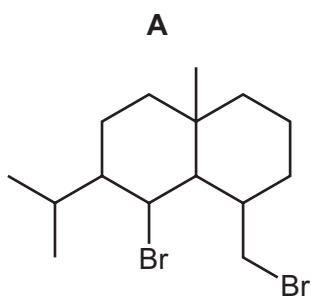
C 3

D 4

21 Sibirene, $C_{15}H_{24}$, is reacted with an excess of $HBr(g)$. The major product is X.



What is the skeletal formula of X?

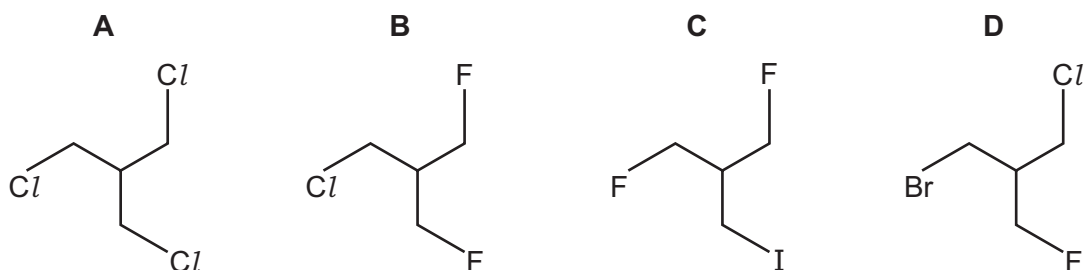


22 Which statement is **not** correct?

- A Combustion of PVC produces a highly acidic gas.
- B PVC molecules are saturated.
- C The empirical formula of PVC is the same as the empirical formula of its monomer.
- D The repeat unit of PVC is -(CHClCHCl)- .

23 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?



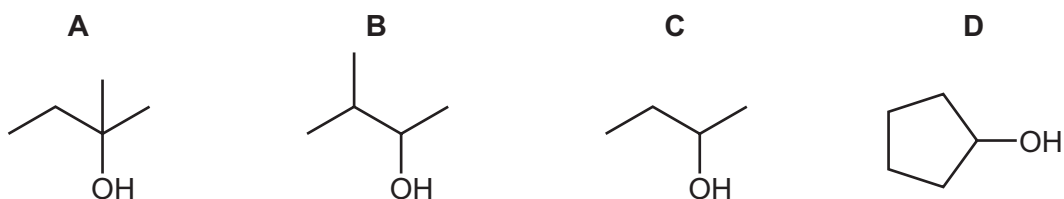
24 Halogenoalkanes react with NaOH(aq) either by an $\text{S}_{\text{N}}1$ mechanism or by an $\text{S}_{\text{N}}2$ mechanism. The mechanism followed by the reaction depends on the structure of the halogenoalkane.

This question is about the reaction of 3-bromo-3-ethylpentane, $(\text{C}_2\text{H}_5)_3\text{CBr}$.

Which statement is correct?

- A The mechanism is $\text{S}_{\text{N}}1$, due to the stabilisation of an intermediate anion by three alkyl groups.
- B The mechanism is $\text{S}_{\text{N}}1$, due to the stabilisation of an intermediate cation by three alkyl groups.
- C The mechanism is $\text{S}_{\text{N}}2$, due to the stabilisation of an intermediate anion by three alkyl groups.
- D The mechanism is $\text{S}_{\text{N}}2$, due to the stabilisation of an intermediate cation by three alkyl groups.

25 Which compound is a secondary alcohol that can be dehydrated to form an alkene with $M_r = 70$?



- 26 When 0.0075 mol of alcohol X are completely burnt in excess oxygen and the gases produced are passed through an excess of limewater (calcium hydroxide solution), 3.0 g of calcium carbonate are produced.

When X is warmed with acidified potassium dichromate(VI) there is a colour change from orange to green.

What could be the identity of X?

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

- 27 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $\text{C}_5\text{H}_{12}\text{O}$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

- 28 A student carried out a **two-stage** synthesis in which $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ was converted into $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$.

Which compound could have been formed by the first stage of this synthesis?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
 C $\text{CH}_3\text{CH}_2\text{CN}$
 D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$

- 29 An ester X has the structural formula $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$. X can be prepared by heating an alcohol Y, under reflux, with ethanoic acid and an acid catalyst.

What is the correct name for Y?

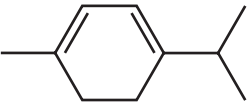
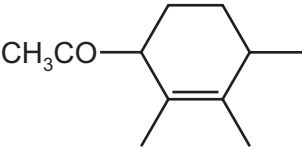
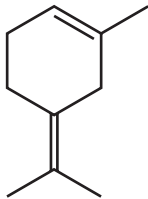
- A butan-1-ol
 B butan-2-ol
 C butan-3-ol
 D methylpropan-2-ol

- 30 Compound **S** can be extracted from natural compounds. Reacting **S** with hot, concentrated KMnO_4 produces the organic product, **T**. Some of the absorptions found in the infra-red spectra of **S** and **T** are described.

S has no strong absorption between 1670 and 1740 cm^{-1} .

T has a strong absorption at 1720 cm^{-1} but has **no** strong, broad absorption between 2500 and 3000 cm^{-1} .

From this information, what could be the formulae of **S** and **T**?

	S	T
A	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}_2$	$\text{CH}_3(\text{CH}_2)_5\text{CO}_2\text{H}$
B		$\text{CH}_3\text{COCH}_2\text{CH}_2\text{COCH}(\text{CH}_3)_2$
C		$\text{CH}_3\text{COCH}(\text{COCH}_3)\text{CH}_2\text{CH}_2\text{CH}(\text{COCH}_3)\text{CH}_3$
D		$\text{HO}_2\text{CCH}_2\text{CH}_2\text{COCH}_2\text{COCH}_3$

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** Complete combustion of a sample of a hydrocarbon gave 0.132 g of carbon dioxide and 0.054 g of water.

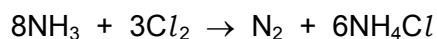
Which formulae could correctly represent this hydrocarbon?

- 1** $\text{CH}_2=\text{CH}_2$
- 2** $\text{CH}_3\text{CH}=\text{CH}_2$
- 3** $\text{CH}_3\text{CH}=\text{CHCH}_3$

- 32** Which statements are correct?

- 1** Magnesium carbonate decomposes at a lower temperature than calcium carbonate.
- 2** Calcium hydroxide is more soluble in water than magnesium hydroxide.
- 3** Calcium is a stronger reducing agent than magnesium.

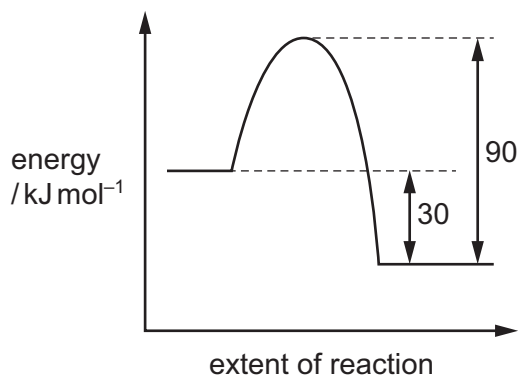
- 33** Ammonia and chlorine react as shown.



Which statements are correct?

- 1** Each nitrogen atom is oxidised.
- 2** Each chlorine atom is reduced.
- 3** Ammonia behaves as a base.

- 34 The diagram shows the reaction pathway for a reversible reaction.



Which statements are correct?

- 1 The forward reaction is exothermic.
 - 2 The enthalpy change for the forward reaction is -30 kJ mol^{-1} .
 - 3 The enthalpy change for the backward reaction is $+90 \text{ kJ mol}^{-1}$.
- 35 The structure of metals is considered to be positive ions surrounded by delocalised electrons.

The melting points of the metals in Period 3 increase with increasing atomic number.

Which statements help to explain this trend from sodium to aluminium?

- 1 The charge on the metal ion increases.
 - 2 There are more delocalised electrons per metal ion.
 - 3 The radius of the metal ion decreases.
- 36 Under room conditions, 600 cm^3 of a gas, X, has a mass of 0.700 g .
- What could X be?
- 1 carbon monoxide
 - 2 ethene
 - 3 nitrogen
- 37 Which compounds, on reaction with NaBH_4 , form a compound with a chiral carbon atom?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_3$
- 2 $\text{CH}_2\text{CHCOCH}_2\text{CH}_3$
- 3 $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$

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

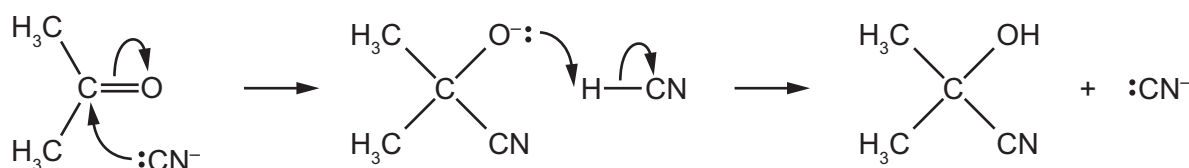
No other combination of statements is used as a correct response.

- 38** Compound Y is a straight chain molecule with formula $C_nH_{2n+1}X$. X is a halogen. The M_r of Y is 137. The halogen atom is on the second carbon atom in the chain.

Which statements are correct?

- Y contains a chiral centre.
- Y can eliminate HX to form two structurally isomeric alkenes.
- Y can eliminate HX to form two geometrically isomeric alkenes.

- 39** Propanone and hydrogen cyanide react together by the mechanism shown.



Which statements about this mechanism are correct?

- CN^- is an electrophile.
- It is an addition reaction.
- Heterolytic bond breaking is involved.

- 40** Acrolein is an organic compound with the molecular formula C_3H_4O . It is used in water treatment and as a herbicide. When acrolein reacts with 2,4-dinitrophenylhydrazine an orange precipitate is obtained. Reaction of acrolein with Tollens' reagent produces a silver mirror.

Which statements are correct?

- Acrolein reacts with alkaline aqueous iodine to produce a yellow precipitate.
- Acrolein can be reduced to a primary alcohol.
- Acrolein decolourises bromine water.

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