



Cambridge International AS & A Level

CHEMISTRY

9701/11

Paper 1 Multiple Choice

May/June 2020

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.

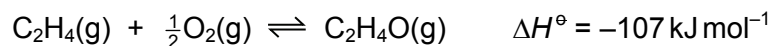


Section A

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 Ethene can be oxidised to form epoxyethane, $\text{C}_2\text{H}_4\text{O}$.



Which set of conditions gives the greatest yield of epoxyethane at equilibrium?

	pressure	temperature / $^\circ\text{C}$
A	high	100
B	high	200
C	low	100
D	low	200

- 2 Cobalt can form the positive ion $\text{Co}(\text{NH}_3)_4\text{Cl}_2^+$.

What is the oxidation number of cobalt in this ion?

- A** +1 **B** +2 **C** +3 **D** +6

- 3 When considering one molecule of ethene, which row describes both the hybridisation of the atomic orbitals in the carbon atoms and the overall bonding?

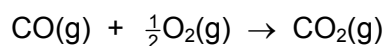
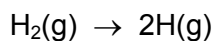
	hybridisation	bonding
A	sp^2	4 σ bonds 1 π bond
B	sp^2	5 σ bonds 1 π bond
C	sp^3	4 σ bonds 1 π bond
D	sp^3	5 σ bonds 1 π bond

- 4 10 cm^3 of ethane is burned in 45 cm^3 of oxygen at a pressure of 101 kPa and a temperature of 200°C . Complete combustion takes place.

What is the total volume of gas present when the reaction is complete, measured under the same conditions?

- A** 30 cm^3 **B** 50 cm^3 **C** 55 cm^3 **D** 60 cm^3

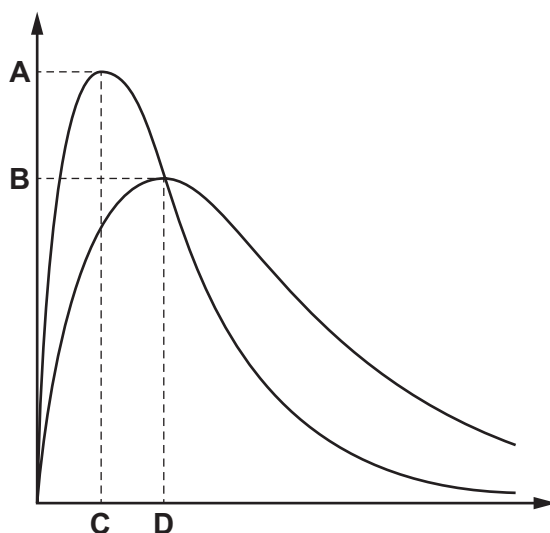
- 5 Two reactions are shown.



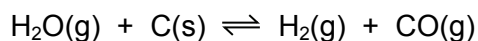
If molar amounts are used, how can the two energy changes associated with these reactions be described?

- A** enthalpy of atomisation and enthalpy of combustion
B enthalpy of atomisation and enthalpy of formation
C bond energy and enthalpy of combustion
D bond energy and enthalpy of formation
- 6 The diagram shows the Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy for molecules of the same sample of gas at the **lower** temperature?



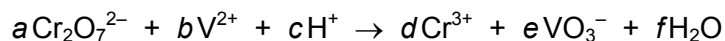
- 7 What are the units of K_p for the reaction shown?



- A** Pa^{-1} **B** Pa **C** Pa^2 **D** no units

- 8 In this question you should use changes in oxidation numbers to balance a chemical equation.

Acidified potassium dichromate(VI) solution can oxidise a solution of V^{2+} ions. The equation for this reaction is shown.



What is the ratio $a:b$ in the correctly balanced equation?

- A** 1:1 **B** 1:2 **C** 2:1 **D** 4:1

- 9 A sample of argon gas has a mass of 0.20 g, at a pressure of 100 000 Pa and a temperature of 12 °C.

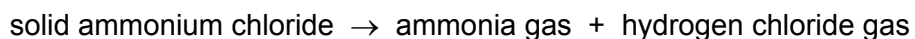
Which volume does the gas occupy?

- A** $1.2 \times 10^{-4} \text{ cm}^3$
B 5.0 cm^3
C 59 cm^3
D 119 cm^3

- 10 In which pair does each species have the same number of unpaired electrons?

- A** Al and Cu^{2+}
B Ca and Cr^{3+}
C Ca and Ni^{2+}
D Fe^{3+} and O^{2-}

- 11 A sample of solid ammonium chloride decomposes on heating.



A total of 2.4×10^{21} molecules of gas is formed.

How many hydrogen atoms are present in the gaseous products?

- A** 1.2×10^{21} **B** 2.4×10^{21} **C** 4.8×10^{21} **D** 9.6×10^{21}

- 12 A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. An excess of aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

An excess of concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

- A X is a pure white colour.
 - B X is pure silver iodide.
 - C Y is pure silver chloride.
 - D Y is yellow.
- 13 6.90 g of an ammonium salt is heated with an excess of aqueous sodium hydroxide. The volume of ammonia produced, measured under room conditions, is 2.51 dm^3 .

Which ammonium salt is used?

- A ammonium carbonate ($M_r = 96.0$)
 - B ammonium chloride ($M_r = 53.5$)
 - C ammonium nitrate ($M_r = 80.0$)
 - D ammonium sulfate ($M_r = 132.1$)
- 14 An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube P.
- An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Q.

Which oxide reacts more readily with water and which filtrate has the **lower** pH?

	oxide reacts more readily with water	test-tube with filtrate of lower pH
A	BaO	P
B	BaO	Q
C	MgO	P
D	MgO	Q

- 15** Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which pair shows two elements which could be Z?

- A** aluminium, magnesium
- B** aluminium, silicon
- C** phosphorus, magnesium
- D** phosphorus, silicon

- 16** Sodium, aluminium and silicon are three elements in Period 3. Each element forms an oxide.

Which row has three correct properties of these oxides?

	sodium oxide	aluminium oxide	silicon dioxide
A	basic	basic	amphoteric
B	giant ionic	giant ionic	simple molecular
C	high melting point	low melting point	high melting point
D	reacts with water	no reaction with water	no reaction with water

- 17** 0.25 g of anhydrous magnesium nitrate is heated strongly until it completely decomposes.

What is the total volume of gas produced, measured under room conditions?

- A** 40 cm³ **B** 81 cm³ **C** 101 cm³ **D** 202 cm³

- 18** Astatine, At, is below iodine in Group 17 of the Periodic Table.

Which statement is most likely to be correct?

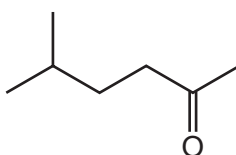
- A** AgAt(s) reacts with an excess of dilute aqueous ammonia to form a solution of a soluble complex.
- B** Astatine and KCl(aq) react to form KAt(aq) and chlorine.
- C** KAt(aq) and dilute sulfuric acid react to form HAt(g).
- D** NaAt(s) and concentrated sulfuric acid react to form astatine.

19 What is the order of increasing melting point of the three chlorides shown?



	lowest melting point	→	highest melting point
A	CCl_4	PCl_5	MgCl_2
B	MgCl_2	CCl_4	PCl_5
C	MgCl_2	PCl_5	CCl_4
D	PCl_5	CCl_4	MgCl_2

20 The skeletal formula of compound X is shown.



Which row is correct?

	molecular formula of X	observation on addition of X to Fehling's reagent
A	$\text{C}_7\text{H}_{14}\text{O}$	no change
B	$\text{C}_7\text{H}_{14}\text{O}$	red precipitate forms
C	$\text{C}_7\text{H}_{16}\text{O}$	no change
D	$\text{C}_7\text{H}_{16}\text{O}$	red precipitate forms

21 Which statement is correct?

- A** 2,2-dimethylpropanoic acid is an isomer of propyl methanoate.
- B** 2-methylbutan-2-ol is an isomer of hexan-3-ol.
- C** 3-methylbutan-2-one is an isomer of pentanal.
- D** 3,3-dimethylbutan-2-one is an isomer of pentan-3-one.

- 22** But-1-ene and but-2-ene are treated separately with cold, dilute acidified manganate(VII) ions.

Four students, W, X, Y and Z, make statements about these alkenes and the diols formed from them.

- W One diol contains two primary alcohol groups.
X One diol contains a primary and a secondary alcohol group.
Y One diol contains two secondary alcohol groups.
Z Both alkenes exhibit *cis-trans* isomerism.

Which two students are correct?

- A** W and Y **B** W and Z **C** X and Y **D** X and Z
- 23** 2-bromo-2-methylpentane is a tertiary halogenoalkane.

Which organic products are formed when 2-bromo-2-methylpentane reacts with a hot concentrated ethanolic solution of sodium hydroxide?

- A** 2-methylpent-1-ene only
B 2-methylpent-1-ene and 2-methylpent-2-ene
C 2-methylpent-2-ene only
D 2-methylpent-2-ene and 4-methylpent-2-ene

- 24** Poly(propene) is an addition polymer.

What are the C–C–C bond angles along its polymer chain?

- A** They are all 109°.
B Half of them are 109° and half are 120°.
C Half of them are 90° and half are 180°.
D They are all 120°.

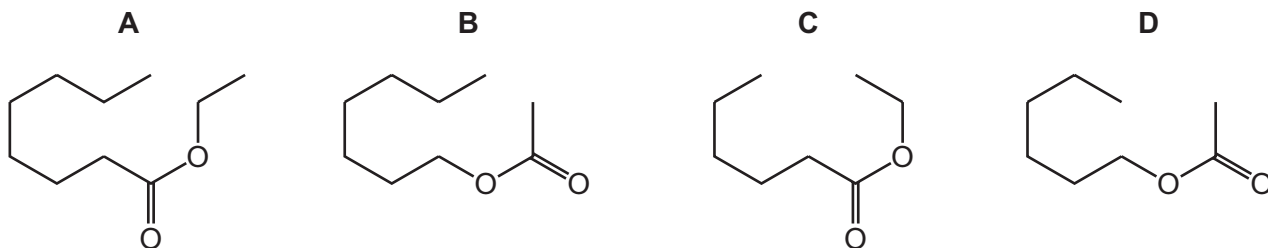
- 25** An alcohol has the molecular formula C₅H₁₂O. It has several isomers.

Which isomer forms a yellow precipitate with alkaline aqueous iodine?

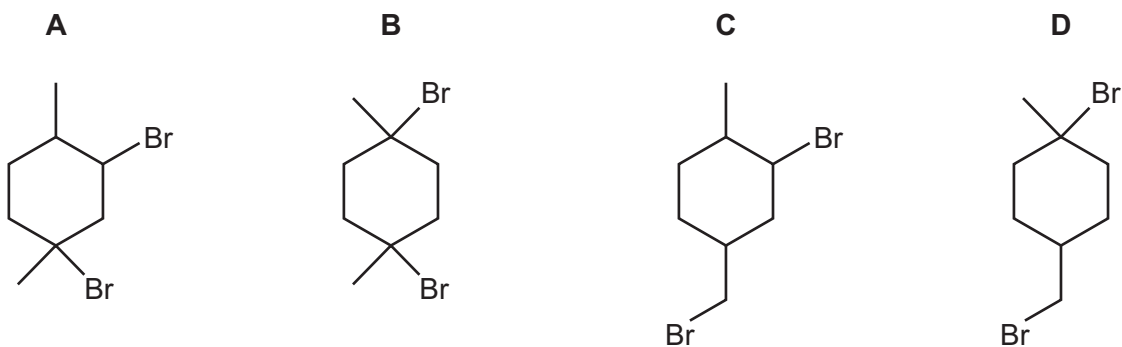
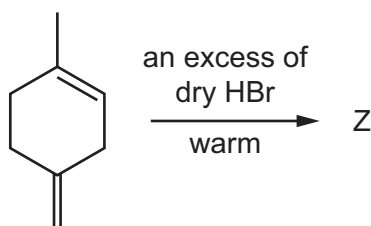
- A** 2,2-dimethylpropan-1-ol
B 2-methylbutan-2-ol
C 3-methylbutan-2-ol
D pentan-3-ol

- 26 When compound X is heated under reflux with aqueous sodium hydroxide solution two products are formed: sodium ethanoate and hexan-1-ol.

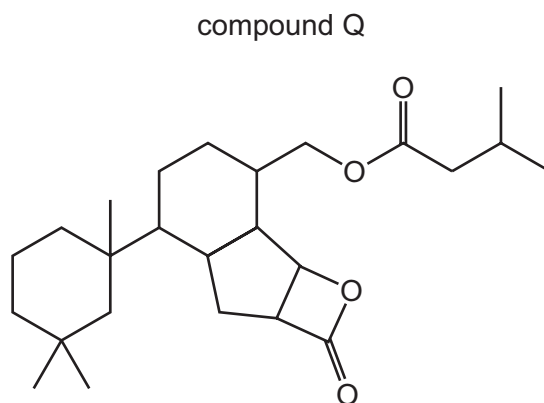
What is compound X?



- 27 What is the major product Z of the following reaction?



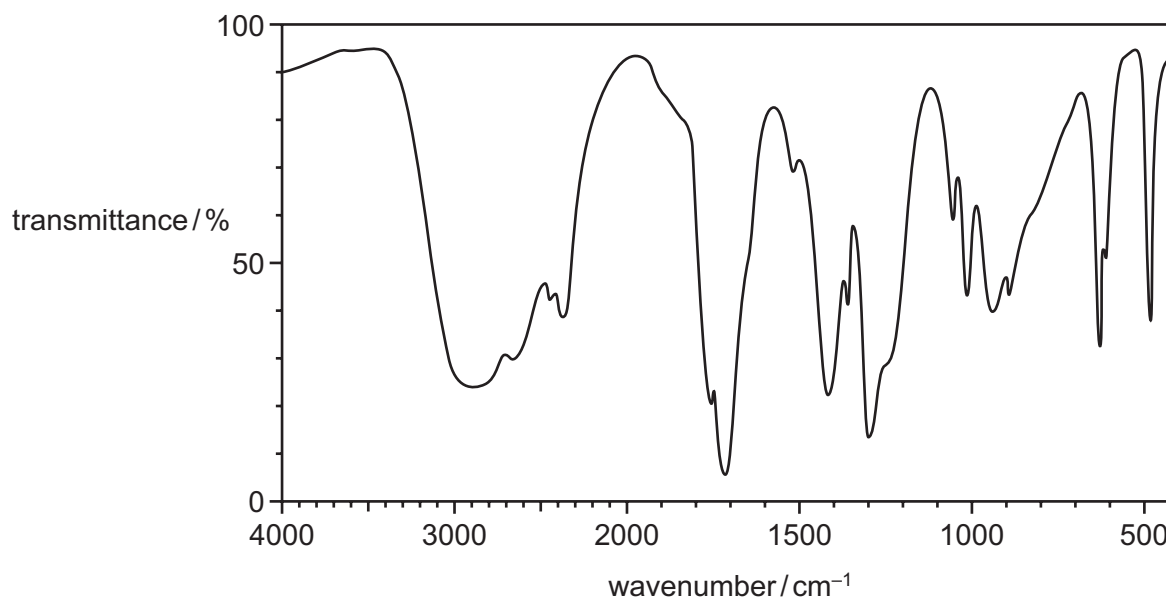
- 28 The structure of compound Q is shown.



How many chiral centres are present in a molecule of Q?

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

29 Compound X has the infra-red spectrum shown.



What could be the identity of compound X?

- A ethanoic acid
- B ethanol
- C ethylethanoate
- D propanone

30 Which reaction produces an organic anion with a good yield?

- A heating ethanenitrile under reflux with dilute sodium hydroxide
- B heating ethanenitrile under reflux with dilute sulfuric acid
- C heating ethane with sodium metal
- D heating ethanol under reflux with dilute sodium hydroxide

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 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that includes the formation of a positive ion?

- 1** first ionisation energy
- 2** heterolytic fission of a covalent bond
- 3** enthalpy change of atomisation

32 Which molecules have no overall dipole moment?

- 1** boron trifluoride
- 2** methane
- 3** phosphorus pentafluoride

33 Carbon exists in several different forms. Two of these forms are buckminsterfullerene and graphene. Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene and graphene are correct?

- 1** Both have delocalised electrons.
- 2** Buckminsterfullerene has a giant molecular structure.
- 3** The carbon atoms in graphene form a tetrahedral lattice.

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 Carbon monoxide burns readily in oxygen to form carbon dioxide.

What does this information suggest?

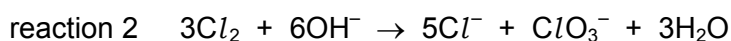
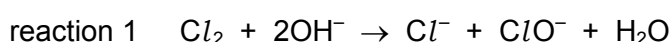
- 1** The +4 oxidation state of carbon is more stable than the +2 state.
- 2** The standard enthalpy change of formation of carbon dioxide is more negative than the standard enthalpy change of formation of carbon monoxide.
- 3** The value of the equilibrium constant for the reaction, $2\text{CO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO}_2\text{(g)}$, is likely to be high.

35 The catalytic converters fitted to cars remove pollutants from the exhaust gases. Some of the reactions that occur involve oxygen, which comes from the air.

Which pollutants in the exhaust gases will react with oxygen on the surface of the catalytic converter?

- 1** NO_2
- 2** unburnt fuel
- 3** CO

36 Chlorine reacts with sodium hydroxide in two different ways depending upon the temperature.



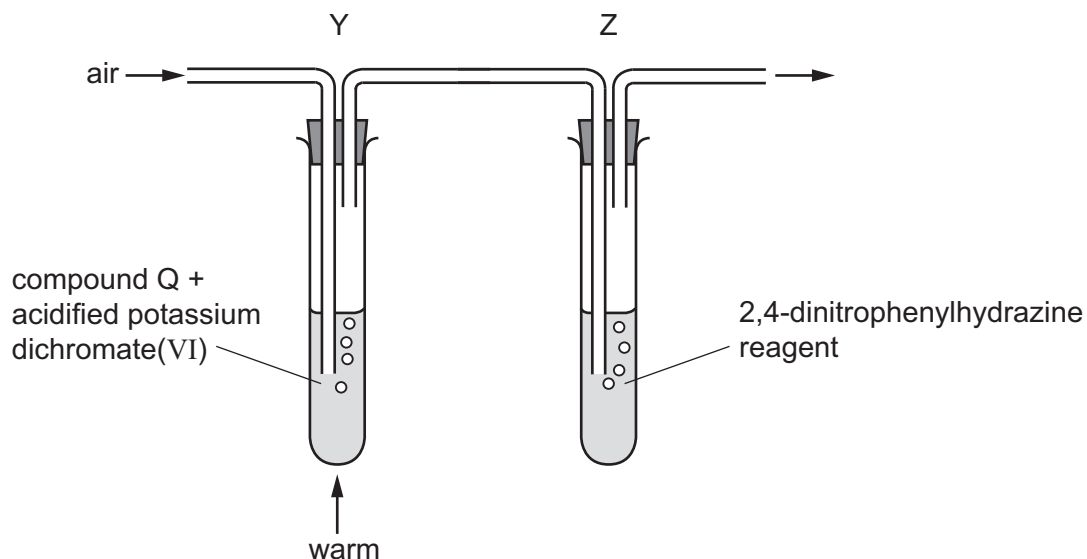
Which statements about these reactions are correct?

- 1** Reaction 2 requires a higher temperature than reaction 1.
- 2** The products of reaction 1 show chlorine in two different oxidation states.
- 3** The products of reaction 2 show oxygen in two different oxidation states.

37 In which of the reactions is the organic compound oxidised by the given reagent?

- 1 $\text{CH}_3\text{CHO} + \text{HCN}$ reagent
- 2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO} + \text{Tollens' reagent}$
- 3 $\text{CH}_3\text{CH}_2\text{CHO} + \text{Fehling's reagent}$

38 When the apparatus is set up as shown, an orange precipitate forms in test-tube Z.



What could compound Q be?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 2 $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
- 3 $(\text{CH}_3)_3\text{COH}$

39 Chlorofluoroalkanes that diffuse into the stratosphere are broken down by ultraviolet radiation.

Radicals are generated that cause depletion of ozone.

What are these radicals?

- 1 chlorine radicals
- 2 fluorine radicals
- 3 alkyl radicals

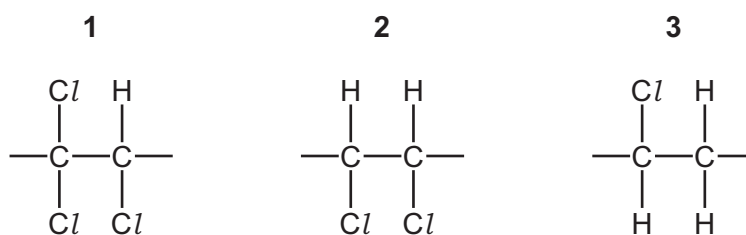
The responses **A** to **D** should be selected on the basis of

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 A mixture of the three isomers of $C_2H_2Cl_2$ is polymerised.

Which sequences will be seen within the polymer chains?



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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 In which carbon allotrope are all electrons localised?

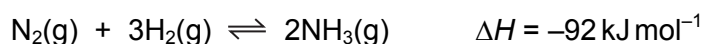
A buckminsterfullerene
B diamond
C graphite
D graphene

- 2 A copper ore contains 3.00% of copper carbonate, CuCO_3 , by mass.

Which mass of copper would be obtained from 1 tonne of the ore?

A 1.91 kg **B** 3.71 kg **C** 15.4 kg **D** 58.4 kg

- 3 The catalysed formation of ammonia by the Haber process can be represented by the equation shown.



Which change in conditions will increase both the rate of formation and the equilibrium yield of ammonia?

A decrease in the temperature
B increase in the temperature
C increase in the pressure
D increase in the surface area of the catalyst

- 4 Solid sulfur consists of S_8 molecules.

Which equation represents the standard enthalpy of atomisation of sulfur?

A $\frac{1}{8}\text{S}_8(\text{s}) \rightarrow \text{S}(\text{g})$
B $\frac{1}{8}\text{S}_8(\text{g}) \rightarrow \text{S}(\text{g})$
C $\text{S}_8(\text{s}) \rightarrow 8\text{S}(\text{g})$
D $\text{S}_8(\text{g}) \rightarrow 8\text{S}(\text{g})$

- 5 In this question you should use changes in oxidation numbers to balance a chemical equation.

The following reaction occurs when MnO_2 is warmed with dilute H_2SO_4 .



What is the ratio of $c : d$ in the correctly balanced equation?

- A 1 : 1 B 1 : 2 C 2 : 3 D 3 : 2

- 6 In this question you should assume air contains 21% oxygen.

What is the minimum volume of air required to ensure complete combustion of 10 cm^3 of butane gas, under room conditions?

- A 14 cm^3 B 27 cm^3 C 65 cm^3 D 310 cm^3

- 7 When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.

What is the most likely explanation for this observation?

- A Bromine is reduced to bromide ions in the bottom layer.
 B Bromine molecules are non-polar.
 C Bromine reacts with water but cannot react with cyclohexane.
 D The product of the reaction between bromine and cyclohexane is coloured.

- 8 In which change are **only** temporary dipole-induced dipole forces overcome?

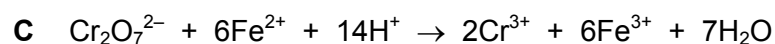
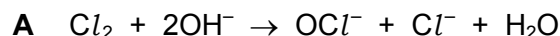
- A $\text{C}_2\text{H}_5\text{OH}(\text{l}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g})$
 B $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$
 C $\text{O}_2(\text{s}) \rightarrow \text{O}_2(\text{l})$
 D $\text{C}_4\text{H}_{10}(\text{l}) \rightarrow \text{C}_4\text{H}_{10}(\text{s})$

- 9 The complete combustion of 2 moles of an alkane produces 400 dm^3 of carbon dioxide measured at 301 K and $1 \times 10^5 \text{ Pa}$. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the alkane?

- A C_8H_{18} B $\text{C}_{16}\text{H}_{34}$ C $\text{C}_{20}\text{H}_{42}$ D $\text{C}_{40}\text{H}_{82}$

10 In which reaction does an element undergo the largest change in oxidation number?



11 PCl_5 decomposes as shown.



1.0 mol of $\text{PCl}_5(\text{g})$, 1.0 mol of $\text{PCl}_3(\text{g})$ and 1.0 mol of $\text{Cl}_2(\text{g})$ are placed in a container of volume 1 dm^3 at 250°C and allowed to reach equilibrium.

At this temperature, the equilibrium mixture contains 1.8 moles of PCl_3 .

What is the value of K_c at 250°C ?

A 1

B 1.8

C 9

D 16.2

12 The fifth to eighth ionisation energies of four elements in Period 3 of the Periodic Table are shown.

Which row refers to chlorine?

	ionisation energies / kJ mol^{-1}			
	fifth	sixth	seventh	eighth
A	6280	21 200	25 900	30 500
B	6990	8 490	27 100	31 700
C	6540	9 330	11 000	33 600
D	7240	8 790	12 000	13 800

13 Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, decomposes when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

A 1.5 g

B 2.3 g

C 3.0 g

D 4.6 g

14 Which statement explains why iodine is less volatile than chlorine?

- A Chlorine is more electronegative than iodine and so has more repulsion between its molecules.
- B The greater number of electrons in iodine leads to larger temporary dipole-induced dipole forces.
- C The I–I bond energy is smaller than the Cl–Cl bond energy.
- D The iodine molecules have stronger permanent dipole-permanent dipole forces.

15 Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product.

How are the carbonate ions behaving during this reaction?

- A Brønsted-Lowry acid
- B Brønsted-Lowry base
- C oxidising agent
- D reducing agent

16 One molecule of an oxide of element Z reacts with six molecules of water to produce an acidic compound.

What is element Z?

- A aluminium
- B phosphorus
- C silicon
- D sulfur

17 Which property shows an **increase** from magnesium to barium?

- A the first ionisation energy of the elements
- B the oxidising power of the metals
- C the solubility of the hydroxides
- D the solubility of the sulfates

- 18** A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

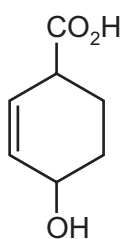
- 19** Most modern cars are fitted with catalytic converters in the exhaust system.

Which three gases are removed by a catalytic converter?

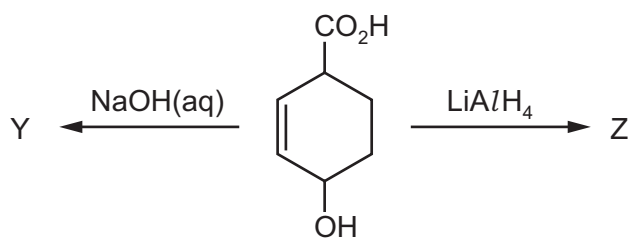
- A** carbon monoxide, hydrocarbons, nitrogen oxides
- B** carbon monoxide, carbon dioxide, nitrogen oxides
- C** carbon monoxide, nitrogen oxides, sulfur dioxide
- D** hydrocarbons, nitrogen oxides, sulfur dioxide

20 Compound X is shown.

compound X



X is treated separately with NaOH(aq) and LiAlH₄ to give Y and Z.



What are Y and Z?

	Y	Z
A		
B		
C		
D		

- 21 The table shows the molecular formulae of three molecules P, Q and R. None of the molecules are cyclic.

molecule	molecular formula
P	CH ₄ O
Q	CH ₂ O ₂
R	CH ₂ O

Which molecules show a strong absorption between 1610 cm⁻¹ and 1750 cm⁻¹ in their infra-red spectra?

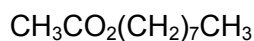
- A** Q only **B** R only **C** Q and R only **D** P, Q and R

- 22 Which row correctly shows the type of mechanism of each of the two reactions?

	C ₂ H ₅ Br + KCN	CH ₃ COCH ₃ + HCN
A	electrophilic substitution	electrophilic addition
B	electrophilic substitution	nucleophilic addition
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	nucleophilic addition

- 23 Ester X is shown.

ester X



Ester X is hydrolysed using aqueous sodium hydroxide.

What is the molecular formula of one of the products?

- A** C₂H₄O₂ **B** C₂H₃O₂Na **C** C₈H₁₆O **D** C₈H₁₇O₂Na

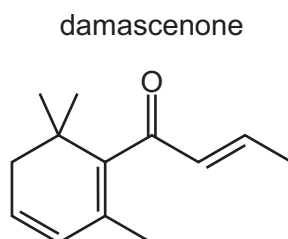
- 24 Which reagent could be used to distinguish between propane-1,2-diol and ethane-1,2-diol?

- A** alkaline aqueous iodine
B aqueous acidified dichromate(VI)
C ethanol and a few drops of concentrated sulfuric acid
D sodium metal

25 Which substance forms propanoic acid as one of the products when it reacts with hot concentrated acidified potassium manganate(VII)?

- A but-1-ene
- B but-2-ene
- C 2-methylpropene
- D 2-methylbut-1-ene

26 The structure of damascenone is shown.



Including damascenone, how many stereoisomers exist with this structural formula?

- A 1
- B 2
- C 4
- D 8

27 How many isomeric esters have the molecular formula C₄H₈O₂?

- A 2
- B 3
- C 4
- D 5

28 Ethene reacts with aqueous bromine to give two products, CH₂BrCH₂Br and CH₂BrCH₂OH.

Which statement about these products is correct?

- A Both products are obtained in this reaction by nucleophilic substitution.
- B Both products are obtained in this reaction by nucleophilic addition.
- C Both products can be hydrolysed to form the same organic compound.
- D Both products can form hydrogen bonds with water.

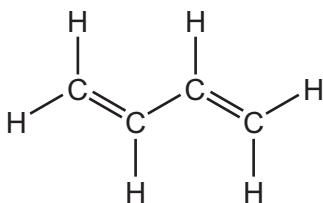
29 PVC is used as a packaging material.

What holds the different polymer strands together in a piece of solid PVC?

- A covalent bonds
- B hydrogen bonds
- C ionic bonds
- D van der Waals' forces

30 The diagram shows the structure of buta-1,3-diene.

buta-1,3-diene



The addition reaction between buta-1,3-diene and two molecules of hydrogen bromide can produce three structurally isomeric products.

How many of these products have at least one chiral centre?

A 0

B 1

C 2

D 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.

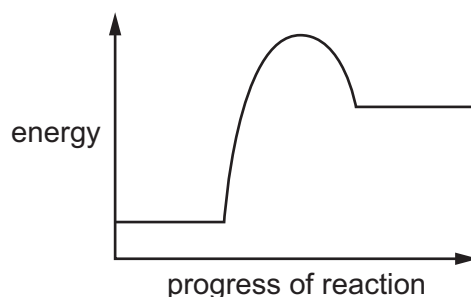
Use of the *Data Booklet* may be appropriate for some questions.

- 31** Scientists are trying to synthesise a new element with proton number 119. The element is predicted to be a Group 1 element in Period 8 of the Periodic Table.

Which predictions are likely to be correct about this element?

- 1** The outermost occupied orbital of one atom of this element will be an s orbital.
- 2** The atomic radius will be the largest of the seven elements in Group 1.
- 3** It will have a greater first ionisation energy than element 118.

- 32** Which reactions would have the reaction profile shown?



- 1** $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
- 2** $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- 3** $2\text{MgO} \rightarrow 2\text{Mg} + \text{O}_2$

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

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

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

33 Which factors can lead to an increase in the rate of a reaction?

- 1** a lower activation energy
- 2** an increase in temperature
- 3** an increase in the concentration of a reactant

34 Sodium and fluorine are both reactive elements. Two atoms are described.

	F	Na
atomic number	9	11
nucleon number	19	23

Which statements about these two atoms, and the ions they can form, are correct?

- 1** One Na atom has two more protons than one F^- ion.
- 2** One Na atom has two more neutrons than one F atom.
- 3** One Na^+ ion has the same number of electrons as one F^- ion.

35 In the atmosphere, which transformations can involve sulfur dioxide as either a reagent or a catalyst?

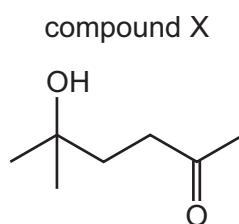
- 1** NO_2 to NO
- 2** NO to NO_2
- 3** CO to CO_2

- 36 The bond P..... of the HBr molecule is Q..... than that of the HI molecule.

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

- 37 Compound X has the structure shown.



Which statements about compound X are correct?

- 1 X will decolourise cold, acidified $\text{KMnO}_4(\text{aq})$.
 - 2 X gives an orange precipitate with 2,4-DNPH reagent.
 - 3 X does not react with Tollens' reagent.
- 38 Propanal reacts with hydrogen cyanide.

Which absorptions are present in the infra-red spectrum of the product?

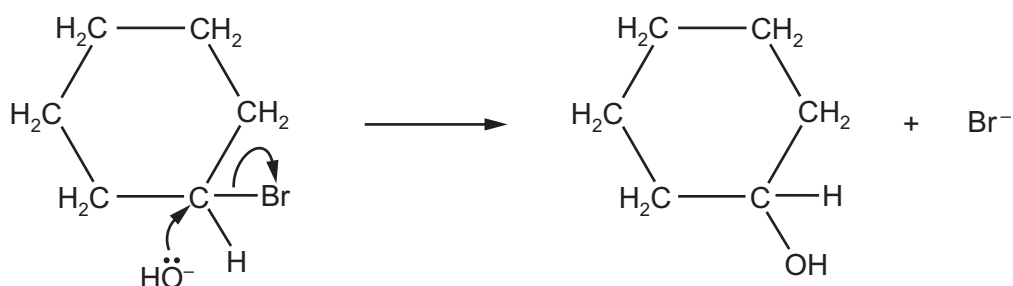
- 1 a weak absorption in the range $2200\text{--}2250\text{ cm}^{-1}$
 - 2 a strong absorption in the range $3200\text{--}3600\text{ cm}^{-1}$
 - 3 a strong absorption in the range $1040\text{--}1300\text{ cm}^{-1}$
- 39 Which alcohols **cannot** be dehydrated to form alkenes?
- 1 CH_3OH
 - 2 $(\text{CH}_3)_3\text{COH}$
 - 3 $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

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.

40 A reaction mechanism is shown.



Which statements about this reaction are correct?

- 1** Heterolytic bond fission occurs.
- 2** It is a substitution reaction.
- 3** OH^- behaves as an electrophile.

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Cambridge International AS & A Level

CHEMISTRY

9701/13

Paper 1 Multiple Choice

May/June 2020

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.



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 particle has equal numbers of protons and neutrons and an electronic structure of $1s^2 2s^2 2p^6 3s^2 3p^6$?

A $^{39}_{18}\text{Ar}$ **B** $^{40}_{20}\text{Ca}^{2+}$ **C** $^{16}_8\text{O}^{2-}$ **D** $^{32}_{16}\text{S}$

- 2 Which molecule contains six bonding electrons?

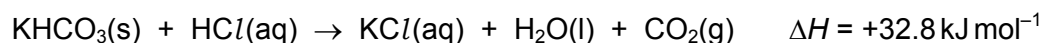
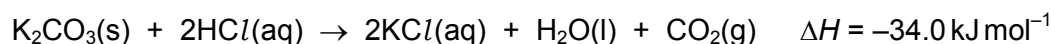
A NCl_3 **B** H_2S **C** C_2H_4 **D** SF_6

- 3 Solid carbon dioxide, CO_2 , is similar to solid iodine, I_2 , in its structure.

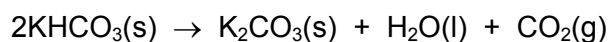
Which statement about solid CO_2 and solid SiO_2 is correct?

- A** Both solid CO_2 and solid SiO_2 exist in a lattice structure.
B Both solid CO_2 and solid SiO_2 have a simple molecular structure.
C Both solid CO_2 and solid SiO_2 have atoms joined by single covalent bonds.
D Both solid CO_2 and solid SiO_2 change spontaneously to gas at s.t.p..

- 4 The enthalpy changes of two reactions are shown.

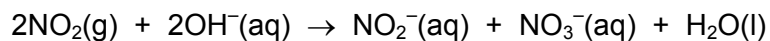
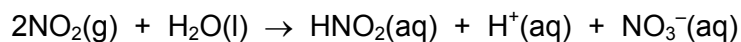
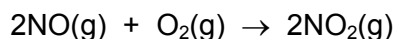
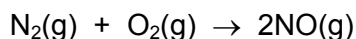


What is the enthalpy change for the reaction shown?



- A** $-31.6 \text{ kJ mol}^{-1}$
B 1.2 kJ mol^{-1}
C 66.8 kJ mol^{-1}
D 99.6 kJ mol^{-1}

- 5 Nitrogen reacts with oxygen to form nitrogen monoxide, NO, and nitrogen dioxide, NO₂. Nitrogen dioxide reacts with water and with hydroxide ions.



What can be deduced using **only** the information from these equations?

- A HNO₂ is a strong acid.
 B HNO₃ is a weak acid.
 C NO₂ is a neutral gas.
 D NO is a reducing agent.
- 6 Which solution has the lowest pH value?

- A 0.01 mol dm⁻³ butanoic acid
 B 0.01 mol dm⁻³ ethanoic acid
 C 0.01 mol dm⁻³ hydrochloric acid
 D 0.01 mol dm⁻³ sulfuric acid

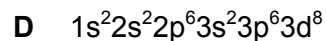
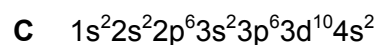
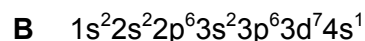
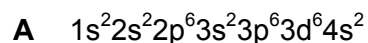
- 7 The element sulfur produces a mass spectrum with the following peaks.

<i>m/e</i> value of peak	relative abundance
32	95.02
33	0.76
34	4.20
36	0.02

Which relative atomic mass of sulfur can be calculated from these data, given to four significant figures?

- A 32.07 B 32.08 C 32.09 D 32.10

8 What is the electronic configuration of an isolated Ni^{2+} ion?



9 At 200°C aluminium chloride is a gas with $M_r = 267$.

What is the number of covalent bonds, dative covalent bonds and lone pairs of electrons in one molecule of aluminium chloride at 200°C ?

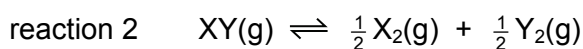
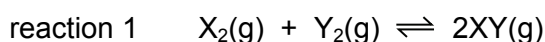
	covalent bonds	dative covalent bonds	lone pairs
A	6	2	0
B	6	2	16
C	6	2	18
D	3	0	9

10 When solid KClO_3 is heated in the absence of air, a mixture of two chlorine compounds in the mole ratio of 3:1 is formed. Chlorine is the only element whose oxidation number changes in this reaction.

What could be the oxidation numbers of chlorine in the two compounds that are formed?

A +3 and -1 B +6 and +4 C +7 and -1 D +7 and +1

11 Two reactions are shown.



The equilibrium constant, K_p , for reaction 1 is 0.0052.

What is K_p for reaction 2?

A 2.6×10^{-3} B 13.9 C 192.3 D 384.6

- 12** Compound T is a white crystalline solid.

When a sample of compound T is mixed with aqueous sodium hydroxide and heated, a gas is produced which turns damp red litmus paper blue.

Further testing of a solution of compound T with aqueous barium chloride produces a dense white precipitate which does not dissolve when dilute hydrochloric acid is added to the mixture.

What is the identity of compound T?

- A** ammonium carbonate
 - B** ammonium sulfate
 - C** sodium carbonate
 - D** sodium sulfate
- 13** Which property explains the trend in volatility of the elements going down Group 17?
- A** decreasing covalent bond strength
 - B** decreasing van der Waals' forces
 - C** increasing covalent bond strength
 - D** increasing van der Waals' forces
- 14** The statements apply to the elements in Group 2.
- Which statement is correct?
- A** As atomic number increases, ionic radius increases.
 - B** As atomic number increases, reducing ability decreases.
 - C** As atomic number increases, first ionisation energy increases.
 - D** As atomic radius increases, first ionisation energy increases.
- 15** Which element, when burned in oxygen, can form an oxide that is a reducing agent?
- A** Na **B** Mg **C** Al **D** S

- 16 Nitrogen oxides are removed from the exhaust gases of internal combustion engines by the action of a catalyst in a catalytic converter.

Which row is correct?

	change in oxidation number of nitrogen	type of catalyst
A	decrease	heterogeneous
B	decrease	homogeneous
C	increase	heterogeneous
D	increase	homogeneous

- 17 The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in an excess of dilute aqueous ammonia to form a colourless solution.

The addition of an excess of dilute nitric acid to the colourless solution produces a white precipitate, Z.

What is Z?

- A** AgCl **B** BaCl_2 **C** $\text{Ba}(\text{NO}_3)_2$ **D** NH_4NO_3

- 18 Which property shows an **increase** from calcium to barium going down Group 2?

- A** the ease of decomposition of the carbonates
B the solubility of the hydroxides
C the solubility of the sulfates
D the volume of hydrogen given off when 1 g of the metal reacts with water

- 19 Element X is in Period 3. It reacts rapidly with water to form an alkaline solution.

Which statement about the **chloride** of element X is correct?

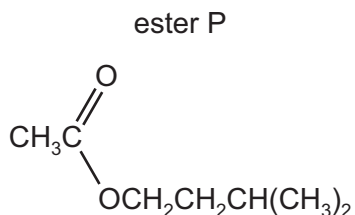
- A** It conducts electricity when molten.
B It has a melting point of less than 100°C .
C It has covalent bonding.
D It reacts rapidly with cold water.

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

When *trans*-pent-2-ene reacts with HBr, how many different products can form?

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

21 Ester P has the following structural formula.



Which compounds are produced when P is hydrolysed using dilute hydrochloric acid?

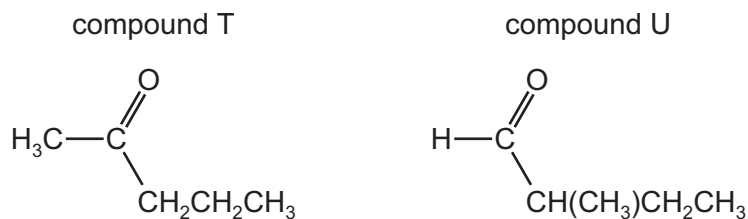
- A** CH_3COCl and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
B $\text{CH}_3\text{CH}_2\text{OH}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CO}_2\text{H}$
C $\text{CH}_3\text{CO}_2\text{H}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CO}_2\text{H}$
D $\text{CH}_3\text{CO}_2\text{H}$ and $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
- 22 There are many non-cyclic alcohols that cannot be oxidised by warm acidified MnO_4^- ions. Alcohol X is the member of this set of alcohols with the **lowest** molecular mass.
- How many moles of oxygen are required for the complete combustion of 1.0 mol of alcohol X?
- A** 3.5 mol **B** 4.5 mol **C** 6.0 mol **D** 6.5 mol
- 23 Butanoic acid can be produced from 1-bromopropane in two steps using reagents V and W as shown.



What could be reagents V and W?

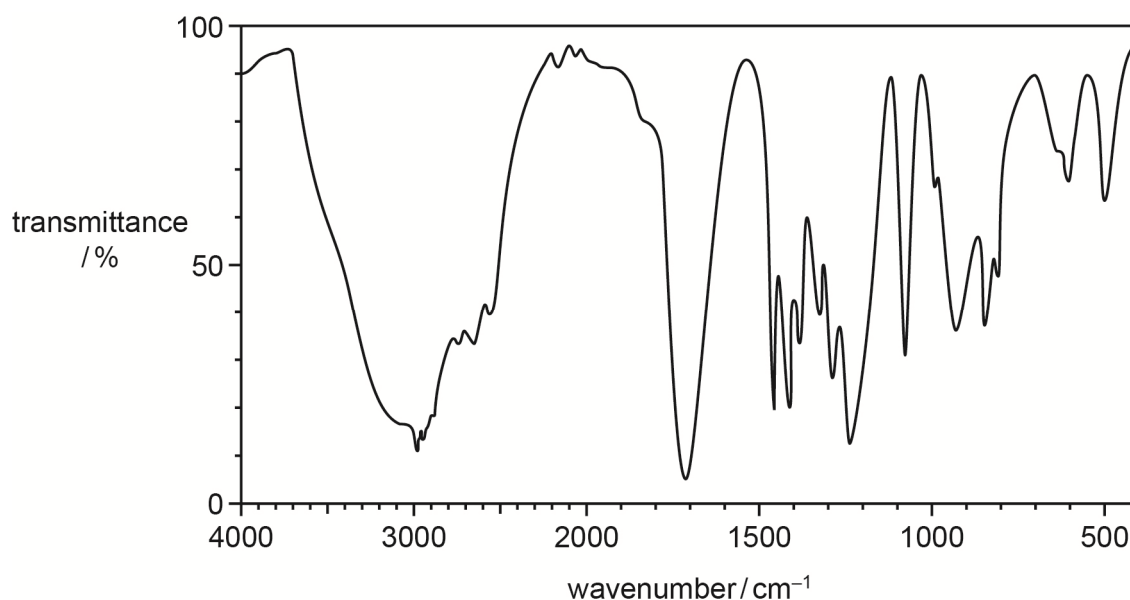
	V	W
A	KCN in ethanol	HCl(aq)
B	KCN in ethanol	NaOH(aq)
C	NH_3 in ethanol	HCl(aq)
D	NaOH(aq)	$\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}(\text{aq})$

24 Which statement about compound T and compound U is correct?



- A T and U are stereoisomers.
- B T can be distinguished from U by the use of alkaline aqueous iodine.
- C T can be reduced by LiAlH_4 but not by NaBH_4 .
- D U can be formed by the oxidation of 3-methylbutan-1-ol.

25 The diagram shows the infrared spectrum of an organic compound.



What could be the identity of this compound?

- A propan-1-ol
- B propanal
- C propanoic acid
- D propanone

26 Which reagent reacts with **both** of the $-\text{OH}$ groups in lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$?

- A acidified potassium dichromate(VI)
- B ethanol
- C sodium
- D sodium hydroxide

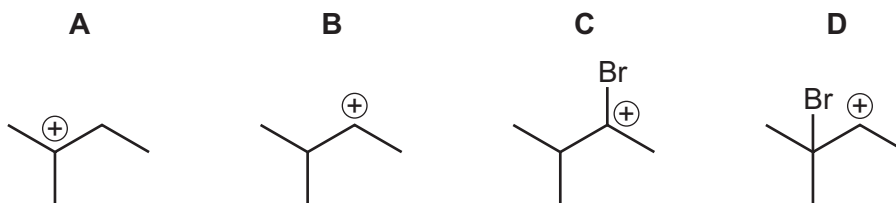
- 27 1,2-dibromopropane can be made from 1-bromopropane in two steps.

Which row is correct?

	step 1	step 2
A	addition	substitution
B	elimination	addition
C	hydrolysis	elimination
D	substitution	hydrolysis

- 28 2-methylbut-2-ene reacts with HBr(g) to form two isomeric products. During the reaction two positively charged intermediates can be made.

Which diagram shows the more stable of the two positively charged intermediates?



- 29 The ester ethyl methanoate is prepared in a school laboratory by reacting a carboxylic acid with an alcohol.

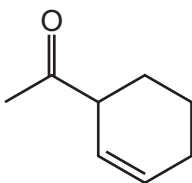
During the reaction, only 50.0% of the alcohol is converted into the ester.

Which mass of alcohol is needed to prepare 10.0 g of the ester?

- A** 3.11 g **B** 8.65 g **C** 12.4 g **D** 32.2 g

30 Compound X has the structure shown.

compound X



Which type of carbonyl group is present and how many chiral centres are there in one molecule of X?

	carbonyl group	chiral centres
A	aldehyde	0
B	aldehyde	1
C	ketone	0
D	ketone	1

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 contain one mole of the underlined substance under room conditions?

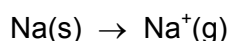
- 1 a balloon containing 24.0 dm³ of helium
- 2 a block of calcium carbonate weighing 100.1 g
- 3 4000 cm³ of a 0.250 mol dm⁻³ solution of sulfuric acid

32 Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene are correct?

- 1 Buckminsterfullerene is a giant covalent molecule.
- 2 Buckminsterfullerene has delocalised electrons.
- 3 Buckminsterfullerene has strong intramolecular bonds.

33 Gaseous sodium ions can be formed from sodium atoms.



Which quantities are required to calculate the enthalpy change of formation of Na⁺(g)?

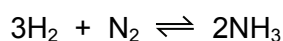
- 1 first ionisation energy of sodium
- 2 enthalpy change of atomisation of sodium
- 3 enthalpy change of formation of sodium

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 Haber process is used in industry to form ammonia from hydrogen and nitrogen.



Which statements about the activation energy for this process are correct?

- 1** The activation energy for the forward reaction is the same as the activation energy for the reverse reaction.
- 2** The activation energy for the reverse reaction is decreased by the addition of iron.
- 3** The activation energy is the minimum energy that colliding particles must possess in order to react.

- 35** Strontium nitrate is heated strongly for several minutes.

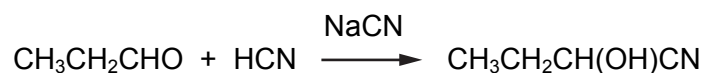
Which statements are correct?

- 1** A brown gas is produced.
- 2** A gas is produced that relights a glowing splint.
- 3** A white powder remains after heating.

- 36** When added to water, which oxides will **not** cause a change in pH?

- 1** Al_2O_3
- 2** SiO_2
- 3** P_4O_{10}

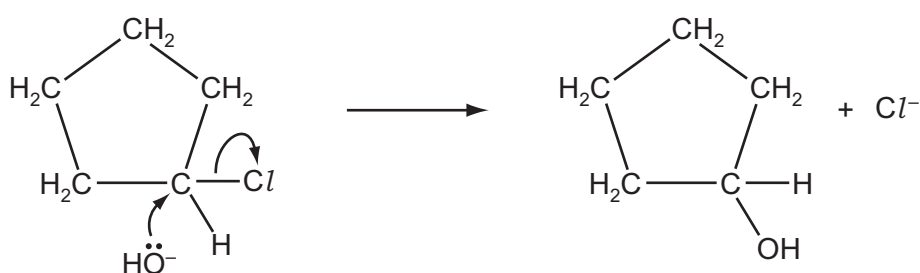
- 37 Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about this catalysed reaction of propanal with hydrogen cyanide are correct?

- 1 The sodium cyanide provides a stronger nucleophile than HCN.
- 2 The reaction can be classified as nucleophilic substitution.
- 3 The hydrogen cyanide molecule attacks the propanal molecule to form an intermediate ion.

- 38 A reaction mechanism is shown.



Which statements about this reaction are correct?

- 1 It is a substitution reaction.
- 2 OH^- behaves as a nucleophile.
- 3 Heterolytic bond fission is involved.

- 39 On complete combustion, a sample of X produces 44 g of carbon dioxide and 27 g of water.

On complete combustion, a sample of Y produces 44 g of carbon dioxide and 18 g of water.

On complete combustion, a sample of Z produces 22 g of carbon dioxide and 9 g of water.

Which substances could be straight chain alkanes?

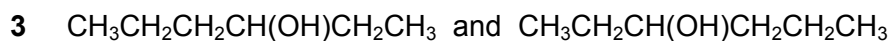
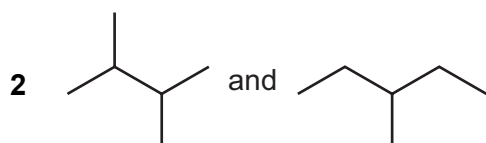
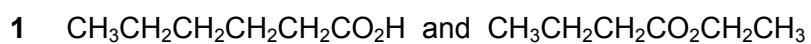
- 1 X
- 2 Y
- 3 Z

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 Which pairs are structural isomers of each other?



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