

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2019

1 hour

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

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Electronic calculators may be used.

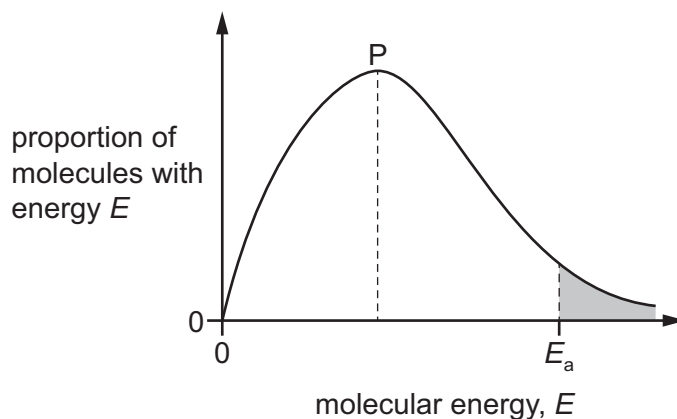
This document consists of **16** printed pages.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

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

- 1 The diagram shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, E_a . The peak of the distribution is labelled P.



If the same reaction is carried out in the presence of a catalyst, which statement is correct?

- A** The peak P is at a lower height and the position of E_a moves to the left.
B The peak P is at a lower height and the position of E_a moves to the right.
C The peak P remains at the same height and the position of E_a moves to the left.
D The peak P remains at the same height and the position of E_a moves to the right.
- 2 Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.

Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

- A** 0.200×12.0
B $\frac{0.200}{12.0}$
C $\frac{12.0}{0.200}$
D $\frac{0.200}{6.02 \times 10^{23}} \times 12.0$
- 3 Which molecule or ion contains the smallest bond angle?

- A** C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

- 4 Four compounds are shown.



How many of these compounds have an odd number of σ bonds?

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

- 5 Ethanal, CH_3CHO , ethanol, $\text{C}_2\text{H}_5\text{OH}$, and methoxymethane, CH_3OCH_3 , are three organic compounds.

Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

- 6 What is the oxidation number of sulfur in each species?

	H_2S	SO_2	H_2SO_3
A	-2	+4	+4
B	-2	+4	+6
C	+2	-4	+4
D	+2	-4	+6

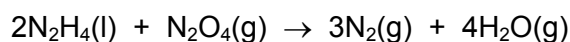
- 7 The following data are needed for this question.

$$\Delta H_f^\ominus(\text{N}_2\text{H}_4(\text{l})) = 50.6 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{N}_2\text{O}_4(\text{g})) = 9.2 \text{ kJ mol}^{-1}$$

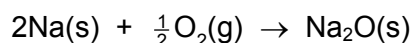
$$\Delta H_f^\ominus(\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

Hydrazine, $\text{N}_2\text{H}_4(\text{l})$, reacts with dinitrogen tetraoxide, $\text{N}_2\text{O}_4(\text{g})$, to form nitrogen gas and water vapour.



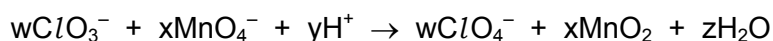
What is the enthalpy change for this reaction?

- A** $-1077.6 \text{ kJ mol}^{-1}$
B $-856.8 \text{ kJ mol}^{-1}$
C $-301.6 \text{ kJ mol}^{-1}$
D $-182.0 \text{ kJ mol}^{-1}$
- 8 Sodium burns in oxygen giving out heat energy and forming the compound Na_2O . The equation for this reaction is shown.



Which statement about the reaction is correct?

- A** $\Delta H^\ominus$ for the reaction is equal to twice the bond energy of the Na–O bond.
B $\Delta H^\ominus$ for the reaction is positive.
C The equation represents the standard enthalpy change of combustion of sodium.
D The equation represents the standard enthalpy change of formation of sodium oxide.
- 9 In the chemical equation, w, x, y and z are all whole numbers.



When the equation is balanced, what are w, x and y?

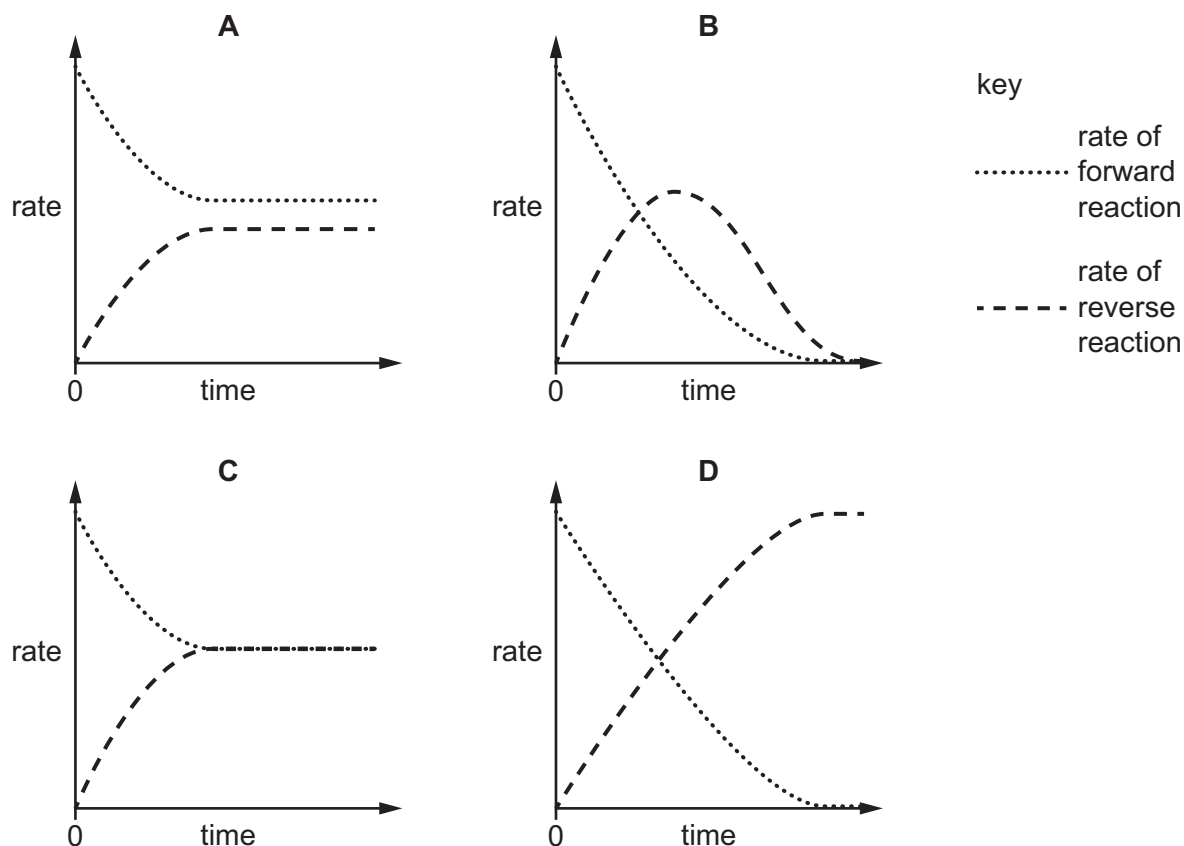
	w	x	y
A	1	1	2
B	2	2	2
C	2	3	8
D	3	2	2

- 10 Two compounds X and Y react to produce compound Z. The reaction is reversible.

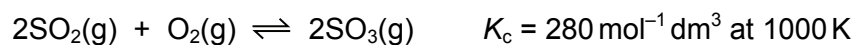


When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

Which graph could represent the change in the rates of the forward and reverse reactions over time?



- 11 The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur dioxide concentration is $0.200 \text{ mol dm}^{-3}$ and the oxygen concentration is $0.100 \text{ mol dm}^{-3}$.

What is the sulfur trioxide concentration?

- A $1.058 \text{ mol dm}^{-3}$
- B $1.120 \text{ mol dm}^{-3}$
- C $2.366 \text{ mol dm}^{-3}$
- D $5.600 \text{ mol dm}^{-3}$

12 Which oxide will cause an increase in pH when added to water?

- A** MgO **B** Al₂O₃ **C** SiO₂ **D** SO₂

13 X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of X, Y and Z?

	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

14 A 5.00g sample of an anhydrous Group 2 metal nitrate loses 3.29g in mass when heated strongly.

Which metal is present?

- A** magnesium
B calcium
C strontium
D barium

15 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg²⁺, the other contains Ba²⁺. Tests are carried out on separate 5 cm³ samples of P and Q.

test 1: add 1 cm³ of 0.1 mol dm⁻³ Na₂SO₄(aq)

test 2: add 1 cm³ of 0.1 mol dm⁻³ NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba ²⁺	more precipitate with Ba ²⁺
B	more precipitate with Ba ²⁺	more precipitate with Mg ²⁺
C	more precipitate with Mg ²⁺	more precipitate with Ba ²⁺
D	more precipitate with Mg ²⁺	more precipitate with Mg ²⁺

16 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

17 Sodium azide, NaN_3 , is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.

The azide ion, N_3^- , has similar chemical properties to the Cl^- ion.

Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

18 Which type of reaction occurs when solid ammonium sulfate is heated with an excess of sodium hydroxide solution?

- A** acid-base
- B** precipitation
- C** redox
- D** thermal decomposition

19 Catalytic converters are fitted in the exhaust systems of many cars.

Which gas:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

- A** carbon dioxide
B carbon monoxide
C hydrocarbon vapour
D nitrogen dioxide

20 Which substance reacts with trichloroethene to give a chiral product?

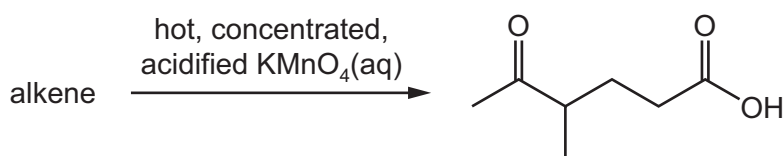
- A** Br₂ **B** HCl **C** NaCN **D** NaOH

21 Alkanes are saturated hydrocarbons.

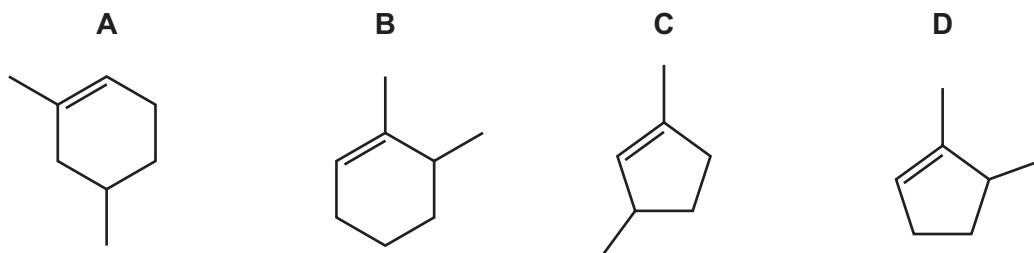
Which type of reaction are alkanes most likely to undergo?

- A** electrophilic addition
B electrophilic substitution
C free radical substitution
D nucleophilic addition

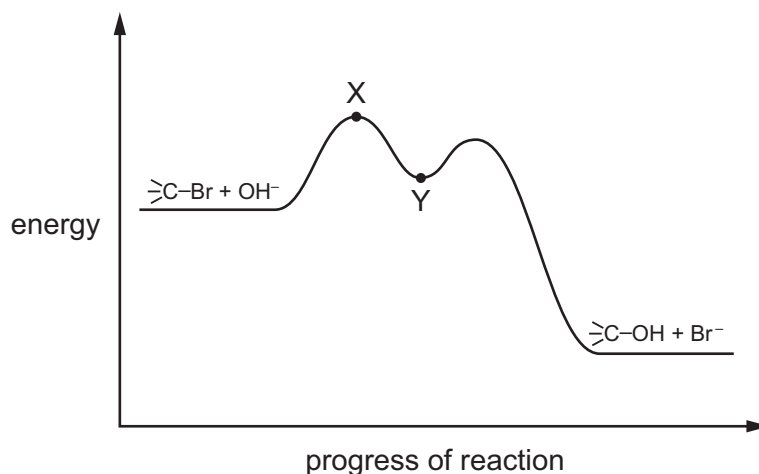
22 An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.



What is the structure of the alkene?



- 23** A tertiary bromoalkane, indicated here by >C-Br , reacts with aqueous NaOH. The mechanism has the reaction pathway shown.



Which point in the diagram is correctly identified?

A X is >C^+

B X is $\left[\text{HO} \cdots \text{C} \cdots \text{Br} \right]^-$

C Y is >C^+

D Y is $\left[\text{HO} \cdots \text{C} \cdots \text{Br} \right]^-$

- 24** Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.

Which compound hydrolyses more rapidly and what is the mechanism?

	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

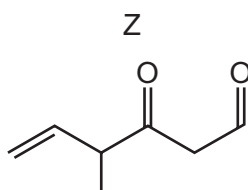
25 Alcohol X is oxidised to form compound Y.

The composition of Y is 54.54% carbon, 36.36% oxygen and 9.10% hydrogen. The M_r of Y is 88.0.

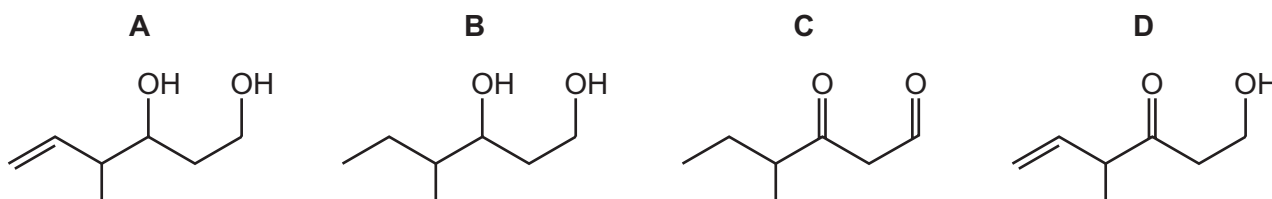
What could be the structure of alcohol X?

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

26 The diagram shows the structure of compound Z.



What is the product of the reaction between compound Z and an excess of NaBH_4 ?



27 Compound Q shows the following reactions.

- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

- A ethanal
- B propan-2-ol
- C propanal
- D propanone

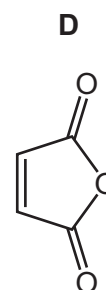
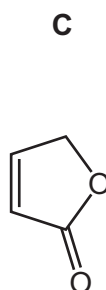
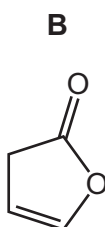
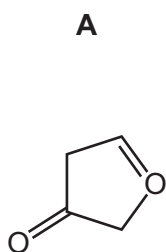
- 28** Tartaric acid, $\text{HO}_2\text{CCH(OH)CH(OH)CO}_2\text{H}$, is found in many plants.

A sample of tartaric acid reacts with an excess of LiAlH_4 to form the organic product J.

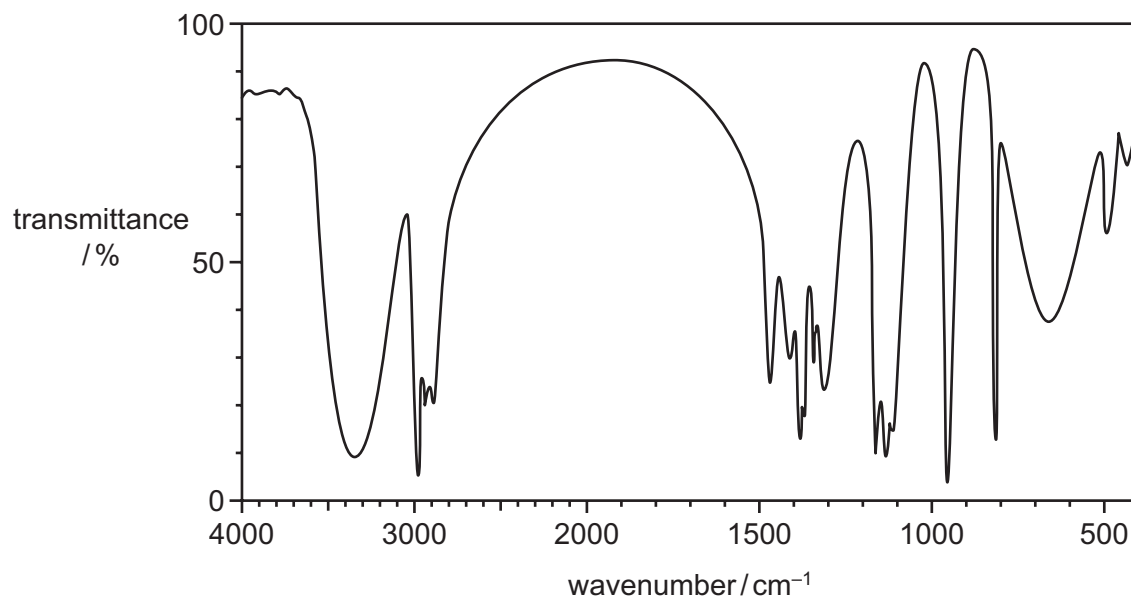
What happens when NaOH(aq) is added to separate samples of tartaric acid and J?

- A** Both tartaric acid and J react.
B Only tartaric acid reacts.
C Only J reacts.
D Neither tartaric acid nor J react.
- 29** When $\text{CH}_2(\text{OH})\text{CH}=\text{CHCO}_2\text{H}$ is warmed with a little concentrated sulfuric acid, a cyclic compound is formed.

What is the skeletal formula of the cyclic compound?



30 The infra-red spectrum of compound P is shown.



What could be compound P?

- A** methyl ethanoate
- B** propanal
- C** propanoic acid
- D** propan-2-ol

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 A particular atom of germanium, Ge, has a nucleon number of 70.

Which statements about a ${}^{70}_{32}\text{Ge}$ atom are correct?

- 1** It has the same number of electrons as a ${}^{79}_{34}\text{Se}^{2+}$ ion.
- 2** It has the same number of neutrons as an atom of ${}^{68}_{30}\text{Zn}$.
- 3** It has half as many protons as an atom of ${}^{160}_{64}\text{Gd}$.

32 The first ionisation energy of chlorine is greater than that of sulfur.

Which factors contribute to this?

- 1** Chlorine has more protons in its nucleus than sulfur does.
- 2** Chlorine has greater electron shielding than sulfur does.
- 3** The covalent bonds in chlorine molecules are stronger than those in sulfur molecules.

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** Liquids X and Y do not react with one another. They have identical boiling points.

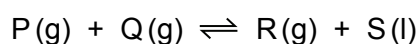
When a particular volume of X is shaken with a similar volume of Y, they form a liquid mixture Z.

The average intermolecular forces in liquid Z are stronger than the average of the forces in X and the forces in Y.

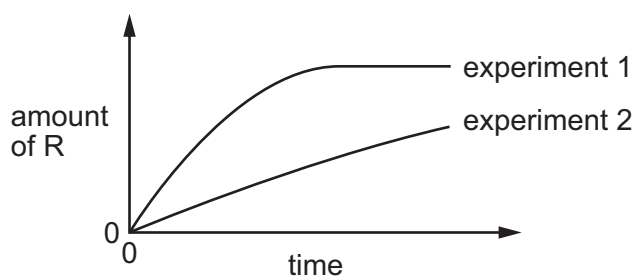
Which deductions from this information are correct?

- 1 The mixing of X and Y is exothermic.
- 2 The vapour pressure of liquid Z will be less than that of either liquid X or liquid Y at the same temperature.
- 3 The boiling point of liquid Z will be lower than that of either liquid X or liquid Y at the same pressure.

- 34** The stoichiometry of a catalysed reaction is shown by the equation below.



Two experiments are carried out in which the amount of R is measured. The results are shown in the diagram.



Which changes in the conditions could explain the results shown?

- 1 A lower pressure was used in experiment 2.
- 2 A different catalyst was used in experiment 2.
- 3 Product S was continuously removed from the reaction vessel in experiment 2.

35 Which statements are correct?

- 1 Chloride ions are oxidised when concentrated sulfuric acid is added to NaCl(s) .
- 2 A disproportionation reaction takes place when chlorine is added to cold NaOH(aq) .
- 3 An acidic solution forms when chlorine is added to water.

36 Nitrogen gas is unreactive, whereas oxygen gas and chlorine gas are reactive.

Which statements help to explain this difference?

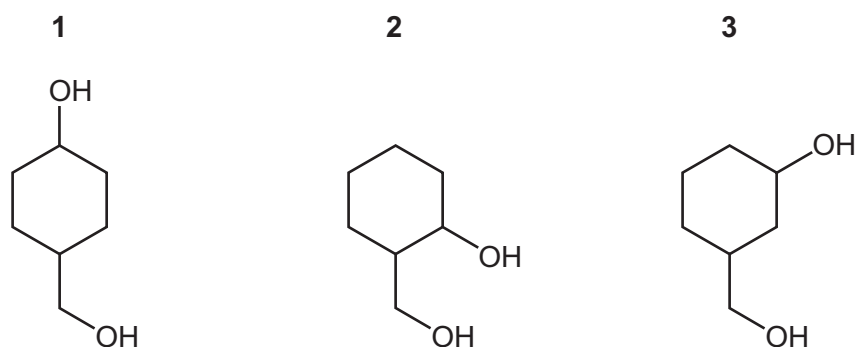
- 1 The two N atoms in an N_2 molecule are held together by a very strong triple bond.
- 2 The triple bond between two N atoms is not polar. The bonds in O_2 and Cl_2 are polar.
- 3 The atoms in N_2 have a full outer shell of electrons. The atoms in O_2 and Cl_2 do not have a full outer shell of electrons.

37 The structure of tiglic acid is $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CO}_2\text{H}$.

Which statements about the properties of one molecule of this acid are correct?

- 1 It contains two π bonds.
- 2 It contains four lone pairs of electrons.
- 3 It has all its atoms in the same plane.

38 Which compounds, on heating with an excess of concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10} ?



39 Hydrogen cyanide reacts with propanone in the presence of potassium cyanide.

Which statements about this reaction are correct?

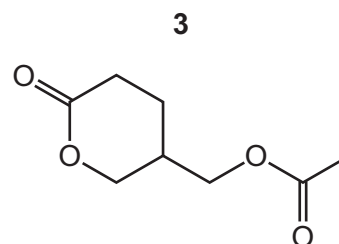
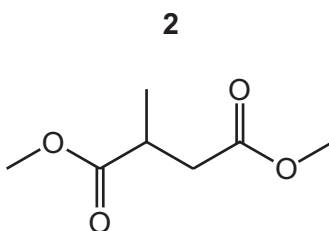
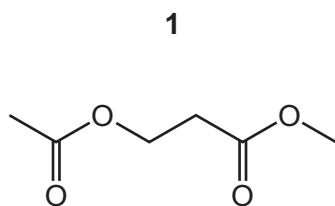
- 1 The cyanide ion is a catalyst for the reaction.
- 2 This is an addition reaction.
- 3 The intermediate behaves as a base.

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 compounds produce three **different** organic products when hydrolysed?



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CHEMISTRY

9701/12

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October/November 2019

1 hour

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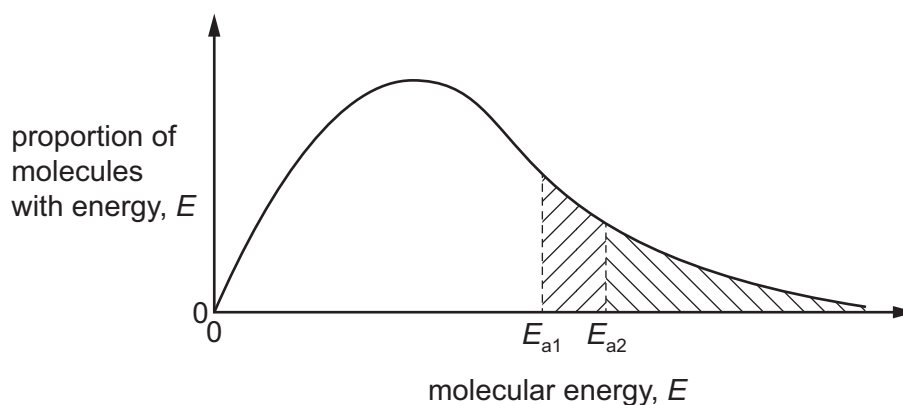
This document consists of **15** printed pages and **1** blank page.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

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

- 1 The diagram shows a Boltzmann distribution of the energies of gaseous molecules and the activation energies, E_a , of a reaction with and without a catalyst.



Which statement about this distribution curve is correct?

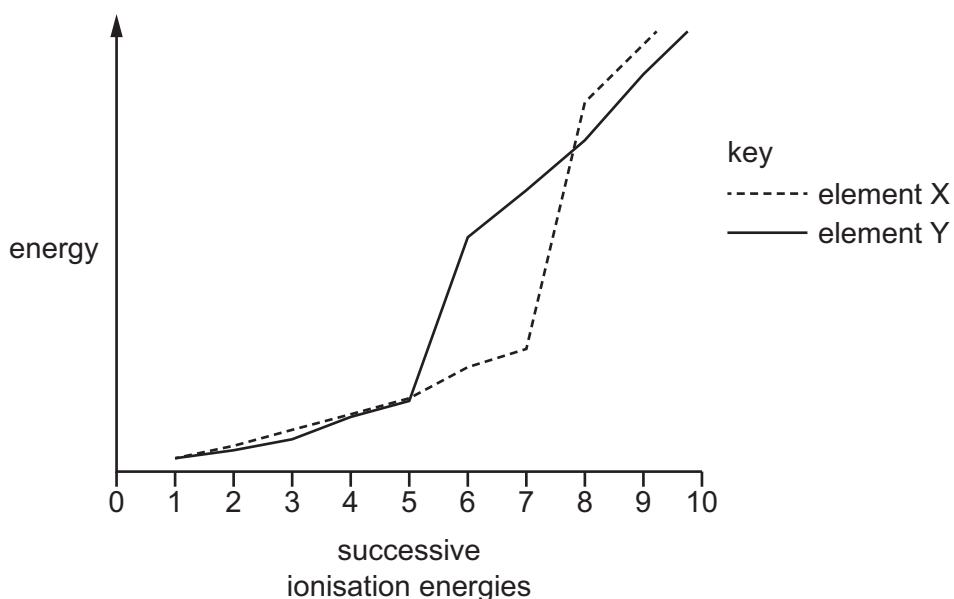
- A** If the temperature of the gas is increased, the maximum of the curve becomes higher.
- B** If the temperature of the gas is increased, the maximum of the curve moves to the left.
- C** The fraction of molecules that react in the presence of a catalyst is shown by .
- D** The fraction of molecules that react in the absence of a catalyst is shown by .
- 2 In this question it should be assumed that $(\text{NH}_4)_2\text{CO}_3 \cdot \text{H}_2\text{O}(\text{s})$ dissolves in water without causing an increase in volume.

Which mass of $(\text{NH}_4)_2\text{CO}_3 \cdot \text{H}_2\text{O}(\text{s})$ should be added to 800 cm^3 of water to form a $0.100 \text{ mol dm}^{-3}$ solution of NH_4^+ ions?

- A** 4.56 g **B** 7.13 g **C** 9.12 g **D** 14.3 g

- 3 The graph shows the successive ionisation energies of element X and element Y.

Both elements are in Period 3.



Which statement is correct?

- A** An atom of element X needs one extra electron for a full outer shell; an atom of element Y needs three extra electrons for a full outer shell.
- B** An atom of element Y has five electrons in the 3p subshell.
- C** Element X has an oxidation number of +7 in most of its compounds.
- D** When element X combines with element Y, the bonding is ionic.
- 4 Which statement about the electrons in a ground state carbon atom is correct?
- A** Electrons are present in four different energy levels.
- B** There are more electrons in p orbitals than there are in s orbitals.
- C** The occupied orbital of highest energy is spherical.
- D** The occupied orbital of lowest energy is spherical.

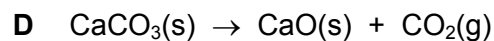
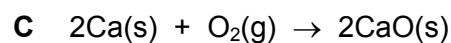
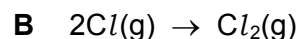
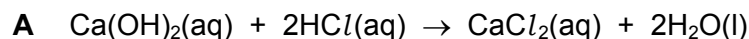
- 5 In this question you should assume the vapour behaves as an ideal gas.

0.175 g of a volatile liquid produces a vapour of volume $4.50 \times 10^{-5} \text{ m}^3$ at 100°C and pressure of $1.013 \times 10^5 \text{ Pa}$.

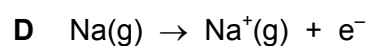
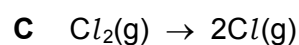
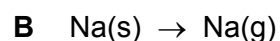
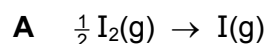
What is the M_r of the liquid?

- A** 31.9 **B** 87.1 **C** 119 **D** 127

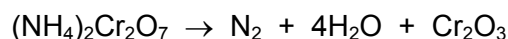
6 Which reaction is endothermic?



7 Which equation correctly represents the standard enthalpy change of atomisation of the given element?



8 $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ decomposes when heated.

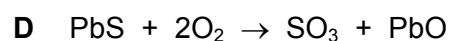
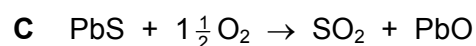
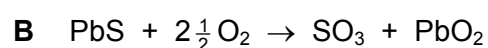
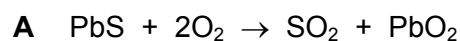


Which element is oxidised and which element is reduced?

	oxidised	reduced
A	chromium	nitrogen
B	hydrogen	chromium
C	nitrogen	chromium
D	nitrogen	hydrogen

9 When lead(II) sulfide, PbS , is heated in air, sulfur dioxide and lead(II) oxide are formed.

What is the equation for the reaction between PbS and oxygen?

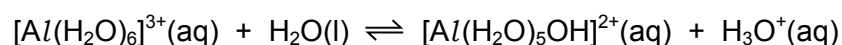


- 10 The decomposition of $\text{SO}_3(\text{g})$ is a dynamic equilibrium.



What happens when the pressure of the system is increased?

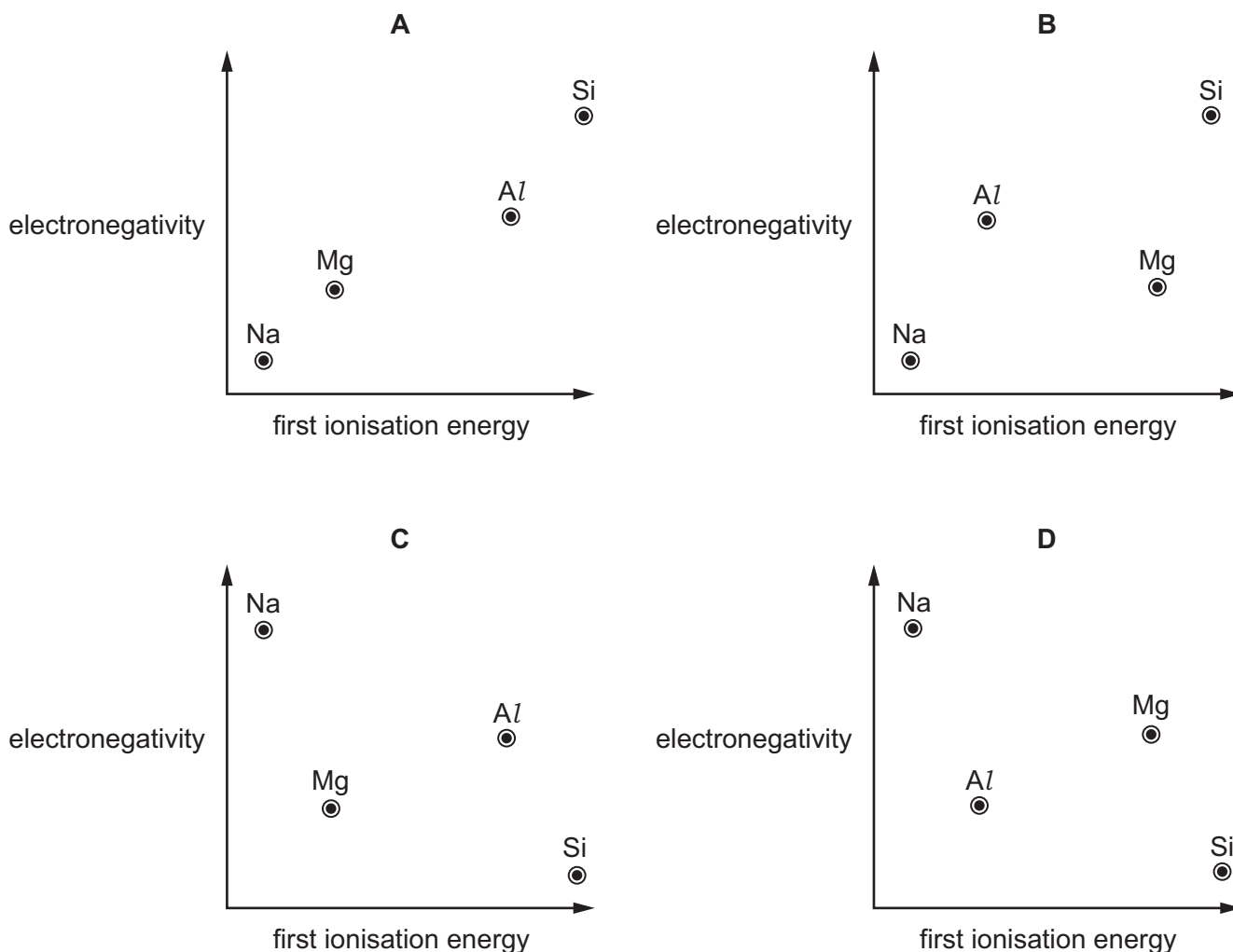
- A The rate of reaction will decrease and the position of the equilibrium will move to the left.
 - B The rate of reaction will decrease and the position of the equilibrium will move to the right.
 - C The rate of reaction will increase and the position of the equilibrium will move to the left.
 - D The rate of reaction will increase and the position of the equilibrium will move to the right.
- 11 Hydrated aluminium ions undergo the following reaction.



Which statement about this reaction is correct?

- A $\text{H}_2\text{O}(\text{l})$ and $[\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq})$ are a conjugate acid-base pair.
- B $\text{H}_2\text{O}(\text{l})$ is acting as an acid as it is donating H^+ ions.
- C If $\text{OH}^-(\text{aq})$ is added, the equilibrium will move to the right.
- D K_c varies as the pH is varied.

12 Which diagram correctly shows the electronegativity of the elements Na, Mg, Al and Si plotted against their first ionisation energies?



13 Which statement about the compounds of Group 2 elements magnesium to barium is correct?

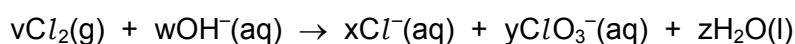
- A** Carbonates of Group 2 elements produce bubbles when added to dilute nitric acid.
- B** Nitrates of Group 2 elements produce nitrogen and oxygen on heating.
- C** Oxides of Group 2 elements produce bubbles when added to dilute hydrochloric acid.
- D** The oxides of Group 2 elements are amphoteric.

- 14 When equal volumes of saturated solutions of barium hydroxide and calcium hydroxide are mixed, a white precipitate, Y, forms. The mixture is filtered and carbon dioxide is bubbled through the filtrate, producing a second white precipitate, Z.

What are Y and Z?

	Y	Z
A	Ba(OH) ₂	Ca(OH) ₂
B	Ba(OH) ₂	CaCO ₃
C	Ca(OH) ₂	BaCO ₃
D	Ca(OH) ₂	Ba(OH) ₂

- 15 Chlorate(V) ions, ClO_3^- , are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.



What are the values of v, x and y in the balanced equation?

	v	x	y
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

- 16 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

- A** bond strength of the hydrogen-halide bond
 - B** first ionisation energy
 - C** solubility of the silver halide in $\text{NH}_3(\text{aq})$
 - D** strength of the van der Waals' forces between molecules of the element
- 17 Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

- A** -2
- B** 0
- C** +4
- D** +6

18 Which emission from an internal combustion engine contributes to the erosion of marble statues?

- A carbon monoxide
- B nitrogen
- C nitrogen dioxide
- D unburnt hydrocarbons

19 Ammonia, carbon dioxide and water react together to form ammonium carbonate.

Which statement about this reaction is correct?

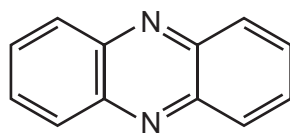
- A It is a redox reaction.
- B It is an acid-base reaction.
- C The H–N–H bond angle decreases as a consequence of this reaction.
- D The three substances react in a 1 : 1 : 1 ratio in this reaction.

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

How many isomers with the formula C_5H_{10} have structures that involve π bonding?

- A 3
- B 4
- C 5
- D 6

21 The diagram shows the skeletal formula of phenazine.



phenazine

What is the empirical formula of phenazine?

- A C_6H_4N
- B C_6H_6N
- C $C_{12}H_8N_2$
- D $C_{12}H_{12}N_2$

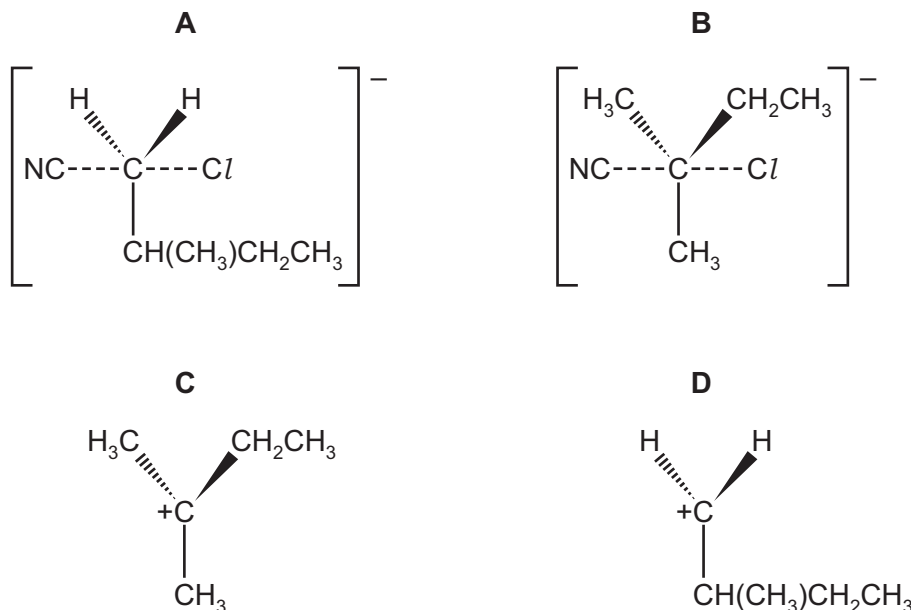
22 An organic compound X reacts with hot, concentrated acidified potassium manganate(VII) solution to give a single carbon-containing product.

What could be X?

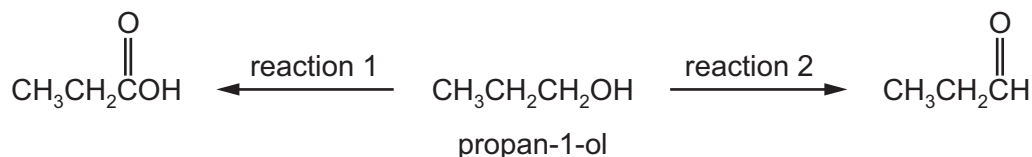
- A $CH_2C(CH_3)_2$
- B $CH_3CHCHCH_3$
- C $CH_2CHCH_2CH_3$
- D $CH_3CH_2CH_2CH_3$

- 23** 1-chloro-2-methylbutane reacts with sodium cyanide in ethanol in a nucleophilic substitution reaction.

What is the most likely intermediate or transition state in this reaction?



- 24** Propan-1-ol can be reacted with acidified potassium dichromate(VI) to form propanoic acid, reaction 1, or propanal, reaction 2.

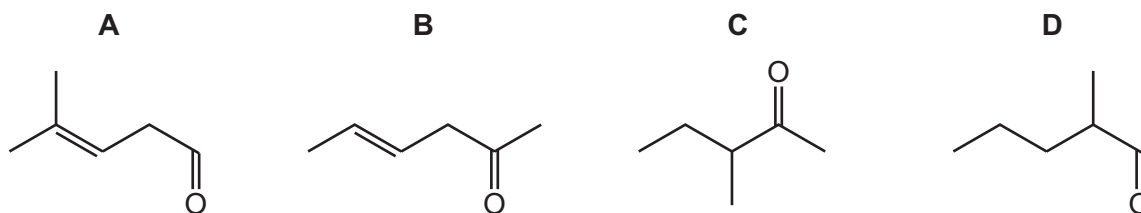


How can the reaction be carried out to ensure that reaction 2 occurs rather than reaction 1?

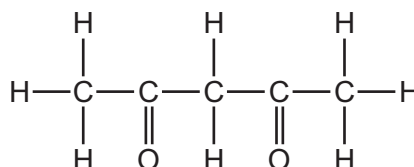
- A** An excess of acidified potassium dichromate(VI) is used.
B An excess of concentrated sulfuric acid is added.
C The reaction mixture is distilled immediately after mixing.
D The reaction mixture is heated under reflux.
- 25** What is the smallest amount of oxygen molecules needed for the complete combustion of 40.0 g of methanol?
- A** 1.88 moles **B** 2.50 moles **C** 3.75 moles **D** 5.00 moles

26 Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.

What could be the structure of compound X?



27 The diagram shows the structure of Y.



Two suggestions are made about Y.

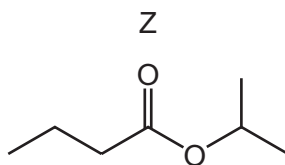
- 1 Y can be oxidised by hot, acidified dichromate(VI) ions.
- 2 One mole of Y gives one mole of tri-iodomethane when it reacts with an excess of alkaline aqueous iodine.

Which suggestions are correct?

- A** both 1 and 2
B 1 only
C 2 only
D neither 1 nor 2

- 28 Esters can be prepared by the reaction of a carboxylic acid with an alcohol in the presence of concentrated sulfuric acid.

Which row gives the correct names of the reagents that would be suitable to prepare ester Z?



	alcohol	carboxylic acid
A	butan-1-ol	methyl propanoic acid
B	propan-1-ol	butanoic acid
C	propan-2-ol	butanoic acid
D	propan-2-ol	propanoic acid

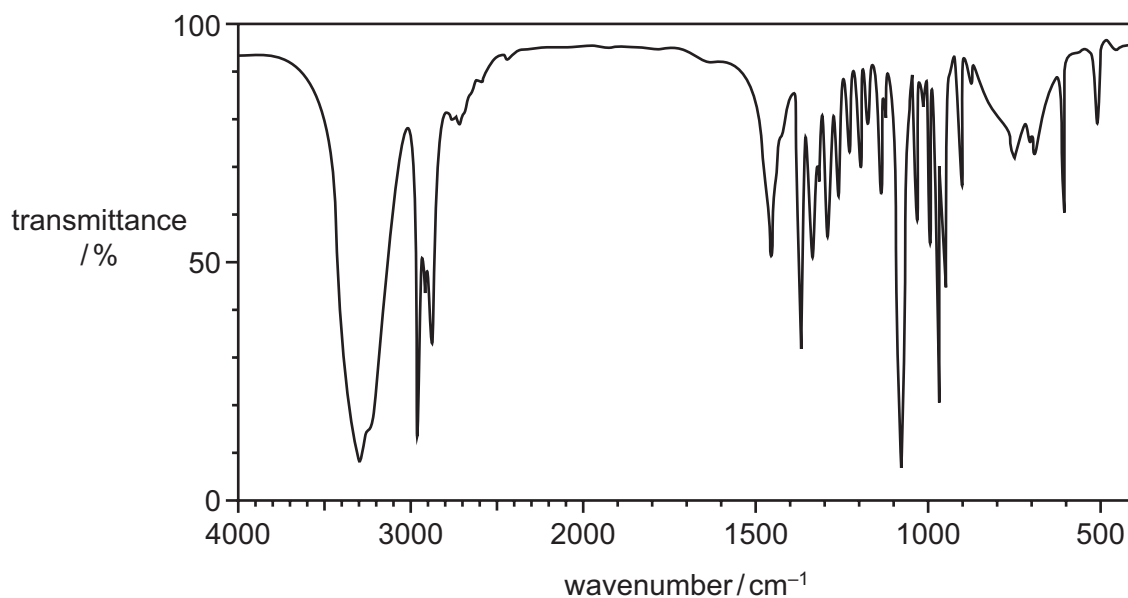
- 29 Compound Q can be hydrolysed by HCl(aq) . The two products of this hydrolysis have the same empirical formula.

What could Q be?

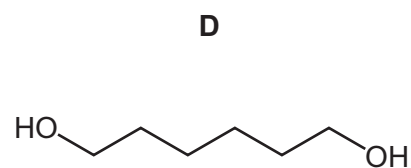
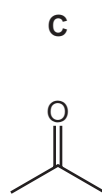
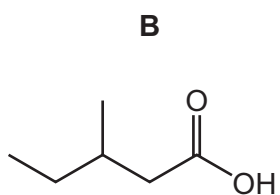
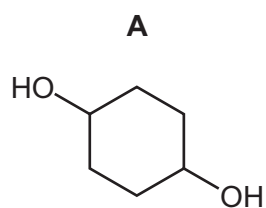
- A** $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{OH}$
- B** $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$
- C** $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- D** $\text{CH}_3\text{CH}_2\text{CH(OH)CH(OH)CH}_2\text{CH}_3$

- 30 Substance T was analysed and found to contain 62.07% carbon, 10.34% hydrogen and 27.59% oxygen.

The infra-red spectrum of substance T is shown.



Which substance could be T?



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 gaseous molecules are polar?

- 1** ammonia
- 2** hydrogen sulfide
- 3** boron trifluoride

32 A carbon monoxide molecule, CO, has three bonds between the carbon atom and the oxygen atom.

Which features are present in one CO molecule?

- 1** two lone pairs of electrons
- 2** a co-ordinate (dative covalent) bond from oxygen to carbon
- 3** two π bonds

33 Carbon can exist as allotropes which include graphite, diamond and a fullerene.

Which statements are correct?

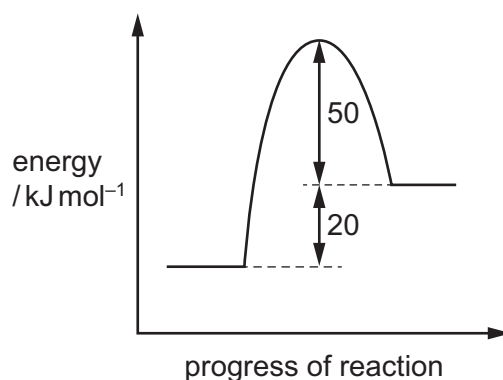
- 1** All three allotropes contain covalent bonds.
- 2** All three allotropes are giant molecular.
- 3** All three allotropes have delocalised electrons.

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 reaction pathway diagram for a reversible reaction is shown.



Which statements are correct?

- 1** The enthalpy change for the backward reaction is -20 kJ mol^{-1} .
- 2** The forward reaction is endothermic.
- 3** The activation energy for the forward reaction is $+70 \text{ kJ mol}^{-1}$.

35 Silicon forms a tetrachloride, SiCl_4 .

Which statements are correct?

- 1** In SiCl_4 , the Si is $\delta+$ and each Cl is $\delta-$.
- 2** SiCl_4 is a liquid at room temperature.
- 3** SiCl_4 reacts with water to give an acidic solution and a precipitate.

36 Which statements about ammonia are correct?

- 1** An ammonia molecule has three bond pairs and one lone pair of electrons.
- 2** When ammonia is bubbled into water the pH of the solution increases.
- 3** Ammonia gas can be made by warming ammonium sulfate with aqueous hydrochloric acid.

37 Following fractional distillation of crude oil, which processes can be used to produce propene from larger hydrocarbon molecules?

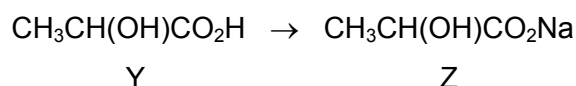
- 1 cracking
- 2 reduction
- 3 polymerisation

38 Bromoethane undergoes nucleophilic substitution reactions.

Which statements are correct?

- 1 Bromoethane reacts with aqueous NaOH to make ethanol.
- 2 Bromoethane reacts with ethanolic NH_3 to make ethylamine.
- 3 Bromoethane reacts with ethanolic KCN to make ethanenitrile.

39 Which reagents, when used in excess, can convert Y into Z?

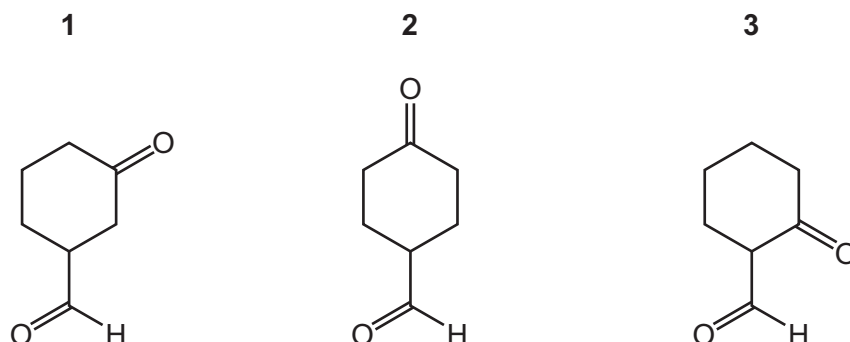


- 1 Na
- 2 Na_2CO_3
- 3 NaOH

40 Each of the compounds below is treated separately with an excess of NaBH_4 .

The product of each reaction is then heated with an excess of concentrated H_2SO_4 .

Which compounds give **only one** final product with the molecular formula C_7H_{10} ?



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CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2019

1 hour

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

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Electronic calculators may be used.

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

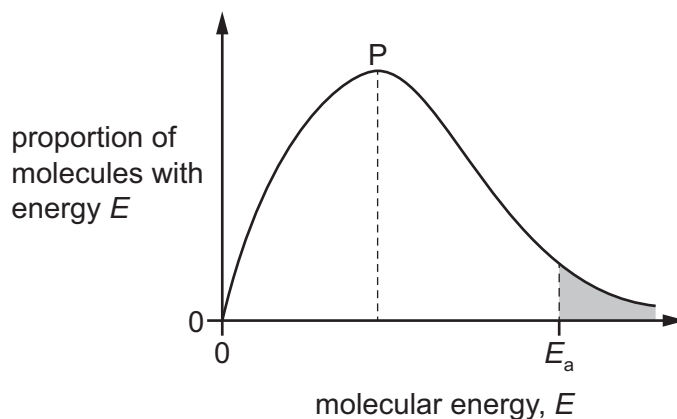


Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

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

- 1 The diagram shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, E_a . The peak of the distribution is labelled P.



If the same reaction is carried out in the presence of a catalyst, which statement is correct?

- A** The peak P is at a lower height and the position of E_a moves to the left.
B The peak P is at a lower height and the position of E_a moves to the right.
C The peak P remains at the same height and the position of E_a moves to the left.
D The peak P remains at the same height and the position of E_a moves to the right.
- 2 Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.

Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

- A** 0.200×12.0
B $\frac{0.200}{12.0}$
C $\frac{12.0}{0.200}$
D $\frac{0.200}{6.02 \times 10^{23}} \times 12.0$
- 3 Which molecule or ion contains the smallest bond angle?

- A** C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

- 4 Four compounds are shown.



How many of these compounds have an odd number of σ bonds?

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

- 5 Ethanal, CH_3CHO , ethanol, $\text{C}_2\text{H}_5\text{OH}$, and methoxymethane, CH_3OCH_3 , are three organic compounds.

Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

- 6 What is the oxidation number of sulfur in each species?

	H_2S	SO_2	H_2SO_3
A	-2	+4	+4
B	-2	+4	+6
C	+2	-4	+4
D	+2	-4	+6

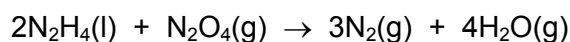
- 7 The following data are needed for this question.

$$\Delta H_f^\ominus(\text{N}_2\text{H}_4(\text{l})) = 50.6 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{N}_2\text{O}_4(\text{g})) = 9.2 \text{ kJ mol}^{-1}$$

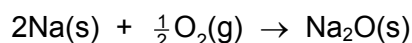
$$\Delta H_f^\ominus(\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

Hydrazine, $\text{N}_2\text{H}_4(\text{l})$, reacts with dinitrogen tetroxide, $\text{N}_2\text{O}_4(\text{g})$, to form nitrogen gas and water vapour.



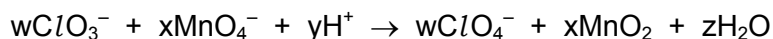
What is the enthalpy change for this reaction?

- A** $-1077.6 \text{ kJ mol}^{-1}$
B $-856.8 \text{ kJ mol}^{-1}$
C $-301.6 \text{ kJ mol}^{-1}$
D $-182.0 \text{ kJ mol}^{-1}$
- 8 Sodium burns in oxygen giving out heat energy and forming the compound Na_2O . The equation for this reaction is shown.



Which statement about the reaction is correct?

- A** $\Delta H^\ominus$ for the reaction is equal to twice the bond energy of the Na–O bond.
B $\Delta H^\ominus$ for the reaction is positive.
C The equation represents the standard enthalpy change of combustion of sodium.
D The equation represents the standard enthalpy change of formation of sodium oxide.
- 9 In the chemical equation, w, x, y and z are all whole numbers.



When the equation is balanced, what are w, x and y?

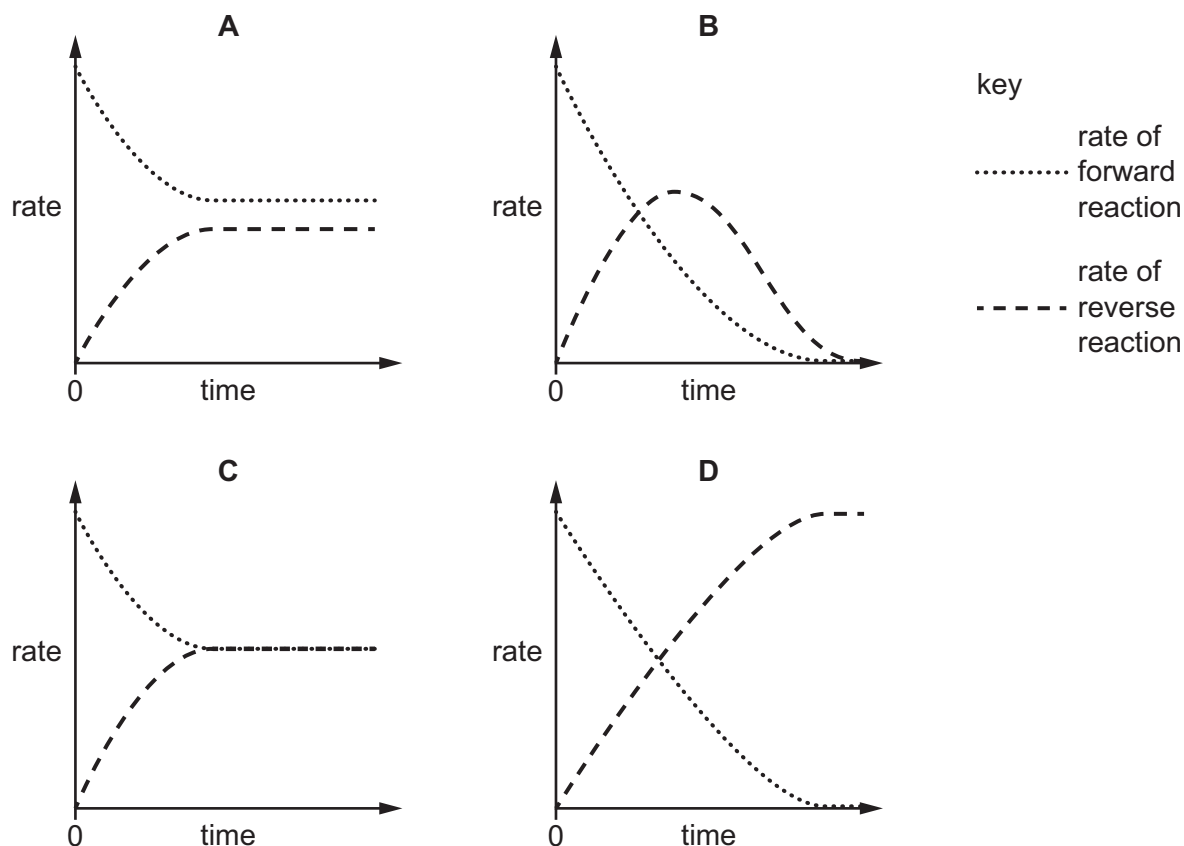
	w	x	y
A	1	1	2
B	2	2	2
C	2	3	8
D	3	2	2

- 10 Two compounds X and Y react to produce compound Z. The reaction is reversible.

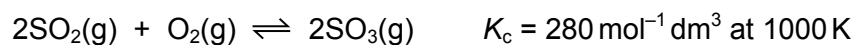


When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

Which graph could represent the change in the rates of the forward and reverse reactions over time?



- 11 The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur dioxide concentration is $0.200 \text{ mol dm}^{-3}$ and the oxygen concentration is $0.100 \text{ mol dm}^{-3}$.

What is the sulfur trioxide concentration?

- A $1.058 \text{ mol dm}^{-3}$
- B $1.120 \text{ mol dm}^{-3}$
- C $2.366 \text{ mol dm}^{-3}$
- D $5.600 \text{ mol dm}^{-3}$

12 Which oxide will cause an increase in pH when added to water?

- A** MgO **B** Al₂O₃ **C** SiO₂ **D** SO₂

13 X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of X, Y and Z?

	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

14 A 5.00g sample of an anhydrous Group 2 metal nitrate loses 3.29g in mass when heated strongly.

Which metal is present?

- A** magnesium
B calcium
C strontium
D barium

15 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg²⁺, the other contains Ba²⁺. Tests are carried out on separate 5 cm³ samples of P and Q.

test 1: add 1 cm³ of 0.1 mol dm⁻³ Na₂SO₄(aq)

test 2: add 1 cm³ of 0.1 mol dm⁻³ NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba ²⁺	more precipitate with Ba ²⁺
B	more precipitate with Ba ²⁺	more precipitate with Mg ²⁺
C	more precipitate with Mg ²⁺	more precipitate with Ba ²⁺
D	more precipitate with Mg ²⁺	more precipitate with Mg ²⁺

- 16 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

- 17 Sodium azide, NaN_3 , is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.

The azide ion, N_3^- , has similar chemical properties to the Cl^- ion.

Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

- 18 Which type of reaction occurs when solid ammonium sulfate is heated with an excess of sodium hydroxide solution?

- A** acid-base
- B** precipitation
- C** redox
- D** thermal decomposition

19 Catalytic converters are fitted in the exhaust systems of many cars.

Which gas:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

- A** carbon dioxide
B carbon monoxide
C hydrocarbon vapour
D nitrogen dioxide

20 Which substance reacts with trichloroethene to give a chiral product?

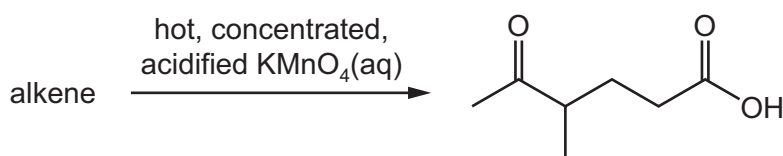
- A** Br_2 **B** HCl **C** NaCN **D** NaOH

21 Alkanes are saturated hydrocarbons.

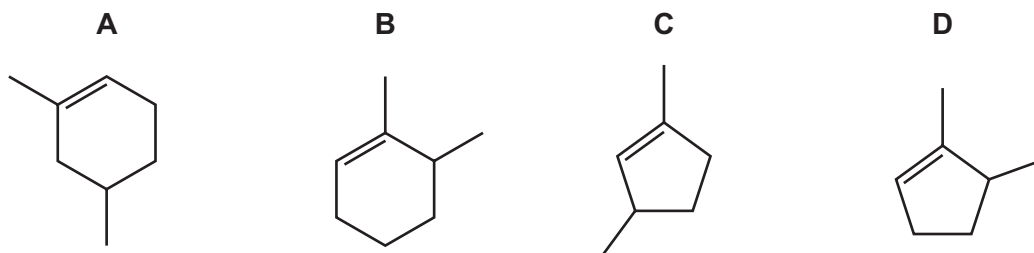
Which type of reaction are alkanes most likely to undergo?

- A** electrophilic addition
B electrophilic substitution
C free radical substitution
D nucleophilic addition

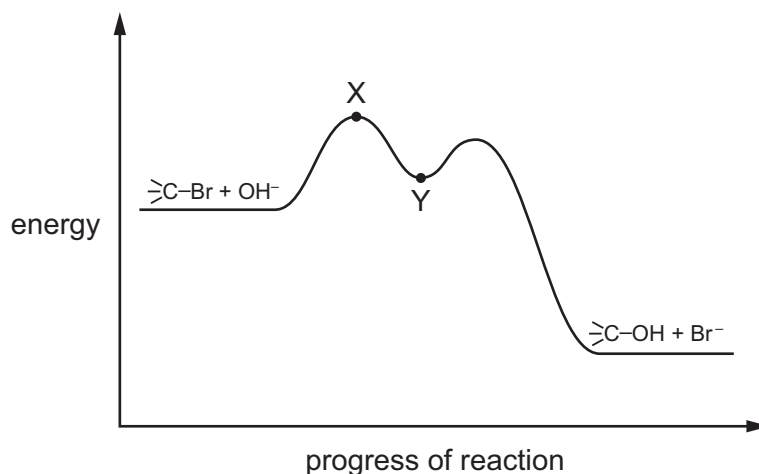
22 An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.



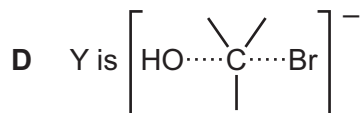
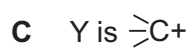
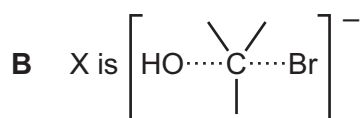
What is the structure of the alkene?



- 23** A tertiary bromoalkane, indicated here by >C-Br , reacts with aqueous NaOH. The mechanism has the reaction pathway shown.



Which point in the diagram is correctly identified?



- 24** Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.

Which compound hydrolyses more rapidly and what is the mechanism?

	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

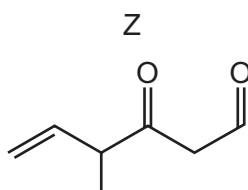
25 Alcohol X is oxidised to form compound Y.

The composition of Y is 54.54% carbon, 36.36% oxygen and 9.10% hydrogen. The M_r of Y is 88.0.

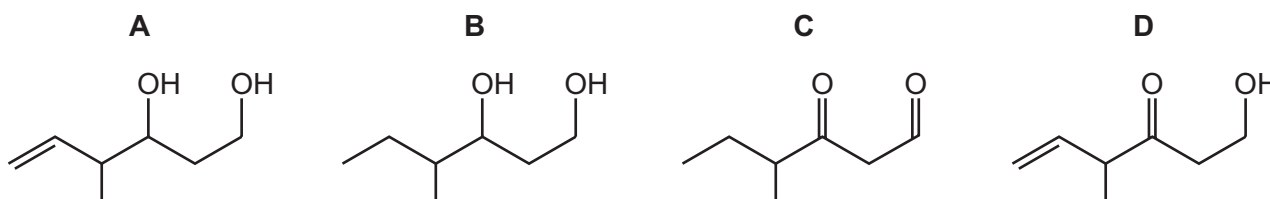
What could be the structure of alcohol X?

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

26 The diagram shows the structure of compound Z.



What is the product of the reaction between compound Z and an excess of NaBH_4 ?



27 Compound Q shows the following reactions.

- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

- A ethanal
- B propan-2-ol
- C propanal
- D propanone

28 Tartaric acid, $\text{HO}_2\text{CCH(OH)CH(OH)CO}_2\text{H}$, is found in many plants.

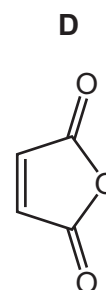
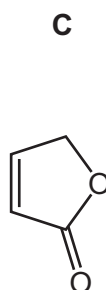
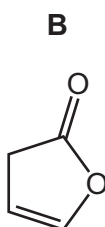
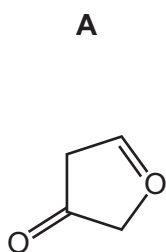
A sample of tartaric acid reacts with an excess of LiAlH_4 to form the organic product J.

What happens when NaOH(aq) is added to separate samples of tartaric acid and J?

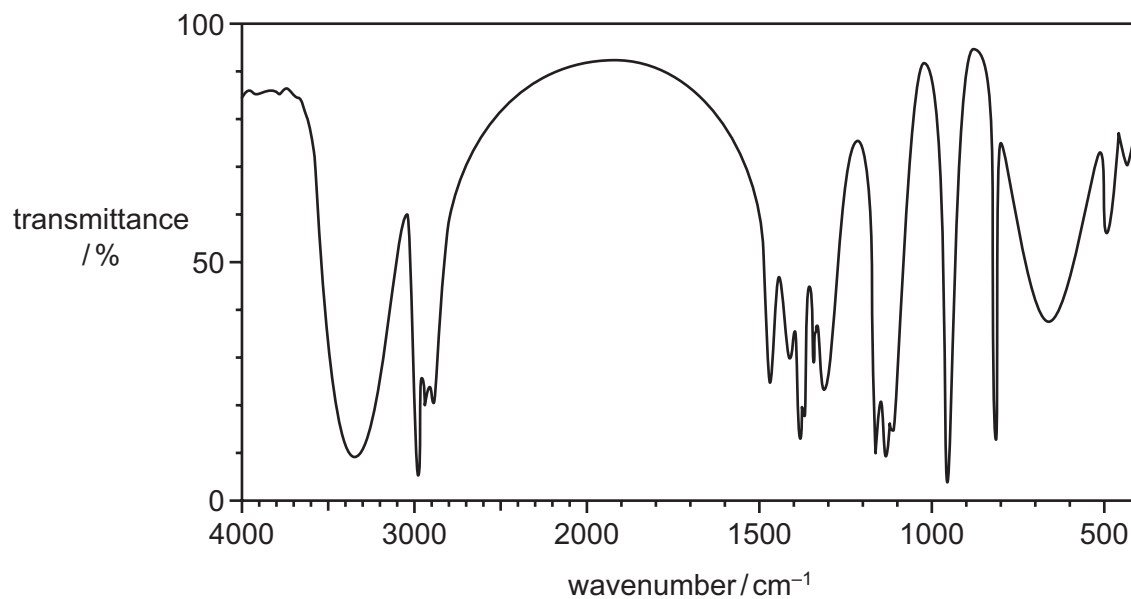
- A** Both tartaric acid and J react.
- B** Only tartaric acid reacts.
- C** Only J reacts.
- D** Neither tartaric acid nor J react.

29 When $\text{CH}_2(\text{OH})\text{CH}=\text{CHCO}_2\text{H}$ is warmed with a little concentrated sulfuric acid, a cyclic compound is formed.

What is the skeletal formula of the cyclic compound?



30 The infra-red spectrum of compound P is shown.



What could be compound P?

- A** methyl ethanoate
- B** propanal
- C** propanoic acid
- D** propan-2-ol

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 A particular atom of germanium, Ge, has a nucleon number of 70.

Which statements about a ${}^{70}_{32}\text{Ge}$ atom are correct?

- 1** It has the same number of electrons as a ${}^{79}_{34}\text{Se}^{2+}$ ion.
- 2** It has the same number of neutrons as an atom of ${}^{68}_{30}\text{Zn}$.
- 3** It has half as many protons as an atom of ${}^{160}_{64}\text{Gd}$.

32 The first ionisation energy of chlorine is greater than that of sulfur.

Which factors contribute to this?

- 1** Chlorine has more protons in its nucleus than sulfur does.
- 2** Chlorine has greater electron shielding than sulfur does.
- 3** The covalent bonds in chlorine molecules are stronger than those in sulfur molecules.

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** Liquids X and Y do not react with one another. They have identical boiling points.

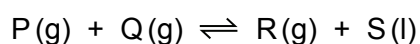
When a particular volume of X is shaken with a similar volume of Y, they form a liquid mixture Z.

The average intermolecular forces in liquid Z are stronger than the average of the forces in X and the forces in Y.

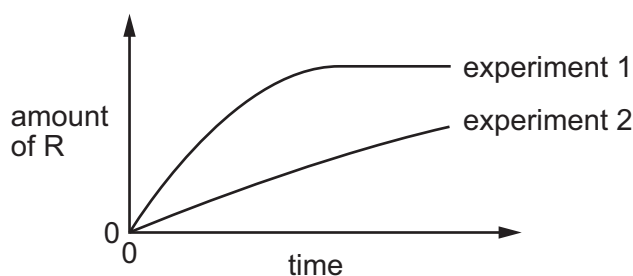
Which deductions from this information are correct?

- 1** The mixing of X and Y is exothermic.
- 2** The vapour pressure of liquid Z will be less than that of either liquid X or liquid Y at the same temperature.
- 3** The boiling point of liquid Z will be lower than that of either liquid X or liquid Y at the same pressure.

- 34** The stoichiometry of a catalysed reaction is shown by the equation below.



Two experiments are carried out in which the amount of R is measured. The results are shown in the diagram.



Which changes in the conditions could explain the results shown?

- 1** A lower pressure was used in experiment 2.
- 2** A different catalyst was used in experiment 2.
- 3** Product S was continuously removed from the reaction vessel in experiment 2.

35 Which statements are correct?

- 1 Chloride ions are oxidised when concentrated sulfuric acid is added to NaCl(s) .
- 2 A disproportionation reaction takes place when chlorine is added to cold NaOH(aq) .
- 3 An acidic solution forms when chlorine is added to water.

36 Nitrogen gas is unreactive, whereas oxygen gas and chlorine gas are reactive.

Which statements help to explain this difference?

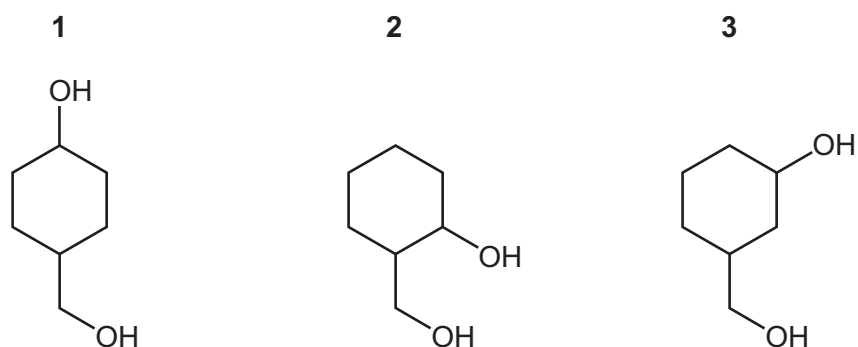
- 1 The two N atoms in an N_2 molecule are held together by a very strong triple bond.
- 2 The triple bond between two N atoms is not polar. The bonds in O_2 and Cl_2 are polar.
- 3 The atoms in N_2 have a full outer shell of electrons. The atoms in O_2 and Cl_2 do not have a full outer shell of electrons.

37 The structure of tiglic acid is $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CO}_2\text{H}$.

Which statements about the properties of one molecule of this acid are correct?

- 1 It contains two π bonds.
- 2 It contains four lone pairs of electrons.
- 3 It has all its atoms in the same plane.

38 Which compounds, on heating with an excess of concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10} ?



39 Hydrogen cyanide reacts with propanone in the presence of potassium cyanide.

Which statements about this reaction are correct?

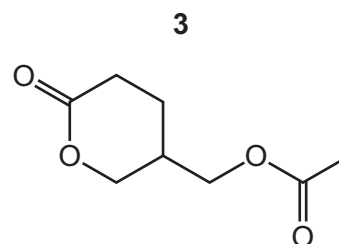
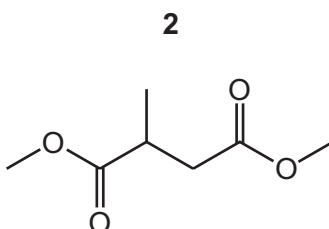
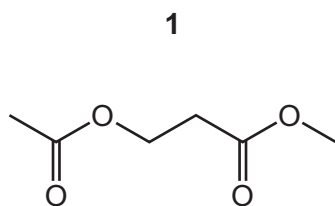
- 1 The cyanide ion is a catalyst for the reaction.
- 2 This is an addition reaction.
- 3 The intermediate behaves as a base.

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 compounds produce three **different** organic products when hydrolysed?



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