

CHEMISTRY

9701/11

Paper 1 Multiple Choice

May/June 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 **14** printed pages and **2** blank pages.

Section A

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

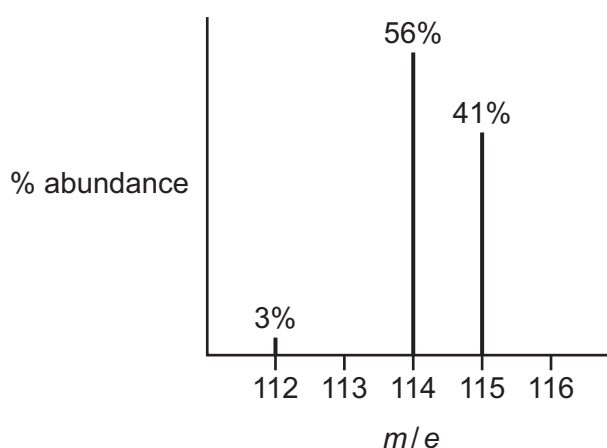
Use of the Data Booklet may be appropriate for some questions.

- 1 The temperature of a sample of an inert gas is increased.

What effect does this have on the number of molecules with the most probable energy and on the number of molecules with high energy?

	number of molecules with the most probable energy	number of molecules with high energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

- 2 A sample of element X is analysed using mass spectrometry. The mass spectrum obtained is shown.



What is the relative atomic mass of this sample of element X?

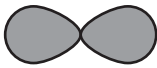
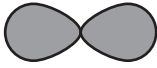
- A** 113.7 **B** 114.0 **C** 114.2 **D** 114.4
- 3 A washing powder contains sodium hydrogencarbonate, NaHCO_3 , as one of the ingredients.
- In a titration, a solution containing 1.00 g of this washing powder requires 7.15 cm^3 of $0.100 \text{ mol dm}^{-3}$ sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

- A** 3.0% **B** 6.0% **C** 12.0% **D** 24.0%

- 4 The outermost electron in an atom of neon occupies a particular orbital.

Which row shows the relative energy and shape of this orbital?

	energy of orbital relative to other occupied orbitals	shape of orbital
A	higher or equal	
B	higher or equal	
C	lower or equal	
D	lower or equal	

- 5 In which species is there a lone pair of electrons?

A CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

- 6 When an evacuated tube of volume 400 cm^3 is filled with gas at 300 K and 101 kPa, the mass of the tube increases by 0.65 g.

Assume the gas behaves as an ideal gas.

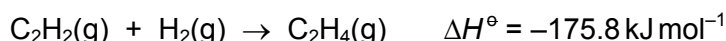
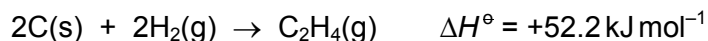
What could be the identity of the gas?

- A** argon
B helium
C krypton
D neon

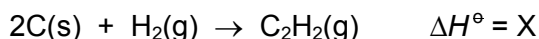
- 7 Under which conditions will nitrogen behave most like an ideal gas?

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

- 8 Two reactions and their enthalpy changes are shown.



These data can be used to calculate the enthalpy change for the reaction shown.



What is the value of X?

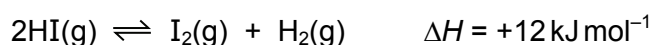
- A** $-228.0 \text{ kJ mol}^{-1}$
B $-123.6 \text{ kJ mol}^{-1}$
C $+123.6 \text{ kJ mol}^{-1}$
D $+228.0 \text{ kJ mol}^{-1}$
- 9 Ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, can be oxidised by KMnO_4 in dilute sulfuric acid. The products of this reaction are carbon dioxide, water, potassium sulfate and manganese(II) sulfate.

In this reaction each ethanedioic acid molecule loses two electrons as it is oxidised. A half-equation for this process is shown.



How many water molecules are produced when five ethanedioic acid molecules are oxidised by KMnO_4 in dilute sulfuric acid?

- A** 5 **B** 8 **C** 10 **D** 16
- 10 Hydrogen iodide gas decomposes reversibly producing iodine vapour and hydrogen.

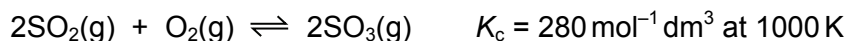


The position of the equilibrium for this reaction may be altered by changing the external conditions.

Which row correctly describes the change in position of equilibrium?

	effect of increasing the pressure	effect of increasing the temperature
A	moves to the right	moves to the right
B	moves to the right	moves to the left
C	no change	moves to the right
D	no change	moves to the left

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



In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3} .

The sulfur dioxide concentration is twice the oxygen concentration.

What is the sulfur dioxide concentration?

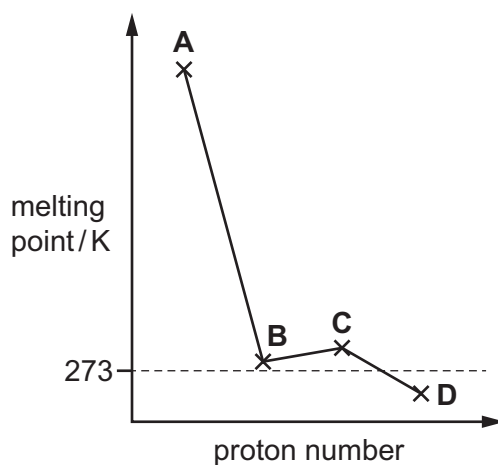
- A** $0.175 \text{ mol dm}^{-3}$
B $0.254 \text{ mol dm}^{-3}$
C $0.318 \text{ mol dm}^{-3}$
D $0.636 \text{ mol dm}^{-3}$
- 12 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

- A** calcium
B magnesium
C potassium
D sodium
- 13 The relative melting points of four consecutive elements in the Periodic Table are shown in the graph.

The elements all have proton numbers less than 20.

Which element is in Group 16?

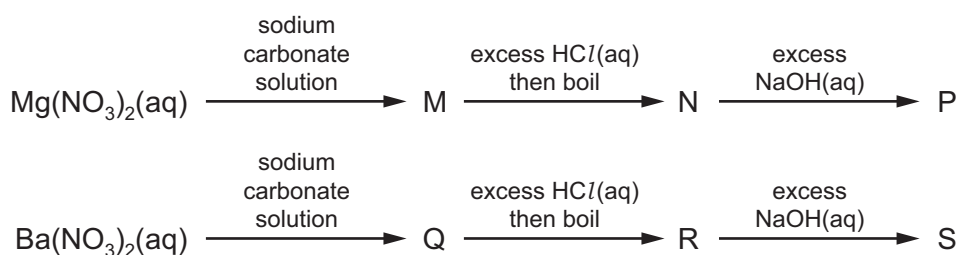


- 14** Substance X reacts with water. A gas is given off and the pH of the solution increases. The solution is then reacted with sulfuric acid and a white precipitate forms.

What could be substance X?

- A** barium
- B** barium oxide
- C** magnesium
- D** magnesium oxide

- 15** Solutions of $0.1 \text{ mol dm}^{-3} \text{ Mg(NO}_3)_2$ and $0.1 \text{ mol dm}^{-3} \text{ Ba(NO}_3)_2$ separately undergo a series of reactions using pure reagents.



M, N and P are magnesium compounds.

Q, R and S are barium compounds.

How many of M, N, P, Q, R and S are white precipitates?

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

- 16** Concentrated sulfuric acid is added to separate solid samples of sodium chloride, sodium bromide and sodium iodide.

With which samples does sulfuric acid act as an oxidising agent?

- A** sodium chloride only
- B** sodium chloride and sodium bromide
- C** sodium bromide and sodium iodide
- D** sodium iodide only

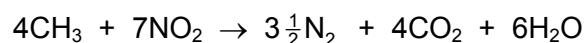
- 17** The reaction of bromine with warm NaOH(aq) produces products with the same oxidation numbers, in the same ratios, as the reaction of chlorine with hot NaOH(aq) .

In one reaction between bromine and warm NaOH(aq) , 30.2 g of a product containing sodium, bromine and oxygen is produced.

Which mass of NaOH has reacted?

- A** 8.00 g
- B** 10.2 g
- C** 20.3 g
- D** 48.0 g

- 18 At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as CH₃ in the catalytic converter of a motor vehicle.



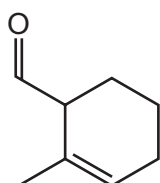
Which row gives the energy change for this reaction and a possible reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO ₂ and H ₂ O have negative $\Delta H_f^\ominus$ values
D	exothermic	double bonds are broken in NO ₂

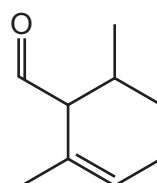
- 19 Which statement is correct?

- A** Ammonia reacts with alkalis to form the ammonium ion.
B Ammonium chloride contains ionic, covalent and co-ordinate bonds.
C The ammonium ion reacts with acids to produce ammonia.
D The bond angle in the ammonium ion is approximately 107°.

- 20 The diagrams show two different compounds.



1



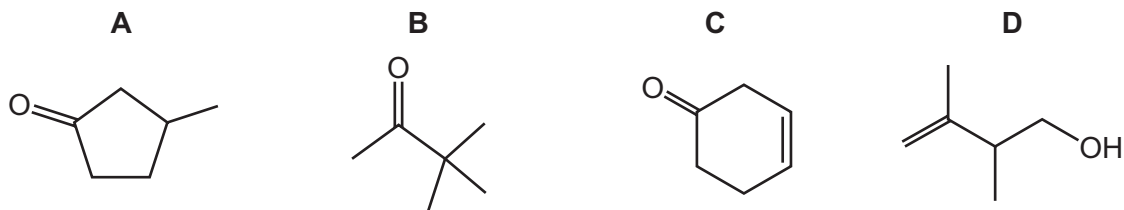
2

What is

- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

21 Which compound has the molecular formula $C_6H_{10}O$?



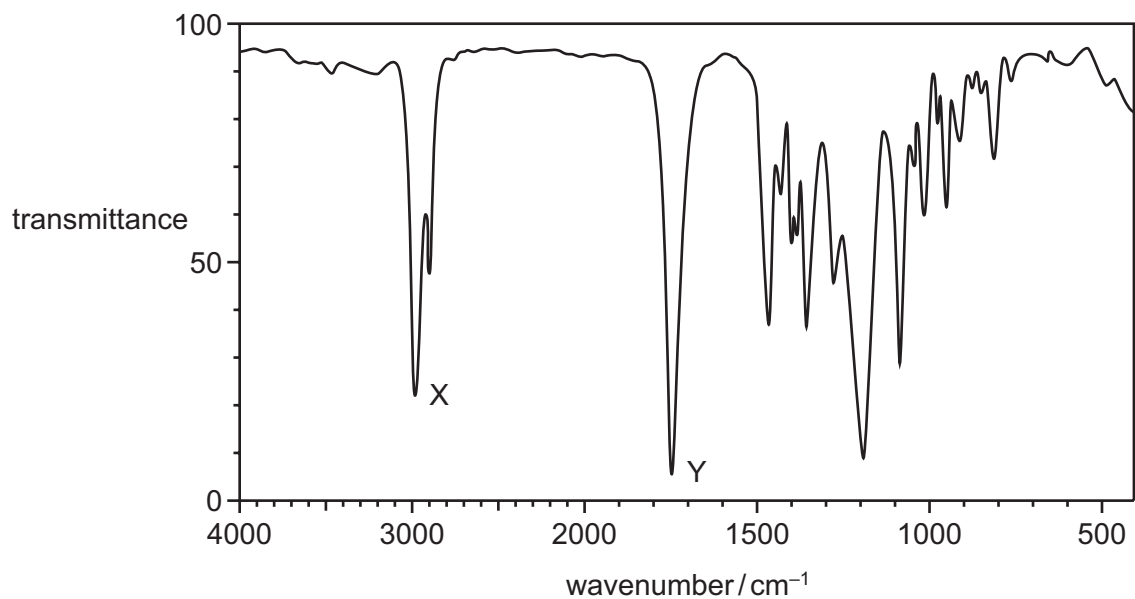
22 What is the structural formula of the major product when hydrogen bromide reacts with 2-methylbut-2-ene?

- A** $CH_2BrCH(CH_3)CH_2CH_3$
B $(CH_3)_2CBrCH_2CH_3$
C $(CH_3)_2CHCHBrCH_3$
D $(CH_3)_2CHCH_2CH_2Br$

23 Which reaction is most likely to involve the formation of a positively charged intermediate?

- A** 1-bromopentane and warm dilute $NaOH(aq)$
B 1-bromo-2,2-dimethylpropane and warm dilute $NaOH(aq)$
C 1-bromo-3-methylbutane and warm dilute $NaOH(aq)$
D 2-bromo-2-methylbutane and warm dilute $NaOH(aq)$

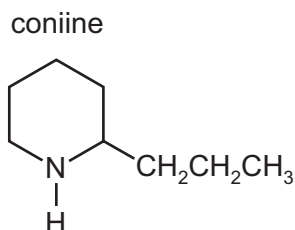
24 The infra-red spectrum of a substance with empirical formula $\text{C}_2\text{H}_4\text{O}$ is shown.



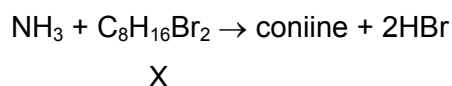
Which bonds are responsible for peak X and peak Y?

	peak X	peak Y
A	C–H	C=C
B	C–H	C=O
C	O–H	C=C
D	O–H	C=O

25 The structure of coniine is shown.



Coniine can be synthesised by reacting ammonia with a dibromo compound, X.



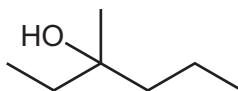
What is the name of compound X?

- A 1,1-dibromo-2-propylcyclopentane
- B 1,2-dibromo-2-propylcyclopentane
- C 1,4-dibromooctane
- D 1,5-dibromooctane

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

3-methylhexan-3-ol reacts with hot, concentrated sulfuric acid to form several isomeric compounds with the molecular formula C_7H_{14} .

3-methylhexan-3-ol



How many isomeric compounds could be formed in this reaction?

- A 3 B 4 C 5 D 6

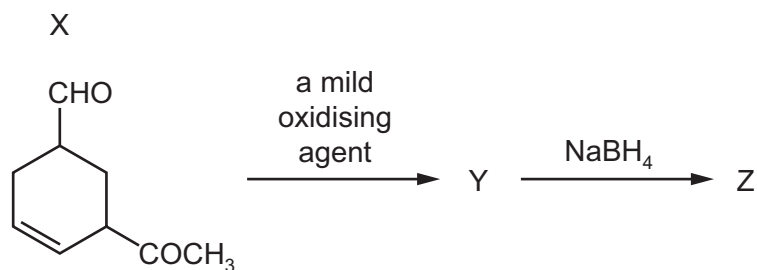
27 An organic compound T undergoes the following reactions.

- T is oxidised by hot, acidified potassium manganate(VII).
- T reacts with sodium to give hydrogen.

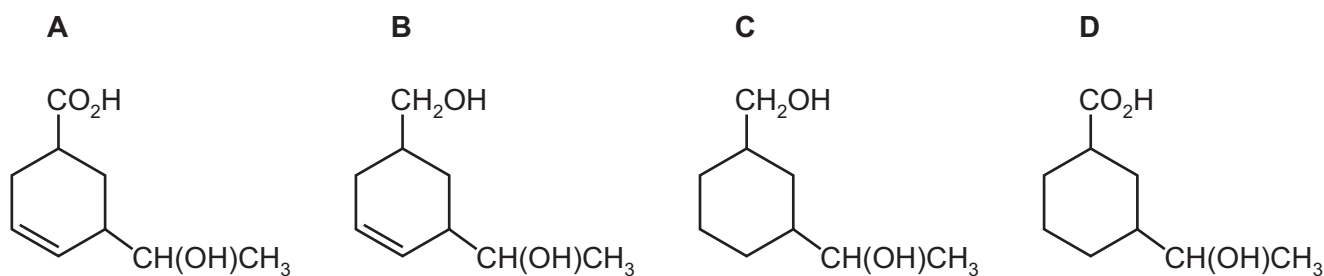
What could be compound T?

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

28 Compound X is treated with two reagents successively, forming compound Z.



What could be Z?



29 Which reagent may be used to distinguish between propanone and ethanol?

- A** 2,4-dinitrophenylhydrazine
- B** bromine water
- C** Fehling's reagent
- D** Tollens' reagent

30 Which compound is chiral?

- A** 1-chloro-3-methylbutane
- B** 2-chloro-2-methylbutane
- C** 2-chloro-3-methylbutane
- D** 3-chloropentane

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 An atom of calcium-48 can form a 2+ ion.

Which statements about this ion are correct?

- 1** It has 20 protons.
- 2** It has 28 neutrons.
- 3** It has 22 electrons.

32 Four elements, W, X, Y and Z, have electronic configurations as shown.

W	X	Y	Z
2,4	2,6	2,8,2	2,8,8,1

Which formulae represent compounds that have boiling points below room temperature?

- 1** WX₂
- 2** YX
- 3** Z₂X

33 Which statements about enthalpy changes are correct?

- 1** The enthalpy change of atomisation is always positive.
- 2** The enthalpy change when a C–C bond is broken is positive.
- 3** The enthalpy change of neutralisation of a weak acid is always negative.

- 34 Vanadium and pepsin can both act as catalysts. Vanadium is a metal. Pepsin is an enzyme.

Which statements are correct for **both** vanadium and pepsin?

- 1 They will speed up any chemical reaction.
- 2 They can lower the activation energy for a reaction.
- 3 They are not used up when they act as catalysts.

- 35 Which oxides, when placed in cold water for one day, will react with the water?

- 1 MgO
- 2 Al_2O_3
- 3 SiO_2

- 36 A mixture of magnesium carbonate and magnesium nitrate is heated strongly in a hard-glass test-tube.

Which gases are formed?

- 1 carbon dioxide
- 2 nitrogen dioxide
- 3 oxygen

- 37 Which statements about poly(alkene)s are correct?

- 1 Poly(alkene)s do not react with $Br_2(aq)$ in the dark.
- 2 Disposal of poly(alkene)s by combustion can produce harmful products.
- 3 Poly(alkene)s do not readily biodegrade.

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

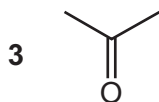
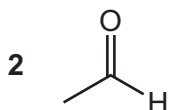
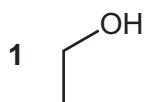
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

38 Compound Y

- reacts with alkaline aqueous iodine to form a yellow precipitate
- changes the colour of warm, acidified potassium dichromate(VI) solution.

What could be compound Y?



39 Carboxylic acids can be made by several different reactions.

Which statements are correct?

- 1 The acid hydrolysis of $\text{CH}_3\text{CH}_2\text{CN}$ will make ethanoic acid.
- 2 The oxidation of $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ will make butanoic acid.
- 3 The oxidation of $\text{CH}_3\text{CH}_2\text{CHO}$ will make propanoic acid.

40 Carboxylic acids react with alcohols to produce esters.

Carboxylic acid X forms **one** ester only with molecular formula $\text{C}_5\text{H}_{10}\text{O}_2$.

What could X be?

- 1 ethanoic acid
- 2 propanoic acid
- 3 butanoic acid

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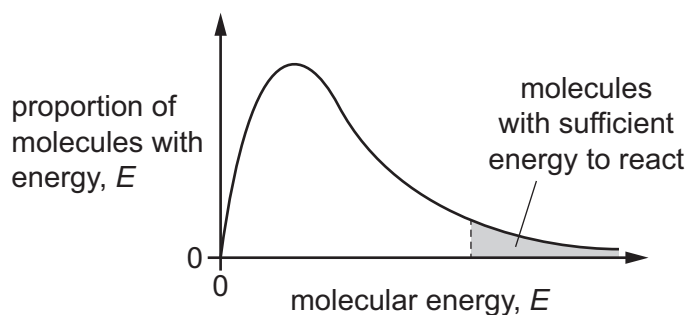
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Section A

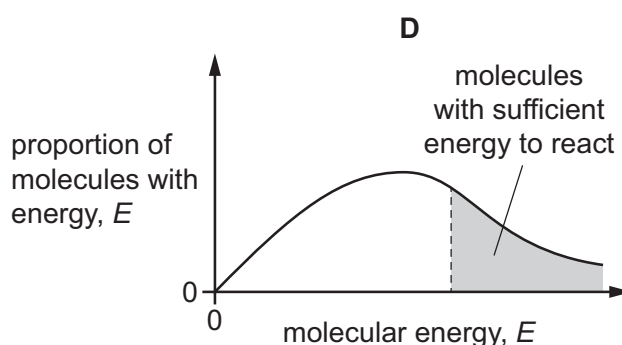
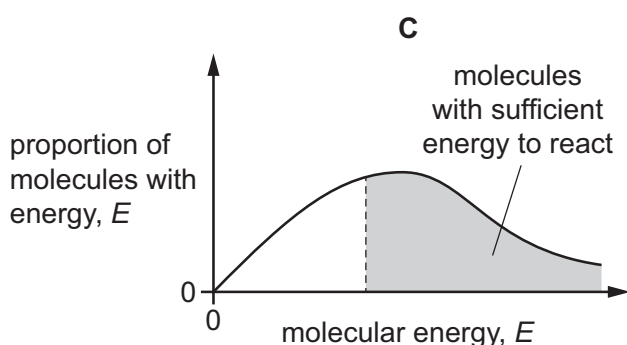
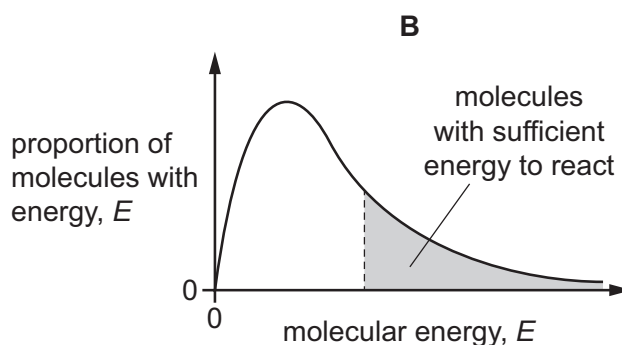
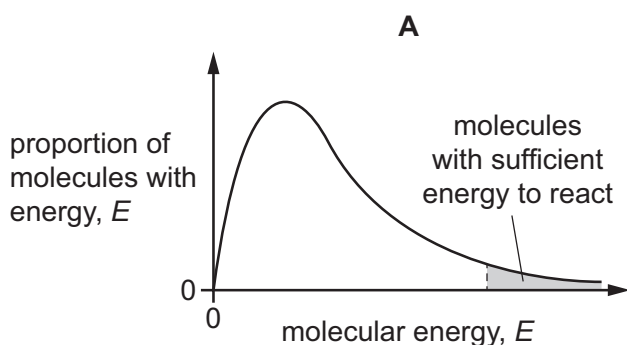
For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

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

- 1 The Boltzmann distribution of molecular energies in a sample of aqueous hydrogen peroxide at room temperature is shown.



Which diagram shows the Boltzmann distribution of molecular energies of aqueous hydrogen peroxide maintained at room temperature when a catalyst, manganese(IV) oxide, is added?

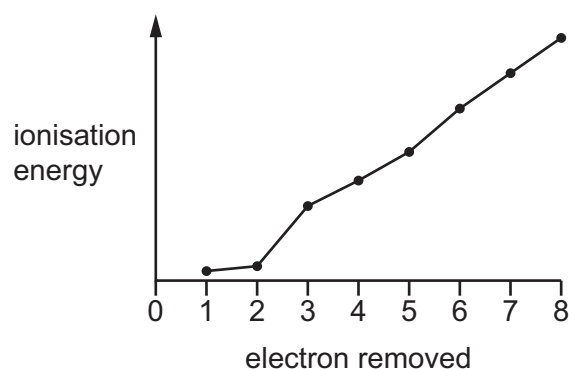
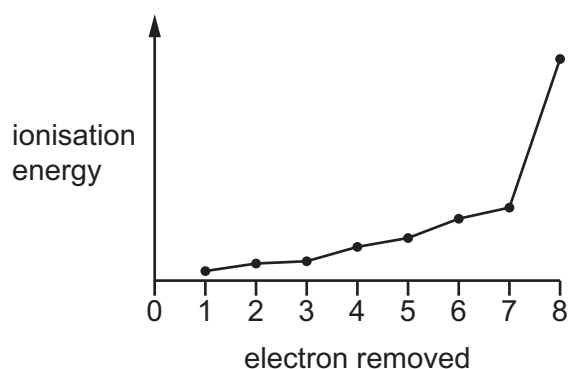


- 2 Oxygen has three stable isotopes, ^{16}O , ^{17}O and ^{18}O . All three isotopes are present in a sample of oxygen gas, O_2 , which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

- A** 3 **B** 5 **C** 6 **D** 9

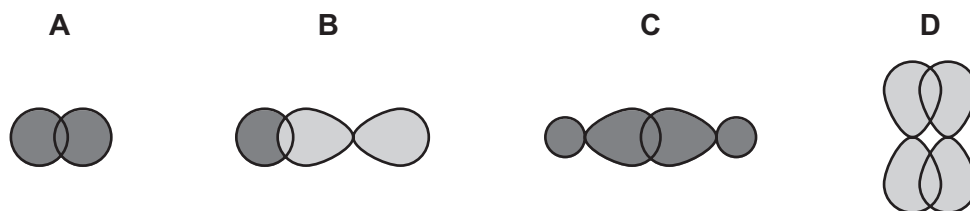
- 3 The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.



What is the formula of the ionic compound formed from these elements?

- A** MgCl_2 **B** CaBr_2 **C** Na_2S **D** K_2Se
- 4 A σ bond is made between two carbon atoms in a molecule of ethene.

Which diagram shows the orbital overlap that occurs to form this bond?

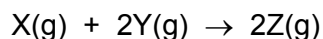


- 5 The table shows some properties of four substances.

Which substance could be potassium iodide?

	melting point of solid / °C	electrical conductivity when molten
A	–66	poor
B	–39	good
C	680	good
D	1600	poor

- 6 X, Y and Z are all gases that behave ideally and react according to the equation shown.

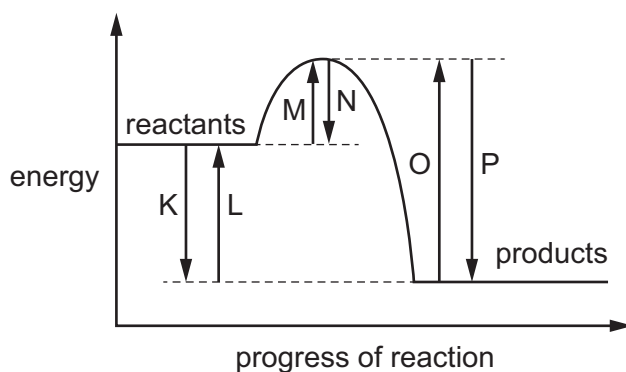


When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 dm^3 , they react to form the maximum amount of Z.

The final temperature of the reaction vessel is 120°C .

What is the final pressure inside the reaction vessel?

- A $4.49 \times 10^6\text{ Pa}$
 B $9.80 \times 10^6\text{ Pa}$
 C $1.47 \times 10^7\text{ Pa}$
 D $1.96 \times 10^7\text{ Pa}$
- 7 Which pair of substances are both simple molecular?
- A C_{60} and graphene
 B C_{60} and iodine
 C graphene and graphite
 D graphite and iodine
- 8 A reaction pathway diagram is shown.



Which row is correct?

	enthalpy change of the forward reaction	activation energy of the reverse reaction
A	K	M
B	K	O
C	L	O
D	P	M

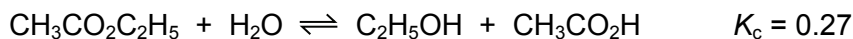
- 9 X is either chlorine or an oxide of chlorine.

X reacts with water, under suitable conditions, to form the two acids HCl and HClO_3 in the mole ratio of 1 (HCl): 5 (HClO_3).

What could be X?

- A** Cl_2 **B** Cl_2O **C** ClO_2 **D** Cl_2O_7

- 10 Ethyl ethanoate undergoes the following reaction.



Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.

At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm^{-3} .

What is the concentration of ethyl ethanoate at equilibrium?

- A** 0.22 mol dm^{-3}
B 0.65 mol dm^{-3}
C 0.81 mol dm^{-3}
D 1.54 mol dm^{-3}

- 11 Which row is an example of heterogeneous catalysis?

	reaction	catalyst
A	esterification	sulfuric acid
B	the Contact process	divanadium pentoxide
C	destruction of the ozone layer	chlorine radicals
D	atmospheric formation of sulfur trioxide	nitrogen dioxide

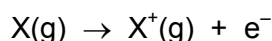
- 12 Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.

Where could element Q be found in the Periodic Table?

	period	group
A	2	1
B	2	14
C	3	14
D	3	15

- 13** The eight elements sodium to argon are in the same period of the Periodic Table.

The equation corresponding to the first ionisation energy is shown.



For which of these eight elements is the electron in this equation removed from a filled orbital?

- A** Mg, Al, Si, P, S, Cl and Ar
B Al, Si, P, S, Cl and Ar only
C Mg, S, Cl and Ar only
D S, Cl and Ar only
- 14** Elements D and E are both in Period 3. Element D has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element E. Elements D and E react together to form compound L.

Which compound could be L?

- A** $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3
- 15** How many of the solutions shown, when added to separate portions of magnesium sulfate solution, produce a white precipitate?
- | | | | |
|------------|------------|--------------------|------------------|
| $HCl(aq)$ | $NH_3(aq)$ | $(NH_4)_2CO_3(aq)$ | $Ba(NO_3)_2(aq)$ |
| A 0 | B 1 | C 2 | D 3 |
- 16** A white solid, Z, is soluble in water. A sample of Z is heated with a Bunsen burner until there is no further change. When the residue is shaken with water a solution is formed with no solid remaining.

What could Z be?

- A** $MgCO_3$ **B** $Mg(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$
- 17** An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.
- How many moles of sodium chloride would be produced in the reaction?
- A** 0.3 **B** 0.5 **C** 0.6 **D** 1.2

18 Ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$, and ammonium nitrate, NH_4NO_3 , are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

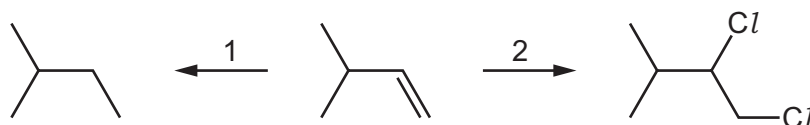
Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

19 Which reaction gives a product that is an atmospheric pollutant causing acid rain?

- A** $3\text{Mg(s)} + \text{SO}_2\text{(g)} \rightarrow \text{MgS(s)} + 2\text{MgO(s)}$
- B** $(\text{NH}_4)_2\text{SO}_4\text{(s)} + \text{Ca(OH)}_2\text{(s)} \rightarrow 2\text{NH}_3\text{(g)} + \text{CaSO}_4\text{(s)} + 2\text{H}_2\text{O(l)}$
- C** $2\text{MnO}_4^-\text{(aq)} + 5\text{SO}_2\text{(g)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{Mn}^{2+}\text{(aq)} + 4\text{H}^+\text{(aq)} + 5\text{SO}_4^{2-}\text{(aq)}$
- D** $2\text{FeSO}_4\text{(s)} \rightarrow \text{Fe}_2\text{O}_3\text{(s)} + \text{SO}_2\text{(g)} + \text{SO}_3\text{(g)}$

20 3-methylbut-1-ene can undergo different types of reaction.



Which row correctly identifies the reaction types?

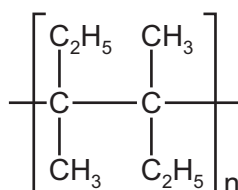
	reaction 1	reaction 2
A	oxidation	electrophilic addition
B	oxidation	nucleophilic addition
C	reduction	electrophilic addition
D	reduction	nucleophilic addition

- 21** Compound X does **not** show cis-trans isomerism.

What could be the identity of compound X?

- A** 1,1,2-trichloropropene
- B** 1,2,3-trichloropropene
- C** 1-chlorobut-1-ene
- D** 1-chlorobut-2-ene

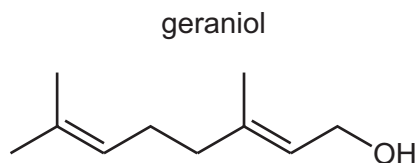
- 22** The diagram shows the repeat unit of an addition polymer.



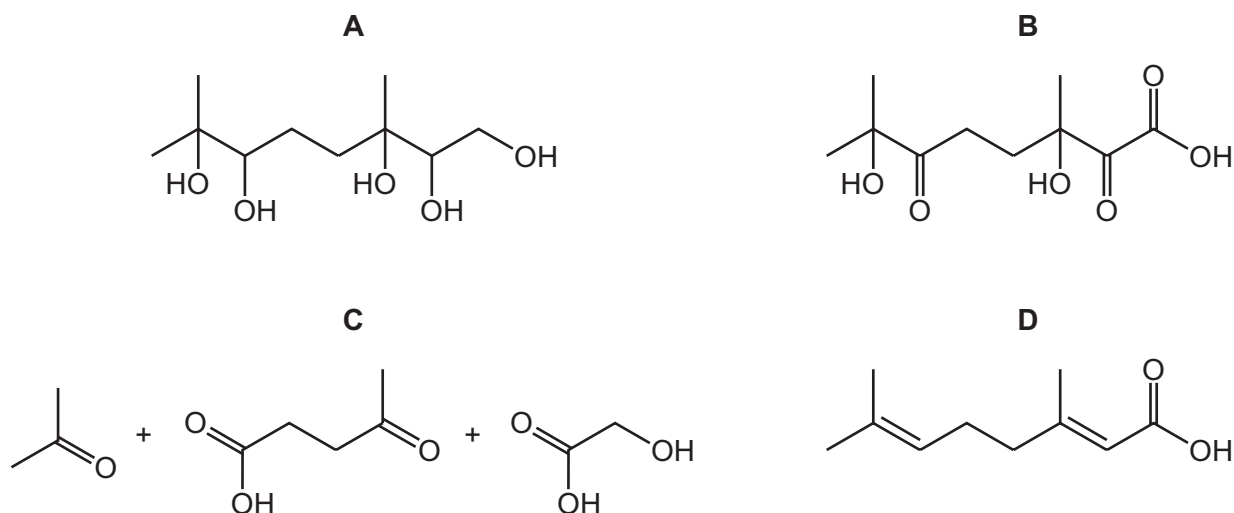
What is the correct name for the monomer that would form this polymer?

- A** cis-1,2-diethyl-1,2-dimethylethene
- B** cis-2-ethyl-3-methylpent-2-ene
- C** trans-2-ethyl-3-methylpent-2-ene
- D** trans-3,4-dimethylhex-3-ene

23 A molecule of geraniol is shown.



What is formed when geraniol is reacted with an excess of cold, dilute, acidified manganate(VII) ions?



24 Alcohol W **cannot** be made by reducing a carboxylic acid with LiAlH_4 . Alcohol W gives only one product when dehydrated with concentrated sulfuric acid.

What could be the identity of W?

- A** butan-1-ol
- B** butan-2-ol
- C** propan-1-ol
- D** propan-2-ol

25 Which product can be made from bromoethane by an elimination reaction?

- A** ethanol
- B** ethene
- C** ethylamine
- D** propanenitrile

26 Propene, bromine and hydrogen bromide are mixed in the dark.

A number of products are formed, some in very small quantities.

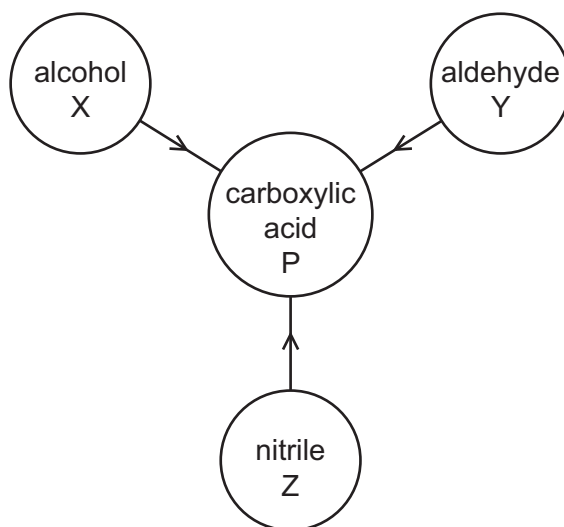
Which substance will **not** be present in the mixture of products?

- A 1-bromopropane
- B 2-bromopropane
- C 1,1-dibromopropane
- D 1,2-dibromopropane

27 Which reagent could be used to distinguish between ethanal and propanal?

- A 2,4-dinitrophenylhydrazine
- B $I_2/NaOH(aq)$
- C $K_2Cr_2O_7/H_2SO_4(aq)$
- D Tollens' reagent

28 The diagram shows that a carboxylic acid P may be formed from X, Y or Z.

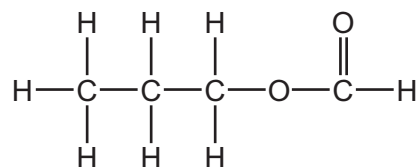


Which row is correct?

	alcohol X is	the change in M_r is greatest for
A	primary	Y to P
B	primary	Z to P
C	secondary	Y to P
D	secondary	Z to P

29 One molecule of compound R is shown.

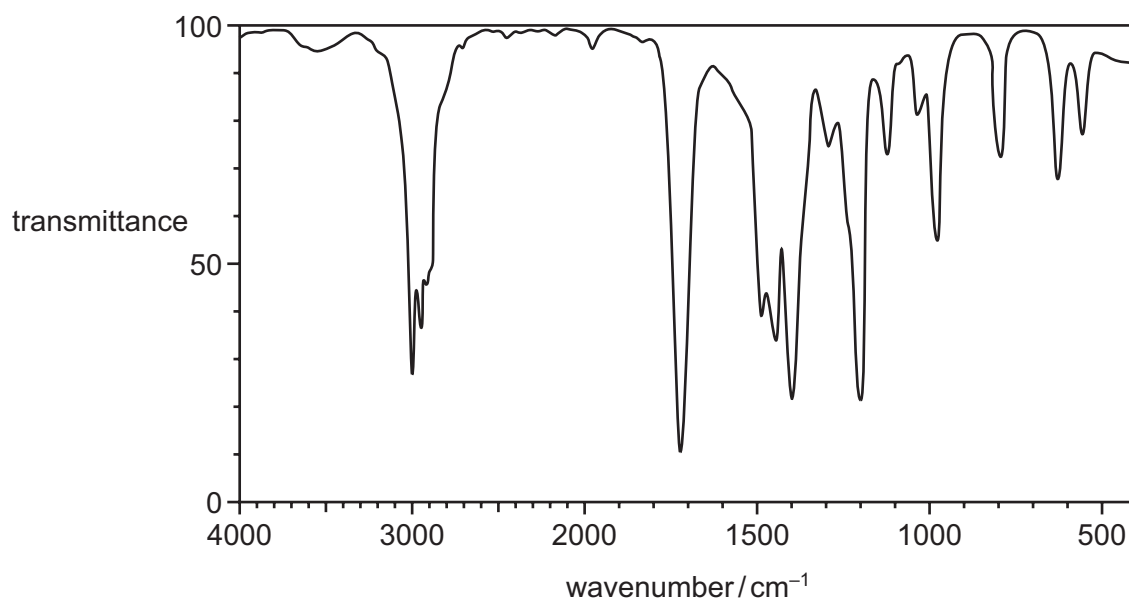
compound R



What is the name of compound R and how does its boiling point compare with that of butanoic acid?

	name of R	boiling point of R
A	methyl propanoate	higher than butanoic acid
B	methyl propanoate	lower than butanoic acid
C	propyl methanoate	higher than butanoic acid
D	propyl methanoate	lower than butanoic acid

30 The diagram shows the infra-red spectrum of Q.



What could be Q?

- A** butan-1-ol
- B** butanoic acid
- C** butanone
- D** 3-hydroxybutanal

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

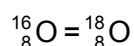
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

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

31 When O_2 reacts with H_2S the products are SO_2 and H_2O .

Mixture Y contains an equal number of the two molecules shown, and **no other molecules**.



Which statements about Y are correct?

- 1** The average M_r in Y is 34.
- 2** If some oxygen molecules are removed from Y, the average M_r of the mixture remains the same.
- 3** When mixture Y is ignited, some H_2S remains unreacted.

32 Which statements about an atom of ${}^{99}\text{Tc}$ are correct?

- 1** It has 13 fewer protons than neutrons.
- 2** It forms ${}^{99}\text{Tc}^{2+}$ which has 45 electrons.
- 3** It has 56 nucleons.

33 In which reactions are nitrogen atoms reduced?

- 1** $2\text{NO}_2 \rightarrow \text{N}_2 + 2\text{O}_2$
- 2** $4\text{NO}_2 \rightarrow 2\text{N}_2\text{O} + 3\text{O}_2$
- 3** $4\text{NO}_2 + 6\text{H}_2\text{O} \rightarrow 4\text{NH}_3 + 7\text{O}_2$

- 34 The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.

Which of the following would leave the equilibrium constant, K_p , for the formation of ammonia unchanged?

- 1 addition of an iron catalyst
- 2 addition of ammonia
- 3 an increase in pressure

- 35 Which reactions involving calcium and its compounds produce two gaseous products?

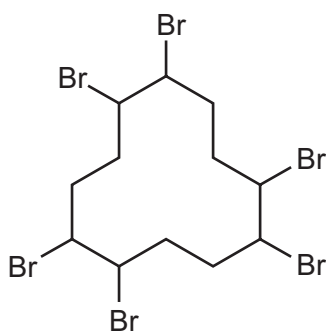
- 1 heating solid anhydrous calcium nitrate
- 2 heating solid anhydrous calcium carbonate
- 3 adding calcium metal to water

- 36 A small quantity of hot, concentrated sulfuric acid is added separately to solid samples of potassium halides, KX.

Which potassium halides react and produce a mixture of products that include a halogen, X_2 ?

- 1 potassium iodide
- 2 potassium bromide
- 3 potassium chloride

- 37 The diagram shows a compound used as a flame retardant.



Which statements about this structure are correct?

- 1 The empirical formula is C_2H_3Br .
- 2 The C_{12} ring is not planar.
- 3 There are six chiral carbon atoms.

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

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

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

38 Halogenoalkanes can be hydrolysed using aqueous sodium hydroxide.

Which compounds tend to be hydrolysed by an S_N1 mechanism?

- 1** CH₃CH₂CCl(CH₃)CH₂CH₃
- 2** CH₃CH₂CBr(CH₃)CH₂CH₃
- 3** CH₃CH₂CH(CH₃)CH₂CH₂Br

39 In an organic synthesis, a 62% yield of product is achieved.

Which conversions are consistent with this information?

- 1** 74.00 g of butan-2-ol → 44.64 g of butanone
- 2** 74.00 g of butan-1-ol → 54.56 g of butanoic acid
- 3** 74.00 g of 2-methylpropan-1-ol → 54.56 g of 2-methylpropanoic acid

40 An oxidising agent that can oxidise ethanal to ethanoic acid or ethanoate ions will also oxidise methanoic acid, HCO₂H, to carbon dioxide and water.

Which reagents, on heating, will react differently with HCO₂H and CH₃CO₂H?

- 1** Na₂CO₃(aq)
- 2** Fehling's reagent
- 3** dilute acidified KMnO₄

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CHEMISTRY

9701/13

Paper 1 Multiple Choice

May/June 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 **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.

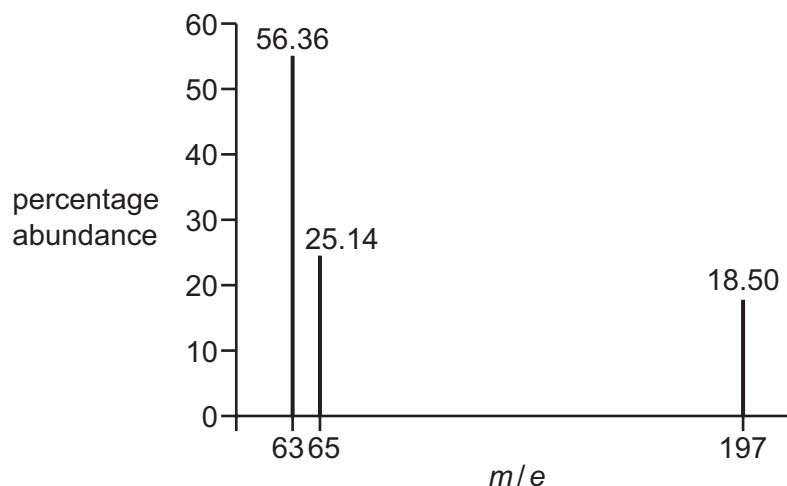
- 1** Manganese and nitrogen can show a range of different oxidation states.

Calculate the sum of the oxidation states of Mn and N in each row of the table.

In which row is this sum the smallest?

	manganese-containing species	nitrogen-containing species
A	MnCl_4	N_2
B	MnCO_3	NO_2^-
C	K_2MnO_4	NH_4^+
D	$\text{Mn}(\text{OH})_3$	NH_2OH

- 2 The mass spectrum of an alloy of copper and gold is shown.



Which expression can be used to calculate the relative atomic mass, A_r , of copper present in this sample?

- A** $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14 + 18.50)}$
- B** $\frac{(56.36 \times 63) + (25.14 \times 65) + (18.50 \times 197)}{(56.36 + 25.14 + 18.50)}$
- C** $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14)}$
- D** $\frac{(56.36 \times 63) + (25.14 \times 65)}{(63 + 65)}$
- 3 Which atom has exactly three unpaired electrons?
- A** an isolated gaseous aluminium atom
- B** an isolated gaseous carbon atom
- C** an isolated gaseous chromium atom
- D** an isolated gaseous phosphorus atom

- 4 Element W is in period three of the Periodic Table and has a solid, white oxide, X. X is thermally stable and has a very high melting point.

X is slightly soluble in water.

Which row describes the structure and bonding of X?

	structure	bonding
A	giant three dimensional lattice	covalent
B	strong double bonds within small molecules	covalent
C	giant three dimensional lattice	ionic
D	strong ionic bonds within small molecules	ionic

- 5 Ethane, CH_3CH_3 , and fluoromethane, CH_3F , have the same number of electrons in their molecules.

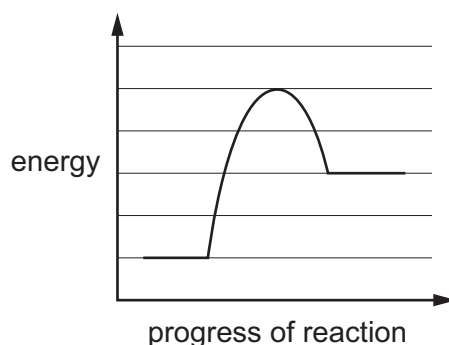
Their boiling points are given.

CH_3CH_3	184.5 K
CH_3F	194.7 K

What is responsible for this difference in boiling points?

- A** CH_3F has a larger M_r than CH_3CH_3 .
- B** CH_3F has a permanent dipole, CH_3CH_3 does not.
- C** CH_3F has a strong C–F bond, CH_3CH_3 does not.
- D** Hydrogen bonding occurs in CH_3F , but not in CH_3CH_3 .

- 6 The reaction pathway diagram for a chemical reaction is shown.



Which statement is correct?

- A** The activation energy of the forward reaction and the enthalpy change of the backward reaction have the same sign.
- B** The activation energy of the forward reaction is more than twice the enthalpy change of the backward reaction and opposite in sign.
- C** The enthalpy change of the forward reaction and the activation energy of the backward reaction have the same sign.
- D** The enthalpy change of the forward reaction is more than twice the activation energy of the backward reaction.
- 7 What changes in conditions or molecular properties make it more likely that gases approach ideal behaviour?
- A** higher pressure
- B** lower temperature
- C** more polar molecules
- D** weaker intermolecular forces

- 8 Ethanol can be oxidised to ethanal by dilute acidified dichromate(VI) ions.

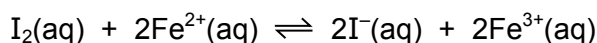
The oxidation reaction equation is $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4\text{O} + 2\text{H}^+ + 2\text{e}^-$.

The reduction reaction equation is $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$.

Which equation is correct?

- A** $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{C}_2\text{H}_5\text{OH} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{C}_2\text{H}_4\text{O}$
- B** $\text{Cr}_2\text{O}_7^{2-} + 12\text{H}^+ + \text{C}_2\text{H}_5\text{OH} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + \text{C}_2\text{H}_4\text{O}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 12\text{H}^+ + 3\text{C}_2\text{H}_5\text{OH} \rightarrow 2\text{Cr}^{3+} + 6\text{H}_2\text{O} + 3\text{C}_2\text{H}_4\text{O}$
- D** $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{C}_2\text{H}_5\text{OH} \rightarrow 2\text{Cr}^{3+} + 6\text{H}_2\text{O} + 3\text{C}_2\text{H}_4\text{O}$

- 9 What is the correct expression for K_c for the reaction shown?



- A $\frac{[\text{I}^{-}][2\text{Fe}^{3+}]}{[\text{I}_2][2\text{Fe}^{2+}]}$ B $\frac{[\text{I}^{-}]^2[\text{Fe}^{3+}]^2}{[\text{I}_2][\text{Fe}^{2+}]^2}$ C $\frac{[\text{I}_2][2\text{Fe}^{2+}]}{[\text{I}^{-}][2\text{Fe}^{3+}]}$ D $\frac{[\text{I}_2][\text{Fe}^{2+}]^2}{[\text{I}^{-}]^2[\text{Fe}^{3+}]^2}$

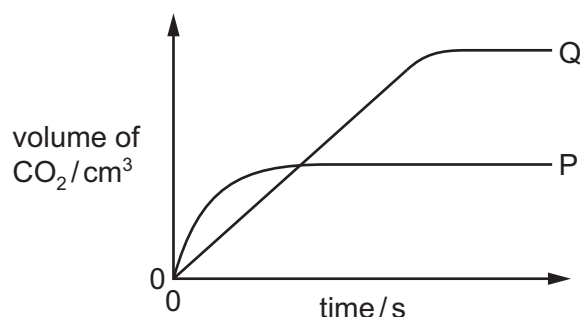
- 10 X and Y react together to form Z in a reversible reaction.

The equilibrium yield of Z is lower at higher temperature.

The equilibrium yield of Z is lower at lower pressure.

Which equation could represent this reaction?

- A $\text{X}(\text{g}) + \text{Y}(\text{g}) \rightleftharpoons \text{Z}(\text{g}) \quad \Delta H = -100 \text{ kJ mol}^{-1}$
 B $\text{X}(\text{g}) + \text{Y}(\text{g}) \rightleftharpoons \text{Z}(\text{g}) \quad \Delta H = +100 \text{ kJ mol}^{-1}$
 C $\text{X}(\text{s}) + \text{Y}(\text{g}) \rightleftharpoons 2\text{Z}(\text{g}) \quad \Delta H = -100 \text{ kJ mol}^{-1}$
 D $\text{X}(\text{s}) + \text{Y}(\text{g}) \rightleftharpoons 2\text{Z}(\text{g}) \quad \Delta H = +100 \text{ kJ mol}^{-1}$
- 11 The volume of carbon dioxide collected by reacting 0.100 mol of magnesium carbonate with 50.0 cm³ of 1.00 mol dm⁻³ sulfuric acid is measured against time. The volume produced is plotted against time and the line labelled P on the graph is obtained.



The experiment is repeated using 0.100 mol of the same magnesium carbonate, and a different sample of acid. All other conditions remain the same. Plotting these results gives the line labelled Q.

Which sample of acid could give the line labelled Q?

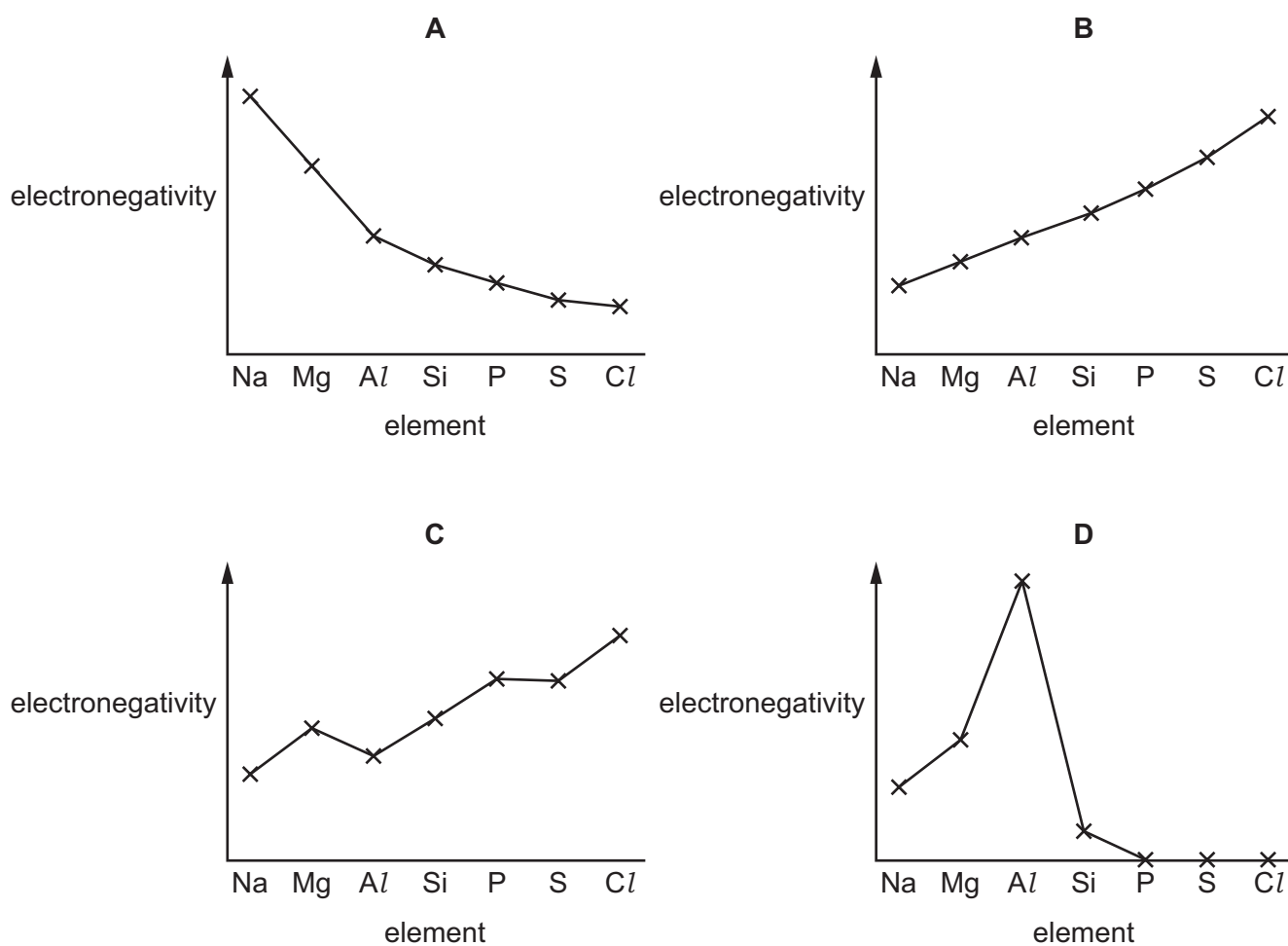
- A 100 cm³ of 0.500 mol dm⁻³ sulfuric acid
 B 100 cm³ of 1.00 mol dm⁻³ sulfuric acid
 C 200 cm³ of 0.500 mol dm⁻³ hydrochloric acid
 D 200 cm³ of 1.00 mol dm⁻³ hydrochloric acid

12 Sodium and sulfur react together to form sodium sulfide, Na_2S .

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium < sulfur	sodium > sulfur
B	sodium < sulfur	sodium < sulfur
C	sodium > sulfur	sodium > sulfur
D	sodium > sulfur	sodium < sulfur

13 Which graph represents the variation in electronegativity for Period 3 elements?



- 14** Dilute hydrochloric acid is added to solid barium carbonate and solid magnesium carbonate in separate test-tubes.

Dilute sodium hydroxide is added to 0.1 mol dm^{-3} barium chloride and 0.1 mol dm^{-3} magnesium chloride in separate test-tubes.

Which row is correct?

	$\text{BaCO}_3(\text{s})$ + $\text{HCl}(\text{aq})$	$\text{BaCl}_2(\text{aq})$ + $\text{NaOH}(\text{aq})$	$\text{MgCO}_3(\text{s})$ + $\text{HCl}(\text{aq})$	$\text{MgCl}_2(\text{aq})$ + $\text{NaOH}(\text{aq})$
A	no change	white ppt	no change	no change
B	effervescence	no change	effervescence	no change
C	effervescence	no change	effervescence	white ppt
D	effervescence	white ppt	effervescence	white ppt

- 15** River water in an agricultural area contains NH_4^+ , CO_3^{2-} , HCO_3^- , Cl^- and NO_3^- ions. In a water treatment plant, this water is treated by adding a calculated quantity of calcium hydroxide.

What is precipitated from the river water when calcium hydroxide is added?

- A** CaCl_2 **B** CaCO_3 **C** $\text{Ca}(\text{NO}_3)_2$ **D** NH_4OH

- 16** The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl , the products are NaHSO_4 and HCl .

With NaI , the products are NaHSO_4 , HI , I_2 , SO_2 , H_2O , S and H_2S .

What is the explanation for this difference in products?

- A** Chloride ions will displace iodine from solution.
B Hydrogen chloride is more volatile than hydrogen iodide.
C Iodide ions are better reducing agents than chloride ions.
D Sulfuric acid is able to act as a dehydrating agent with NaI .

- 17** An aqueous solution of a calcium compound is treated with a mixture of dilute aqueous nitric acid and aqueous silver nitrate. The resulting white precipitate dissolves when dilute aqueous ammonia is added.

What is the relative molecular mass, M_r , of the calcium compound?

- A** 54.0 **B** 75.6 **C** 111.1 **D** 199.9

18 Which statement about the ammonium ion is correct?

- A It can act as a Brønsted-Lowry base.
- B It can react with OH^- to give ammonia.
- C It is pyramidal with bond angles of 107° .
- D The nitrogen atom is sp^2 hybridised.

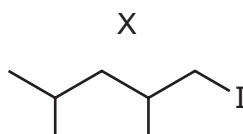
19 In a catalytic converter 5.6 g of carbon monoxide reacts with an excess of nitrogen monoxide.

What is produced in this reaction?

- A 2.4 g of C and 6.0 g of NO_2
- B 2.4 g of C and 9.2 g of NO_2
- C 8.8 g of CO_2 and 1.4 g of N_2
- D 8.8 g of CO_2 and 2.8 g of N_2

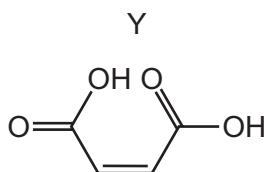
20 The Finkelstein reaction occurs when NaI in propanone reacts with a chloroalkane or bromoalkane. The halogen is directly replaced by I. The reaction only works for primary halogenoalkanes.

Which halogenoalkane produces compound X?



- A $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{Br}$
- B $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CH}_2\text{Br}$
- C $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{Cl}$
- D $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{Cl}$

21 The diagram shows the skeletal formula of compound Y.



What is the empirical formula of Y?

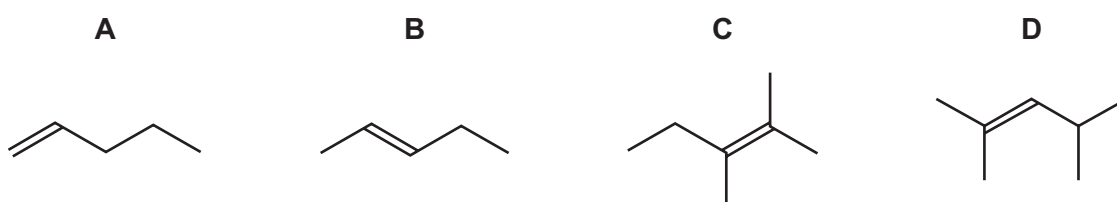
- A CHO
- B CH_2O_2
- C C_2HO_2
- D $\text{C}_4\text{H}_4\text{O}_4$

- 22 In polymer Z every carbon atom in the polymer chain is bonded to one hydrogen atom and one methyl group.

Which alkene could be polymerised to make polymer Z?

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

- 23 Which compound would produce a carboxylic acid and a ketone when treated with hot, concentrated acidified manganate(VII) ions?



- 24 Water is added to a sample of 2,3-dibromohexane.

Some of the 2,3-dibromohexane undergoes complete hydrolysis and some of it undergoes partial hydrolysis.

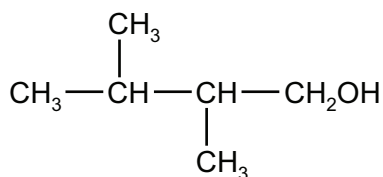
What is **not** present in the mixture of products?

- A $\text{CH}_3\text{CH}(\text{OH})\text{CHBrCH}_2\text{CH}_2\text{CH}_3$
 - B $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_3$
 - C $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
 - D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CHBrCH}_3$
- 25 Which statement about the mechanism of an $\text{S}_{\text{N}}1$ reaction of a halogenoalkane is correct?
- A A nucleophile is substituted by an electrophile.
 - B One intermediate is formed from two reacting molecules.
 - C The intermediate is stabilised by adjacent alkyl groups.
 - D The intermediate is uncharged.

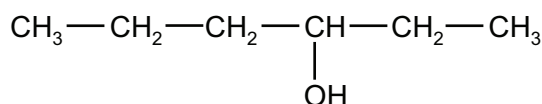
- 26 Structural isomerism and stereoisomerism should be considered when answering this question.

Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

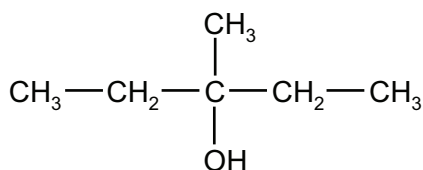
A



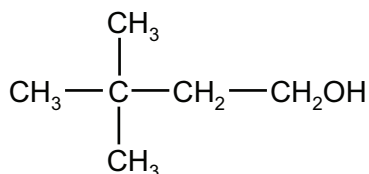
B



C



D



- 27 Compound Q reacts with 2,4-dinitrophenylhydrazine to give a precipitate.

Compound Q does not produce a precipitate when warmed with Fehling's solution.

What could be the identity of compound Q?

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

- 28 Structural isomerism **only** should be considered when answering this question.

A set of isomeric compounds, with molecular formula $C_5H_{10}O$, all react in a 1:1 ratio with an excess of HCN by nucleophilic addition.

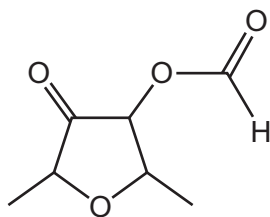
How many isomeric compounds are in the set?

- A 5 B 6 C 7 D 8

- 29 Which pair of substances could react to give the ester $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$?

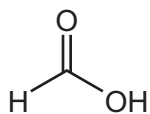
- A ethanol and ethanoic acid
 B methanol and ethanoic acid
 C methanol and propanoic acid
 D propan-1-ol and methanoic acid

30 An ester is shown.

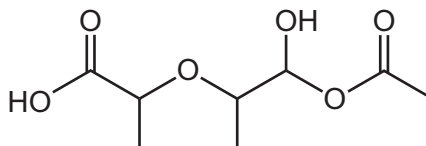


What is the structure of the carboxylic acid that would be obtained by acid hydrolysis of the ester linkage?

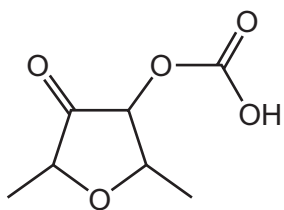
A



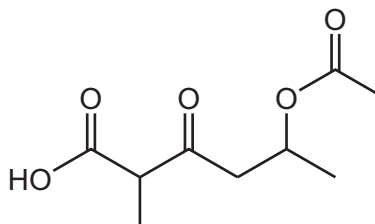
B



C



D



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 deductions about the $^{209}_{83}\text{Bi}$ atom are correct?

- 1** It has 83 electrons.
- 2** It has 126 nucleons.
- 3** It has 83 neutrons.

32 Which statements are correct when referring to the two common isotopes of chlorine?

- 1** The isotopes have different masses.
- 2** The isotopes have different numbers of nucleons.
- 3** The isotopes have the same chemical reactions.

33 For which enthalpy changes is the value of ΔH always negative?

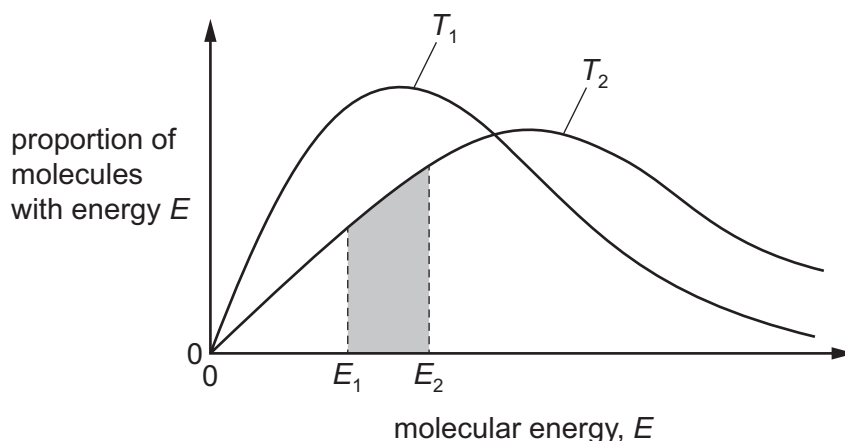
- 1** combustion
- 2** hydration
- 3** solution

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 diagram shows the Boltzmann distribution of molecular energies in one mole of a gas at two temperatures, T_1 and T_2 .



Which statements are correct?

- 1** The shaded area represents the proportion of molecules with energies between E_1 and E_2 at temperature T_2 .
- 2** No particles have zero energy at either temperature.
- 3** T_2 is a higher temperature than T_1 .

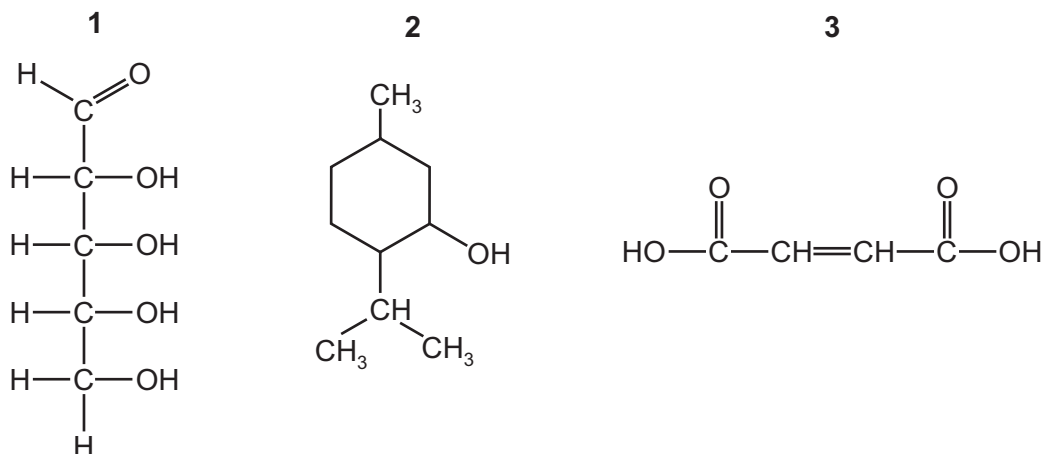
- 35** Which statements about sodium chloride are correct?

- 1** It is a product of the reaction between chlorine and cold aqueous sodium hydroxide.
- 2** It is a product of the reaction between chlorine and hot aqueous sodium hydroxide.
- 3** It is a product of the reaction between chlorine and aqueous sodium bromide.

- 36** Which gases will dissolve in water causing a lowering of the pH?

- 1** ammonia
- 2** sulfur dioxide
- 3** nitrogen dioxide

37 Which compounds have optical isomers?



38 Bromine reacts with ethene in an addition reaction.

Which statements about this reaction are correct?

- 1 It is the basis of a test for unsaturation in alkenes.
- 2 It leads to an increase in each of the H–C–H bond angles.
- 3 A nucleophile attacks the C=C bond in ethene.

39 An unknown organic compound Z reacts with sodium to give a combustible gas as one product. Z does **not** give a yellow precipitate with alkaline aqueous iodine.

What is a possible identity of Z?

- 1 ethanoic acid
- 2 pentan-3-ol
- 3 propan-1-ol

40 An organic molecule X has a molecular formula of $\text{C}_5\text{H}_{10}\text{O}_2$. Its infra-red spectrum has a strong peak at 1250 cm^{-1} , a strong peak at 1720 cm^{-1} but no strong peak above 3100 cm^{-1} .

What could X be?

- 1 ethyl propanoate
- 2 methyl butanoate
- 3 1-hydroxypentan-3-one

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