

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2015

1 hour

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

* 2 8 5 7 6 1 8 2 2 7 *



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 **13** printed pages and **3** 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.

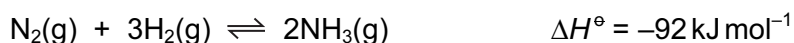
- 1 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12 300

What could be the formula of a chloride of X?

- A** XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

- 2 Which set of conditions gives the highest yield of ammonia at equilibrium?



	catalyst	pressure	temperature
A	absent	high	low
B	absent	low	high
C	present	high	high
D	present	low	low

- 3 *Use of the Data Booklet is relevant to this question.*

The compound S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S_2O_7 is hydrolysed?

- A** 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

- 4 Nitrogen, N_2 , and carbon monoxide, CO , both have $M_r = 28$.

The boiling point of N_2 is 77 K.

The boiling point of CO is 82 K.

What could be responsible for this difference in boiling points?

- A** CO molecules have a permanent dipole, the N_2 molecules are not polar.
B N_2 has σ and π bonding, CO has σ bonding only.
C N_2 has a strong $\text{N}\equiv\text{N}$ bond, CO has a $\text{C}=\text{O}$ bond.
D The CO molecule has more electrons than the N_2 molecule.

- 5 Some car paints contain small flakes of silica, SiO_2 .

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

- 6 Solid sulfur consists of molecules made up of eight atoms covalently bonded together.

The bonding in sulfur dioxide is $\text{O}=\text{S}=\text{O}$.

enthalpy change of combustion of S_8 , $\Delta H_c^\circ \text{S}_8(\text{s}) = -2376 \text{ kJ mol}^{-1}$

energy required to break 1 mole $\text{S}_8(\text{s})$ into gaseous atoms = 2232 kJ mol^{-1}

$\text{O}=\text{O}$ bond enthalpy = 496 kJ mol^{-1}

Using these data, what is the value of the $\text{S}=\text{O}$ bond enthalpy?

- A** 239 kJ mol^{-1} **B** 257 kJ mol^{-1} **C** 319 kJ mol^{-1} **D** 536 kJ mol^{-1}

- 7 Use of the Data Booklet is relevant for this question.

In an experiment, the burning of 1.45 g (0.025 mol) of propanone was used to heat 100 g of water. The initial temperature of the water was 20.0°C and the final temperature of the water was 78.0°C .

Which experimental value for the enthalpy change of combustion for propanone can be calculated from these results?

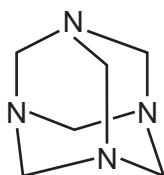
- A** $-1304 \text{ kJ mol}^{-1}$
B -970 kJ mol^{-1}
C -352 kJ mol^{-1}
D $-24.2 \text{ kJ mol}^{-1}$

- 8 Which row correctly describes the electrodes that can be used in a diaphragm cell for the production of chlorine, hydrogen and sodium hydroxide?

	anode	cathode
A	steel	graphite
B	steel	titanium
C	titanium	graphite
D	titanium	steel

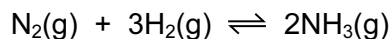
- 9 Hexamine is a crystalline solid used as a fuel in portable stoves.

The diagram shows its skeletal structure.



What is the empirical formula of hexamine?

- A** CH₂N **B** C₃H₆N₂ **C** C₄H₈N₄ **D** C₆H₁₂N₄
- 10 A mixture of nitrogen and hydrogen gases, at a temperature of 500 K, was put into an evacuated vessel of volume 6.0 dm³. The vessel was then sealed.

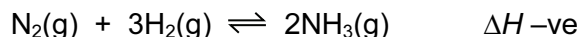


The mixture was allowed to reach equilibrium. It was found that 7.2 mol of N₂ and 12.0 mol of H₂ were present in the equilibrium mixture. The value of the equilibrium constant, K_c , for this equilibrium is 6.0×10^{-2} at 500 K.

What is the concentration of ammonia present in the equilibrium mixture at 500 K?

- A** 0.58 mol dm⁻³
B 0.76 mol dm⁻³
C 3.5 mol dm⁻³
D 27 mol dm⁻³

- 11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.



What will increase the rate of the forward reaction?

- A adding argon to the mixture but keeping the total volume constant
 - B decreasing the temperature
 - C increasing the total pressure by reducing the total volume at constant temperature
 - D removing ammonia as it is made but keeping the total volume of the mixture the same
- 12 **X** is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.

What could be the identity of **X**?

- A magnesium
 - B calcium
 - C strontium
 - D barium
- 13 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

- A barium carbonate
 - B barium chloride
 - C barium hydroxide
 - D barium sulfate
- 14 *Use of the Data Booklet is relevant to this question.*

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

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

- 15 The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
mp/K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

- A** the changes in first ionisation energy from sodium to aluminium
B the increase in electronegativity from sodium to aluminium
C the increase in the A_r of the elements from sodium to aluminium
D the increase in the number of outer electrons in each atom from sodium to aluminium
- 16 **X** is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.
- A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide solution.
- What could be the identity of **X**?
- A** Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3
- 17 Which statement about bromine is correct?
- A** Bromine is insoluble in non-polar solvents.
B Bromine vapour is more dense than air.
C Bromine will not vaporise significantly under normal conditions.
D Gaseous bromine is purple.
- 18 The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in excess dilute aqueous ammonia to form a colourless solution.

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

What is **Z**?

- A** AgCl **B** $BaCl_2$ **C** $Ba(NO_3)_2$ **D** NH_4NO_3

- 19 Element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.

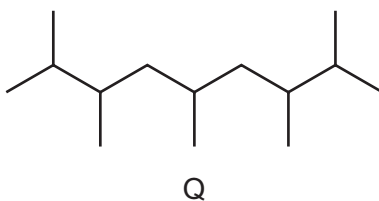
Student P 'The molecule of Y contains lone pairs of electrons.'

Student Q 'The oxidation number of X increases by 1 from Y to Z.'

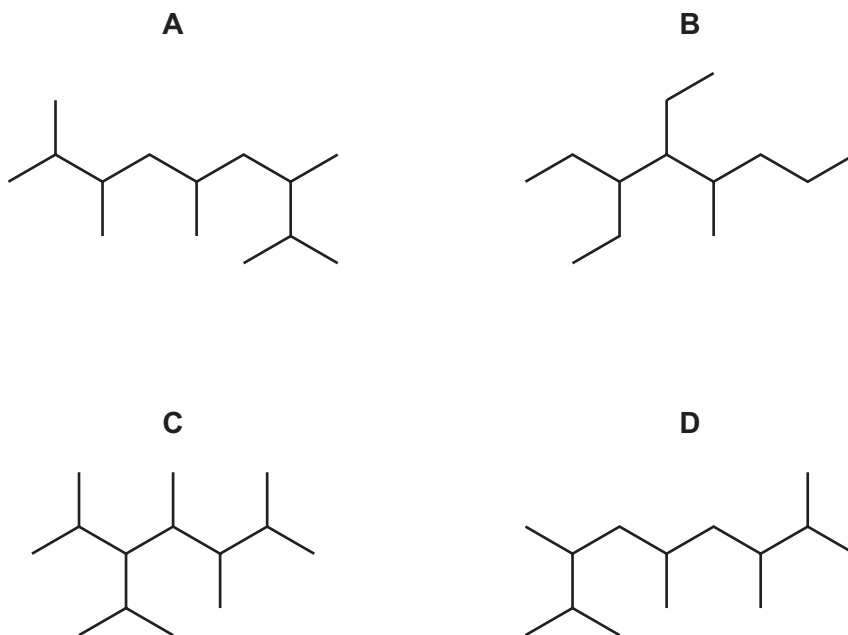
X could be carbon or nitrogen or sulfur.

Which student(s) made a correct statement?

- A P only
 B Q only
 C both P and Q
 D neither P nor Q
- 20 How many isomeric esters have the molecular formula $C_4H_8O_2$?
- A 2 B 3 C 4 D 5
- 21 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



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



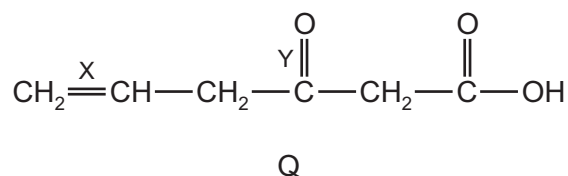
- 22 Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.

The table below shows the boiling points of some alkanes.

alkane	boiling point / °C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

What is the correct explanation for the difference in the boiling points of the three isomers with $M_r = 72$?

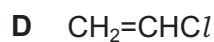
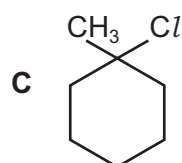
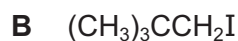
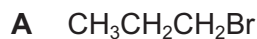
- A** Boiling point is dependent upon the length of the carbon chain **only**.
- B** Increased branching on a carbon chain increases the boiling point.
- C** Increased branching reduces the strength of the intermolecular hydrogen bonding.
- D** Increased branching reduces the strength of the intermolecular van der Waals' forces.
- 23 Compound Q contains three double bonds per molecule.



Which bond, X or Y, will be ruptured by hot, concentrated acidified KMnO_4 and how many lone pairs of electrons are present in one molecule of Q?

	bond ruptured by hot, concentrated acidified KMnO_4	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

24 Which compound undergoes an S_N1 substitution reaction with NaOH(aq) ?



25 If the starting material is iodoethane, which sequence of reactions will produce propanoic acid as the main final product in good yield?

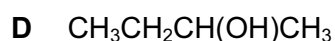
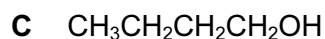
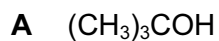
A add NaOH(aq) , isolate the organic product, add acidified $\text{K}_2\text{Cr}_2\text{O}_7$ and boil under reflux

B add NaOH(aq) , isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

C heat with HCN in ethanol, isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

D heat with KCN in ethanol, isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

26 Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?



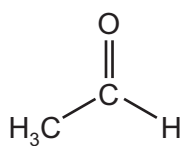
27 Butan-2-ol can be made by reducing X with H_2/Ni .

Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.

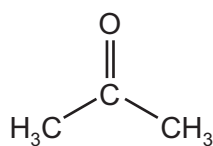
Which row is correct?

	X is	<i>cis-trans</i> isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

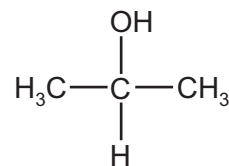
28 Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q

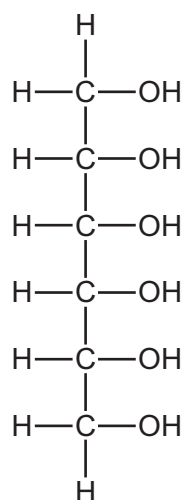


R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

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

29 Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.



sorbitol

How many chiral centres are present in sorbitol?

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

30 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

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

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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

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

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

31 Which statements about orbitals in a krypton atom are correct?

- 1** The 1s and 2s orbitals have the same energy as each other but different sizes.
- 2** The third energy level ($n=3$) has three subshells and nine orbitals.
- 3** The 3d subshell has five orbitals that have the same energy as each other in an isolated atom.

32 The Group IV elements carbon, silicon and germanium can all exist in the giant molecular structure which is also found in diamond. The bond lengths in these structures are given below.

element X	C	Si	Ge
bond length X–X/nm	0.154	0.234	0.244

Why does the bond length increase down the group?

- 1** Orbital overlap decreases down the group.
- 2** Atomic radius increases down the group.
- 3** Nuclear charge increases down the group.

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 The salt NaClO_3 is used as a non-selective weedkiller.

On careful heating, this reaction occurs: $4\text{NaClO}_3 \rightarrow \text{NaCl} + 3\text{NaClO}_4$.

On strong heating this reaction occurs: $\text{NaClO}_4 \rightarrow \text{NaCl} + 2\text{O}_2$.

The overall reaction is $2\text{NaClO}_3 \rightarrow 2\text{NaCl} + 3\text{O}_2$.

What do these equations show?

- 1** NaClO_3 can behave as an oxidising agent.
- 2** NaClO_3 can behave as a reducing agent.
- 3** The oxidation numbers of chlorine in the three compounds shown are +6, +8 and -1.

34 Which statements correctly describe an effect of a rise in temperature on a gas-phase reaction?

- 1** More particles now have energies greater than the activation energy.
- 2** The energy distribution profile changes with more particles having the most probable energy.
- 3** The activation energy of the reaction is decreased.

35 Which statements concerning the Group II elements magnesium, calcium and barium are correct?

- 1** Their reactivity increases with increasing relative atomic mass.
- 2** The oxidation number exhibited in their stable compounds is +2.
- 3** On strong heating, their nitrates give off oxygen only.

36 Sulfur dioxide is used as a food preservative.

Which statements about sulfur dioxide, SO_2 , are correct?

- 1** SO_2 behaves as an antioxidant.
- 2** Aqueous SO_2 contains SO_3^{2-} ions.
- 3** SO_2 inhibits the growth of mould and yeasts.

- 37 An oxidising agent that can oxidise ethanal to ethanoic acid, or to ethanoate ions, will also oxidise methanoic acid, HCO_2H , to carbon dioxide and water.

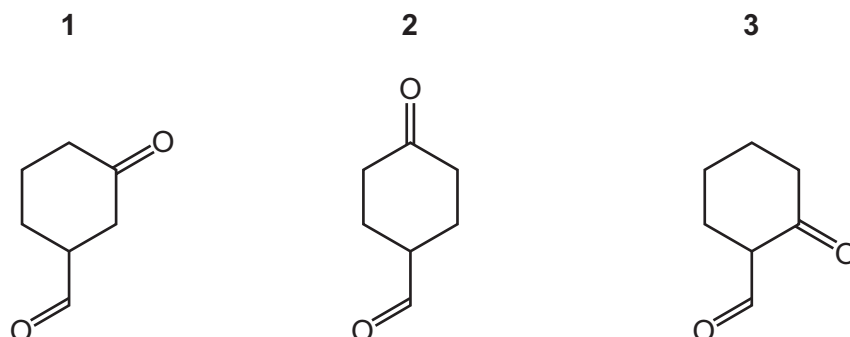
Which reagents, on heating, will react differently with HCO_2H and $\text{CH}_3\text{CO}_2\text{H}$?

- 1 $\text{Na}_2\text{CO}_3(\text{aq})$
- 2 Fehling's reagent
- 3 dilute acidified KMnO_4

- 38 Each of the compounds below is treated separately with excess NaBH_4 . The product of each reaction is then heated with excess concentrated H_2SO_4 .

In each case, one or more products are formed with molecular formula C_7H_{10} .

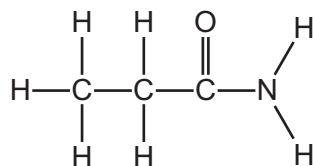
Which compounds give **only one** final product with the molecular formula C_7H_{10} ?



- 39 Which reactions result in the formation of propanoic acid?

- 1 $\text{CH}_3\text{CH}_2\text{CO}_2\text{Na}$ with dilute $\text{H}_2\text{SO}_4(\text{aq})$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$ with hot, concentrated $\text{H}^+/\text{MnO}_4^-(\text{aq})$
- 3 $\text{CH}_3\text{CH}_2\text{OH}$ with $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}(\text{aq})$

- 40 The diagram shows the structure of propanamide.



propanamide

Which statements about the hydrolysis of propanamide are correct?

- 1 Propanamide can be hydrolysed by heating under reflux with $\text{H}_2\text{SO}_4(\text{aq})$.
- 2 Propanamide can be hydrolysed by heating under reflux with $\text{NaOH}(\text{aq})$.
- 3 Propanamide can be hydrolysed by cold water.

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Electronic calculators may be used.

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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.

1 Which type of bonding is **never** found in elements?

- A** covalent
- B** ionic
- C** metallic
- D** van der Waals' forces

2 Arsenic chloride, AsCl_3 , reacts with sodium borohydride, NaBH_4 .



What are the numbers **p**, **q**, **r**, **s** and **t** when this equation is balanced correctly?

	p	q	r	s	t
A	2	3	2	3	1
B	3	3	3	3	2
C	4	3	4	3	3
D	4	4	4	4	3

3 Three substances have the physical properties shown in the table.

substance	melting point / $^{\circ}\text{C}$	boiling point / $^{\circ}\text{C}$	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	-70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	V	W
A	Na	KCl	SiCl_4
B	Na	NaF	$\text{C}_2\text{H}_5\text{Br}$
C	Zn	KCl	HCl
D	Zn	NaF	SiCl_4

- 4 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

- A** 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

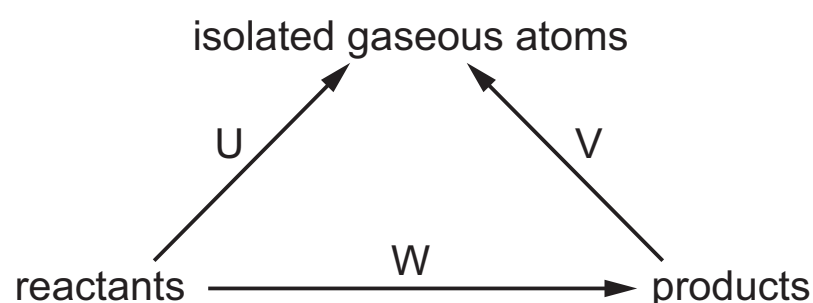
- 5 Calcium forms an ionic compound with carbon, called calcium carbide. The oxidation number of carbon in calcium carbide is -1 .

Calcium carbide is readily hydrolysed by water giving two products only.

What could be the formulae of calcium carbide and the two products of hydrolysis?

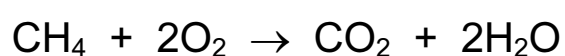
	calcium carbide	products
A	Ca_2C	CaO and C_2H_4
B	Ca_2C	$\text{Ca}(\text{OH})_2$ and C_2H_2
C	CaC_2	CaO and C_2H_4
D	CaC_2	$\text{Ca}(\text{OH})_2$ and C_2H_2

- 6 Hess' law may be used to determine enthalpy changes using average bond energies, as shown in the diagram.



U is the sum of the average bond energies of the reactants, and V is the sum of the average bond energies of the products.

For the reaction shown below, which expression will give a value for W, the enthalpy change of combustion of methane?



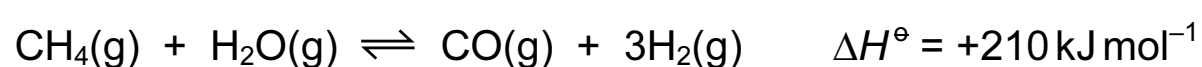
- A** $U - V$ **B** $U + V$ **C** $2(U - V)$ **D** $V - U$

- 7 The process of electrolysis can be used to purify copper, and to extract aluminium from an aluminium oxide/cryolite mixture.

What are the reactions at the anode in each of these processes?

	purification of copper	extraction of aluminium
A	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$	$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^{-}$
B	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$	$4\text{OH}^{-} \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^{-}$
C	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$	$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^{-}$
D	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$	$4\text{OH}^{-} \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^{-}$

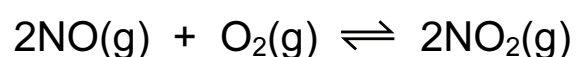
- 8 Hydrogen can be obtained by reacting methane with steam.



Which conditions of pressure and temperature will give the greatest equilibrium yield of hydrogen?

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

- 9 Nitrogen monoxide reacts with oxygen in a reversible reaction according to the equation shown below.



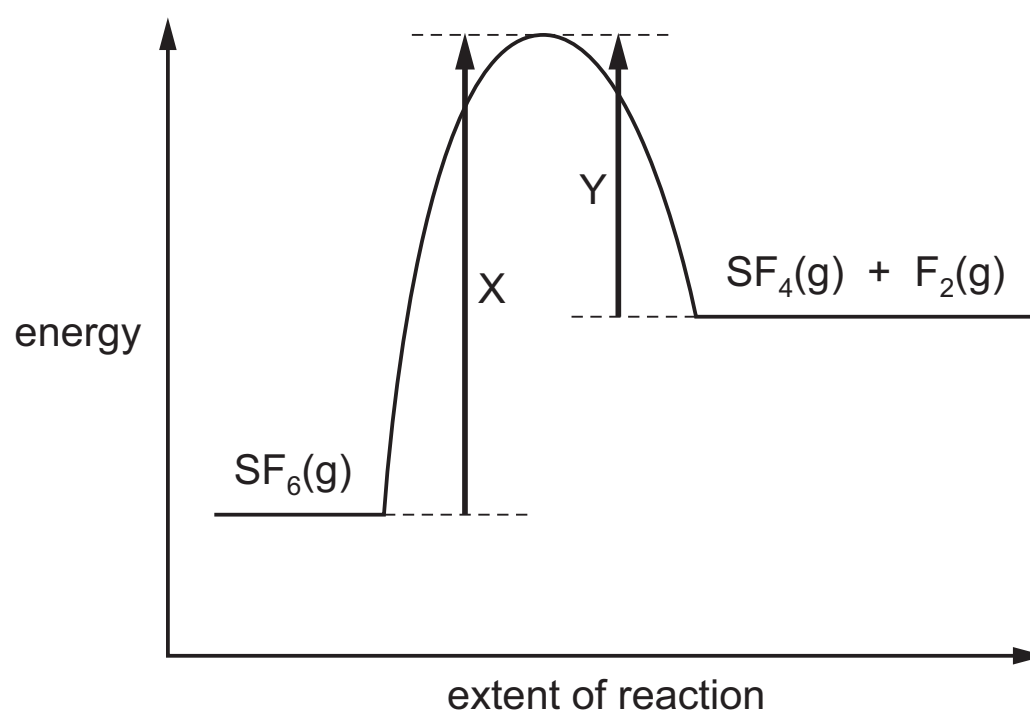
The partial pressures of each of the components in an equilibrium mixture are shown in the table.

partial pressure NO / kPa	partial pressure O ₂ / kPa	partial pressure NO ₂ / kPa
10	30	20

What is the numerical value of the equilibrium constant, K_p , for this equilibrium?

- A** 6.67×10^{-2} **B** 1.33×10^{-1} **C** 7.50 **D** 15.0

- 10 The decomposition reaction $\text{SF}_6(\text{g}) \rightarrow \text{SF}_4(\text{g}) + \text{F}_2(\text{g})$ can be described by the reaction pathway diagram shown.



What are the values of $\Delta H^\ominus$ and E_a for this reaction?

	$\Delta H^\ominus$	E_a
A	X	X + Y
B	X	Y
C	X – Y	X
D	Y – X	X

- 11 Which row correctly describes what happens when the temperature of a chemical reaction is **decreased**?

	activation energy (E_a)	number of successful collisions
A	decreases	decreases
B	decreases	increases
C	remains the same	decreases
D	remains the same	increases

- 12 Which property decreases on descending Group II?

- A** radius of the cation, M^{2+}
- B** reactivity of the element with water
- C** shielding of outermost electrons
- D** the ease of thermal decomposition of the carbonates, MCO_3

13 *Use of the Data Booklet is relevant to this question.*

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783g of anhydrous barium nitrate reacts with an excess of aluminium?

- A** 46.8 cm³ **B** 72.0 cm³ **C** 93.6 cm³ **D** 144 cm³

14 Which chloride of a Period 3 element dissolves in water to form a solution with a pH of 7?

- A** aluminium chloride
B phosphorus(V) chloride
C silicon(IV) chloride
D sodium chloride

15 *Use of the Data Booklet is relevant to this question.*

Which row correctly compares the electrical conductivity and first ionisation energy of magnesium and aluminium?

	higher electrical conductivity	higher first ionisation energy
A	aluminium	aluminium
B	aluminium	magnesium
C	magnesium	aluminium
D	magnesium	magnesium

- 16** Use of the Data Booklet is relevant to this question.

Brine is concentrated aqueous sodium chloride.

In the commercial electrolysis of brine, the products are chlorine, hydrogen and sodium hydroxide.

What is the maximum yield of each of these products when 58.5 kg of sodium chloride are electrolysed as brine?

	yield of chlorine / kg	yield of hydrogen / kg	yield of sodium hydroxide / kg
A	35.5	1	40
B	35.5	2	40
C	71	1	40
D	71	2	80

- 17** A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. Some observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

- A** Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.
- B** Concentrated phosphoric acid is a stronger oxidising agent than iodine.
- C** Concentrated sulfuric acid is a stronger oxidising agent than chlorine.
- D** Concentrated sulfuric acid is a stronger oxidising agent than iodine.
- 18** A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. Excess aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

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

Which statement about X or Y is correct?

- A** X is a pure white colour.
- B** X is pure silver iodide.
- C** Y is pure silver chloride.
- D** Y is yellow.

19 *Use of the Data Booklet is relevant to this question.*

4.70 g of an ammonium salt is heated with excess aqueous sodium hydroxide. The volume of ammonia gas given off, measured at room temperature and pressure, is 1.41 dm^3 .

Which ammonium salt was used?

- A** ammonium bromide ($M_r = 97.9$)
- B** ammonium carbonate ($M_r = 96$)
- C** ammonium nitrate ($M_r = 80$)
- D** ammonium sulfate ($M_r = 132.1$)

20 Which ester is formed when the alcohol $\text{CH}_3\text{CH}_2\text{OH}$ is reacted with $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$?

- A** butyl ethanoate
- B** ethyl butanoate
- C** ethyl propanoate
- D** propyl ethanoate

21 Which compound shows optical isomerism?

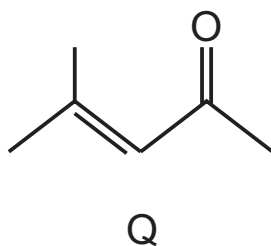
- A** 2-chloropropane
- B** 1,2-dichloropropane
- C** 1,3-dichloropropane
- D** 2,2-dichloropropane

22 Methanoic acid, HCO_2H , has acidic properties similar to those of other carboxylic acids. In addition it can be oxidised by the same oxidising agents that are capable of oxidising aldehydes.

Which pair consists of two compounds that will give the same observations with Fehling's reagent?

- A** HCO_2H and $\text{CH}_3\text{CO}_2\text{H}$
- B** HCO_2H and $\text{CH}_3\text{CO}_2\text{CH}_3$
- C** HCO_2H and $\text{CH}_3\text{CH}_2\text{COCH}_3$
- D** HCO_2H and $\text{CH}_3\text{CH}_2\text{CHO}$

23 Compound Q can be made from propanone.



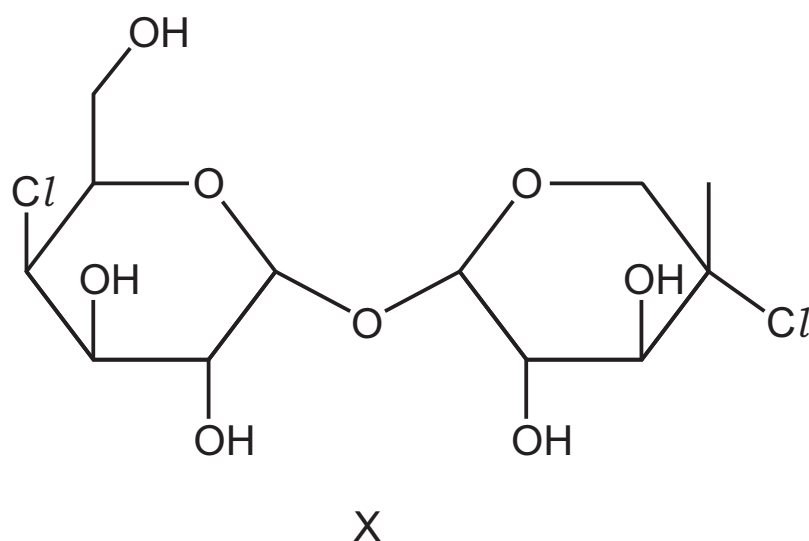
Which types of reaction will Q undergo?

- A** nucleophilic addition and electrophilic addition
 - B** nucleophilic addition and nucleophilic substitution
 - C** nucleophilic addition only
 - D** nucleophilic substitution and electrophilic addition
- 24** The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

Which compound would cause the most depletion of the ozone layer?

- A** CCl_3F **B** CF_4 **C** CO_2 **D** SO_2

25 Compound X has been investigated for use as an artificial sweetener.



The two C–Cl bonds can be hydrolysed by hot NaOH(aq). The C–O–C bonds **cannot** be hydrolysed by hot NaOH(aq).

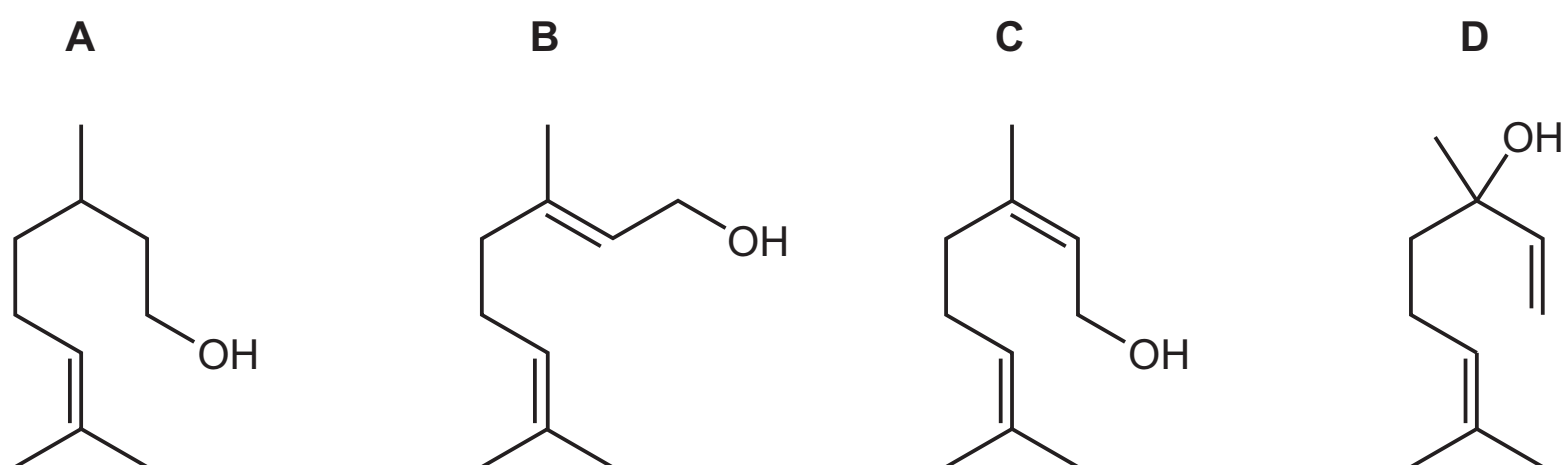
What are the numbers of specified types of –OH groups before and after hydrolysing the two C–Cl bonds?

	before hydrolysis	after hydrolysis		
	secondary	primary	secondary	tertiary
A	0	1	2	4
B	0	2	1	4
C	4	1	5	1
D	4	2	4	1

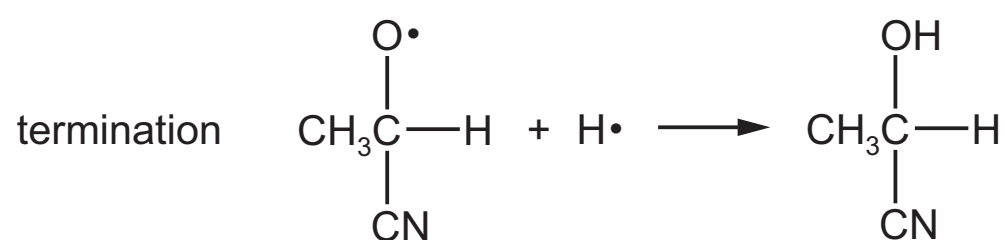
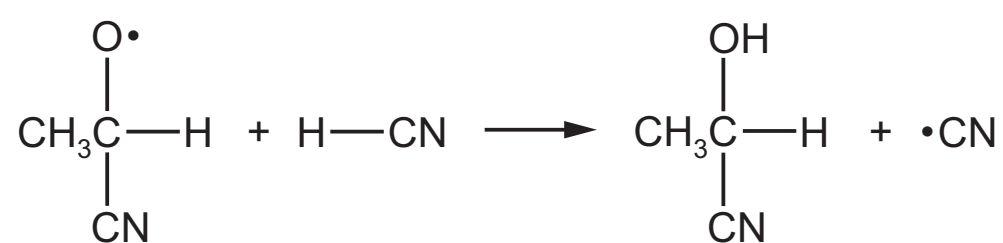
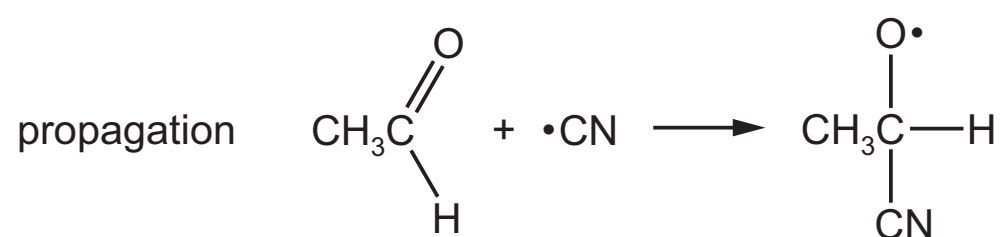
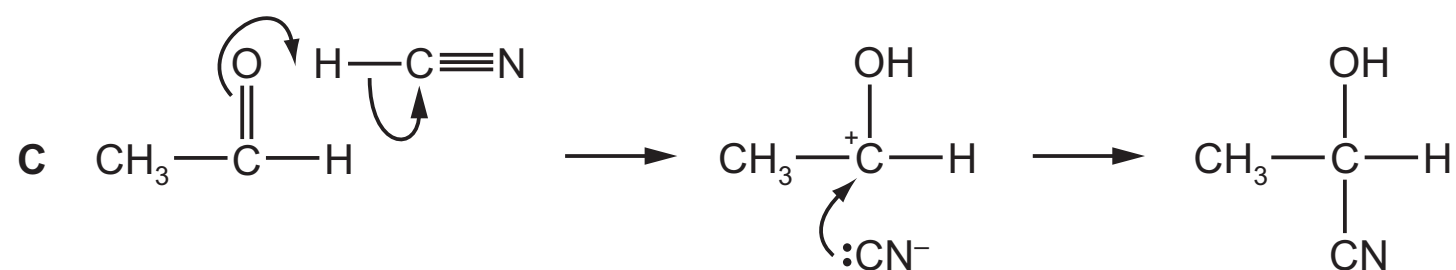
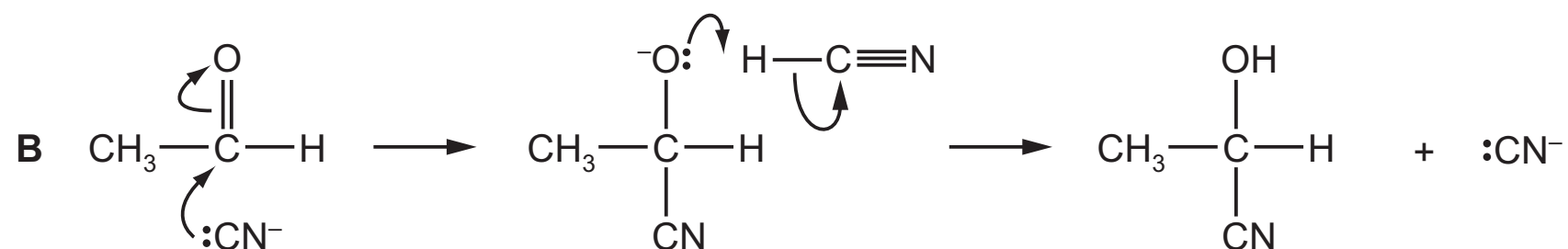
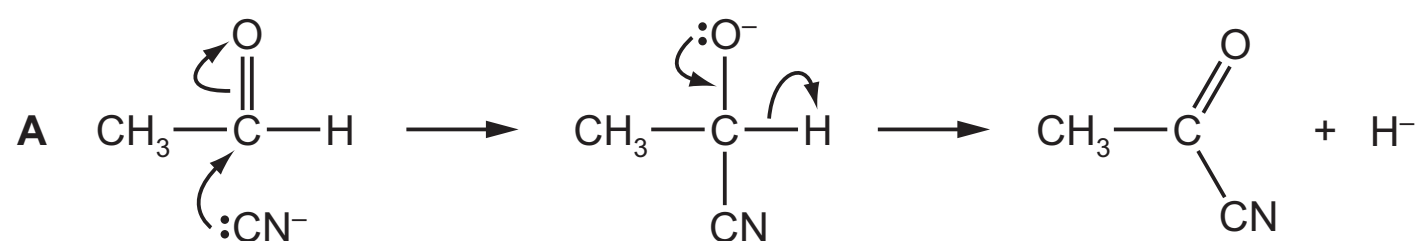
26 The compounds below are all produced by plants.

Each compound is warmed with acidified potassium dichromate(VI).

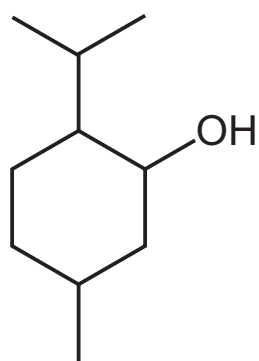
Which compound will give a different observation to the other three?



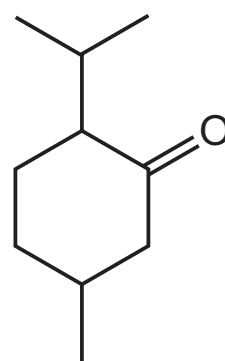
27 What is the mechanism for the reaction of ethanal, CH_3CHO , with hydrogen cyanide, HCN , in the presence of a base?



28 Menthol and menthone are both found in peppermint oil.



menthol

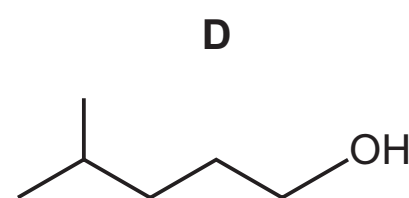
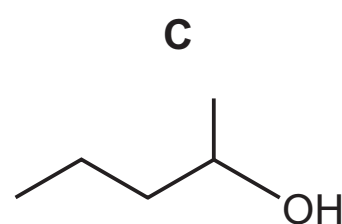
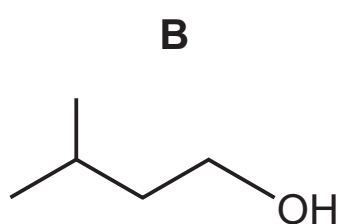
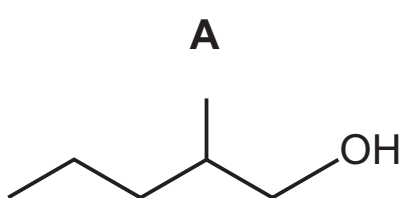


menthone

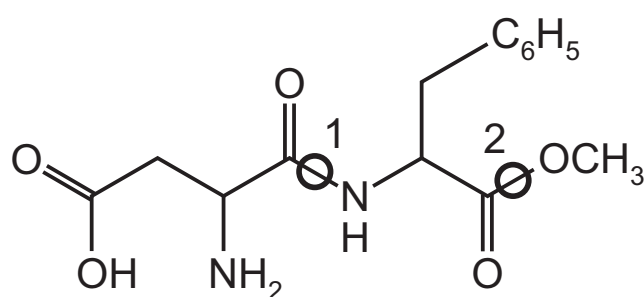
Which statement about these compounds is correct?

- A Both compounds can undergo mild oxidation.
- B Both compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
- C Menthol can be formed from menthone by reaction with NaBH_4 .
- D Menthone gives a positive test when warmed with Tollens' reagent.

29 What is the skeletal formula of 2-methylpentan-1-ol?



30 The structure of aspartame, which is used as an artificial sweetener, is shown.



aspartame

If aspartame is warmed in aqueous alkali, which of bonds 1 and 2 will be broken?

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

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.

31 The relative molecular mass, M_r , of a particular sample of chlorine is 72.0.

Which properties of the atoms in this sample will be the same for all of the atoms?

- 1** radius
- 2** nucleon number
- 3** isotopic mass

32 Which of the following influence the size of the ionisation energy of an atom?

- 1** the amount of shielding by the inner electrons
- 2** the charge on the nucleus
- 3** the distance between the outer electrons and the nucleus

33 Which equations can apply to an ideal gas?

[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

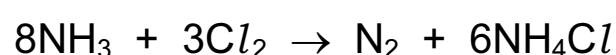
1 $p = \frac{\rho RT}{M}$ **2** $pV = \frac{cRT}{M}$ **3** $pV = MRT$

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 Ammonia and chlorine react in the gas phase.



Which statements are correct?

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

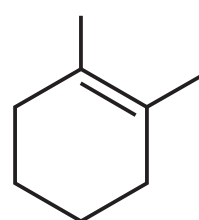
35 Which statements about calcium and strontium compounds are correct?

- 1** When calcium oxide and strontium oxide are added to water they both produce alkalis.
- 2** Calcium hydroxide is more soluble than strontium hydroxide.
- 3** Calcium sulfate is less soluble than strontium sulfate.

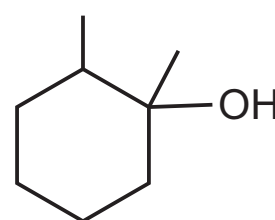
36 Which descriptions of the ammonium ion are correct?

- 1** It contains ten electrons.
- 2** It has a bond angle of 109.5° .
- 3** It has only three bonding pairs of electrons.

37 Compound Q is obtained by adding H_2O across the double bond in compound P.



P



Q

Which statements about these two compounds are correct?

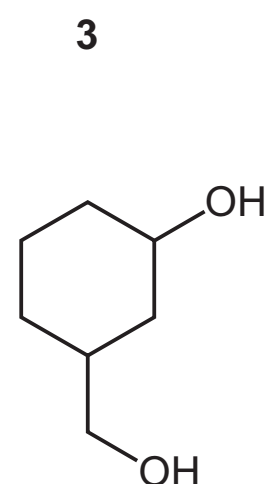
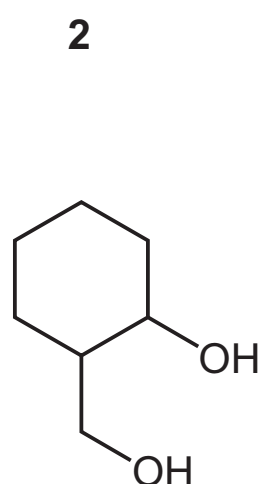
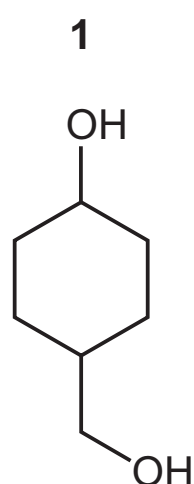
- 1** P shows *cis-trans* isomerism.
- 2** Q contains two chiral centres.
- 3** Q is a tertiary alcohol.

- 38 **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when excess dilute aqueous ammonia is added.

What could be the identity of **X**?

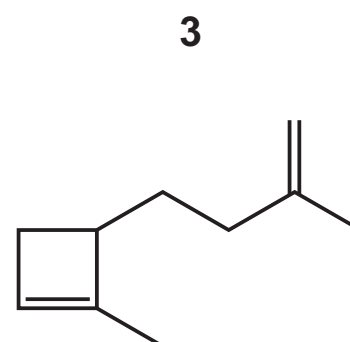
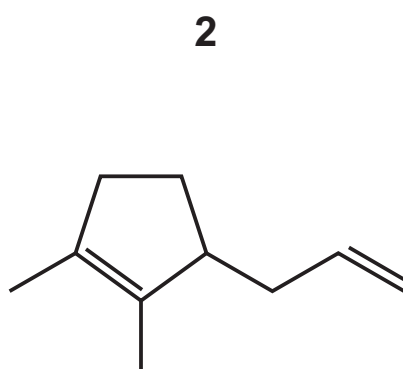
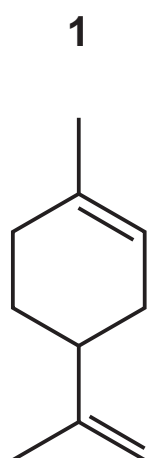
- 1 2-chlorobutane
- 2 2-bromobutane
- 3 iodomethane

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



- 40 Compound **Z** is heated with concentrated acidified potassium manganate(VII). This produces an equimolar mixture of CO_2 and $CH_3COCH_2CH_2CH(COCH_3)CH_2CO_2H$.

What could be the structural formula of **Z**?



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CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2015

1 hour

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

* 8 0 5 0 0 2 2 5 2 2 *



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 **13** printed pages and **3** 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.

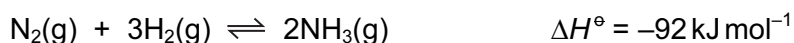
- 1 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12 300

What could be the formula of a chloride of X?

- A** XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

- 2 Which set of conditions gives the highest yield of ammonia at equilibrium?



	catalyst	pressure	temperature
A	absent	high	low
B	absent	low	high
C	present	high	high
D	present	low	low

- 3 *Use of the Data Booklet is relevant to this question.*

The compound S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S_2O_7 is hydrolysed?

- A** 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

- 4 Nitrogen, N_2 , and carbon monoxide, CO , both have $M_r = 28$.

The boiling point of N_2 is 77 K.

The boiling point of CO is 82 K.

What could be responsible for this difference in boiling points?

- A** CO molecules have a permanent dipole, the N_2 molecules are not polar.
B N_2 has σ and π bonding, CO has σ bonding only.
C N_2 has a strong $\text{N}\equiv\text{N}$ bond, CO has a $\text{C}=\text{O}$ bond.
D The CO molecule has more electrons than the N_2 molecule.

- 5 Some car paints contain small flakes of silica, SiO_2 .

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

- 6 Solid sulfur consists of molecules made up of eight atoms covalently bonded together.

The bonding in sulfur dioxide is $\text{O}=\text{S}=\text{O}$.

enthalpy change of combustion of S_8 , $\Delta H_c^\circ \text{S}_8(\text{s}) = -2376 \text{ kJ mol}^{-1}$

energy required to break 1 mole $\text{S}_8(\text{s})$ into gaseous atoms = 2232 kJ mol^{-1}

$\text{O}=\text{O}$ bond enthalpy = 496 kJ mol^{-1}

Using these data, what is the value of the $\text{S}=\text{O}$ bond enthalpy?

- A** 239 kJ mol^{-1} **B** 257 kJ mol^{-1} **C** 319 kJ mol^{-1} **D** 536 kJ mol^{-1}

- 7 Use of the Data Booklet is relevant for this question.

In an experiment, the burning of 1.45 g (0.025 mol) of propanone was used to heat 100 g of water. The initial temperature of the water was 20.0°C and the final temperature of the water was 78.0°C .

Which experimental value for the enthalpy change of combustion for propanone can be calculated from these results?

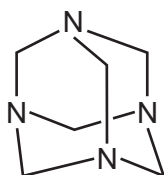
- A** $-1304 \text{ kJ mol}^{-1}$
B -970 kJ mol^{-1}
C -352 kJ mol^{-1}
D $-24.2 \text{ kJ mol}^{-1}$

- 8 Which row correctly describes the electrodes that can be used in a diaphragm cell for the production of chlorine, hydrogen and sodium hydroxide?

	anode	cathode
A	steel	graphite
B	steel	titanium
C	titanium	graphite
D	titanium	steel

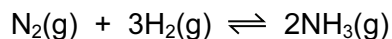
- 9 Hexamine is a crystalline solid used as a fuel in portable stoves.

The diagram shows its skeletal structure.



What is the empirical formula of hexamine?

- A** CH₂N **B** C₃H₆N₂ **C** C₄H₈N₄ **D** C₆H₁₂N₄
- 10 A mixture of nitrogen and hydrogen gases, at a temperature of 500 K, was put into an evacuated vessel of volume 6.0 dm³. The vessel was then sealed.

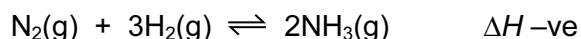


The mixture was allowed to reach equilibrium. It was found that 7.2 mol of N₂ and 12.0 mol of H₂ were present in the equilibrium mixture. The value of the equilibrium constant, K_c , for this equilibrium is 6.0×10^{-2} at 500 K.

What is the concentration of ammonia present in the equilibrium mixture at 500 K?

- A** 0.58 mol dm⁻³
B 0.76 mol dm⁻³
C 3.5 mol dm⁻³
D 27 mol dm⁻³

- 11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.



What will increase the rate of the forward reaction?

- A adding argon to the mixture but keeping the total volume constant
 - B decreasing the temperature
 - C increasing the total pressure by reducing the total volume at constant temperature
 - D removing ammonia as it is made but keeping the total volume of the mixture the same
- 12 **X** is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.

What could be the identity of **X**?

- A magnesium
 - B calcium
 - C strontium
 - D barium
- 13 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

- A barium carbonate
 - B barium chloride
 - C barium hydroxide
 - D barium sulfate
- 14 *Use of the Data Booklet is relevant to this question.*

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

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

- 15 The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
mp/K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

- A** the changes in first ionisation energy from sodium to aluminium
- B** the increase in electronegativity from sodium to aluminium
- C** the increase in the A_r of the elements from sodium to aluminium
- D** the increase in the number of outer electrons in each atom from sodium to aluminium
- 16 **X** is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.
- A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide solution.
- What could be the identity of **X**?
- A** Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3
- 17 Which statement about bromine is correct?
- A** Bromine is insoluble in non-polar solvents.
- B** Bromine vapour is more dense than air.
- C** Bromine will not vaporise significantly under normal conditions.
- D** Gaseous bromine is purple.
- 18 The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in excess dilute aqueous ammonia to form a colourless solution.

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

What is **Z**?

- A** $AgCl$ **B** $BaCl_2$ **C** $Ba(NO_3)_2$ **D** NH_4NO_3

- 19 Element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.

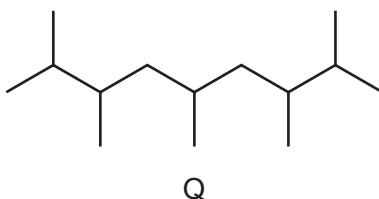
Student P 'The molecule of Y contains lone pairs of electrons.'

Student Q 'The oxidation number of X increases by 1 from Y to Z.'

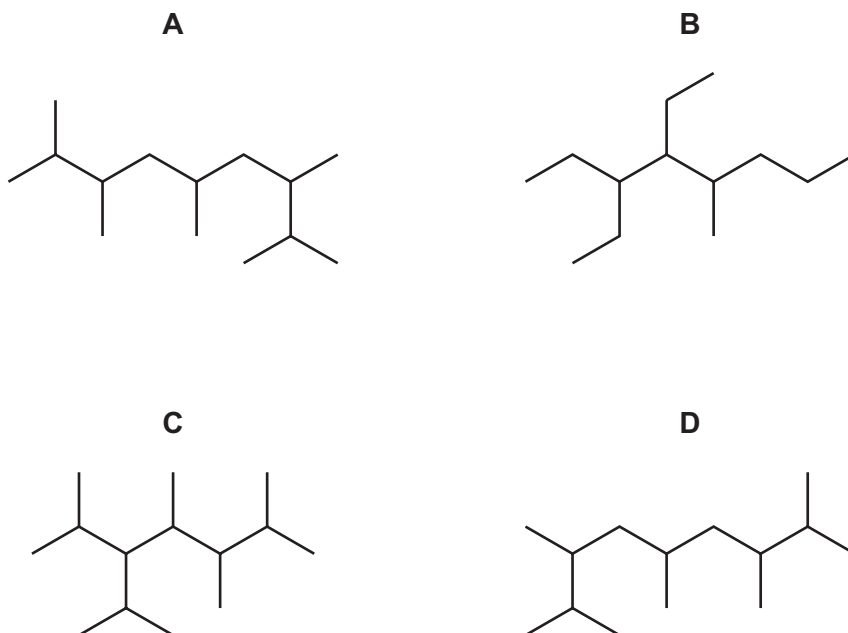
X could be carbon or nitrogen or sulfur.

Which student(s) made a correct statement?

- A P only
 B Q only
 C both P and Q
 D neither P nor Q
- 20 How many isomeric esters have the molecular formula $C_4H_8O_2$?
- A 2 B 3 C 4 D 5
- 21 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



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



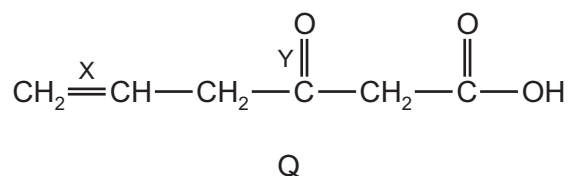
- 22** Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.

The table below shows the boiling points of some alkanes.

alkane	boiling point / °C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

What is the correct explanation for the difference in the boiling points of the three isomers with $M_r = 72$?

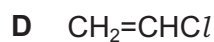
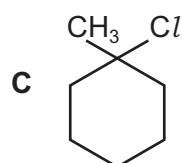
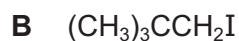
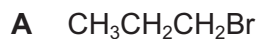
- A** Boiling point is dependent upon the length of the carbon chain **only**.
- B** Increased branching on a carbon chain increases the boiling point.
- C** Increased branching reduces the strength of the intermolecular hydrogen bonding.
- D** Increased branching reduces the strength of the intermolecular van der Waals' forces.
- 23** Compound Q contains three double bonds per molecule.



Which bond, X or Y, will be ruptured by hot, concentrated acidified KMnO_4 and how many lone pairs of electrons are present in one molecule of Q?

	bond ruptured by hot, concentrated acidified KMnO_4	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

24 Which compound undergoes an S_N1 substitution reaction with NaOH(aq) ?



25 If the starting material is iodoethane, which sequence of reactions will produce propanoic acid as the main final product in good yield?

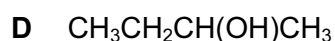
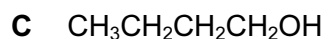
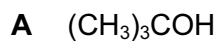
A add NaOH(aq) , isolate the organic product, add acidified $\text{K}_2\text{Cr}_2\text{O}_7$ and boil under reflux

B add NaOH(aq) , isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

C heat with HCN in ethanol, isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

D heat with KCN in ethanol, isolate the organic product, add $\text{H}_2\text{SO}_4(\text{aq})$ and boil under reflux

26 Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?



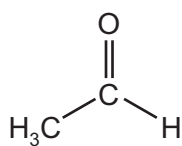
27 Butan-2-ol can be made by reducing X with H_2/Ni .

Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.

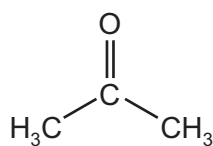
Which row is correct?

	X is	<i>cis-trans</i> isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

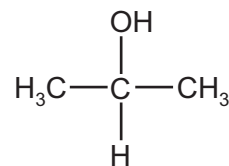
28 Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q

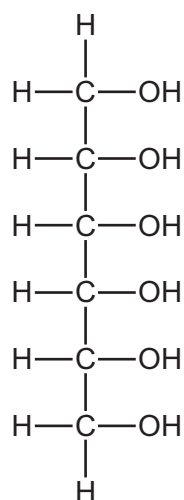


R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

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

29 Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.



sorbitol

How many chiral centres are present in sorbitol?

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

30 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

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

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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

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

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

31 Which statements about orbitals in a krypton atom are correct?

- 1** The 1s and 2s orbitals have the same energy as each other but different sizes.
- 2** The third energy level ($n=3$) has three subshells and nine orbitals.
- 3** The 3d subshell has five orbitals that have the same energy as each other in an isolated atom.

32 The Group IV elements carbon, silicon and germanium can all exist in the giant molecular structure which is also found in diamond. The bond lengths in these structures are given below.

element X	C	Si	Ge
bond length X–X/nm	0.154	0.234	0.244

Why does the bond length increase down the group?

- 1** Orbital overlap decreases down the group.
- 2** Atomic radius increases down the group.
- 3** Nuclear charge increases down the group.

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 The salt NaClO_3 is used as a non-selective weedkiller.

On careful heating, this reaction occurs: $4\text{NaClO}_3 \rightarrow \text{NaCl} + 3\text{NaClO}_4$.

On strong heating this reaction occurs: $\text{NaClO}_4 \rightarrow \text{NaCl} + 2\text{O}_2$.

The overall reaction is $2\text{NaClO}_3 \rightarrow 2\text{NaCl} + 3\text{O}_2$.

What do these equations show?

- 1** NaClO_3 can behave as an oxidising agent.
- 2** NaClO_3 can behave as a reducing agent.
- 3** The oxidation numbers of chlorine in the three compounds shown are +6, +8 and -1.

34 Which statements correctly describe an effect of a rise in temperature on a gas-phase reaction?

- 1** More particles now have energies greater than the activation energy.
- 2** The energy distribution profile changes with more particles having the most probable energy.
- 3** The activation energy of the reaction is decreased.

35 Which statements concerning the Group II elements magnesium, calcium and barium are correct?

- 1** Their reactivity increases with increasing relative atomic mass.
- 2** The oxidation number exhibited in their stable compounds is +2.
- 3** On strong heating, their nitrates give off oxygen only.

36 Sulfur dioxide is used as a food preservative.

Which statements about sulfur dioxide, SO_2 , are correct?

- 1** SO_2 behaves as an antioxidant.
- 2** Aqueous SO_2 contains SO_3^{2-} ions.
- 3** SO_2 inhibits the growth of mould and yeasts.

- 37 An oxidising agent that can oxidise ethanal to ethanoic acid, or to ethanoate ions, will also oxidise methanoic acid, HCO_2H , to carbon dioxide and water.

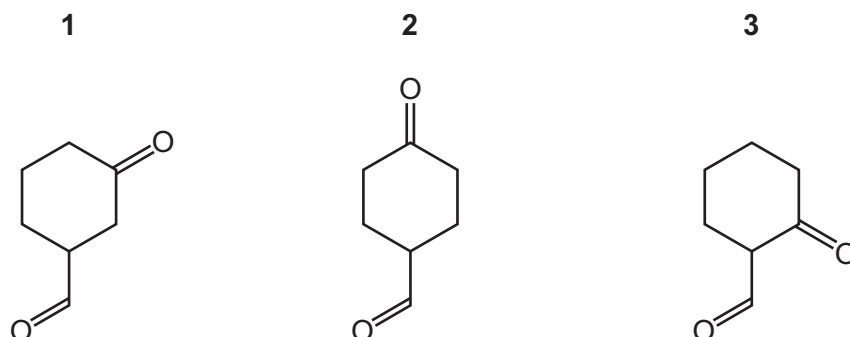
Which reagents, on heating, will react differently with HCO_2H and $\text{CH}_3\text{CO}_2\text{H}$?

- 1 $\text{Na}_2\text{CO}_3(\text{aq})$
- 2 Fehling's reagent
- 3 dilute acidified KMnO_4

- 38 Each of the compounds below is treated separately with excess NaBH_4 . The product of each reaction is then heated with excess concentrated H_2SO_4 .

In each case, one or more products are formed with molecular formula C_7H_{10} .

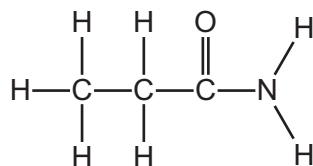
Which compounds give **only one** final product with the molecular formula C_7H_{10} ?



- 39 Which reactions result in the formation of propanoic acid?

- 1 $\text{CH}_3\text{CH}_2\text{CO}_2\text{Na}$ with dilute $\text{H}_2\text{SO}_4(\text{aq})$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$ with hot, concentrated $\text{H}^+/\text{MnO}_4^-(\text{aq})$
- 3 $\text{CH}_3\text{CH}_2\text{OH}$ with $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}(\text{aq})$

- 40 The diagram shows the structure of propanamide.



propanamide

Which statements about the hydrolysis of propanamide are correct?

- 1 Propanamide can be hydrolysed by heating under reflux with $\text{H}_2\text{SO}_4(\text{aq})$.
- 2 Propanamide can be hydrolysed by heating under reflux with $\text{NaOH}(\text{aq})$.
- 3 Propanamide can be hydrolysed by cold water.

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