UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **October/November 2013**

1 hour

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

9509356916

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, 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.

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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 At the age of 17, in a woodshed in Ohio, Charles Martin Hall discovered the commercial process for the production of aluminium metal by the electrolysis of a mixture of bauxite, Al_2O_3, and cryolite, Na_3AlF_6.

What is the main purpose of the cryolite?

A Al_2O_3 is covalent, and AlF_6^{3-} ions interact with it to produce Al^{3+} ions which can be discharged at the cathode.

B Cryolite is a base, forming $NaAlO_2$ with bauxite, enabling aluminium to be discharged at the anode.

C Cryolite minimises the release of O^{2-} ions at the graphite anodes, which are otherwise burnt away to CO.

D Cryolite reduces the melting point of the bauxite.

2 In which reaction does a single nitrogen atom have the greatest change in oxidation number?

A $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

B $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

C $2NO + O_2 \rightarrow 2NO_2$

D $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

3 The following half reactions occur when potassium iodate(V), KIO_3, in hydrochloric acid solution oxidises iodine to ICl_2^-.

$$IO_3^- + 2Cl^- + 6H^+ + 4e^- \rightarrow ICl_2^- + 3H_2O$$

$$I_2 + 4Cl^- \rightarrow 2ICl_2^- + 2e^-$$

What is the ratio of IO_3^- to I_2 in the balanced chemical equation for the overall reaction?

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

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

In which set do all species contain the same number of electrons?

A Co^{2+}, Co^{3+}, Co^{4+}

B F^-, Br^-, Cl^-

C Na^+, Mg^{2+}, Al^{3+}

D K_2SO_4, K_2SeO_4, K_2TeO_4

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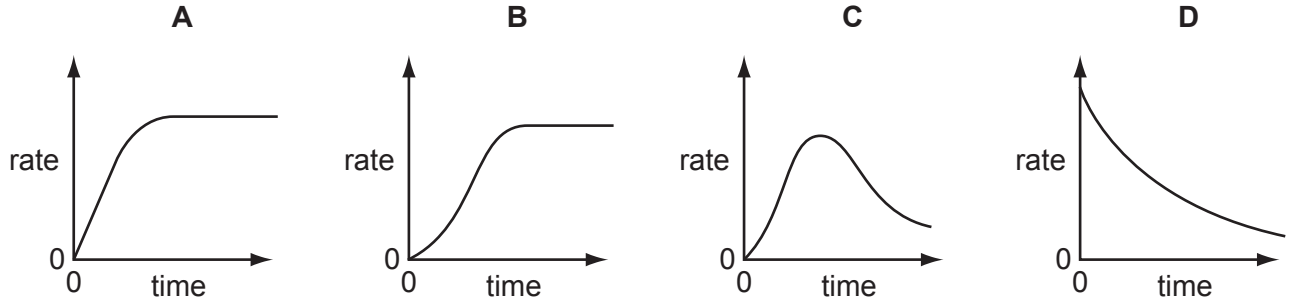
5 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve was obtained if the rate of reaction was plotted against time for an autocatalytic reaction?

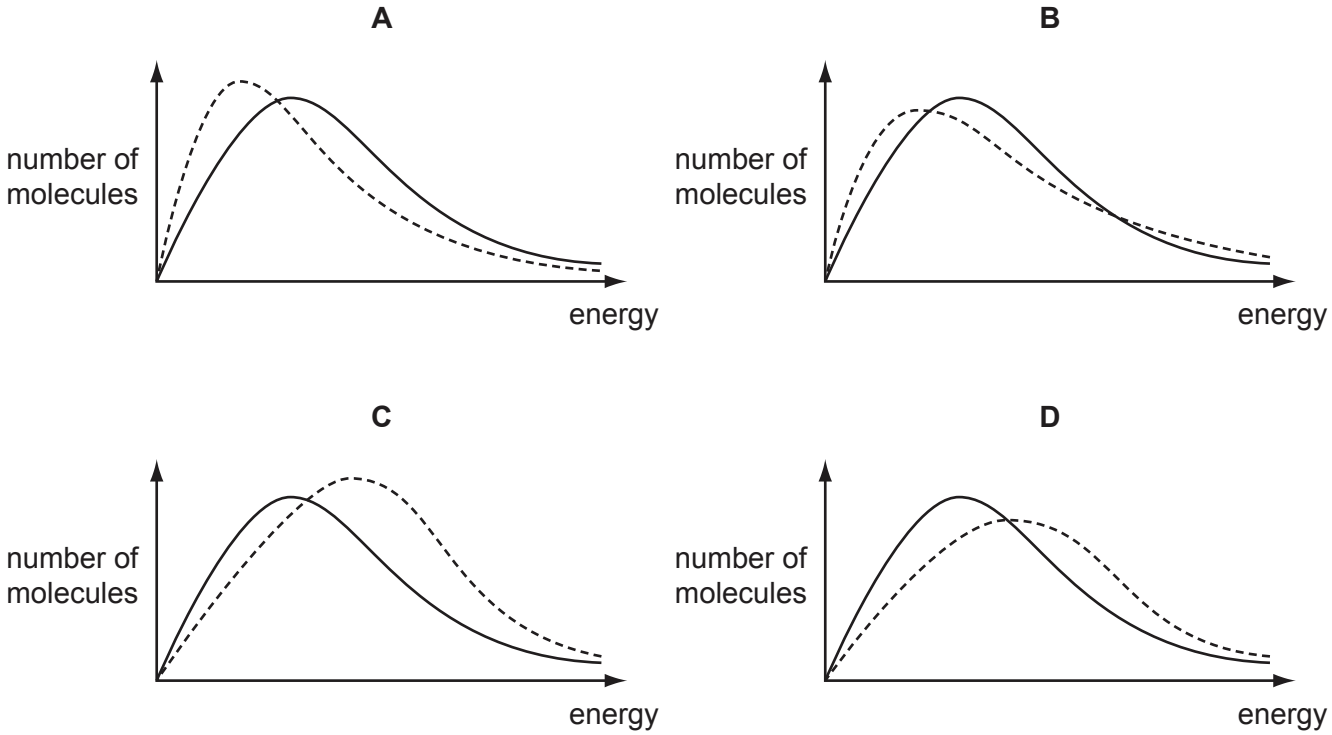


6 The diagrams below show the Boltzmann distribution for air at two temperatures.

The solid line represents the distribution at –20 °C.

The dotted line represents the distribution at –10 °C.

Which diagram is correct?



7 Which stage in the free radical substitution of methane by chlorine will have the lowest activation energy?

A $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

B $Cl\bullet + Cl\bullet \rightarrow Cl_2$

C $Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$

D $Cl_2 \rightarrow Cl\bullet + Cl\bullet$

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

The approximate percentage composition of the atmosphere on four different planets is given in the table below.

The density of a gas may be defined as the mass of 1 dm^3 of the gas measured at s.t.p.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules
A	Jupiter	H_2 89.8, He 10.2
B	Neptune	H_2 80.0, He 19.0, CH_4 1.0
C	Saturn	H_2 96.3, He 3.25, CH_4 0.45
D	Uranus	H_2 82.5, He 15.2, CH_4 2.3

9 Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\dfrac{(1.76)^2}{(2.32)(6.96)^3}$

B $\dfrac{(1.76)^2}{(2.32)(6.32)^3}$

C $\dfrac{(2.08)^2}{(2.32)(6.32)^3}$

D $\dfrac{(2.40)^2}{(2.32)(6.00)^3}$

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

Which sodium compound contains 74.2 % by mass of sodium?

A sodium carbonate

B sodium chloride

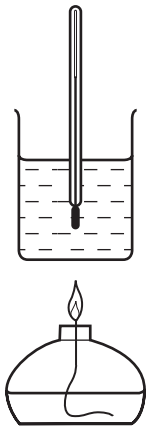
C sodium hydroxide

D sodium oxide

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

A student carried out an experiment to determine the enthalpy change for the combustion of methanol.

The following results were obtained by the student.



start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

How much of the heat energy produced by the burning of methanol went into the water?

A 209 J **B** 13 794 J **C** 20 691 J **D** 22 154 J

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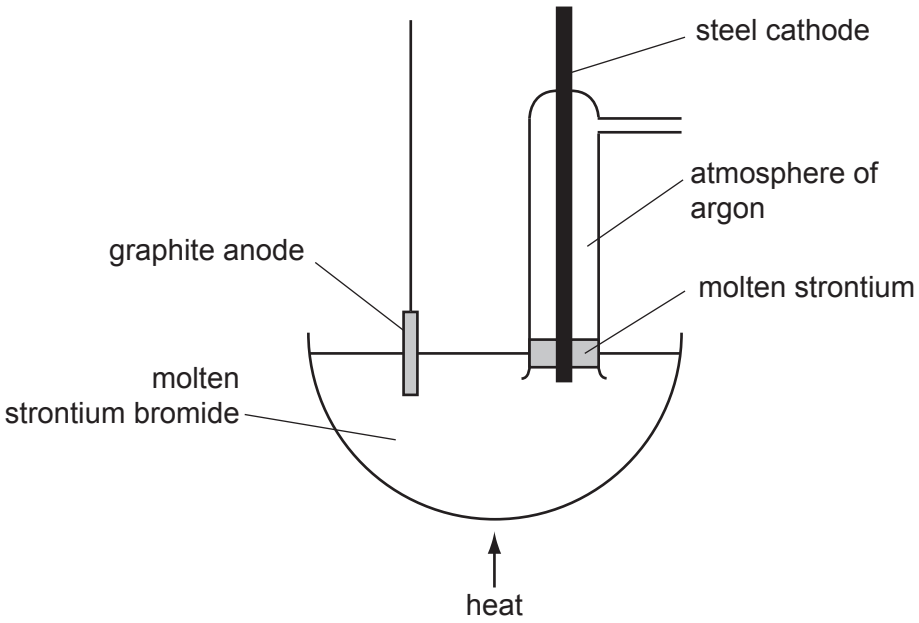
12 Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

B The argon keeps the strontium molten.

C The argon stops the molten strontium rising too high in the tube.

D Without the argon, strontium oxide would form in the air.

13 A metal, **X**, reacts with water to produce a colourless solution which gives a white precipitate when mixed with aqueous sulfuric acid.

What is metal **X**?

A barium

B magnesium

C potassium

D sodium

14 Which property **increases** in value going down Group II?

A electronegativity

B ionic radius

C maximum oxidation number

D second ionisation energy

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15 Which row correctly identifies the uses of some of the compounds of Group II metals?

	used as a refractory lining in kilns	used in agriculture to increase the pH of a soil
A	CaO	$Ca(OH)_2$
B	CaO	$Mg(OH)_2$
C	MgO	$Ca(OH)_2$
D	MgO	$Mg(OH)_2$

16 Solid potassium halides react with concentrated sulfuric acid, according to the following equations.

reaction 1 $2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$

reaction 2 $2KBr + 2H_2SO_4 \rightarrow K_2SO_4 + SO_2 + Br_2 + 2H_2O$

reaction 3 $8KI + 5H_2SO_4 \rightarrow 4K_2SO_4 + H_2S + 4I_2 + 4H_2O$

What is the largest **change** in the oxidation number of sulfur in each of these reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	0	4	8

17 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

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18 Transition metals and their compounds are used as catalysts.

Which row is correct?

	transition metal present in the catalyst used in the Contact process	transition metal present in the catalyst used in the Haber process
A	iron	iron
B	iron	vanadium
C	vanadium	iron
D	vanadium	vanadium

19 Consecutive elements **X**, **Y** and **Z** are in the third period of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What could be the identities of **X**, **Y** and **Z**?

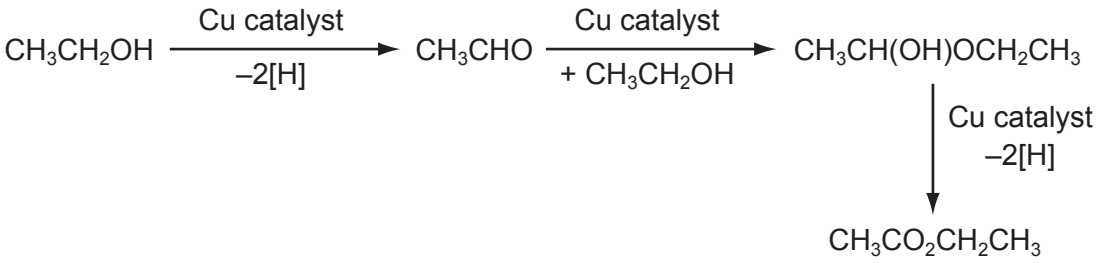
A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulfur

20 A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.



Which process is involved at some stage in this reaction sequence?

A electrophilic addition

B nucleophilic addition

C nucleophilic substitution

D reduction

21 Which reaction will give the best yield of 1-chloropropane?

A chlorine gas with propene gas in the dark

B propan-1-ol with dilute NaCl(aq)

C propan-1-ol with PCl_5

D propene with dilute HCl(aq)

22 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

leaf alcohol

What will be formed when 'leaf alcohol' is oxidised using an excess of hot, acidified $K_2Cr_2O_7$(aq)?

A $CH_3CH_2CH(OH)CH(OH)CH_2CO_2H$

B $CH_3CH_2COCOCH_2CO_2H$

C $CH_3CH_2CH{=}CHCH_2CO_2H$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

23 Which compound exhibits stereoisomerism?

A $CH_3CHCl CH_3$

B $CH_3CHCl CH_2Cl$

C $CH_3CCl_2CH_3$

D $CH_2ClCH_2CH_2Cl$

24 A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.

The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.

How should the first step in the mechanism be described?

A attack by a nucleophile on a carbon atom with a partial positive charge

B heterolytic bond fission followed by an attack by an electrophile on a carbanion

C heterolytic bond fission followed by an attack by a nucleophile on a carbocation

D homolytic bond fission followed by an attack by a nucleophile on a carbocation

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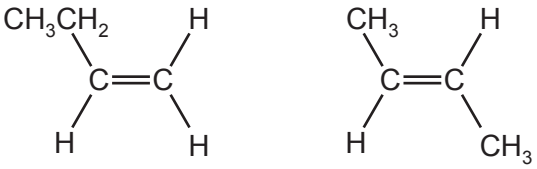
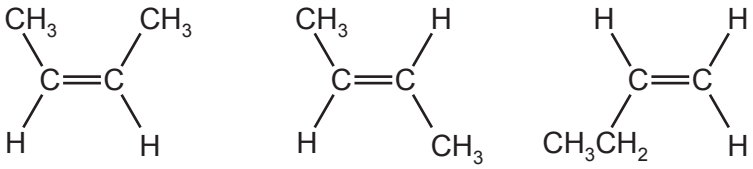
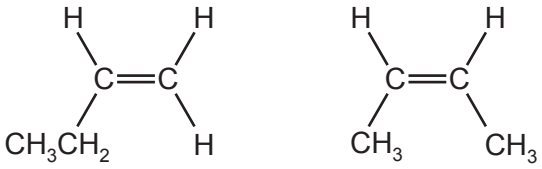
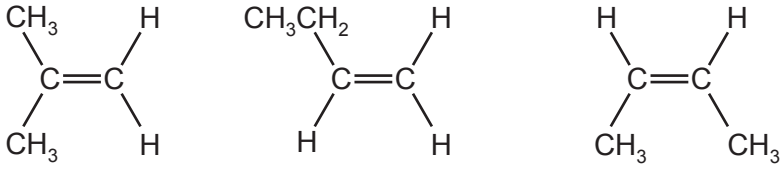
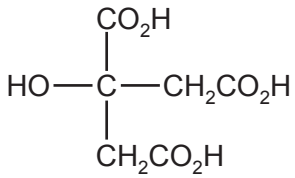
25 What are the only structures formed when butan-2-ol is heated with concentrated H_2SO_4?

A	
B	
C	
D	

26 How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?



citric acid

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

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27 Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). Both these oxidising agents change colour as they are reduced.

What is the colour of each oxidising agent before and after it has reacted?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

28 In which reaction is the organic compound oxidised?

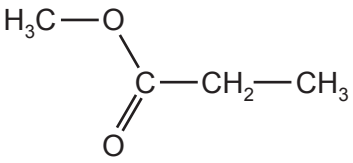
A CH_3CH_2OH + concentrated H_3PO_4

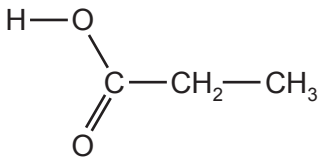
B $CH_3CH_2CH_2CHO$ + Tollens' reagent

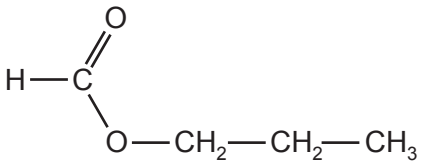
C CH_3COCH_3 + 2,4-dinitrophenylhydrazine reagent

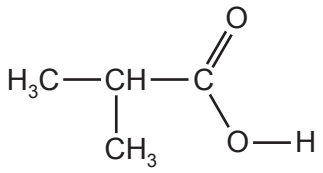
D CH_3CN + dilute H_2SO_4

29 How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?









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

30 Which types of bond breakage and bond formation occur in the addition polymerisation of alkenes?

	bond breakage	bond formation
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

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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 X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}\text{Ar}$

2 $^{40}_{20}\text{Ca}^{2+}$

3 $^{39}_{19}\text{K}^{+}$

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

Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

1 There is an empty 2p orbital in one atom of the element.

2 The principal quantum number of the highest occupied orbital is 2.

3 They form compounds in which their atoms form bonds with four other atoms.

33 What are necessary properties of a dynamic equilibrium?

1 Equal amounts of reactants and products are present.

2 Concentrations of reactants and products remain constant.

3 The rate of the forward reaction is the same as the rate of the reverse reaction.

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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 If N_2O_4 gas is placed in a sealed vessel the following equilibrium is established.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The forward reaction is endothermic.

What happens when the temperature is increased?

1 The equilibrium constant increases.

2 The partial pressure of NO_2 increases.

3 The activation energy is unchanged.

35 Which types of bonding are present in ammonium carbonate, $(NH_4)_2CO_3$?

1 ionic

2 covalent

3 co-ordinate (dative covalent)

36 Sulfur dioxide and sulfites are used in food preservation.

Why are they used for this purpose?

1 They are reducing agents which slow down the oxidation of food.

2 They inhibit the growth of aerobic bacteria.

3 They react with $NO_2(g)$ converting it to NO(g).

37 The organic compound **X** gives a precipitate when warmed with aqueous silver nitrate. This precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

1 1-bromopropane

2 2-chlorobutane

3 2-iodo,2-methylpropane

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38 An organic compound **Y**, molecular formula $C_6H_{14}O$, may be oxidised to compound **Z**, molecular formula $C_6H_{12}O_2$.

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

1 $CH_3CH_2CH(CH_2OH)CH_2CH_3$

2 $(CH_3)_3CCH_2CH_2OH$

3 $CH_3CH_2CH(CH_3)CH_2CH_2OH$

39 Which reactions can be used to make an alcohol in the laboratory?

1 hydrolysis of a bromoalkane with NaOH(aq)

2 reduction of a ketone with $NaBH_4$

3 reduction of an aldehyde with $NaBH_4$

40 The compounds below are treated with hydrogen cyanide.

Which compounds react and produce a molecule containing a chiral centre?

1 butanal

2 pentan-3-one

3 2-chlorobutane

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