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.
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Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
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There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
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This document consists of **15** printed pages and **1** blank page.

Section A

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

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+}

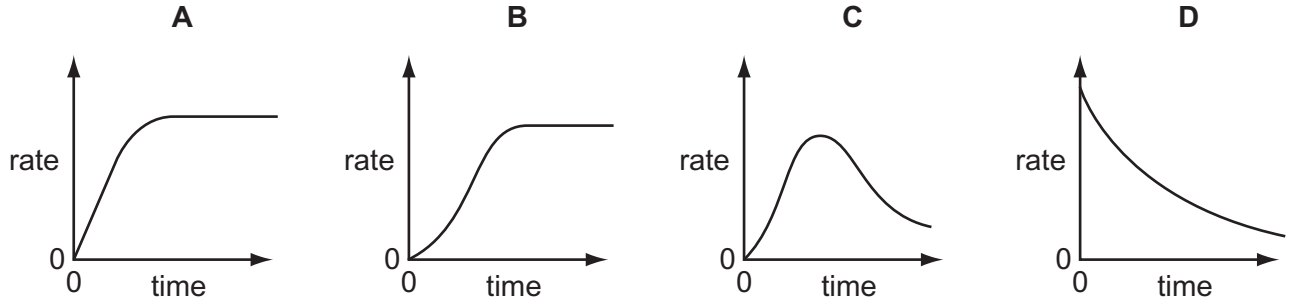
B F^-, Br^-, Cl^-

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

D K_2SO_4, K_2SeO_4, K_2TeO_4

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?

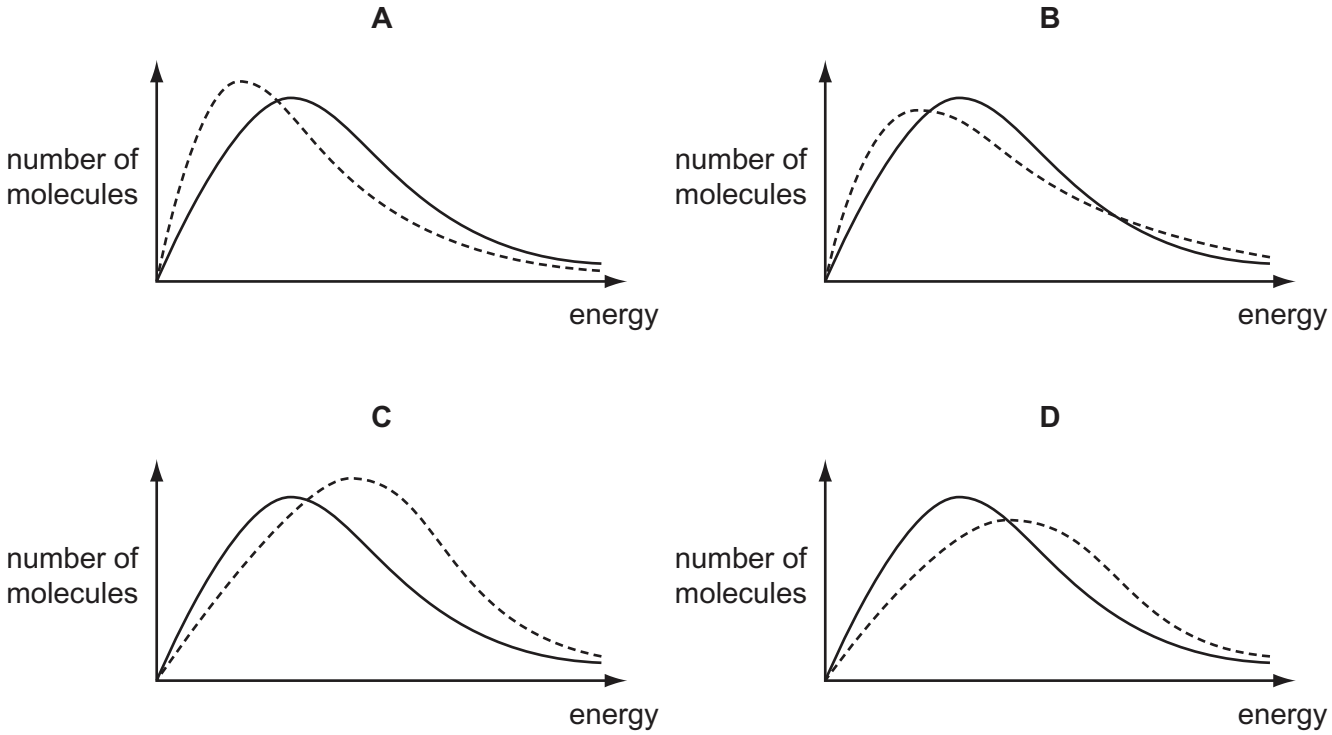


6 The diagrams below show the Boltzmann distribution for air at two temperatures.

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

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

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

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

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

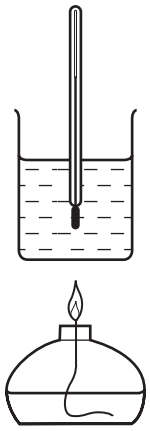
C sodium hydroxide

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.

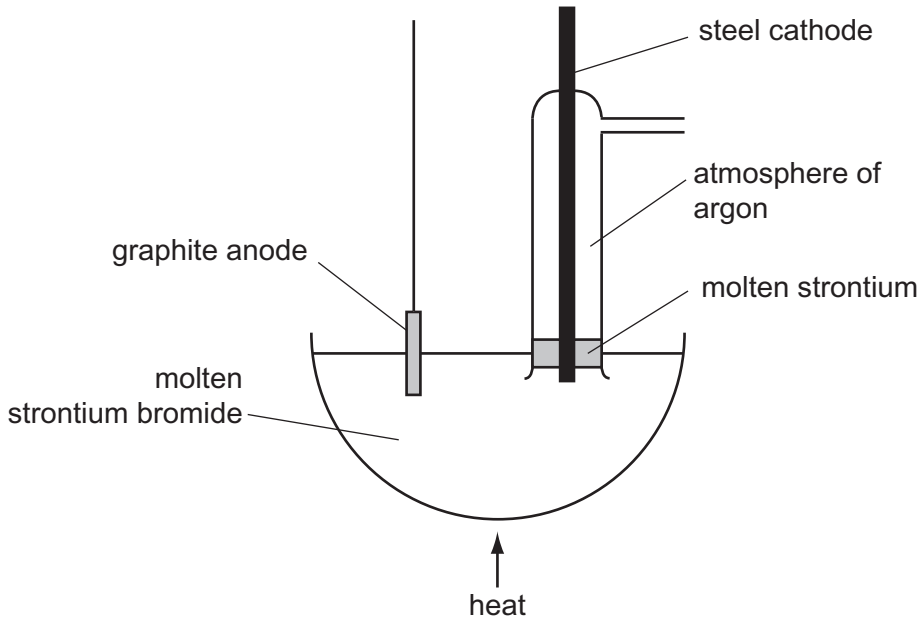


start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

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

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

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.

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**?

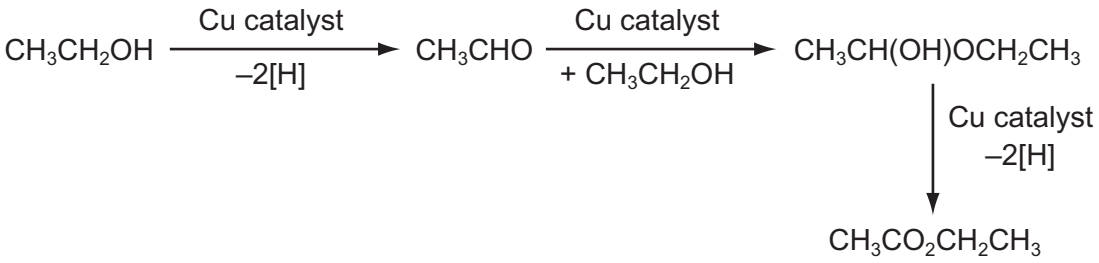
A sodium, magnesium, aluminium

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?

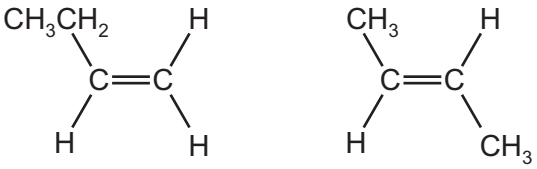
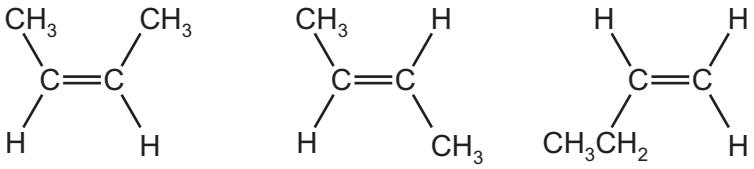
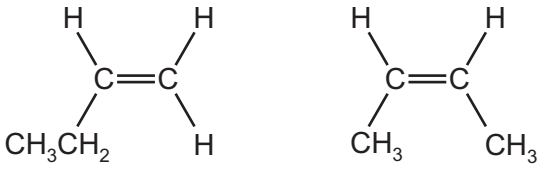
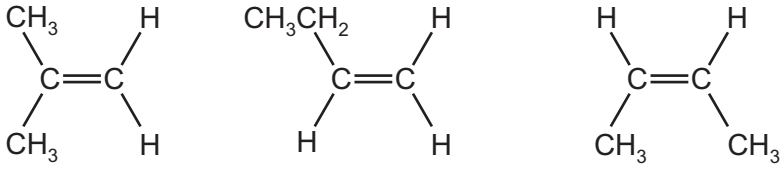
A attack by a nucleophile on a carbon atom with a partial positive charge

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

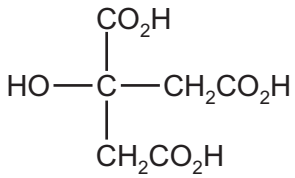
C heterolytic bond fission followed by an attack by a nucleophile on a carbocation

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

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

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?

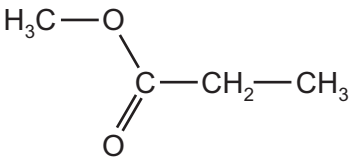
A CH_3CH_2OH + concentrated H_3PO_4

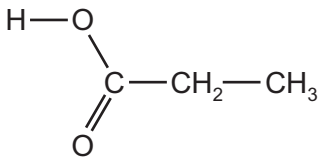
B $CH_3CH_2CH_2CHO$ + Tollens' reagent

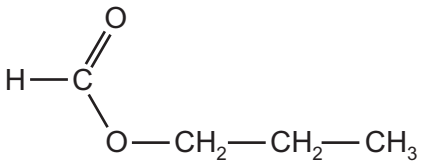
C CH_3COCH_3 + 2,4-dinitrophenylhydrazine reagent

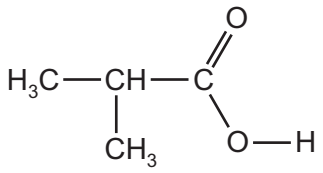
D CH_3CN + dilute H_2SO_4

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

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.

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

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

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?

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

D K_2SO_4, K_2SeO_4, K_2TeO_4

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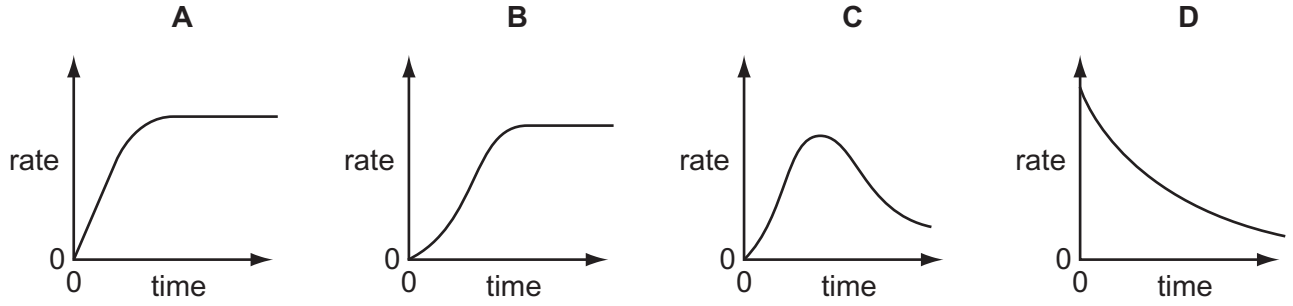
Which curve was obtained if the rate of reaction was plotted against time for an autocatalytic reaction?



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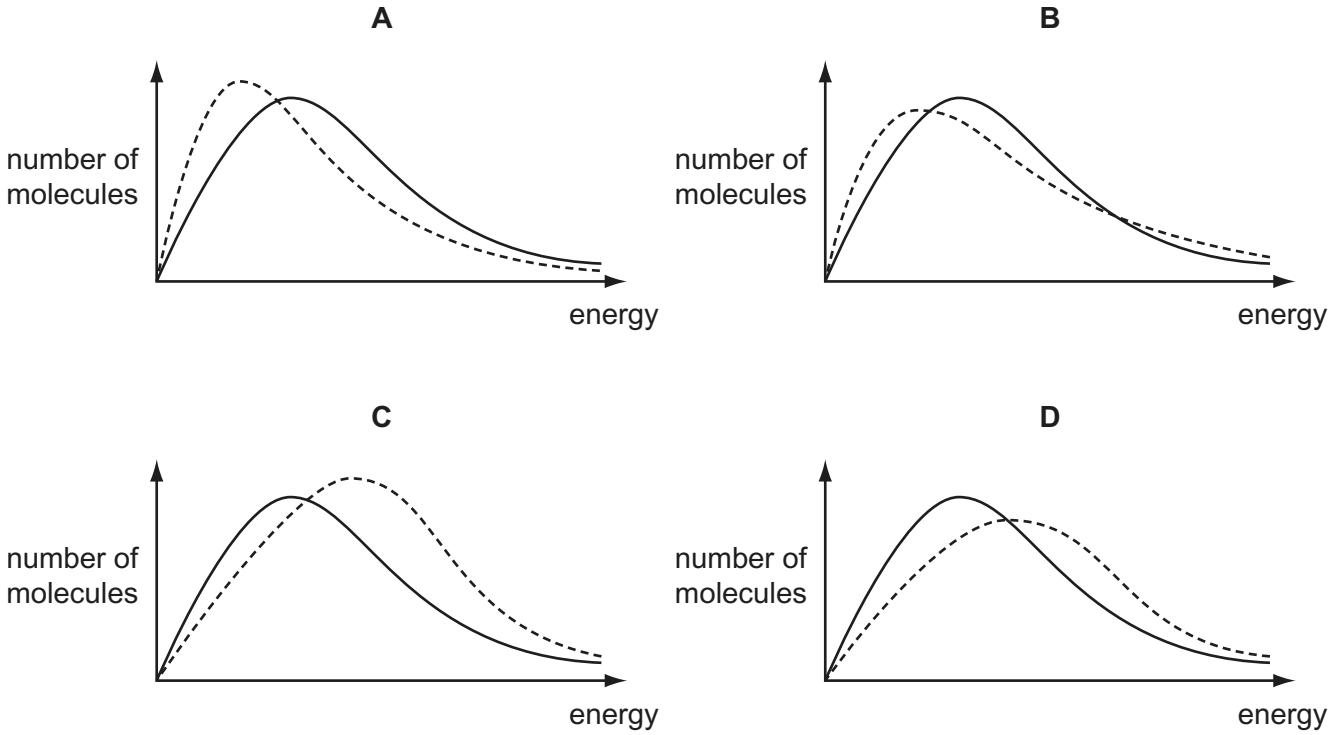

7 Which stage in the free radical substitution of methane by chlorine will have the lowest activation energy?

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

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

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

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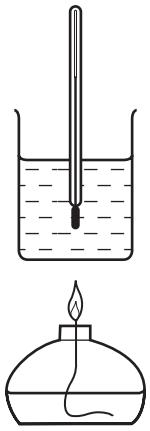
A student carried out an experiment to determine the enthalpy change for the combustion of methanol.

The following results were obtained by the student.

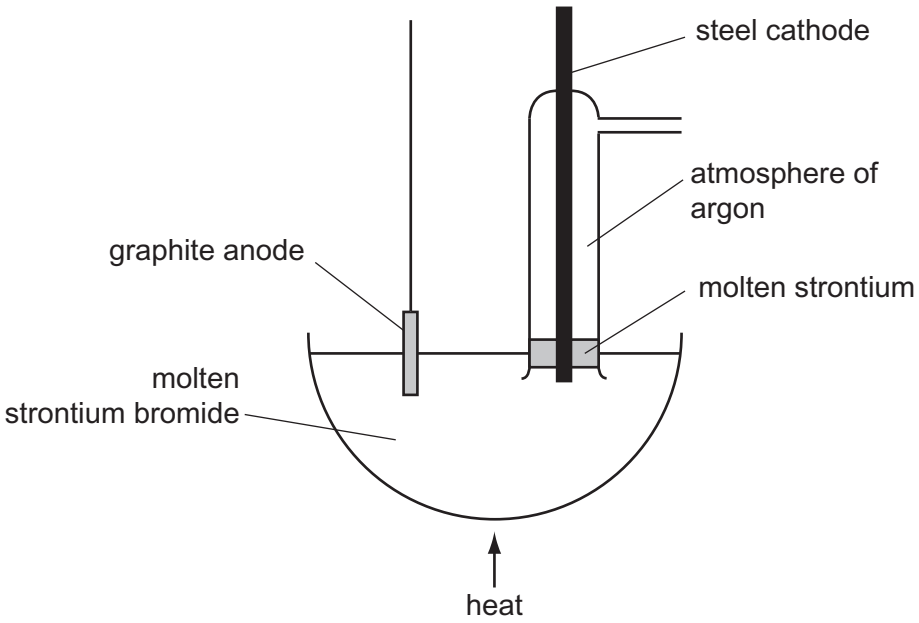


start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

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

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

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.

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**?

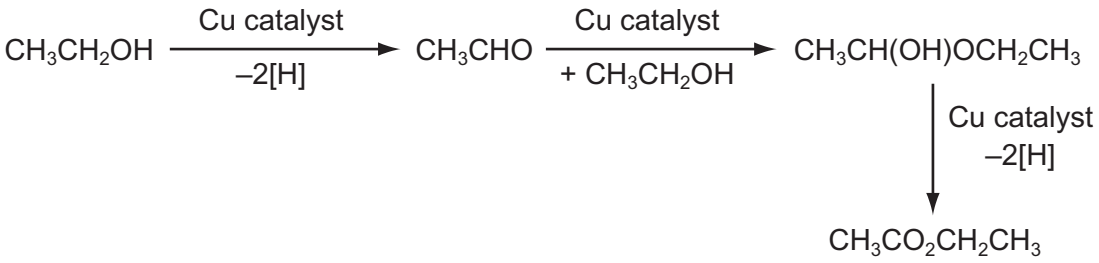
A sodium, magnesium, aluminium

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?

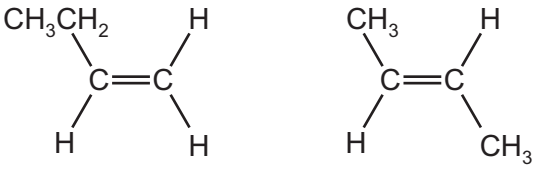
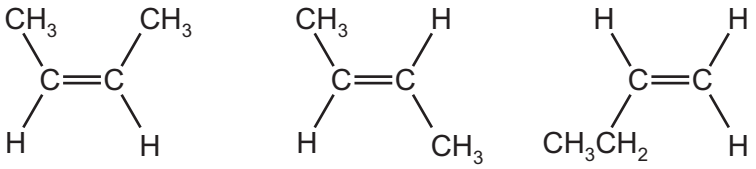
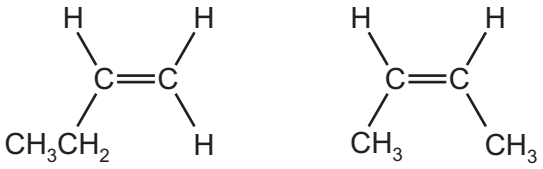
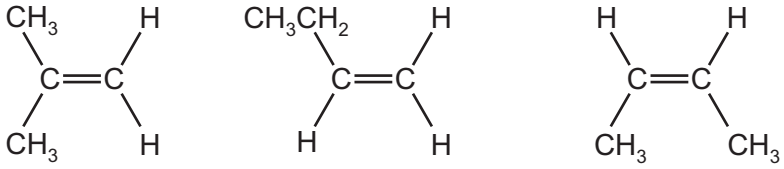
A attack by a nucleophile on a carbon atom with a partial positive charge

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

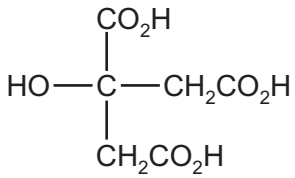
C heterolytic bond fission followed by an attack by a nucleophile on a carbocation

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

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

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?

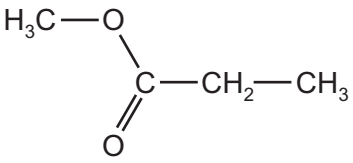
A CH_3CH_2OH + concentrated H_3PO_4

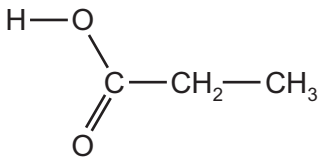
B $CH_3CH_2CH_2CHO$ + Tollens' reagent

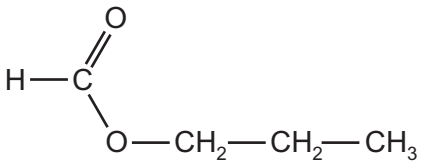
C CH_3COCH_3 + 2,4-dinitrophenylhydrazine reagent

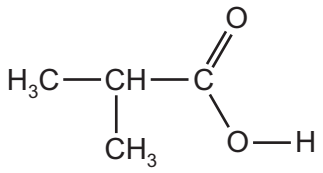
D CH_3CN + dilute H_2SO_4

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

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.

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

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

CHEMISTRY **9701/13**

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

* 2 3 4 0 9 5 3 0 9 3 *

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 **12** printed pages.

Section A

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

1 Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

A –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

2 In the extraction of aluminium by electrolysis, why is it necessary to dissolve aluminium oxide in molten cryolite?

A to reduce the very high melting point of the electrolyte

B cryolite is a base; aluminium oxide is amphoteric

C cryolite reacts with the aluminium oxide to form ions

D molten aluminium oxide alone would not conduct electricity

3 A $10\,cm^3$ sample of $0.30\,mol\,dm^{-3}$ $Tl^+NO_3^-$ required $20\,cm^3$ of $0.10\,mol\,dm^{-3}$ acidified NH_4VO_3 to oxidise it to Tl^{3+} in solution. Vanadium is the only element reduced in this reaction.

What is the oxidation number of the vanadium in the reduced form?

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

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

Element X forms X^- ions that can be oxidised to element X by acidified potassium manganate(VII).

What could be the values of the first four ionisation energies of X?

	1st	2nd	3rd	4th
A	418	3070	4600	5860
B	577	1820	2740	11 600
C	590	1150	4940	6480
D	1010	1840	2040	4030

5 $Na_2S_2O_3$ reacts with dilute HC*l* to give a pale yellow precipitate. If 1 cm^3 of 0.1 mol dm^{-3} HC*l* is added to 10 cm^3 of 0.02 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with 1 cm^3 of 0.1 mol dm^{-3} HC*l* and 10 cm^3 of 0.05 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

A The activation energy of the reaction is lower when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

B The collisions between reactant particles are more violent when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

C The reactant particles collide more frequently when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

D The reaction proceeds by a different pathway when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

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

A $Cl_2 \rightarrow 2Cl\bullet$

B $Cl\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HCl$

C $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$

D $Cl\bullet + C_2H_5\bullet \rightarrow C_2H_5Cl$

7 Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the equation $pV = nRT$.

The measurements are used to calculate the relative molecular mass, M_r, of a compound.

Which conditions of pressure and temperature would give the most accurate value of M_r?

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

8 Which solid contains more than one kind of bonding?

A copper

B diamond

C ice

D magnesium oxide

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

When an evacuated fluorescent light tube of volume 300 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.02 g. The gas obeys the ideal gas equation $pV = nRT$.

What is the identity of the gas?

A argon

B krypton

C neon

D nitrogen

10 Nitrogen reacts with hydrogen to produce ammonia.

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

A mixture of 1.00 mol of nitrogen, 3.00 mol of hydrogen and 1.98 mol of ammonia is allowed to reach equilibrium in a sealed vessel under certain conditions. It was found that 1.64 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\dfrac{(0.70)^2}{(1.64)(4.92)^3}$

B $\dfrac{(1.34)^2}{(1.64)(3.64)^3}$

C $\dfrac{(1.64)(4.92)^3}{(0.70)^2}$

D $\dfrac{(1.64)(3.64)^3}{(1.34)^2}$

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

Which calcium compound contains 54.1 % by mass of calcium?

A calcium hydroxide

B calcium nitrate

C calcium oxide

D calcium sulfate

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

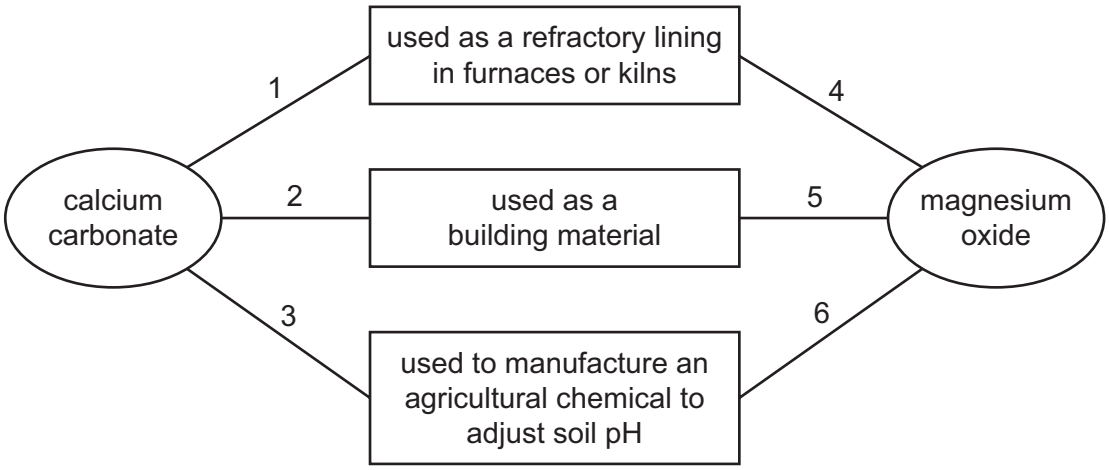
The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The reaction produces the metal oxides and nitrogen.

$$10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$$

Which mass of barium oxide is produced when 5.40 g of aluminium powder reacts with an excess of anhydrous barium nitrate?

A 1.62 g **B** 3.06 g **C** 9.18 g **D** 10.2 g

13 The diagram shows some applications of compounds of Group II elements.



Which numbered links are correct?

	calcium carbonate	magnesium oxide
A	1, 2 and 3	4 and 5 only
B	1, 2 and 3	5 and 6 only
C	2 and 3 only	4 only
D	2 and 3 only	6 only

14 River water in a chalky agricultural area may contain Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. In a water treatment plant, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated from the river water following the addition of calcium hydroxide?

A $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** $Mg(NO_3)_2$

15 Ammonia exists as simple covalent molecules, NH_3. Ammonia can react with suitable reagents to form products containing ammonium ions, NH_4^+. Ammonia can also react with suitable reagents to form products containing amide ions, NH_2^-.

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

A ammonia molecules, ammonium ions and amide ions

B ammonia molecules and ammonium ions only

C ammonia molecules only

D ammonium ions only

16 Carbon, nitrogen and sulfur are non-metals.

Which statement about their oxides, XO_2, is correct? (Where X represents carbon, nitrogen or sulfur.)

A All of the XO_2 molecules are linear.

B In XO_2, each element has its highest oxidation number.

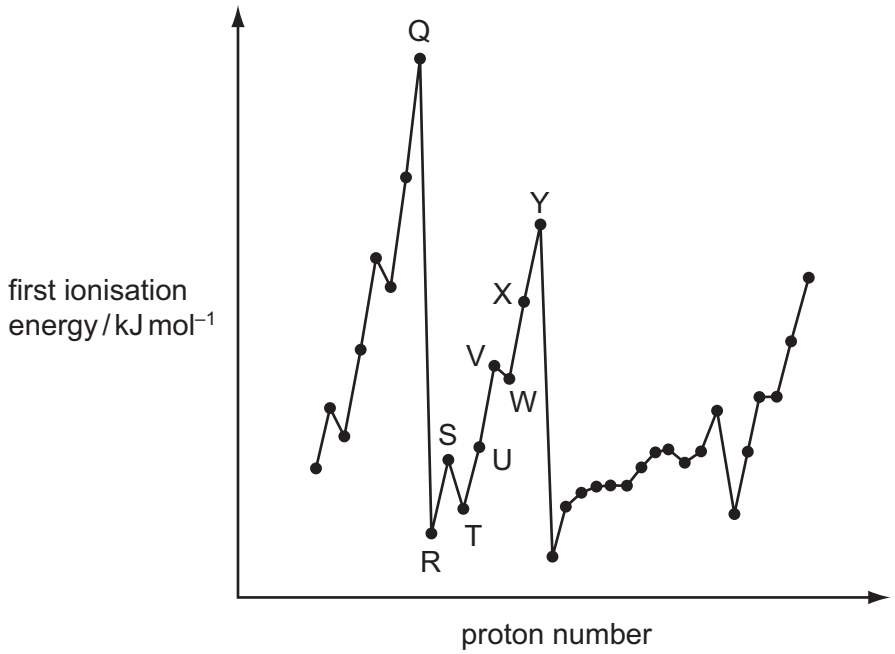
C All XO_2 molecules dissolve in water to form dibasic acids.

D All XO_2 molecules are formed as a result of burning petrol in a car engine.

17 Which oxide is insoluble in aqueous sodium hydroxide?

A MgO **B** Al_2O_3 **C** P_4O_{10} **D** SO_2

18 The graph below shows the variation of the first ionisation energy with the number of protons for some elements.



Which statement is correct?

A Elements Q and Y are in the same period in the Periodic Table.

B The general increase from elements R to Y is due to increasing atomic radius.

C The small decrease between elements S and T is due to decreased shielding.

D The small decrease between elements V and W is due to repulsion between paired electrons.

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

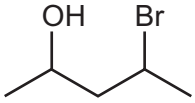
Elements **J** and **K** react together to form compound **L**. Elements **J** and **K** are both in Period 3. Element **J** has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element **K**.

Which compound could be **L**?

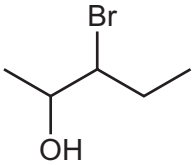
A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

20 Which diagram gives the skeletal formula of 2-bromopentan-4-ol?

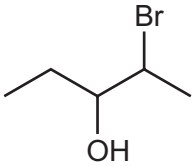
A



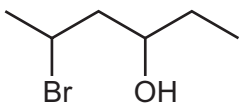
B



C



D



21 Including structural and stereoisomers, how many isomers are there of $C_2H_2Br_2$?

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

22 Which reaction will give the best yield of 2-chloropropane?

A chlorine gas with propane gas in the presence of uv light

B chlorine gas with propene gas in the dark

C propan-2-ol with dilute NaCl(aq)

D propan-2-ol with PCl_5

23 Pent-2-ene, $CH_3CH_2CH{=}CHCH_3$, reacts in a similar way to ethene.

Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.

What will be produced in the greatest amount?

A $CH_3CH_2CH(OH)CH(OH)CH_3$

B $CH_3CH_2COCOCH_3$

C a mixture of $CH_3CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH_2CH(OH)CH_3$

D CH_3CH_2COOH and CH_3COOH

24 Including structural and stereoisomers, how many isomeric products are produced when alcoholic KOH reacts with 2-chlorobutane?

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

25 Chlorofluorocarbons, CFCs, can be used as refrigerants, aerosol propellants and fire extinguishers.

CFCs such as CCl_3F and CCl_2F$_2$ are more stable than chloroalkanes such as CCl_4.

What is the reason for their greater stability?

A Fluorine has a higher first ionisation energy than chlorine.

B Fluorine radicals are more stable than chlorine radicals.

C The C–F bond energy is larger than the C–Cl bond energy.

D The C–F bond is more polar than the C–Cl bond.

26 Halogenoalkanes react with aqueous NaOH to give alcohols. The mechanism involved is either S_N1 or S_N2.

Which halogenoalkane produces the highest percentage of product by an S_N1 mechanism, when treated with aqueous NaOH?

A 2-bromopropane

B 2-chloropropane

C 1-iodo-2-methylpropane

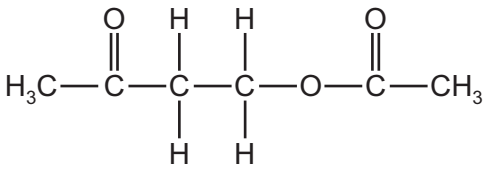
D 2-iodo-2-methylpropane

27 An alcohol with molecular formula $C_nH_{2n+1}OH$ has a chiral carbon atom but does not react with hot, acidified $K_2Cr_2O_7$.

What is the smallest possible value for n?

A 5 **B** 6 **C** 7 **D** 8

28 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

A $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

29 How many hydrogen atoms are added to each molecule of ethanal when it is reacted with $NaBH_4$ in water?

A 1 **B** 2 **C** 4 **D** 6

30 Which fragment could appear in the chain produced by polymerising 1,1-dichloroethene?

A $-CH_2-CH_2-CCl_2-CCl_2-CH_2-CH_2-$

B $-CHCl-CHCl-CHCl-CHCl-CHCl-CHCl-$

C $-CH_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

D $-CCl_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

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 $^{1}H_{3}^{+}$ ion was first characterised by J. J. Thomson over a century ago. ^{6}Li is a rare isotope of lithium which forms the $^{6}Li^{+}$ ion.

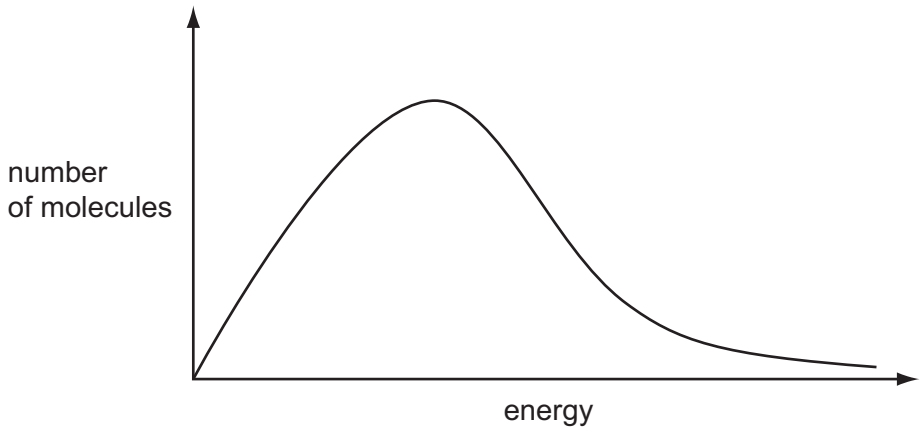
Which statements are correct?

1 Both ions contain the same number of protons.

2 Both ions contain the same number of electrons.

3 Both ions contain the same number of neutrons.

32 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1 increasing the concentration of reactants

2 increasing the temperature

3 the addition of a catalyst

33 Methanoic acid molecules, HCO_2H, and hydrogen carbonate ions, HCO_3^-, can both behave as acids.

Why does a solution of methanoic acid have a lower pH than a solution of sodium hydrogen carbonate of the same concentration?

1 HCO_2H molecules dissociate more fully than HCO_3^- ions do.

2 Each HCO_2H molecule has two hydrogen atoms; each HCO_3^- ion only has one.

3 Methanoic acid is a weaker acid than sodium hydrogen carbonate.

34 The following equilibrium is an exothermic reaction in the forward direction.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

What happens when the concentration of CrO_4^{2-} ions **increases and** the temperature **decreases**?

1 The concentration of $Cr_2O_7^{2-}$ ions increases.

2 The equilibrium constant increases.

3 The activation energy decreases.

35 Which processes involve the conversion of sulfur dioxide into sulfur trioxide?

1 the combustion of sulfur contaminated fossil fuels

2 the Contact process for manufacturing sulfuric acid

3 the catalytic oxidation of sulfur dioxide by oxides of nitrogen

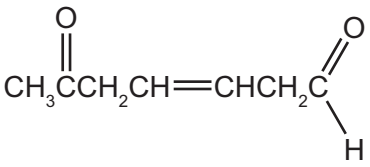
36 Which chlorides of Period 3 elements will form a neutral solution when added to water?

1 NaCl

2 Al_2Cl_6

3 PCl_5

37 A series of tests was carried out on the compound shown below.



Which pairs of reagents would **both** give a positive result for this compound?

1 Tollens' reagent and a solution containing acidified dichromate(VI) ions

2 aqueous bromine and Fehling's reagent

3 2,4-dinitrophenylhydrazine reagent and sodium carbonate

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 The reaction of ethanal, CH_3CHO, with HCN to form a cyanohydrin is catalysed by NaCN.

What are features of the intermediate of this reaction?

1 It is chiral.

2 It has a single negative charge on one of its atoms.

3 It is a nucleophile.

39 The ester $C_2H_5CO_2CH_2CH_2CH_3$ can be made in a school or college laboratory by a sequence of reactions using compound **X** as the **only** organic material.

What might be the identity of compound **X**?

1 $CH_3CH_2CH_2OH$

2 CH_3CH_2CHO

3 CH_3COCH_3

40 The structural formulae of two compounds are shown below.

Which statements about these compounds are correct?

1 The two compounds are structural isomers of each other.

2 The empirical formula of both compounds is C_3H_6O.

3 Both compounds are carboxylic acids.