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

CHEMISTRY **9701/01**

Paper 1 Multiple Choice **May/June 2007**

1 hour

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

* 1 6 0 3 3 1 1 0 6 0 *

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.

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.

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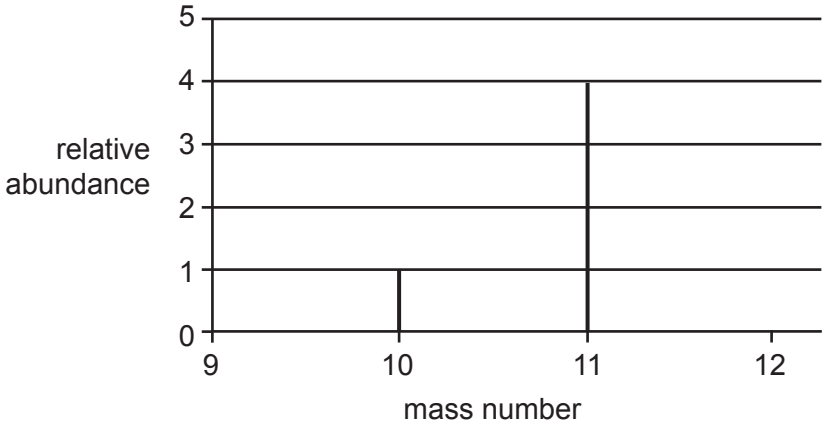
Section A

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

1 The isotopic composition of an element is indicated below.



What is the relative atomic mass of the element?

A 10.2 **B** 10.5 **C** 10.8 **D** 11.0

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

Oxides of nitrogen are pollutant gases which are emitted from car exhausts.

In urban traffic, when a car travels one kilometre, it releases 0.23 g of an oxide of nitrogen N_xO_y, which occupies 120 cm^3.

What are the values of x and y?
(Assume 1 mol of gas molecules occupies 24.0 dm^3.)

A $x = 1$, $y = 1$

B $x = 1$, $y = 2$

C $x = 2$, $y = 1$

D $x = 2$, $y = 4$

3 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A Atoms are very small in size.

B No atom can be split into simpler parts.

C All the atoms of a particular element have the same mass.

D All the atoms of one element are different in mass from all the atoms of other elements.

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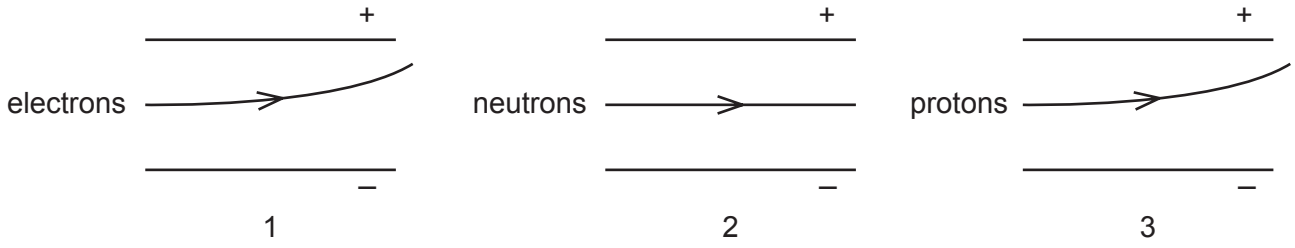
4 The diagrams show the possible paths of subatomic particles moving in an electric field in a vacuum.



Which diagrams are correct?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

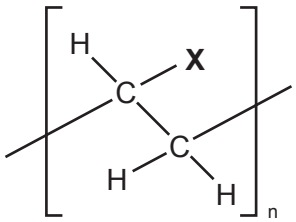
D 1, 2 and 3

5 The CN^- ion is widely used in the synthesis of organic compounds.

What is the pattern of electron pairs in this ion?

	bonding pairs of electrons	lone pairs on carbon atom	lone pairs on nitrogen atom
A	2	1	1
B	2	2	1
C	3	1	1
D	3	1	2

6 Plastic bottles for 'fizzy drinks' are made from a polymer with the following structure.



The ability of the polymer to prevent escape of carbon dioxide through the wall of the bottle depends on the ability of the group **X** to form hydrogen bonds with the carbon dioxide in the drink.

Which group **X** best prevents loss of carbon dioxide?

A C*l* **B** CN **C** CO_2CH_3 **D** OH

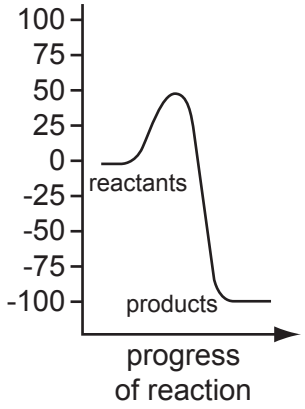
7 An exothermic chemical reaction proceeds by two stages.

$$\text{reactants} \xrightarrow{\text{stage 1}} \text{intermediate} \xrightarrow{\text{stage 2}} \text{products}$$

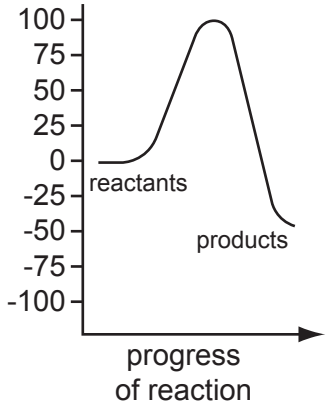
The activation energy of stage 1 is 50 kJ mol^{-1}. The overall enthalpy change of reaction is –100 kJ mol^{-1}.

Which diagram represents the reaction pathway for this reaction?

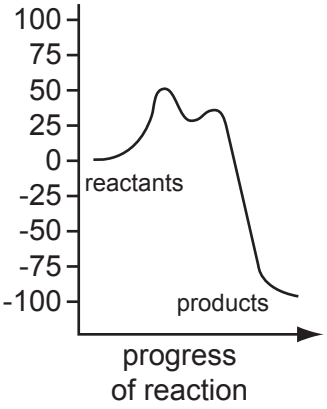
A



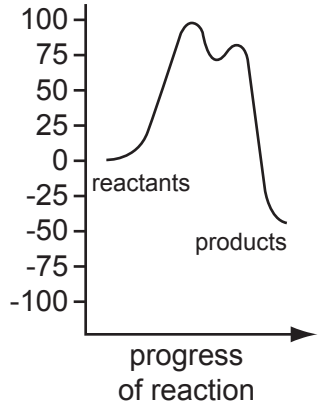
B



C



D



8 Skiers trapped by snowstorms use heat packs to keep warm. The heat may be generated by the reaction below.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \quad ; \quad \Delta H^{\ominus} = -1648\,\text{kJ}$$

What is the standard enthalpy change of formation of iron(III) oxide?

A 0 kJ mol^{-1}

B –824 kJ mol^{-1}

C –1648 kJ mol^{-1}

D –3296 kJ mol^{-1}

9 Two equilibria are shown below.

reaction I $\quad 2X_2(g) + Y_2(g) \rightleftharpoons 2X_2Y(g)$

reaction II $\quad X_2Y(g) \rightleftharpoons X_2(g) + \frac{1}{2}Y_2(g)$

The numerical value of K_c for reaction I is 2.

Under the same conditions, what is the numerical value of K_c for reaction II?

A $\frac{1}{\sqrt{2}}$ **B** $\frac{1}{2}$ **C** $\frac{1}{4}$ **D** –2

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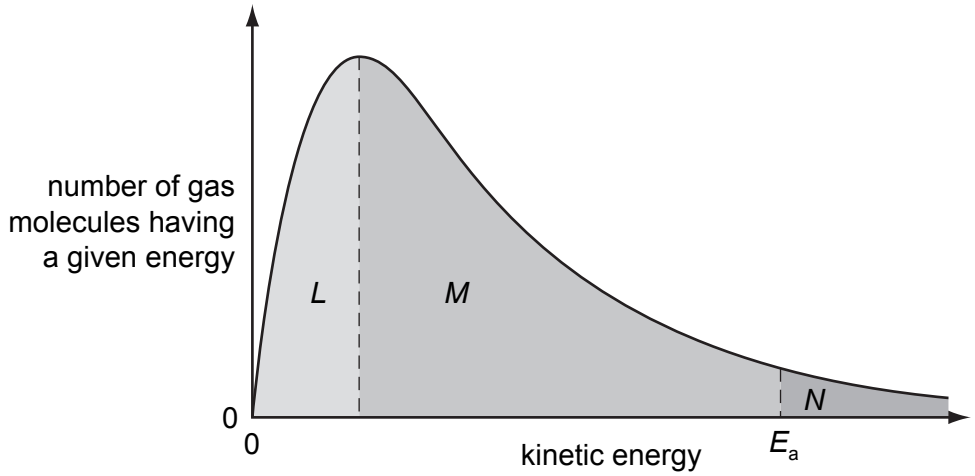
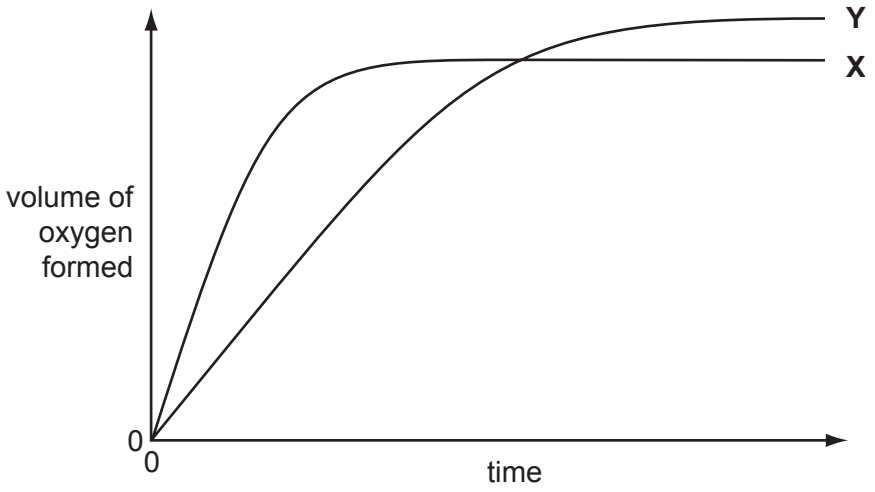
10 The Boltzmann distribution shows the number of molecules having a particular kinetic energy at constant temperature.



If the temperature is decreased by 10 °C, what happens to the size of the areas labelled *L*, *M* and *N*?

	L	*M*	*N*
A	decreases	decreases	decreases
B	decreases	increases	decreases
C	increases	decreases	decreases
D	increases	decreases	increases

11 In the diagram, curve **X** was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve **Y**?

A adding water

B adding some 0.1 mol dm^{-3} hydrogen peroxide

C using less manganese(IV) oxide

D lowering the temperature

12 Which chlorine compound has bonding that can be described as ionic with some covalent character?

A NaCl **B** $MgCl_2$ **C** $AlCl_3$ **D** $SiCl_4$

13 $AlCl_3$ reacts with $LiAlH_4$ and $(CH_3)_3N$ to give $(CH_3)_3NAlH_3$.

Which statement about $(CH_3)_3NAlH_3$ is correct?

A It contains hydrogen bonding.

B It is dimeric.

C The Al atom has an incomplete octet of electrons.

D The bonds around the Al atom are tetrahedrally arranged.

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14 Slaked lime, $Ca(OH)_2$, may be made from limestone, $CaCO_3$.

On heating in a lime kiln at 1000 °C, limestone decomposes as follows.

reaction 1 $\quad CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Water is then reacted with calcium oxide, CaO, as follows.

reaction 2 $\quad CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

15 In the treatment of domestic water supplies, chlorine is added to the water to form chloric(I) acid, HC*l*O.

$$Cl_2(aq) + H_2O(l) \rightarrow H^+(aq) + Cl^-(aq) + HClO(aq)$$

This reacts further to give the chlorate(I) ion.

$$HClO(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO^-(aq)$$

Both HC*l*O and C*l*O$^-$ kill bacteria by oxidation.

What is the change in oxidation number of chlorine in forming the chlorate(I) ion from the aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

16 The standard enthalpy changes of formation of HC*l* and HI are –92 kJ mol^{-1} and +26 kJ mol^{-1} respectively.

Which statement is **most** important in explaining this difference?

A Chlorine is more electronegative than iodine.

B The activation energy for the H_2 / C*l*$_2$ reaction is much less than that for the H_2 / I_2 reaction.

C The bond energy of HI is smaller than the bond energy of HC*l*.

D The bond energy of I_2 is smaller than the bond energy of C*l*$_2$.

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17 Methyl mercaptan, CH_3SH, is one of the substances responsible for bad breath and is often used to impart a smell to natural gas in a pipeline.

What will be formed when CH_3SH is burned in an excess of air?

A CO CO_2 H_2S

B CO H_2O SO_3

C CO_2 H_2O SO_2

D CO_2 H_2O SO_3

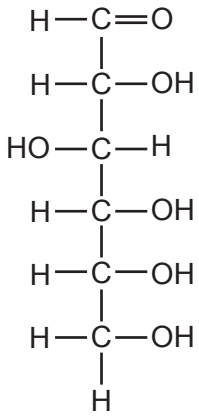
18 A solid nitrate fertiliser reacts with an alkali to produce a gas which turns damp pH paper blue.

What is the empirical formula of this fertiliser?

A NO_3 **B** NHO_3 **C** NH_2O **D** $N_2H_4O_3$

19 Glucose, $C_6H_{12}O_6$, is a product of photosynthesis.

It has the following structure.



How many *chiral* centres does the molecule have?

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

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20 Under the Montreal Protocol, the manufacture of chlorofluorocarbons has been phased out, and they are being replaced by fluorocarbons.

One chlorofluorocarbon which was widely used as a solvent is CCl_2FCClF_2. Large stocks of it remain. One process to use up these stocks is to convert it into the fluorocarbon CH_2FCF_3 by the following route.

$$CCl_2FCClF_2 \xrightarrow{\text{step 1}} CCl_3CF_3 \xrightarrow{\text{step 2}} CCl_2FCF_3 \xrightarrow{\text{step 3}} CH_2FCF_3$$

What type of reaction is step 2?

A electrophilic substitution

B free radical reduction

C isomerisation

D nucleophilic substitution

21 Which reagent could be used to convert $CH_3CO_2CH_3$ into $ClCH_2CO_2CH_3$?

A concentrated hydrochloric acid at 100 °C

B phosphorus pentachloride at room temperature

C sulphur dichloride oxide (thionyl chloride, $SOCl_2$) at 50 °C

D chlorine in bright sunlight at 100 °C

22 In which reaction is a carbocation (carbonium ion) an intermediate?

A $CH_2{=}CH_2 + Br_2 \longrightarrow CH_2BrCH_2Br$

B $CH_3CH_2Br + NaOH \longrightarrow CH_3CH_2OH + NaBr$

C $CH_3CH_3 + Cl_2 \longrightarrow CH_3CH_2Cl + HCl$

D $CH_3CHO + HCN \xrightarrow{CN^-} CH_3CH(OH)CN$

23 The compound 1,2-dichloroethene, $C_2H_2Cl_2$, has been used as an industrial solvent for a number of compounds including fats, camphor and caffeine.

Which statement about this compound is **incorrect**?

A The compound can be catalytically hydrogenated.

B The compound is a planar molecule.

C The compound shows *cis-trans* isomerism.

D The compound shows optical isomerism.

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24 Which term describes the action of NaOH(aq) on a bromoalkane?

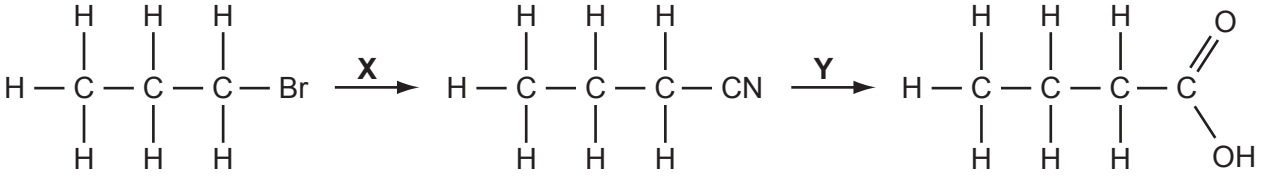
A acid-base reaction

B electrophilic substitution

C elimination of HBr

D nucleophilic substitution

25 **X** and **Y** are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of **X** and **Y**?

	X	Y
A	NH_3	HC*l*(aq)
B	KCN in C_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HC*l*(aq)
D	HCN	NaOH(aq)

26 An alcohol with molecular formula $C_nH_{2n+1}OH$ has a chiral carbon atom but does not react with MnO_4^- / H^+.

What is the least number of carbon atoms such an alcohol could possess?

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

27 Which reagent gives the same visible result with propanal and with propan-2-ol?

A 2,4-dinitrophenylhydrazine reagent

B acidified potassium dichromate(VI)

C sodium

D Tollens' reagent

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28 Compound **X** will decolourise a warm acidified solution of manganate(VII) ions and forms orange crystals on reaction with 2,4-dinitrophenylhydrazine.

What is **X**?

A $CH_3CH=CHCH_2OH$

B $CH_3COCH_2CH_3$

C $CH_3CH_2CH_2CHO$

D $CH_3CH(OH)CH_2CO_2H$

29 Which compound would undergo nucleophilic addition?

A ethene, C_2H_4

B bromoethane, C_2H_5Br

C ethanal, CH_3CHO

D ethane, C_2H_6

30 Which formula represents the organic compound formed by the reaction of propanoic acid with methanol in the presence of concentrated sulphuric acid as a catalyst?

A $CH_3CH_2COCH_3$

B $CH_3CH_2CO_2CH_3$

C $CH_3CO_2CH_2CH_3$

D $CH_3CH_2CH_2CO_2CH_3$

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

The technetium–99 isotope (^{99}Tc) is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.

2 It has 43 protons.

3 It has 99 nucleons.

32 Which of the following solids contain more than one type of chemical bond?

1 brass (an alloy of copper and zinc)

2 graphite

3 ice

33 Many crude oils contain sulphur as H_2S. During refining, by the Claus process, the H_2S is converted into solid sulphur, which is then removed.

reaction I $\quad 2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$

reaction II $\quad 2H_2S(g) + SO_2(g) \rightarrow 2H_2O(l) + 3S(s)$

Which statements about the Claus process are correct?

1 H_2S is oxidised in reaction I.

2 SO_2 oxidises H_2S in reaction II.

3 SO_2 behaves as a catalyst.

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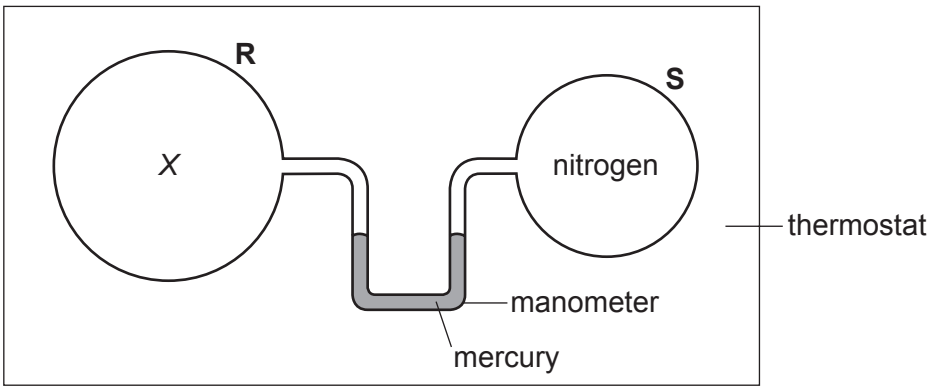
34 Two bulbs **R** and **S**, connected by a mercury manometer, are held in a thermostat, as shown. The volume of **R** is twice that of **S**. **R** contains gas, *X*, at the same pressure as the nitrogen in **S**.



When the temperature is increased, which gases in bulb **R** would cause the mercury level in the right-hand limb of the manometer to rise?

1 an equilibrium mixture $N_2F_4(g) \rightleftharpoons 2NF_2(g)$; ΔH positive

2 an equilibrium mixture $CH_3NC(g) \rightleftharpoons CH_3CN(g)$; ΔH negative

3 nitrogen

35 Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

1 The elements become more electronegative from sodium to chlorine.

2 Aluminium oxide is the only oxide which is insoluble in water.

3 The maximum oxidation state is shown by silicon.

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

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It is a good reducing agent.

37 Nitrogen and oxygen react in a hot car engine to form nitrogen monoxide which is a serious pollutant in our cities and in the countryside. However, nitrogen and oxygen do not react at room temperature.

Which statements help to explain why nitrogen and oxygen do not react at room temperature?

1 The reaction is endothermic.

2 A high activation energy is required.

3 Nitrogen has a high bond energy.

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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.

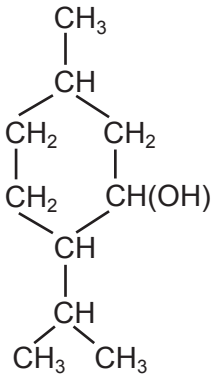
38 What types of reaction are undergone by 2-bromopropane?

1 elimination

2 free radical substitution

3 nucleophilic substitution

39 Menthol, from oil of mint, is used in soaps and perfumes.



menthol

Which statements about menthol are correct?

1 There is a total of two chiral centres present in the menthol molecule.

2 On reaction with concentrated sulphuric acid, menthol produces a mixture of two alkenes.

3 A solution of acidified potassium dichromate(VI), on warming with menthol, changes colour from orange to green.

40 Fats and grease that build up on pans used in cooking are esters. Pans which are dirty from fats or grease may be cleaned by heating them with a reagent that will react with the ester group.

What may be used to clean such pans by this reaction?

1 vinegar - aqueous ethanoic acid, CH_3CO_2H

2 alcohol - ethanol, C_2H_5OH

3 baking powder - sodium hydrogencarbonate, $NaHCO_3$

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