GradeMax

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2016**

1 hour

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

2378680830

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.

IB16 06_9701_12/3RP
© UCLES 2016

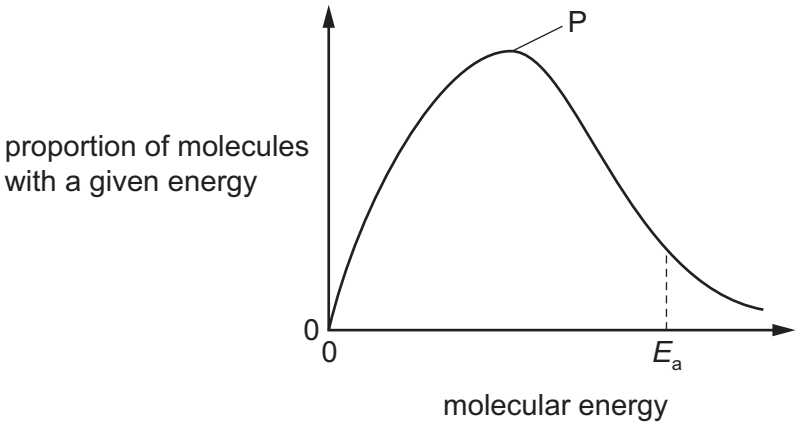
GradeMax

Section A

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

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

1 The diagram shows the Boltzmann distribution of energies in 1 mole of a gas. The gas can take part in a reaction with an activation energy, E_a.



Which statement correctly describes the effect of an increase in temperature?

A Peak P will be higher and fewer molecules will have energy > E_a.

B Peak P will be higher and more molecules will have energy > E_a.

C Peak P will be lower and fewer molecules will have energy > E_a.

D Peak P will be lower and more molecules will have energy > E_a.

2 Four electronic configurations are shown below. Three of these configurations belong to atoms of the elements chlorine, sodium and vanadium.

Which electronic configuration belongs to an atom of another element?

A $1s^2 2s^2 2p^6 3s^1$

B $1s^2 2s^2 2p^6 3s^2 3p^5$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

© UCLES 2016

GradeMax

3 Elements X and Y are in the same group of the Periodic Table.

The table shows the first six ionisation energies of X and Y in $kJ\,mol^{-1}$.

	1st	2nd	3rd	4th	5th	6th
X	800	1600	2400	4300	5400	10400
Y	1000	1800	2700	4800	6000	12300

What could be the identities of X and Y?

	X	Y
A	antimony, Sb	arsenic, As
B	arsenic, As	antimony, Sb
C	selenium, Se	tellurium, Te
D	tellurium, Te	selenium, Se

4 In China, the concentration of blood glucose, $C_6H_{12}O_6$, is measured in mmol / l. In Pakistan, the concentration of blood glucose is measured in mg / dl.

The unit l is a litre ($1\,dm^3$). The unit dl is a decilitre ($0.1\,dm^3$).

A blood glucose concentration of 18.5 mmol / l indicates a health problem.

What is 18.5 mmol / l converted to mg / dl?

A 33.3 mg / dl **B** 178 mg / dl **C** 333 mg / dl **D** 3330 mg / dl

5 Each of the four species in this question are isolated and gaseous.

Which species is **not** planar?

A BF_3 **B** CH_3^+ **C** C_2H_4 **D** NH_3

6 Argon is a gas used to fill electric light bulbs.

Under which conditions of pressure and temperature will argon behave most like an ideal gas?

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

© UCLES 2016

[Turn over

GradeMax

7 0.10 g of the volatile liquid X formed 0.025 dm^3 of vapour at 100 °C and atmospheric pressure.

1 mol of vapour occupies 22.4 dm^3 at 0 °C and atmospheric pressure.

What is the relative molecular mass of X?

A $\frac{0.025 \times 273 \times 22.4}{0.10 \times 373}$

B $\frac{0.025 \times 373 \times 22.4}{0.10 \times 273}$

C $\frac{0.10 \times 273 \times 22.4}{0.025 \times 373}$

D $\frac{0.10 \times 373 \times 22.4}{0.025 \times 273}$

8 The equation for the complete combustion of propan-1-ol is shown.

$$CH_3CH_2CH_2OH(l) + 4\tfrac{1}{2}O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Standard enthalpy changes of formation are given.

compound	$CH_3CH_2CH_2OH(l)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$	–303 kJ mol^{-1}	–394 kJ mol^{-1}	–286 kJ mol^{-1}

What is the standard enthalpy change of combustion of propan-1-ol, in kJ mol^{-1}?

A –394 – 286 – 303

B 303 – (4 × 286) – (3 × 394)

C 394 + 286 – 303

D (3 × 394) + (4 × 286) + 303

9 In the treatment of domestic water supplies, chlorine is added to the water to form HC*l*O.

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

The HC*l*O reacts further to give C*l*O^- ions.

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

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

What is the change in oxidation number of chlorine when forming the C*l*O^- ion from aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

© UCLES 2016

10 When solid ammonium chloride dissociates at a certain temperature in a 0.500 dm^3 container, ammonia and hydrogen chloride are formed.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The initial amount of ammonium chloride was 1.00 mol, and when the system had reached equilibrium there was 0.300 mol of ammonium chloride.

What is the numerical value of K_c for this reaction under these conditions?

A 0.490 **B** 1.63 **C** 1.96 **D** 3.27

11 Which stage in the free radical substitution of ethane by chlorine has 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 $Cl\bullet + C_2H_5\bullet \rightarrow C_2H_5Cl$

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

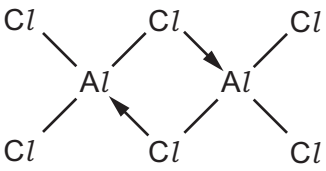
How do the atomic radius and ionic radius of sodium compare with those of sulfur?

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

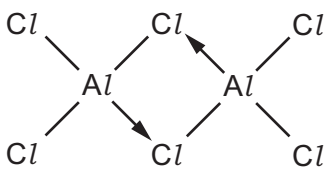
13 Solid aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

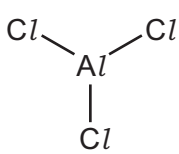
A



B



C



D

$Al^{3+}(Cl^-)_3$

14 A 0.005 mol sample of anhydrous calcium carbonate was completely thermally decomposed to give 100 cm^3 of gas measured at a certain temperature and pressure.

In a separate experiment carried out at the same temperature and pressure, a 0.005 mol sample of anhydrous calcium nitrate was completely thermally decomposed. The volume of gaseous products was measured.

What total volume of gaseous products was produced from the calcium nitrate?

A 50 cm^3 **B** 100 cm^3 **C** 200 cm^3 **D** 250 cm^3

15 Ammonia gas, NH_3, and hydrogen sulfide gas, H_2S, react together to form the salt ammonium sulfide, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, **X**.
The addition of HC*l*(aq) to a separate portion of this solution produces a gas, **Y**.

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

	X	**Y**
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

16 A solid, **T**, was placed in an excess of the liquid **U**.

A colourless gas was given off and a white precipitate was seen. The precipitate was not **T**.

What could be the identities of **T** and **U**?

	T	**U**
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HC*l*

© UCLES 2016

17 Nitrogen(II) oxide, NO, nitrogen(IV) oxide, NO_2, carbon monoxide, CO, and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

	NO	NO_2	CO	hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced

18 An excess of chlorine gas, Cl_2, is passed through 60 cm^3 of cold aqueous 0.1 mol dm^{-3} sodium hydroxide. In a separate experiment an excess of chlorine gas is passed through 60 cm^3 of hot aqueous 0.1 mol dm^{-3} sodium hydroxide until no further reaction takes place.

How much **more** sodium chloride will be produced by the reaction with hot NaOH than with cold NaOH?

A 0.002 moles

B 0.003 moles

C 0.005 moles

D 0.006 moles

19 Fluorine and iodine are Group 17 elements. Their melting points are different due to differing strengths of van der Waals' forces between molecules.

Which row is correct?

	melting point	strength of van der Waals' forces between molecules
A	$F_2 > I_2$	$F_2 > I_2$
B	$F_2 > I_2$	$F_2 < I_2$
C	$F_2 < I_2$	$F_2 < I_2$
D	$F_2 < I_2$	$F_2 > I_2$

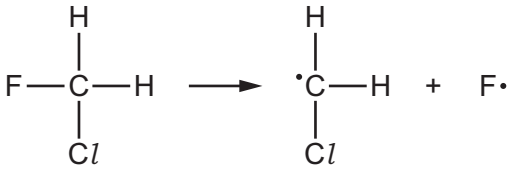
© UCLES 2016

GradeMax

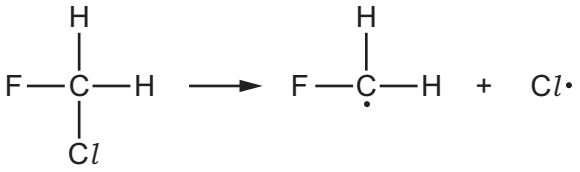
20 Chlorofluorocarbons damage the ozone layer by undergoing reactions with a free radical mechanism. The first stage of this is initiation.

Which equation is most likely to be the initiation stage when chlorofluoromethane is involved in such a reaction?

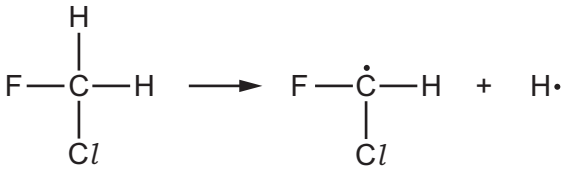
A



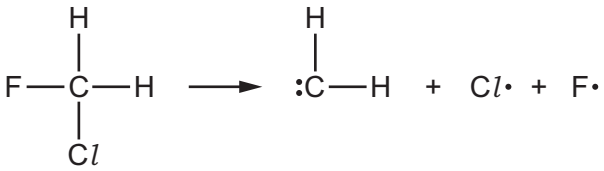
B



C

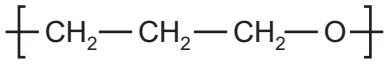


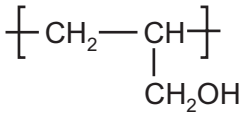
D

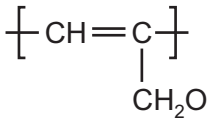


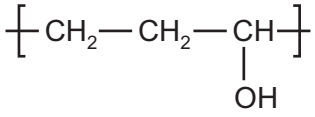
21 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2{=}CHCH_2OH$.

Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A 

B 

C 

D 

© UCLES 2016

GradeMax

22 Oct-1-ene, $CH_3(CH_2)_5CH{=}CH_2$, can be thermally cracked.

Which combination of compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

$CH_2{=}CH_2$	$CH_3CH{=}CH_2$	$CH_3CH_2CH_3$	$CH_2{=}CHCH{=}CH_2$
W	X	Y	Z

A W, X, Y and Z

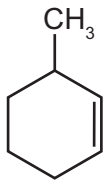
B W, X and Y only

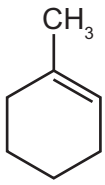
C W, X and Z only

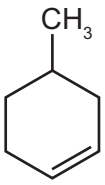
D W and X only

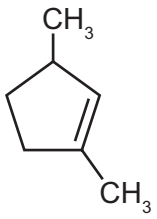
23 A cycloalkene with the molecular formula C_7H_{12} was oxidised by hot concentrated acidified MnO_4^-. The only organic product was 2-methylhexane-1,6-dioic acid.

What is the identity of the cycloalkene?

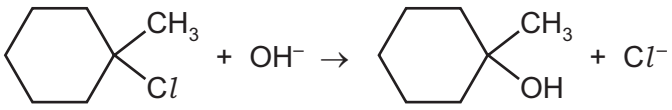
A 

B 

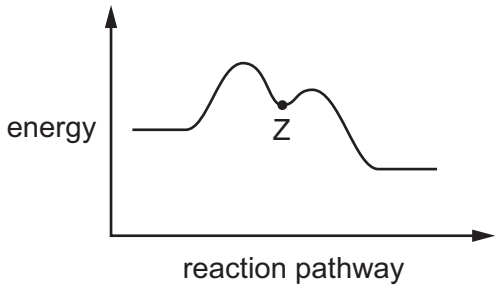
C 

D 

24 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

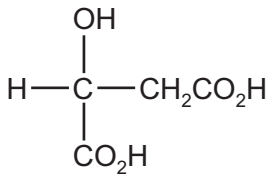
What is the charge on this carbon atom at point Z?

A $\delta+$ **B** + **C** $\delta-$ **D** –

© UCLES 2016

[Turn over

25 Malic acid is found in apples.



malic acid

Which reagent will react with only one of the –OH groups in the malic acid molecule?

A ethanoic acid in the presence of concentrated sulfuric acid

B sodium

C sodium hydrogen carbonate

D sodium hydroxide

26 Which organic compound would **not** give **either** a yellow precipitate when treated with alkaline aqueous iodine **or** an orange precipitate when treated with 2,4-dinitrophenylhydrazine reagent?

A propanal

B propan-1-ol

C propan-2-ol

D propanone

27 In which reaction is the organic compound oxidised?

A $CH_3CH_2CH_2CHO$ + Tollens' reagent

B $CH_3CH_2CH_2CHO$ + $LiAlH_4$

C $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

D $CH_3CO_2C_2H_5$ + dilute H_2SO_4

28 How many of the following compounds produce a carboxylic acid on heating under reflux with an excess of hot acidified $K_2Cr_2O_7$?

CH_3CH_2CHO

CH_3COCH_3

$CH_3CH_2CH_2OH$

$CH_3CH(OH)CH_3$

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

© UCLES 2016

GradeMax

29 How many isomeric esters, including structural isomers and stereoisomers, can be made with the molecular formula $C_5H_{10}O_2$, if methanoic acid is one of the two reactants used?

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

30 Compound X, $C_4H_8O_2$, has an unbranched carbon chain. An aqueous solution of X has an approximate pH of 3.

Compound Y, C_3H_8O, is a secondary alcohol.

X and Y are reacted together in the presence of a little concentrated sulfuric acid to form Z as the major organic product.

What is the structural formula of Z?

A $(CH_3)_2CHCO_2CH_2CH_2CH_3$

B $CH_3(CH_2)_2CO_2CH(CH_3)_2$

C $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$

D $(CH_3)_2CHCO_2CH(CH_3)_2$

© UCLES 2016

[Turn over

GradeMax

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 In an experiment, 10 cm^3 of an organic compound, **J**, in the gaseous state was sparked with an excess of oxygen. 20 cm^3 of carbon dioxide and 5 cm^3 of nitrogen were obtained among the products. All gas volumes were measured at the same temperature and pressure.

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

1 $C_2H_6N_2$

2 C_2H_3N

3 C_2H_7N

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

X	Y	Z
2,6	2,8,1	2,8,7

Which formulae represent compounds that conduct electricity in the liquid state?

1 YZ

2 Y_2X

3 Z_2X

© UCLES 2016

GradeMax

33 In this question, all gases can be assumed to behave ideally.

A chemist heats a mixture of nitrogen and oxygen gases in a sealed container at a constant temperature until the mixture reaches a dynamic equilibrium containing $N_2(g)$, $O_2(g)$ and NO(g).

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

The chemist repeats the experiment at the same temperature using the same initial amounts of $N_2(g)$ and $O_2(g)$, but at a much higher pressure.

Which statements about the second experiment at higher pressure are correct?

1 At higher pressure, there are more particles per unit volume.

2 The composition of the equilibrium mixture does not change.

3 There are more collisions per second so equilibrium is reached faster.

34 An ethanol burner can be used to heat water. If appropriate measurements are taken, a value for the enthalpy of combustion of ethanol can be calculated. The equation

$$\text{heat transferred} = -mc\Delta T$$

is used as part of the calculation.

Which symbols are correctly described?

1 ΔT is the change in temperature of the water.

2 m is the mass of water used in the experiment.

3 c is the specific heat capacity of ethanol.

© UCLES 2016

[Turn over

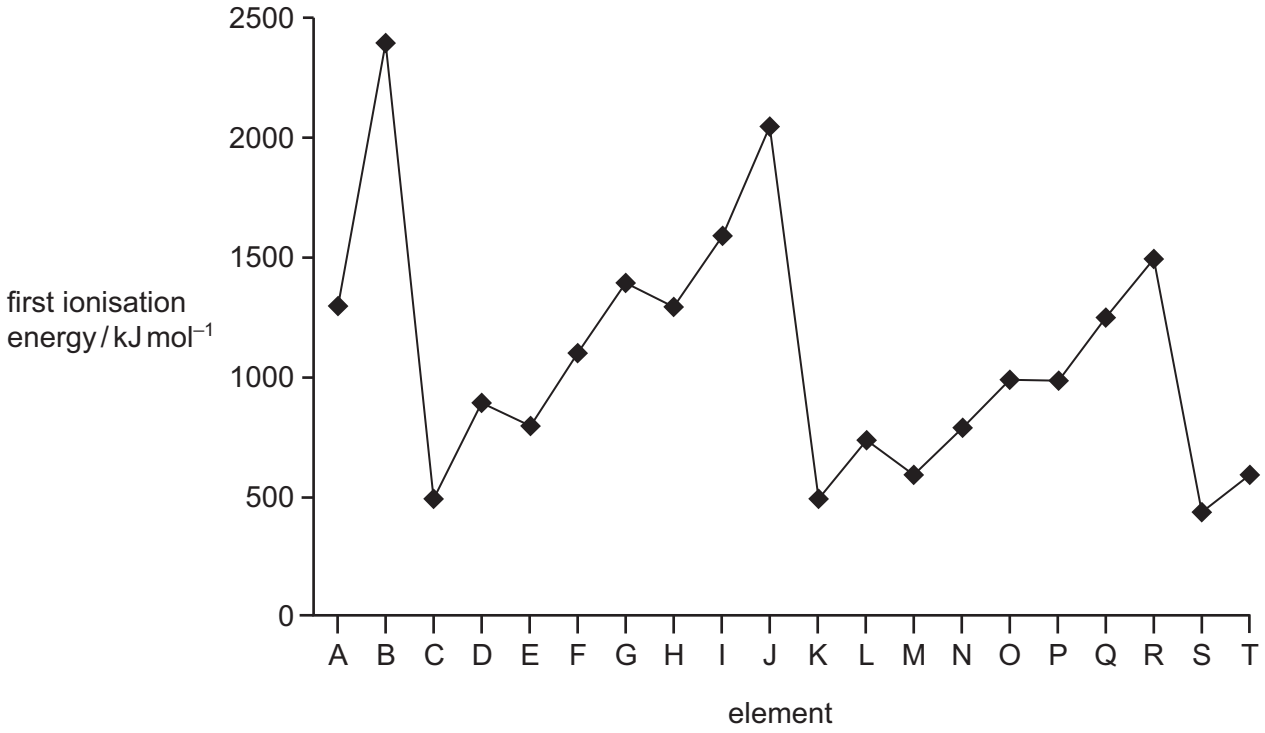
The responses **A** to **D** should be selected on the basis of

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.

35 The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph.

The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

1 Elements B, J and R are in Group 18 of the Periodic Table.

2 Atoms of elements D and L contain two electrons in their outer shells.

3 Atoms of elements G and O contain a half-filled p subshell.

36 Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

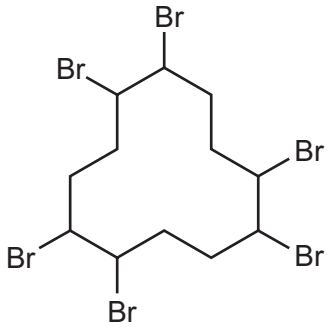
1 thermal stability

2 bond length

3 ease of oxidation

© UCLES 2016

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



Which statements about this structure are correct?

1 The empirical formula is C_2H_3Br.

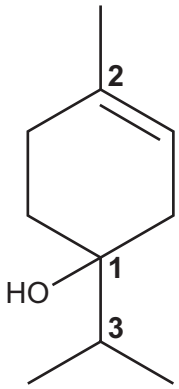
2 The C_{12} ring is not planar.

3 There are six chiral carbon atoms.

38 One of the active ingredients in tea-tree oil is terpinen-4-ol.

In the diagram of the skeletal formula of terpinen-4-ol, three of the carbon atoms are labelled **1**, **2** and **3**.

Which of the labelled carbon atoms are chiral?



terpinen-4-ol

GradeMax

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.

39 Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \xrightarrow{NaCN} CH_3CH_2CH(OH)CN$$

Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The sodium cyanide provides a stronger nucleophile than HCN.

2 The reaction can be classified as nucleophilic substitution.

3 The hydrogen cyanide molecule attacks the propanal molecule to form an intermediate ion.

40 Which syntheses will be successful?

1 $CH_3CH_2CH_3$ from $CH_3CH{=}CH_2 + LiAlH_4$

2 $CH_3CH(OH)CH_3$ from $CH_3COCH_3 + NaBH_4$

3 $CH_3CH_2CH_2OH$ from $CH_3CH_2CHO + NaBH_4$

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© UCLES 2016