Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2014**

1 hour

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

* 6 6 6 9 3 6 0 0 8 8 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

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Section A

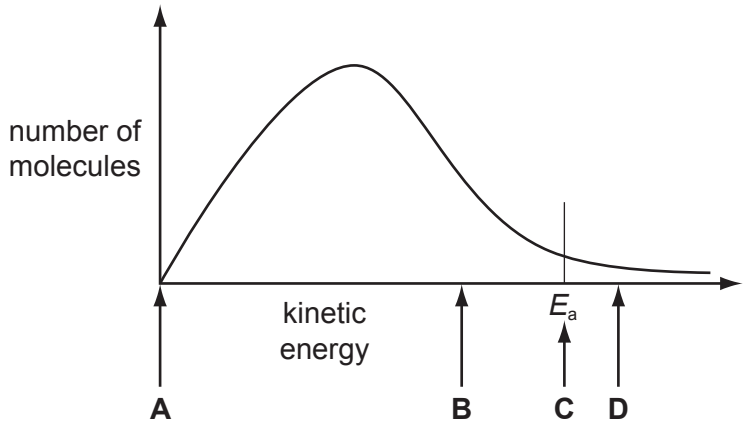
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 The diagram below represents, for a given temperature, the Boltzmann distribution of the kinetic energy of the molecules in a mixture of two gases that react slowly together.

The activation energy for the reaction, E_a, is marked.

When the reaction is catalysed, the rate of reaction increases a little.

What will be the position of E_a for the catalysed reaction?



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

In some types of spectroscopy, it is important to know if ions are isoelectronic. This means that they contain equal numbers of electrons.

Which ion is **not** isoelectronic with K^+?

A Ca^{2+} **B** Cl^- **C** S^{2-} **D** Ti^{3+}

3 Which row shows properties of a ceramic material?

	melting point / K	boiling point / K	conductivity of solid
A	156	352	none
B	922	1380	good
C	2130	2943	good
D	3125	3873	none

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4 Impure copper is purified by electrolysis. The electrolyte used in this process is aqueous copper(II) sulfate.

Which reaction takes place at the anode?

A $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

B $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

C $2OH^-(aq) \rightarrow \frac{1}{2}O_2(g) + H_2O(l) + 2e^-$

D $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

5 Hydrogen sulfide, H_2S, is released from volcanoes. It reacts with oxygen in the air to form sulfur dioxide.

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

$\Delta H_f^\ominus [H_2S(g)] = -21\,kJ\,mol^{-1}$

$\Delta H_f^\ominus [H_2O(l)] = -286\,kJ\,mol^{-1}$

$\Delta H_f^\ominus [SO_2(g)] = -297\,kJ\,mol^{-1}$

What is the standard enthalpy change of this reaction?

A $-1208\,kJ\,mol^{-1}$

B $-1124\,kJ\,mol^{-1}$

C $-562\,kJ\,mol^{-1}$

D $-541\,kJ\,mol^{-1}$

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

In some countries, anhydrous calcium chloride is used as a drying agent to reduce dampness in houses. The anhydrous salt absorbs enough water to form the dihydrate $CaCl_2.2H_2O$.

What is the percentage increase in mass?

A 14% **B** 24% **C** 32% **D** 36%

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7 Copper and iodine are both shiny crystalline solids.

Which forces exist between particles in solid copper and between neighbouring iodine molecules in solid iodine?

	copper	iodine
A	ionic bonds	covalent bonds
B	ionic bonds	van der Waals' forces
C	metallic bonds	covalent bonds
D	metallic bonds	van der Waals' forces

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

Ferrochrome is an alloy of iron and chromium. Ferrochrome can be dissolved in dilute sulfuric acid to produce a mixture of $FeSO_4$ and $Cr_2(SO_4)_3$. The $FeSO_4$ reacts with $K_2Cr_2O_7$ in acid solution according to the following equation.

$$14H^+ + 6Fe^{2+} + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

When 1.00 g of ferrochrome is dissolved in dilute sulfuric acid, and the resulting solution titrated, 13.1 cm^3 of 0.100 mol dm^{-3} $K_2Cr_2O_7$ is required for complete reaction.

What is the percentage by mass of Fe in the sample of ferrochrome?

A 1.22 **B** 4.39 **C** 12.2 **D** 43.9

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

When an evacuated glass tube of volume 200 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.06 g.

What is the identity of the gas?

A argon

B krypton

C neon

D xenon

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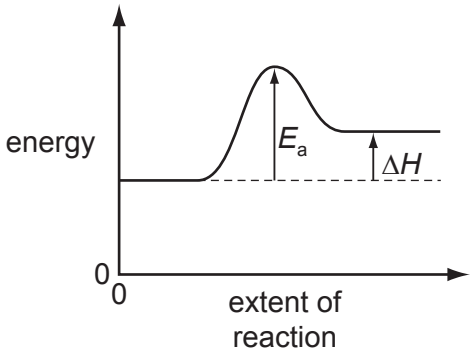
10 Nitrogen monoxide is an atmospheric pollutant that is formed inside car engines by an endothermic reaction between nitrogen and oxygen.

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \qquad \Delta H = +66\,kJ\,mol^{-1}$$

Which labelled diagram correctly represents the energy profile for this reaction?

A



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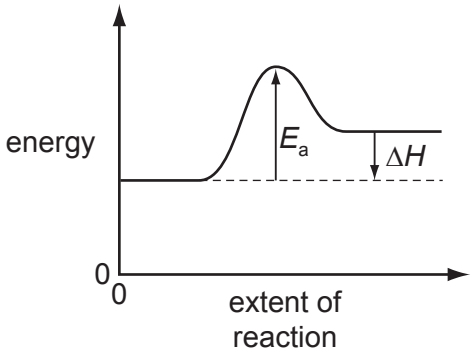

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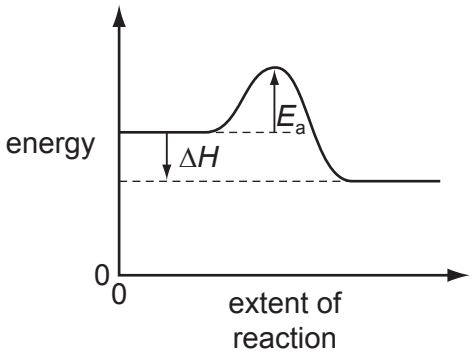
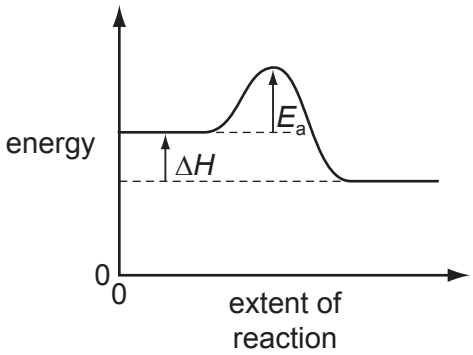


D



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

When 0.47 g of a hydrocarbon was completely burnt in air, the energy released heated 200 g of water from 23.7 °C to 41.0 °C.

What was the amount of energy absorbed by the water?

A $0.47 \times 4.18 \times 17.3\,J$

B $0.47 \times 4.18 \times (273 + 17.3)\,J$

C $200 \times 4.18 \times 17.3\,J$

D $200 \times 4.18 \times (273 + 17.3)\,J$

12 What is the **ionic** equation for the reaction between aqueous sodium carbonate and dilute nitric acid?

A $2HNO_3(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + 2NO_3^-(aq)$

B $2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$

C $2HNO_3(aq) + Na_2CO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$

D $2HNO_2(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + 2NO_2^-(aq)$

13 Pieces of calcium and magnesium are reacted separately with cold water.

Pieces of calcium and magnesium are also burned separately with oxygen.

Which row correctly describes the observations from these reactions?

	calcium with cold water	magnesium with cold water	calcium with oxygen	magnesium with oxygen
A	rapid bubbling	slow bubbling	red flame	white flame
B	rapid bubbling	slow bubbling	white flame	red flame
C	slow bubbling	rapid bubbling	red flame	white flame
D	slow bubbling	rapid bubbling	white flame	red flame

14 **X**, **Y** and **Z** are compounds of three elements in Period 3. Their electrical conductivities are shown in the table.

	X	**Y**	**Z**
conductivity of the compound in the molten state	good	does not conduct	does not conduct
conductivity of the mixture obtained by adding the compound to water	good	good	does not conduct

What could be compounds **X**, **Y** and **Z**?

	X	**Y**	**Z**
A	Al_2O_3	$SiCl_4$	NaF
B	NaF	Al_2O_3	$SiCl_4$
C	NaF	$SiCl_4$	SiO_2
D	$SiCl_4$	Al_2O_3	SiO_2

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15 A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water. Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was added, the precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder have consisted of?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

16 **X** is a mixture of two compounds of Group II elements.

X can undergo thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture **X**?

A $MgCl_2$ and $CaCO_3$

B $MgCO_3$ and $Ca(NO_3)_2$

C $Mg(NO_3)_2$ and $Ca(NO_3)_2$

D MgO and $CaSO_4$

17 An element **Y** reacts according to the following sequence.

$$\mathbf{Y} \xrightarrow{\text{burns in } O_2} \text{white solid} \xrightarrow{HCl(aq)} \text{solution} \xrightarrow{NaOH(aq)} \text{white precipitate} \xrightarrow{\text{an excess of } NaOH(aq)} \text{solution}$$

What could be element **Y**?

A Al **B** Ca **C** Mg **D** P

18 One molecule of the oxide of element **Z** reacts with six molecules of water to produce an acidic compound.

What is element **Z**?

A aluminium

B phosphorus

C sodium

D sulfur

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19 A student examines two semi-precious stones; one is agate, SiO_2, and the other is calcite, $CaCO_3$.

How could they be distinguished?

A Add a fixed amount of cold aqueous sodium hydroxide to each separately and measure any temperature change.

B Heat each separately over a gentle Bunsen flame and note which one melts first.

C Shake each separately with dilute hydrochloric acid and test any gas formed.

D Shake each separately with distilled water and add a few drops of Universal Indicator.

20 In this question, structural isomerism **and** stereoisomerism should be considered.

How many isomeric aldehydes have the formula $C_5H_{10}O$?

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

21 Aldehydes and ketones are carbonyl compounds.

Which of them react with **both** $LiAlH_4$ and Tollens' reagent?

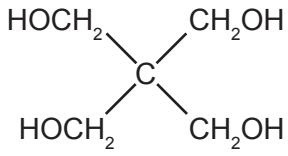
A aldehydes only

B both aldehydes and ketones

C ketones only

D neither aldehydes nor ketones

22 Pentaerythritol is used as an intermediate in the manufacture of paint.



pentaerythritol

Which statement about pentaerythritol is correct?

A It can be dehydrated by concentrated sulfuric acid to form an alkene.

B Its empirical formula and its molecular formula are different.

C It does not react with acidified potassium manganate(VII).

D One mole of it gives two moles of hydrogen gas on reaction with an excess of sodium.

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23 A compound **Y**, C_4H_9Br, undergoes hydrolysis in aqueous alkali to form an alcohol, C_4H_9OH. The rate of this reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of **Y**?

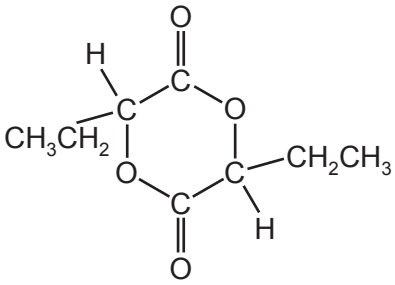
A $CH_3CH_2CH_2CH_2Br$

B $CH_3CH_2CHBrCH_3$

C $(CH_3)_2CHCH_2Br$

D $(CH_3)_3CBr$

24 Compound **X** can be made from 2-hydroxybutanoic acid.



compound **X**

What should be heated with 2-hydroxybutanoic acid in order to make compound **X**?

A acidified potassium dichromate(VI)

B aluminium oxide

C concentrated sulfuric acid

D dilute sodium hydroxide

25 The compound known as 'gamma-linolenic acid' is found in the seeds of the evening primrose plant.

$$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_4CO_2H$$

gamma-linolenic acid

How many *cis-trans* isomers are there with this structural formula?

A 3 **B** 6 **C** 8 **D** 12

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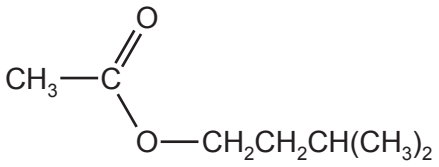
26 Pheromones are used by insects and other animals as a means of communication.

The pheromone in a bee sting is 3-methylbutyl ethanoate.



3-methylbutyl ethanoate

What are the organic products when 3-methylbutyl ethanoate is heated under reflux with aqueous sodium hydroxide?

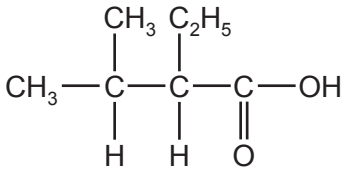
A CH_3CO_2H and $(CH_3)_2CHCH_2CH_2OH$

B CH_3CO_2H and $(CH_3)_2CHCH_2CH_2O^-Na^+$

C $CH_3CO_2^-Na^+$ and $(CH_3)_2CHCH_2CH_2OH$

D $CH_3CO_2^-Na^+$ and $(CH_3)_2CHCH_2CH_2O^-Na^+$

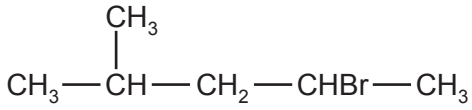
27 The compound 2-ethyl-3-methylbutanoic acid is used as a flavouring in some food.



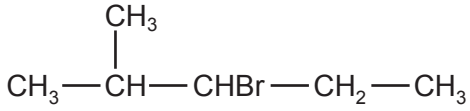
2-ethyl-3-methylbutanoic acid

Which compound will produce 2-ethyl-3-methylbutanoic acid when heated under reflux with sodium cyanide in ethanol, followed by acid hydrolysis of the reaction product?

A



B



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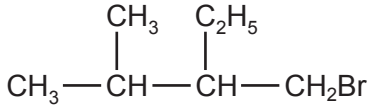
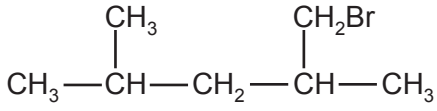


D

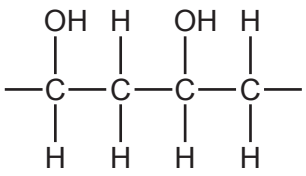


28 Poly(ethenol) can be used to make plastic bags that dissolve in water.

It may be considered to be made by addition polymerisation of CH_2=CH(OH).

Which structure represents a length of the polymer chain consisting of two monomer residues?

A



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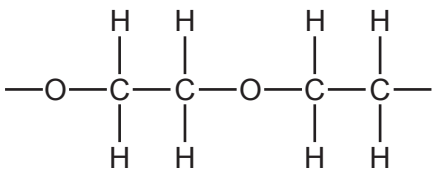

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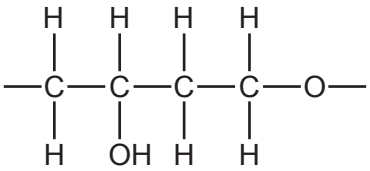
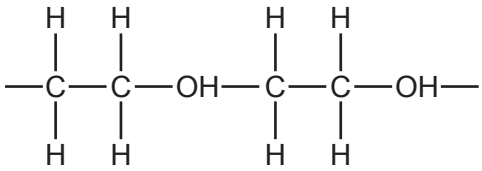
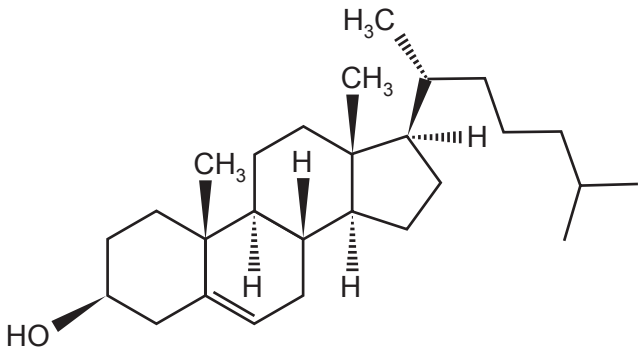


D



29 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Student X stated that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y stated that this molecule displays *cis-trans* isomerism at the C = C double bond.

Which of the students are correct?

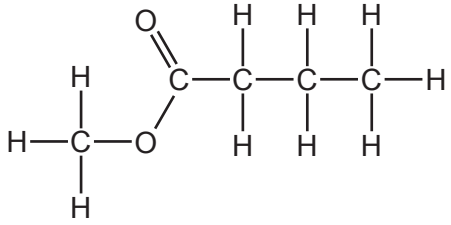
A both X and Y

B neither X nor Y

C X only

D Y only

30 Methyl butanoate, $C_5H_{10}O_2$, is an ester used in the food industry to give products the flavour of apples.



methyl butanoate

Including methyl butanoate, how many **structural** isomers are there of $C_5H_{10}O_2$ that are esters?

A 6 **B** 8 **C** 9 **D** 10

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 a solution that contains both Br_2 and Cl_2, a process takes place that produces BrO_3^- ions.

The process is represented by the following equations.

equation 1 $\quad Br_2 + H_2O \rightarrow HBr + HBrO$

equation 2 $\quad 3HBrO + Cl_2 \rightarrow 2Cl^- + BrO_3^- + Br_2 + 3H^+$

Which statements about these reactions are correct?

1 Chlorine is reduced in equation 2.

2 Bromine is oxidised in both equation 1 and equation 2.

3 Bromine is reduced in both equation 1 and equation 2.

32 Which statements are correct when referring to the isotopes of a single element?

1 The isotopes have different masses.

2 The isotopes have different numbers of nucleons.

3 The isotopes have different chemical reactions.

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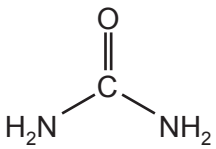
The responses **A** to **D** should be selected on the basis of

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.

33 Which types of intermolecular forces can exist between adjacent urea molecules?



urea

1 hydrogen bonding

2 permanent dipole-dipole forces

3 instantaneous dipole-induced dipole forces

34 Which names can be applied to the enthalpy change of the reaction shown?

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)$$

1 enthalpy change of formation

2 enthalpy change of combustion

3 enthalpy change of hydration

35 Compared with the HI molecule, the bond ……P…… of the HBr molecule is ……Q……

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

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36 Element **X** is a solid. It is found in some fuels.

Its oxide **Y** is formed in car engines. **Y** is acidic.

Further oxidation of **Y** to **Z** can occur in the atmosphere.

Which statements about **Y** and **Z** are correct?

1 Molecule **Y** has lone pairs of electrons.

2 The atmospheric oxidation of **Y** to **Z** is a catalysed reaction.

3 **Y** is a colourless gas.

37 Which statements about the photochemical chlorination of ethane are correct?

1 A propagation step in the mechanism is $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$.

2 Butane is present in the products.

3 The initiation step is the heterolytic fission of chlorine.

38 Which compounds produce pent-2-ene as either one of the products, or as the only product, on heating with potassium hydroxide in ethanol?

1 $CH_3CH_2CH_2CH_2CH_2Br$

2 $CH_3CHBrCH_2CH_2CH_3$

3 $CH_3CH_2CHBrCH_2CH_3$

39 Which reactions have a coloured organic product?

1 ethanal + 2,4-dinitrophenylhydrazine reagent

2 ethanol + acidified potassium dichromate(VI)

3 ethene + cold dilute acidified potassium manganate(VII)

40 Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

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

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 mechanism involves two steps.

3 The product of the reaction has a chiral carbon atom.

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