Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2014**

1 hour

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

8387079243

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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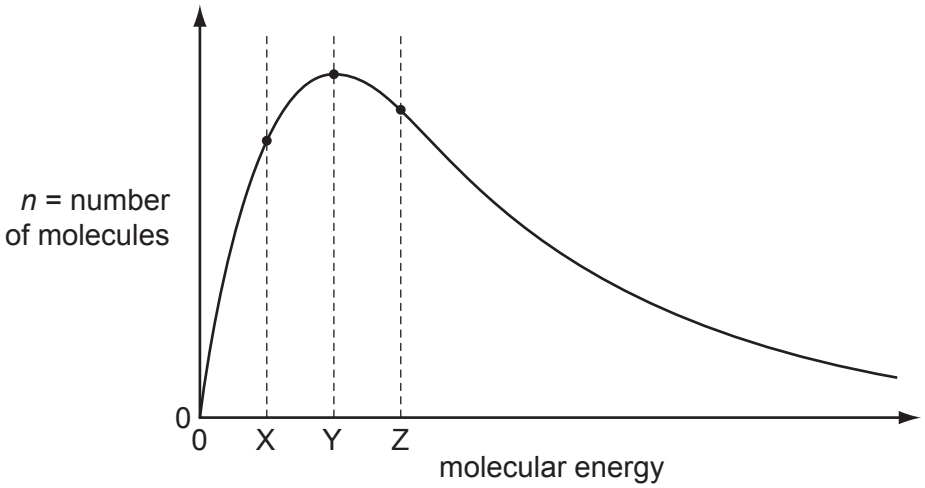
Section A

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

1 The Boltzmann distribution for a gas at constant temperature is shown below.



If the temperature of the gas is **reduced** by 10 °C the graph changes shape.

What happens to the values of *n* for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

2 Which compound has the greatest total number of lone pairs of electrons in the valence shells of all of its atoms?

A CH_3Cl **B** CO_2 **C** N_2H_4 **D** NH_4CN

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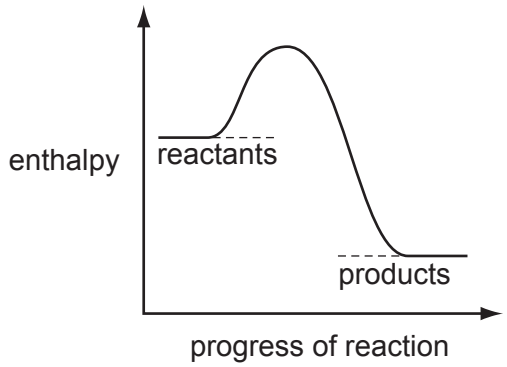
3 A reaction pathway diagram is shown.



Which enthalpy change could the diagram **not** apply to?

A enthalpy of atomisation

B enthalpy of combustion

C enthalpy of formation

D enthalpy of neutralisation

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

The most common ion-molecule reaction in gas clouds of the Universe is as shown.

$$H_2(g) + H_2^+(g) \rightarrow H(g) + H_3^+(g)$$

What could be the composition of an H_3^+ ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

5 The electrolysis of brine using the diaphragm cell is an important industrial process.

What happens at the anode?

A Chloride ions are oxidised.

B Hydrogen gas is produced.

C Hydroxide ions are formed.

D The electrode reaction is $2Cl^-(aq) + 2e^- \rightarrow Cl_2(g)$.

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6 Hydrazine, N_2H_4, is used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -534\,kJ\,mol^{-1}$$

Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

A Hydrazine is a liquid.

B The activation energy is too high.

C The N≡N bond is very strong.

D The reaction is exothermic.

7 A 10.0 cm^3 bubble of an ideal gas is formed on the sea bed where it is at a pressure of 2020 kPa.

Just below the sea surface the pressure is 101 kPa and the temperature is the same as the sea bed.

What is the volume of the bubble when it rises to just below the sea surface?

A 10.0 cm^3 **B** 20.2 cm^3 **C** 200 cm^3 **D** 2 020 000 cm^3

8 Four substances have the physical properties shown.

Which substance is an ionic solid?

	melting point / °C	boiling point / °C	electrical conductivity of solid	electrical conductivity of molten substance	electrical conductivity of aqueous solution
A	–115	–85	poor	poor	good
B	660	2470	good	good	insoluble
C	993	1695	poor	good	good
D	1610	2230	poor	poor	insoluble

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9 The enthalpy change of formation of $Mn(NO_3)_2(s)$ is $-696\,kJ\,mol^{-1}$.
The enthalpy change of formation of $MnO_2(s)$ is $-520\,kJ\,mol^{-1}$.
The enthalpy change of formation of $NO_2(g)$ is $+33\,kJ\,mol^{-1}$.

On heating, $Mn(NO_3)_2$ decomposes into MnO_2 and NO_2.

$$Mn(NO_3)_2(s) \rightarrow MnO_2(s) + 2NO_2(g)$$

What is the value of the standard enthalpy change of this reaction?

A $-242\,kJ\,mol^{-1}$

B $-209\,kJ\,mol^{-1}$

C $+209\,kJ\,mol^{-1}$

D $+242\,kJ\,mol^{-1}$

10 X is an element in Period 2.

In which fluoride is the F – X – F angle the largest?

A BF_3 **B** CF_4 **C** NF_3 **D** OF_2

11 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

12 A student investigated the chloride of a Period 3 element. This is what he wrote down as his record of what he did and what he saw.

> The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes heating.

What can be deduced from this record?

A At least one of the recorded observations is incorrect.

B The compound was magnesium chloride, $MgCl_2$.

C The compound was phosphorus pentachloride, PCl_5.

D The compound was sodium chloride, $NaCl$.

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

X is an s-block element. **X** forms an insoluble carbonate with the formula $\mathbf{X}CO_3$. **X** forms a hydroxide that is more soluble than strontium hydroxide.

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

A barium

B calcium

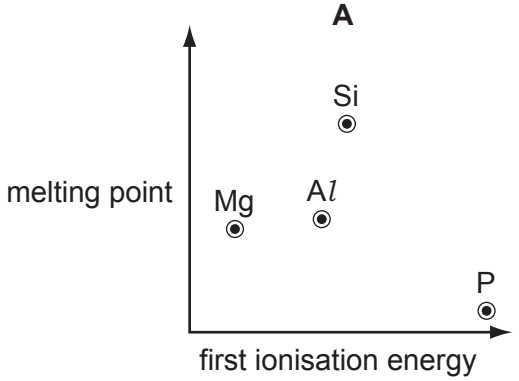
C cobalt

D rubidium

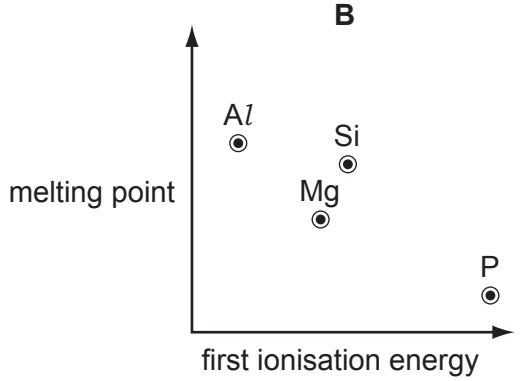
14 *Use of the Data Booklet is relevant to this question*.

Which graph correctly shows the melting points of the elements Mg, A*l*, Si and P plotted against their first ionisation energies?

A



B



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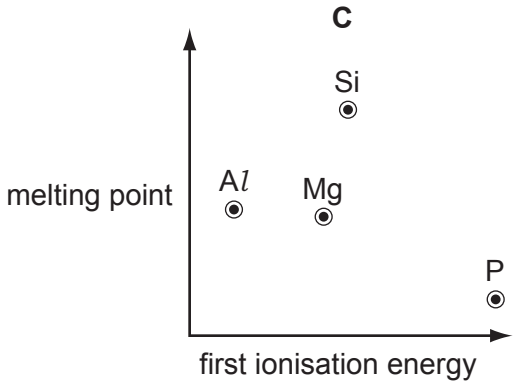
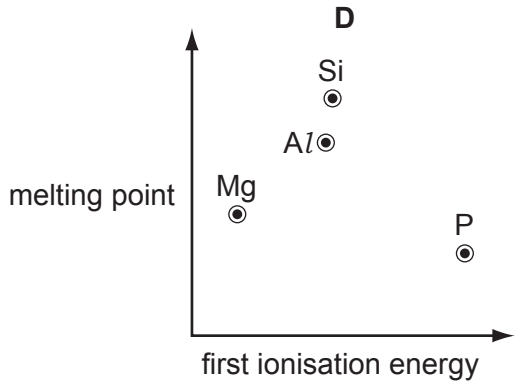


D



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15 Which substance will **not** be a product of the thermal decomposition of hydrated magnesium nitrate?

A dinitrogen monoxide

B magnesium oxide

C oxygen

D steam

16 The species Ne, Na^+ and Mg^{2+} are isoelectronic. This means that they have the same number of electrons.

In which order do their radii increase?

	smallest ⟶		largest
A	Ne	Na^+	Mg^{2+}
B	Ne	Mg^{2+}	Na^+
C	Mg^{2+}	Ne	Na^+
D	Mg^{2+}	Na^+	Ne

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

In an experiment, 0.6 mol of chlorine gas, Cl_2, is reacted with an excess of hot aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen and chlorine.

Which mass of this product is formed?

A 21.3 g **B** 44.7 g **C** 63.9 g **D** 128 g

18 Which properties do compounds of aluminium and silicon have in common?

A Aqueous solutions of their chlorides contain aluminium or silicon cations.

B Their chlorides have co-ordinate bonding.

C Their oxides are amphoteric.

D Their oxides are insoluble in water.

19 When strontium is burnt in oxygen, what colour is the flame?

A green

B red

C white

D yellow

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20 Diesters can be made from diacids such as propane-1,3-dioic acid, $HO_2CCH_2CO_2H$.

Which combination of reactants would form the diester $CH_3CH_2OCOCH_2CH_2CO_2CH_2CH_3$?

A butane-1,4-dioic acid and ethanol

B ethanedioic acid and propan-1-ol

C ethanedioic acid, ethanol and butan-1-ol

D propane-1,3-dioic acid, ethanol and propan-1-ol

21 In the presence of ultraviolet light, ethane and chlorine react to give a mixture of products.

Which compound could be present in the mixture of products?

A CH_3Cl

B $CH_3CH_2CH_2Cl$

C $CH_3CH_2CH_2CH_3$

D $CH_3CH_2CH_2CH_2CH_3$

22 Compound **X** produces a carboxylic acid when heated under reflux with acidified potassium dichromate(VI). Compound **X** has no reaction with sodium metal.

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

A propanal

B propanone

C propan-1-ol

D propan-2-ol

23 Which molecule could **not** be obtained from the cracking of a molecule of nonane, $CH_3(CH_2)_7CH_3$?

A $CH_2=CHCH=CH_2$

B $CH_3CH_2CH_2CH_2CH_3$

C $CH_3CH_2CH_2CH_2CH_2CH=CH_2$

D $(CH_3CH_2CH_2)_3CH$

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24 A student investigates four different fuels. Each fuel is used separately to raise the temperature of 1 dm^3 of water from 20 °C to 100 °C. Each fuel undergoes complete combustion. All other conditions are the same in each experiment.

Which fuel would produce the **smallest** amount of carbon dioxide in these experiments?

	fuel	energy released per mole of fuel
A	ethanol	1367 kJ mol^{-1}
B	methane	890 kJ mol^{-1}
C	methanol	715 kJ mol^{-1}
D	propane	2220 kJ mol^{-1}

25 Most alcohols can be dehydrated to give alkenes.

Which alcohol can be dehydrated to give three different isomeric alkenes?

A $CH_3(CH_2)_3CH_2OH$

B $CH_3(CH_2)_2CH(OH)CH_3$

C $CH_3CH_2CH(OH)CH_2CH_3$

D $CH_3C(CH_3)_2CH_2OH$

26 Hept-4-enal is present in cow's milk.

$$CH_3CH_2CH{=}CHCH_2CH_2CHO$$

hept-4-enal

Which row correctly shows the product formed when hept-4-enal is treated with the given reducing agent?

	reducing agent	product
A	H_2 + Ni	$CH_3(CH_2)_5CH_2OH$
B	H_2 + Ni	$CH_3(CH_2)_5CH_3$
C	$NaBH_4$	$CH_3(CH_2)_5CH_2OH$
D	$NaBH_4$	$CH_3(CH_2)_5CHO$

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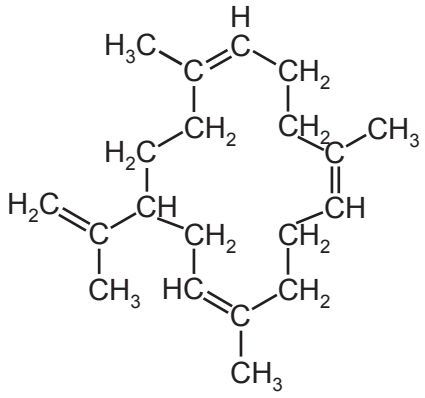
27 The naturally-occurring molecule shown below can be made by the addition of four identical monomer molecules.



What could be the structural formula of the monomer?

A $CH_3CH_2CH_2CH=CH_2$

B $CH_3CH=CHCH=CH_2$

C $CH_2=C(CH_3)CH_2CH_3$

D $CH_2=C(CH_3)CH=CH_2$

28 The compound cetyl palmitate, $C_{15}H_{31}CO_2C_{16}H_{33}$, is a waxy solid.

When cetyl palmitate is heated under reflux with an excess of aqueous sodium hydroxide, which products will be formed?

A $C_{15}H_{31}ONa$ and $C_{16}H_{33}CO_2Na$

B $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}ONa$

C $C_{15}H_{31}OH$ and $C_{16}H_{33}CO_2Na$

D $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}OH$

29 One reaction in the Krebs cycle, in which energy is released to the human body, is the conversion of fumaric acid into malic acid.

$$HO_2CCH=CHCO_2H \rightarrow HO_2CCH(OH)CH_2CO_2H$$

fumaric acid malic acid

Which reagent(s) could achieve this conversion in the laboratory?

A acidified $KMnO_4(aq)$

B $Br_2(aq)$ followed by hot $NaOH(aq)$

C $H_2O(l)$ with Pt catalyst

D $H_2O(g)$ with H_2SO_4

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30 The free radical substitution reaction between methane and chlorine involves initiation, propagation and termination stages.

Which row is correct?

	involved in initiation stage	radical produced in a propagation stage
A	heterolytic fission	H•
B	heterolytic fission	CH_3•
C	homolytic fission	H•
D	homolytic fission	CH_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 In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

1 One atom of Uuh has one more neutron than one atom of Uuq.

2 One Uuq^{2-} ion has the same number of electrons as one atom of Uuh.

3 One Uuh^{+} ion has the same number of electrons as one Uuq^{-} ion.

32 P and Q are two liquid compounds with similar M_r values. Molecules of P attract each other by hydrogen bonds. Molecules of Q attract each other by van der Waals' forces only.

How do the properties of P and Q differ?

1 P has higher surface tension than Q.

2 P has a higher boiling point than Q.

3 P is less viscous than Q.

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33 Many crude oils contain H_2S. During refining, by the Claus process, the H_2S is converted into solid sulfur, 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.

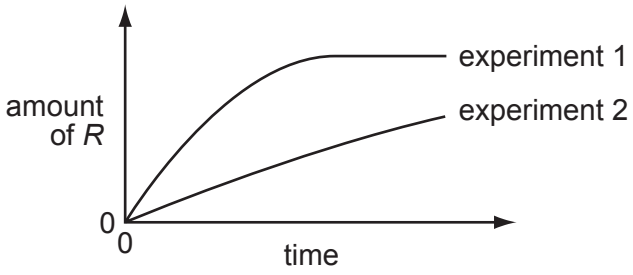
2 SO_2 oxidises H_2S in reaction II.

3 Hydrogen is oxidised in reaction II.

34 The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(l)$$

Two experiments were carried out in which the rate of production of *R* was measured. The results are shown in the diagram below.



Which changes in the conditions might explain the results shown?

1 A lower pressure was used in experiment 2.

2 A different catalyst was used in experiment 2.

3 Product *S* was continuously removed from the reaction vessel in experiment 2.

35 Which statements explain why sulfur dioxide is used as a food preservative?

1 It is a reducing agent and therefore an anti-oxidant.

2 It prevents alcohols in foods forming sour-tasting acids.

3 It does not smell and therefore can be used in large quantities.

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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.

36 The intermolecular forces between iodine molecules are instantaneous dipole-induced dipole forces.

Which statements explain why iodine has these intermolecular forces?

1 An iodine molecule is polar and experiences an attraction from a lone pair of electrons on an adjacent molecule.

2 An iodine molecule has a fluctuating dipole because the electrons in a molecule are more mobile than the nuclei.

3 The electron charge cloud within an I_2 molecule may become unsymmetrical and may then attract other I_2 molecules.

37 Which reactions must be warmed to form a solid product?

1 CH_3CH_2CHO + 2,4-dinitrophenylhydrazine reagent

2 CH_3CH_2CHO + Fehling's reagent

3 CH_3CH_2CHO + Tollens' reagent

38 When hydrolysed with dilute sulfuric acid, which compounds produce propanoic acid?

1 $CH_3CH_2CO_2CH_3$

2 $CH_3CH_2CH_2CN$

3 $CH_3CH_2CH_2Cl$

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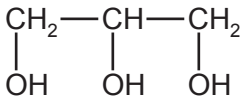
39 Propane-1,2,3-triol is the raw material for many important industrial chemical processes.



propane-1,2,3-triol

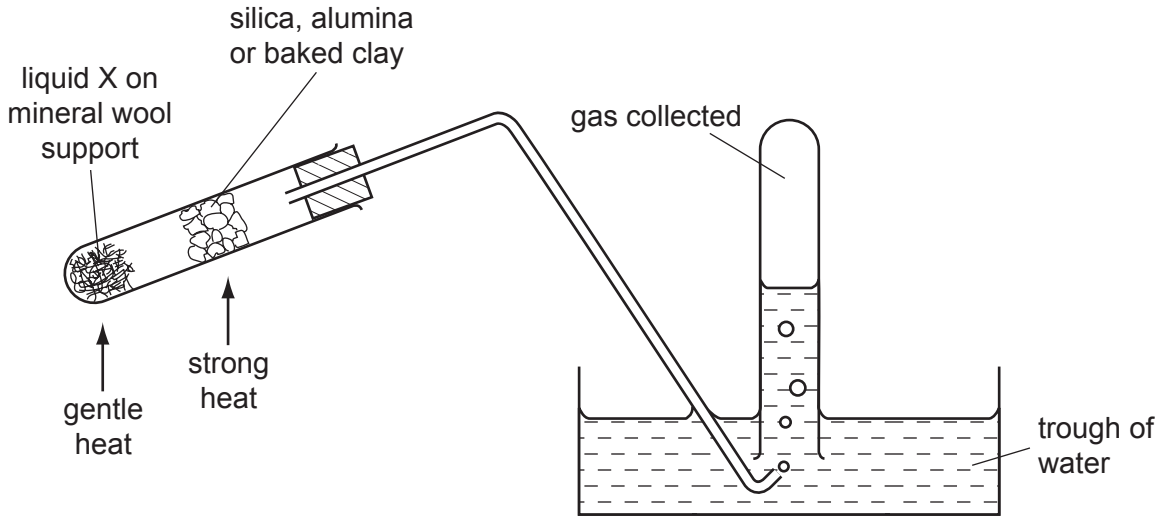
Which statements about propane-1,2,3-triol are correct?

1 It reacts with carboxylic acids to form compounds containing up to three ester groups.

2 It can be oxidised to form compounds with aldehyde and ketone functional groups.

3 It can be oxidised to form compounds with up to three carboxylic acid groups.

40 The diagram shows an experimental set-up which can be used in several different experiments.



Which processes could be demonstrated by using the above apparatus?

1 oxidation of ethanol (liquid X)

2 dehydration of ethanol (liquid X)

3 cracking of paraffin (liquid X)

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