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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2013**

1 hour

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

9832573678

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 **14** printed pages and **2** blank pages.

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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 In the redox reaction shown, how do the oxidation states of vanadium and sulfur change?

$$VO_2^{+} + SO_2 \rightarrow V^{3+} + SO_4^{2-}$$

	vanadium		sulfur	
	from	to	from	to
A	+1	+3	0	–2
B	+1	+3	+4	+6
C	+5	+3	0	–2
D	+5	+3	+4	+6

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

In which species are the numbers of protons, neutrons and electrons **all** different?

A $^{19}_{9}F^{-}$ **B** $^{23}_{11}Na^{+}$ **C** $^{31}_{15}P$ **D** $^{32}_{16}S^{2-}$

3 The first six ionisation energies of four elements are given.

Which element is most likely to be in Group IV of the Periodic Table?

	ionisation energy / kJ mol^{-1}					
	1st	2nd	3rd	4th	5th	6th
A	494	4 560	6 940	9 540	13 400	16 600
B	736	1 450	7 740	10 500	13 600	18 000
C	1 090	2 350	4 610	6 220	37 800	47 000
D	1 400	2 860	4 590	7 480	9 400	53 200

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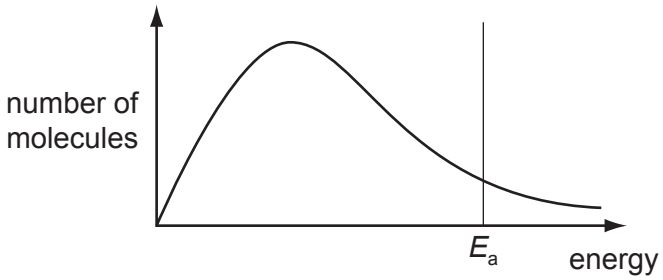
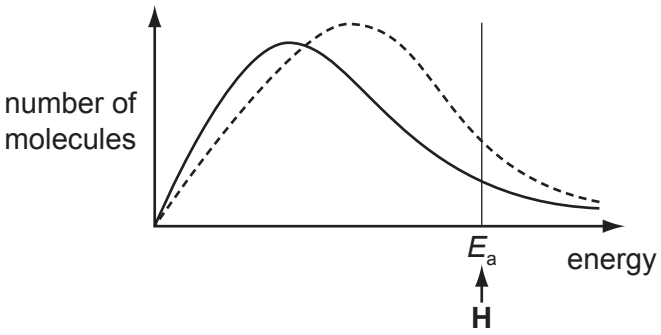
4 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that will react together. The activation energy for the reaction, E_a, is marked.



The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, **H** represents the activation energy at the higher temperature.

Which diagram is correct?

A



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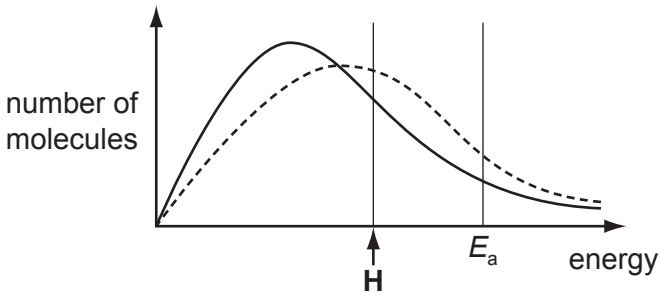

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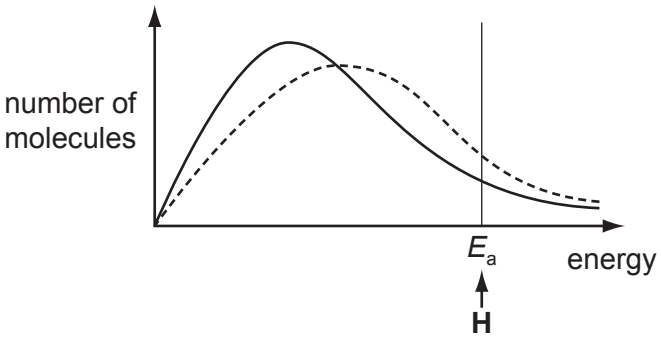
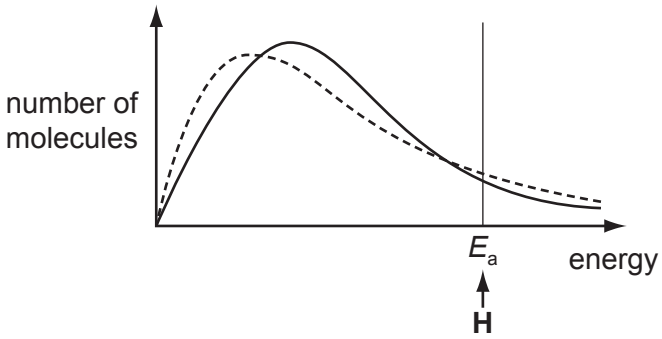


D



5 Crotonaldehyde, $CH_3CH=CHCHO$, can be obtained by oxidising butadiene, $CH_2=CHCH=CH_2$, using air or oxygen. One method is to pass a mixture of butadiene and oxygen through a hot aqueous solution of palladium(II) ions, $Pd^{2+}(aq)$, which catalyse the reaction.

Which statement is **not** correct about the action of the $Pd^{2+}(aq)$ ions?

A Changing the concentration of the $Pd^{2+}(aq)$ will have an effect on the rate of the reaction.

B $Pd^{2+}(aq)$ increases the energy of the reacting molecules.

C $Pd^{2+}(aq)$ lowers the activation energy for the reaction.

D $Pd^{2+}(aq)$ provides a different route for the reaction.

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6 Which **least** resembles an ideal gas at room temperature and pressure?

A ammonia

B helium

C hydrogen

D methane

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

When 0.15 g of an organic compound is vaporised, it occupies a volume of 65.0 cm^3 at 405 K and 1.00×10^5 Nm^{-2}.

Using the expression $pV = nRT$, which of the following expressions should be used to calculate the relative molecular mass, M_r, of the compound?

A $\dfrac{0.15 \times 65 \times 10^{-6} \times 1 \times 10^5}{8.31 \times 405}$

B $\dfrac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-3}}$

C $\dfrac{0.15 \times 65 \times 10^{-3} \times 1 \times 10^5}{8.31 \times 405}$

D $\dfrac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-6}}$

8 Which compound is the only gas at room temperature and pressure?

A $CH_3CH_2CH_2NH_2$ $M_r = 59.0$

B $CH_3CH_2CH_2OH$ $M_r = 60.0$

C CH_2OHCH_2OH $M_r = 62.0$

D CH_3CH_2Cl $M_r = 64.5$

9 Which formula represents the empirical formula of a compound?

A CH_4O **B** C_2H_4 **C** C_6H_{12} **D** H_2O_2

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

A washing powder contains sodium hydrogencarbonate, $NaHCO_3$, as one of the ingredients. In a titration, a solution containing 1.00 g of washing powder requires 7.15 cm^3 of 0.100 mol dm^{-3} sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

A 3.0 **B** 6.0 **C** 12.0 **D** 24.0

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

This question should be answered using bond enthalpy data. The equation for the complete combustion of methanal is given below.

$$H_2C{=}O \; + \; O_2 \; \rightarrow \; CO_2 \; + \; H_2O$$

What is the enthalpy change of combustion of methanal?

A $+416\,kJ\,mol^{-1}$

B $+396\,kJ\,mol^{-1}$

C $-344\,kJ\,mol^{-1}$

D $-690\,kJ\,mol^{-1}$

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

Anhydrous magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated, giving a white solid and a mixture of two gases **X** and **Y**.

Y is oxygen.

What is the ratio $\frac{\text{mass of } \mathbf{X} \text{ released}}{\text{mass of } \mathbf{Y} \text{ released}}$?

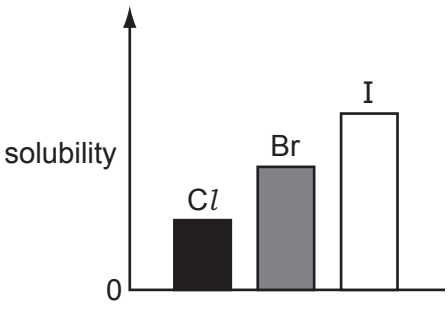
A $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

13 In which row of the table are all statements comparing magnesium and barium correct?

	fourth ionisation energy of magnesium	fourth ionisation energy of barium	reaction of magnesium with cold water	reaction of barium with cold water
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

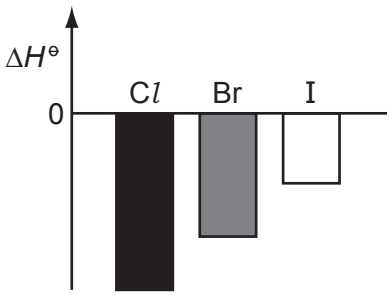
14 Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown.

student P



solubility of AgX(s) in $NH_3(aq)$

student Q



$\Delta H^{\ominus}$ for $H_2(g) + X_2(g) \rightarrow 2HX(g)$

Which of the student's diagrams are correct?

A both P and Q

B P only

C Q only

D neither P nor Q

15 When iodine is heated, a vapour is produced.

Which row of the table correctly identifies the species in the vapour and its colour?

	species	colour
A	I(g)	brown
B	I(g)	purple
C	$I_2(g)$	brown
D	$I_2(g)$	purple

16 How do the strengths of the covalent bonds within molecules, and the van der Waals' forces between molecules, vary going down Group VII from chlorine to bromine to iodine?

	strength of covalent bonds	strength of van der Waals' forces
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

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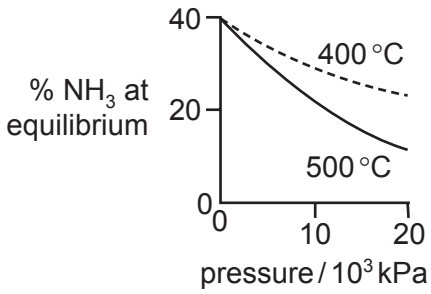
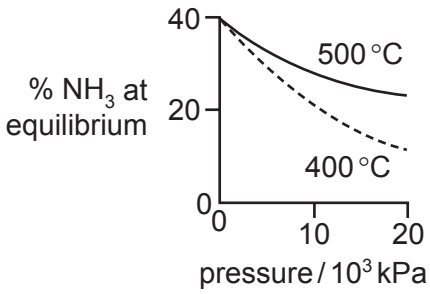
17 Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

Which diagram correctly represents these two graphs?

A



B



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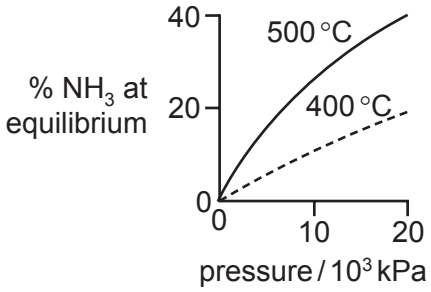

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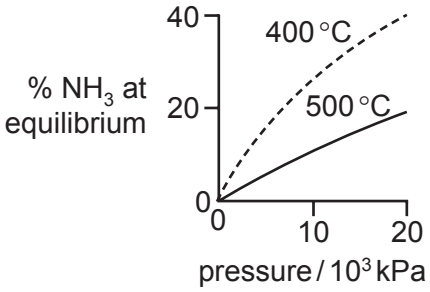

18 In a famous experiment, Wöhler heated 'inorganic' ammonium cyanate in the absence of air. The only product of the reaction was 'organic' urea, $CO(NH_2)_2$. No other products were formed in the reaction.

What is the formula of the cyanate ion present in ammonium cyanate?

A CNO^- **B** CNO^{2-} **C** CO^- **D** NO^-

19 Transition elements and their compounds are important as catalysts.

In which process is a transition element compound used, rather than the element itself?

A catalytic converters

B Contact process

C Haber process

D hydrogenation of oils

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20 Ethene reacts with steam in the presence of sulfuric acid.

$$C_2H_4 + H_2O \rightarrow CH_3CH_2OH$$

What type of reaction is this?

A acid / base

B addition

C hydrolysis

D substitution

21 What is true of every nucleophile?

A It attacks a double bond.

B It has a lone pair of electrons.

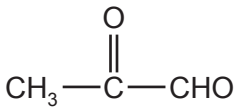
C It is a single atom.

D It is negatively charged.

22 How many isomers, including structural and stereoisomers, with the formula C_4H_8 have structures that involve π bonding?

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

23 Burnt sugar has a characteristic smell caused partly by the following compound.



This compound contains two functional groups.

Which reagent will react with **both** functional groups?

A acidified potassium dichromate(VI)

B Fehling's solution

C hydrogen cyanide

D sodium hydroxide

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24 Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

A concentrated sulfuric acid, followed by bromine

B concentrated sulfuric acid, followed by hydrogen bromide

C ethanolic sodium hydroxide, followed by bromine

D ethanolic sodium hydroxide, followed by hydrogen bromide

25 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.

What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

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

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

C homolytic bond fission followed by an attack by an electrophile on a carbanion

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

26 Which compound gives an organic product with a lower boiling point when it is heated under reflux with an excess of acidified potassium dichromate(VI)?

A 2-methylbutan-1-ol

B 2-methylbutan-2-ol

C pentan-1-ol

D pentan-2-ol

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

Which volume of oxygen, at room temperature and pressure, is needed for complete combustion of 0.1 mol of ethanol?

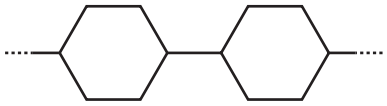
A 7.2 dm^3 **B** 8.4 dm^3 **C** 14.4 dm^3 **D** 16.8 dm^3

28 Cyclohexene, shown below, can form an addition polymer.

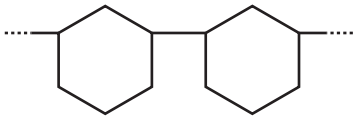


Which structure represents a section of the polymer including two cyclohexene residues?

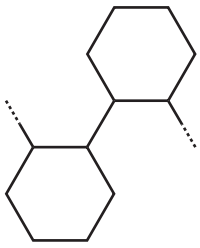
A



B



C



D



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 CCl_2FCClF_2 can be converted into 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 1?

A addition

B elimination

C isomerisation

D oxidation

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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 A space shuttle's upward thrust came from the following reaction between aluminium and ammonium perchlorate.

$$10Al + 6NH_4ClO_4 \rightarrow 4Al_2O_3 + 2AlCl_3 + 12H_2O + 3N_2$$

Which statements about this reaction are correct?

1 Aluminium is oxidised.

2 Chlorine is reduced.

3 Nitrogen is oxidised.

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

Which statements are correct when referring to the atoms ^{23}Na and ^{24}Mg?

1 They have the same number of full electron orbitals.

2 They have the same number of neutrons.

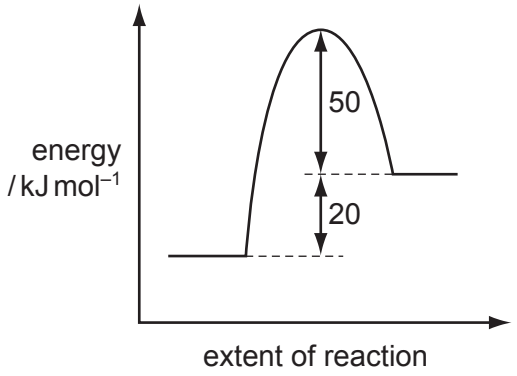
3 They are both reducing agents.

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 The reaction pathway for a reversible reaction is shown below.



Which statements are correct?

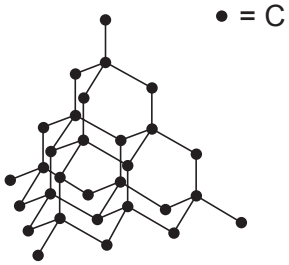
1 The enthalpy change for the backward reaction is –20 kJ mol^{-1}.

2 The forward reaction is endothermic.

3 The activation energy for the forward reaction is +70 kJ mol^{-1}.

34 Which diagrams represent part of a giant molecular structure?

1



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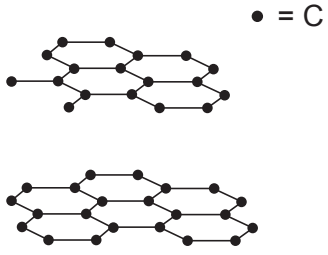

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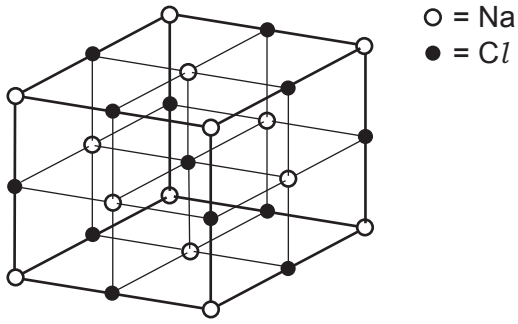

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35 Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 More acid is neutralised by 2.0 g of **X** than by 2.0 g of **W**.

2 The M_r of **X** is greater than the M_r of **Y** by 44.0.

3 The metallic element in **Y** reacts with cold water more quickly then the metallic element in **W**.

36 Element **J** is a solid. It occurs as a contaminant of fossil fuels.

Its oxide **K** is formed in car engines.

In the atmosphere, **K** can be further oxidised to **L**.

Which statements about **J**, **K** and **L** are correct?

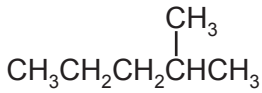
1 Atoms of **J** have paired p electrons.

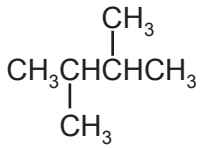
2 The atmospheric oxidation of **K** to **L** is a catalysed reaction.

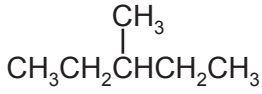
3 With water, **L** forms a strong acid.

37 During the bromination of methane, the free radical $CH_3\bullet$ is generated. A possible terminating step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a terminating step during the bromination of **propane**?

1 

2 

3 

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 Fabrics for use in aircraft seating are treated with a coating containing a halogenoalkane.

Why is this coating used?

1 The treated fabric burns less easily, improving safety.

2 The treated fabric forms hydrogen bonds to water more readily, so it is easier to wash.

3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

39 A liquid **X** is known to be either a single organic compound or a mixture of organic compounds. When treated with sodium, **X** gives off hydrogen gas.

When treated with 2,4-dinitrophenylhydrazine reagent, **X** gives orange crystals.

Which deductions about **X** can definitely be made?

1 At least one component of **X** is a carbonyl compound.

2 Only one of the components of **X** is a carbonyl compound.

3 At least one component of **X** is an alcohol.

40 Ethanoic acid, CH_3CO_2H, is an important chemical which is used in the industrial manufacture of rayon and aspirin.

Which processes can be used to make ethanoic acid?

1 hydrolysis of ethanenitrile

2 oxidation of ethanol

3 oxidation of ethanal

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