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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2011**

1 hour

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

* 4 2 9 8 6 4 6 2 5 4 *

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.

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 Which equation represents the second ionisation energy of an element X?

A $X(g) \rightarrow X^{2+}(g) + 2e^-$

B $X^+(g) \rightarrow X^{2+}(g) + e^-$

C $X(g) + 2e^- \rightarrow X^{2-}(g)$

D $X^-(g) + e^- \rightarrow X^{2-}(g)$

2 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

A The nuclear charge of the elements increases.

B The outer electron is in an 's' subshell.

C The repulsion between spin-paired electrons increases.

D The shielding effect of the inner shells increases.

3 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?

A to ensure the aluminium is not oxidised

B to ensure the anode is not oxidised

C to lower the melting point of the aluminium oxide

D to prevent corrosion of the cathode

4 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?

$$NO_3^-(aq) \xrightarrow{\textbf{A}} NO_2^-(aq) \xrightarrow{\textbf{B}} NO(g) \xrightarrow{\textbf{C}} N_2O(g) \xrightarrow{\textbf{D}} N_2(g)$$

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5 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

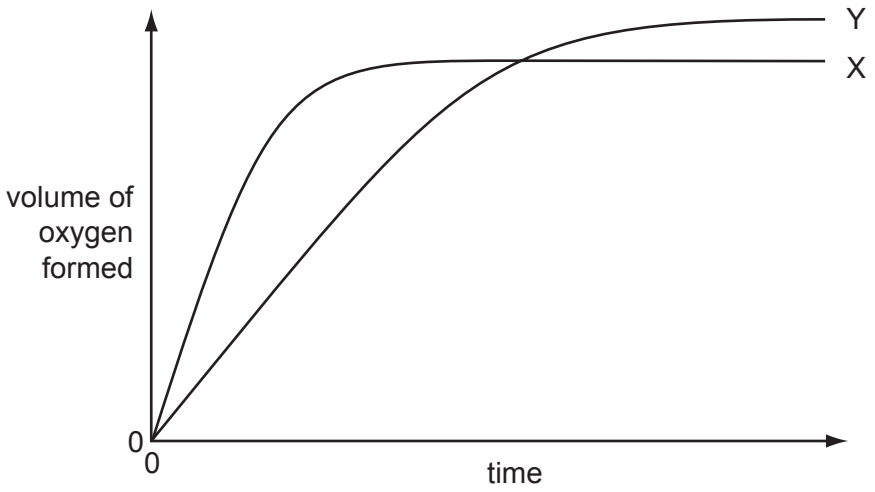
A An iron catalyst is used.

B Maintaining the higher pressures is more expensive.

C The equilibrium yield of ammonia is increased at lower pressures.

D The rate of the reaction is increased at lower pressures.

6 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?

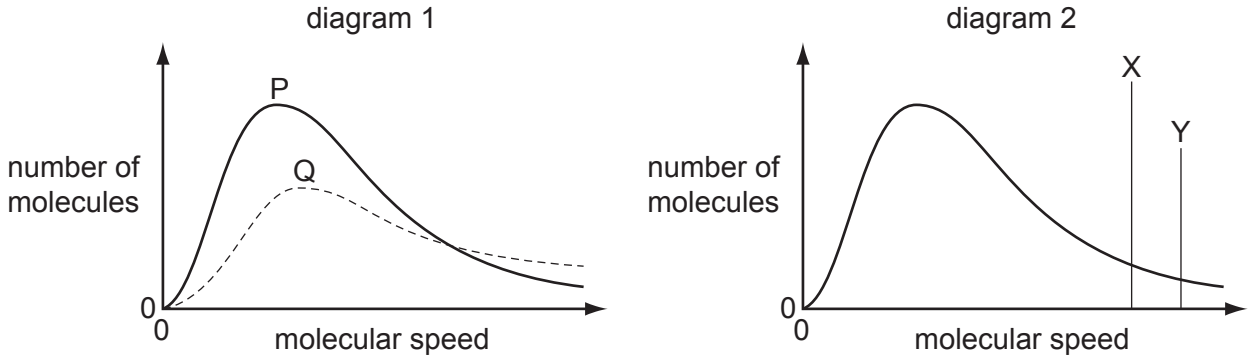
A adding some 0.1 mol dm^{-3} hydrogen peroxide

B adding water

C lowering the temperature

D using less manganese(IV) oxide

7 Different Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

8 50 cm^3 of 2.50 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm^3 of 2.50 mol dm^{-3} NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g^{-1} K^{-1}.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

A $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

B $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)}$ J mol^{-1}

C $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

D $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)}$ J mol^{-1}

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9 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \qquad \Delta H = -2775\,kJ\,mol^{-1}$$

The bond energy of an X–H bond is $395\,kJ\,mol^{-1}$.

What is the bond energy of an X–X bond?

A $-405.0\,kJ\,mol^{-1}$

B $-202.5\,kJ\,mol^{-1}$

C $+202.5\,kJ\,mol^{-1}$

D $+405.0\,kJ\,mol^{-1}$

10 In which change would only van der Waals' forces have to be overcome?

A evaporation of ethanol $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B melting of ice $H_2O(s) \rightarrow H_2O(l)$

C melting of solid carbon dioxide $CO_2(s) \rightarrow CO_2(l)$

D solidification of butane $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

11 Hydrazine, N_2H_4, is widely 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.

12 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

A $15\,cm^3$ **B** $20\,cm^3$ **C** $30\,cm^3$ **D** $60\,cm^3$

13 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp / °C	801	2852	3550
bp / °C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO_2
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO_2

14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

A It has an M_r of 40.3.

B It is basic.

C It is a white solid.

D It is very soluble in water.

15 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

A $NO(g) + CO(g) \rightarrow NO_2(g) + C(s)$

B $NO(g) + CO_2(g) \rightarrow NO_2(g) + CO(g)$

C $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

D $2NO(g) + CO_2(g) \rightarrow 2NO_2(g) + C(s)$

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16 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row in the following table contains the ions X^-, Y^- and Z^- in order of their decreasing strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

17 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

18 Ammonium nitrate, NH_4NO_3, is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

A It can cause environmental problems.

B It consists of 35 % nitrogen by mass.

C It is insoluble in water.

D Nitric acid is used in its manufacture.

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19 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.

$$BrCH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which reagents could be used for this synthesis?

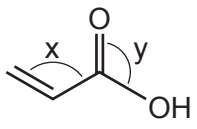
	step 1	step 2
A	HCN(g)	HC*l*(aq)
B	HCO_2Na(aq)	HC*l*(aq)
C	KCN(aq / alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7$ / H_2SO_4(aq)

20 The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

21 Acrylic acid is produced from propene, a gaseous product of oil refineries.



acrylic acid

Which statement about acrylic acid is **not** correct?

A Both bond angles x and y are approximately 120°.

B It decolourises aqueous bromine.

C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

D It reacts with an alcohol to give an ester.

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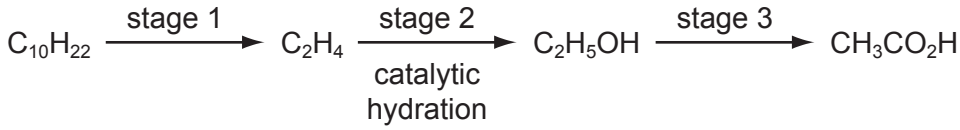
22 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.



Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

23 A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

A butan-1-ol

B butan-2-ol

C butanal

D 2-methylpropan-2-ol

24 Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

A $CH_3CH_2CH_2CHO$

B $CH_3COCH_2COCH_3$

C $H_2C{=}CHCH_2CHO$

D $OHCCH_2CH_2CHO$

25 Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

A 0 **B** 1 **C** 2 **D** 3

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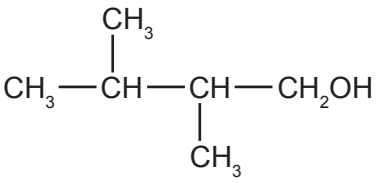
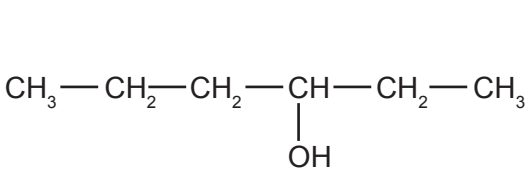
26 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

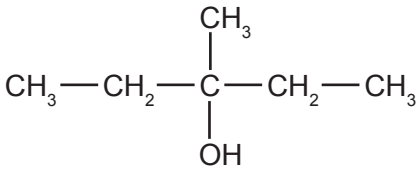
A



B



C



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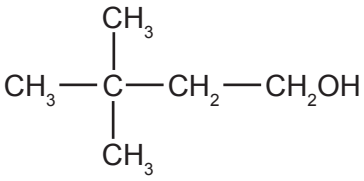
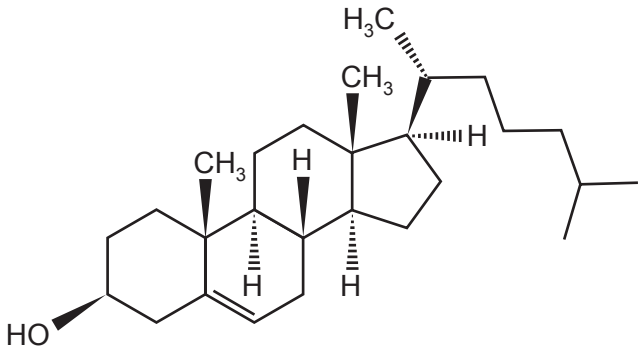


27 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

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

Student Y claimed 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

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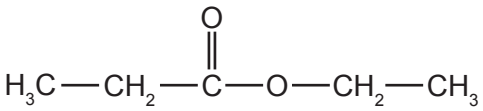
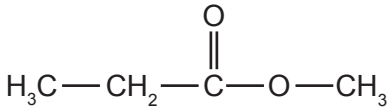
28 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?

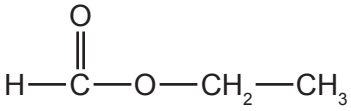
A



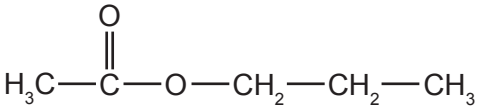
B



C



D



29 The functional group in a primary alcohol is $–CH_2OH$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

A Al_2O_3 **B** CH_3CO_2H **C** HBr **D** Na

30 Aldehydes and ketones are carbonyl compounds.

Which of them react with $NaBH_4$ **and** react with Fehling's reagent?

A both aldehydes and ketones

B aldehydes only

C ketones only

D neither aldehydes nor ketones

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 Which are features of the structure of metallic copper?

1 a lattice of ions

2 delocalised electrons

3 ionic bonds

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

Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?

[All volumes are measured at room conditions.]

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.

2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

33 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

1 Water can act as either an acid or a base.

2 Sulfuric acid, H_2SO_4, does not behave as an acid when dissolved in ethanol, C_2H_5OH.

3 The ammonium ion acts as a base when dissolved in liquid ammonia.

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34 Which descriptions of the ammonium ion are correct?

1 It contains ten electrons.

2 It has a bond angle of 109.5°.

3 It has only three bonding pairs of electrons.

35 *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 can oxidise iodide to iodine.

36 Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.

2 Magnesium chloride dissolves in water to give a slightly acidic solution.

3 Sodium chloride dissolves in water to give an alkaline solution.

37 Which alkenes, on reaction with steam at 600 K and 6 x 10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

1 $(CH_3)_2C=CH_2$

2 $CH_3CH=CHCH_3$

3 $CH_3CH_2CH=CH_2$

38 Which oxides react with water to give a solution of pH 10 or higher?

1 CaO

2 Na_2O

3 SrO

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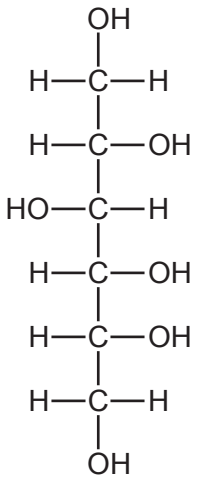
The responses **A** to **D** should be selected on the basis of

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.

39 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



sorbitol

Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

1 aldehyde

2 carboxylic acid

3 ketone

40 Bromoethane undergoes all of the conversions shown.

Which conversions are examples of nucleophilic substitution?

1 $C_2H_5Br \rightarrow C_2H_5CN$

2 $C_2H_5Br \rightarrow C_2H_5OH$

3 $C_2H_5Br \rightarrow C_2H_5NH_2$

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