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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2012**

1 hour

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

* 3 2 6 7 9 8 9 5 5 5 *

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 Ammonia is manufactured by the Haber Process, in an exothermic reaction.

Assuming that the amount of catalyst remains constant, which change will **not** bring about an increase in the rate of the forward reaction?

A decreasing the size of the catalyst pieces

B increasing the pressure

C increasing the temperature

D removing the ammonia as it is formed

2 In which species does the underlined atom have an incomplete outer shell?

A $\underline{B}F_3$ **B** $\underline{C}H_3^-$ **C** $F_2\underline{O}$ **D** $H_3\underline{O}^+$

3 The value of the second ionisation energy of calcium is $1150\,kJ\,mol^{-1}$.

Which equation correctly represents this statement?

A $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$; $\Delta H^\ominus = +1150\,kJ\,mol^{-1}$

B $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$; $\Delta H^\ominus = +1150\,kJ\,mol^{-1}$

C $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$; $\Delta H^\ominus = -1150\,kJ\,mol^{-1}$

D $Ca(g) \rightarrow Ca^{2+}(g) + 2e^-$; $\Delta H^\ominus = -1150\,kJ\,mol^{-1}$

4 The equation for a reaction is shown.

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)\ ;\ \Delta H = x\ kJ\,mol^{-1}$$

Which pair of descriptions is fully correct for this reaction?

	type(s) of enthalpy change	value of x
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

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5 Propanone has the molecular formula C_3H_6O.

The enthalpy change of combustion of hydrogen is $-286\,kJ\,mol^{-1}$.
The enthalpy change of combustion of carbon is $-394\,kJ\,mol^{-1}$.
The enthalpy change of combustion of propanone is $-1786\,kJ\,mol^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

A $-1106\,kJ\,mol^{-1}$

B $-540\,kJ\,mol^{-1}$

C $-254\,kJ\,mol^{-1}$

D $+1106\,kJ\,mol^{-1}$

6 Two conversions are outlined below.

$$NH_4^+ \rightarrow NH_3$$

$$C_2H_4 \rightarrow C_2H_6$$

What similar feature do these two conversions have?

A a lone pair of electrons in the product

B change in oxidation state of an element

C decrease in bond angle of the species involved

D disappearance of a π bond

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

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30 °C.

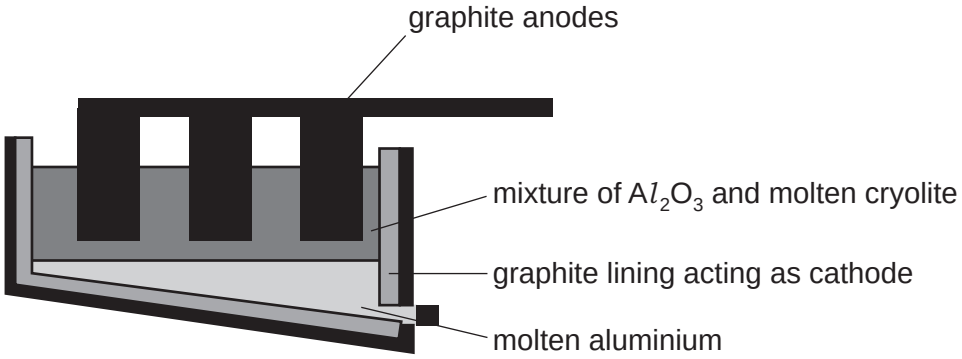
What is the volume of the vessel?

A $49\,cm^3$ **B** $494\,cm^3$ **C** $48\,900\,cm^3$ **D** $494\,000\,cm^3$

8 Under which set of conditions is a gas most likely to behave ideally?

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

9 The diagram shows a cell for the manufacture of aluminium.



Which statement is **incorrect**?

A Aluminium ions are oxidised in this process.

B Aluminium is liberated at the cathode by the reaction $Al^{3+} + 3e^- \rightarrow Al$.

C The cryolite acts as a solvent.

D The graphite anode burns away.

10 The oxide of titanium, TiO_2, is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?

A It is oxidised from +3 to +4.

B It is reduced from +3 to +2.

C It is reduced from +6 to +4.

D There is no change in the oxidation number.

11 Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium, *x* mol of R were present and the total number of moles present was (2 + *x*).

What is the equation for this equilibrium?

A $P \rightleftharpoons 2Q + R$

B $2P \rightleftharpoons 2Q + R$

C $2P \rightleftharpoons Q + R$

D $2P \rightleftharpoons Q + 2R$

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

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

A aragonite, $CaCO_3$

B artinite, $MgCO_3.Mg(OH)_2.3H_2O$

C barytocalcite, $BaCO_3.CaCO_3$

D dolomite, $CaCO_3.MgCO_3$

13 Aluminium chloride catalyses certain reactions by forming carbocations with chloroalkanes as shown.

$$RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$$

Which property makes this reaction possible?

A $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.

B $AlCl_3$ is a covalent molecule.

C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.

D The chlorine atom in RCl has a vacant p orbital.

14 The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

A BaO(aq) **B** CaO(aq) **C** MgO(aq) **D** SrO(aq)

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

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

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16 The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

17 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.

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

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

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

A –1 **B** 0 **C** +1 **D** +2

18 What trend is observed on descending Group VII?

A The colours of the elements become lighter.

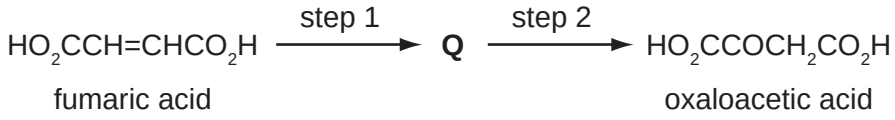
B The elements become more volatile.

C The hydrides of the elements become more thermally stable.

D The reactions of the elements with hydrogen become less vigorous.

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19 Fumaric acid can be converted into oxaloacetic acid by a two-step process involving the intermediate **Q**.



Each of these steps can be achieved in the laboratory by a single reagent.

What could be the intermediate **Q** and the reagent for step 2?

	Q	reagent for step 2
A	$HO_2CCHBrCH_2CO_2H$	warm acidified $KMnO_4$
B	$HO_2CCHBrCH(OH)CO_2H$	warm NaOH(aq)
C	$HO_2CCH(OH)CH_2CO_2H$	Fehling's solution
D	$HO_2CCH(OH)CH_2CO_2H$	warm acidified $K_2Cr_2O_7$

20 Carbon monoxide, CO, nitrogen monoxide, NO, and sulfur dioxide, SO_2, may all be present in the exhaust fumes from a car engine.

Which reaction concerning these compounds occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2

B NO_2 is reduced to NO by CO

C NO_2 is reduced to NO by SO_2

D SO_2 is oxidised to SO_3 by CO_2

21 An organic compound **J** reacts with sodium to produce an organic ion with a charge of –3. **J** reacts with NaOH(aq) to produce an organic ion with a charge of –1.

What could be the structural formula of **J**?

A $HO_2CCH(OH)CH_2CO_2H$

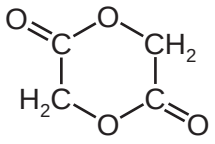
B $HO_2CCH(OH)CH_2CHO$

C $HOCH_2CH(OH)CH_2CO_2H$

D $HOCH_2COCH_2CHO$

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22 Compound C is used in textile and leather processing.



compound C

Which starting material(s), on gentle heating with a few drops of concentrated sulfuric acid, generates compound C?

A CH_3COOH only

B $HOCH_2COOH$ only

C CH_3COOCH_2COOH only

D CH_3COOH mixed with $HOCH_2COOH$

23 How many isomeric esters have the molecular formula $C_4H_8O_2$?

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

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

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

A 32.4 % and 67.6 %

B 38.3 % and 61.7 %

C 42.3 % and 57.7 %

D 50.0 % and 50.0 %

25

$CH_3COCH_2CH_2OH$	CH_3COCH_2CHO	$CH_3CH(OH)CH_2CH_3$	$CH_3CH_2CH_2CHO$
W	*X*	*Y*	*Z*

Which of these compounds can be oxidised by acidified dichromate(VI) solution and also gives a positive response to Tollens' reagent?

A *W* and *X* only

B *W* and *Y* only

C *X* and *Z* only

D *Y* and *Z* only

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26 Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?

A CH_3CHO

B $CH_3CH_2COCH_2CH_3$

C $CH_3CO_2CH_3$

D HCHO

27 The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

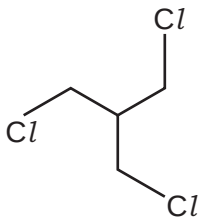
Which compound would cause the most depletion of the ozone layer?

A CCl_3F **B** CF_4 **C** $CHClF_2$ **D** CH_2F_2

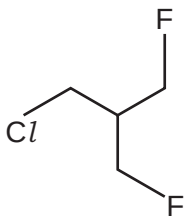
28 The presence of halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would produce a precipitate quickest?

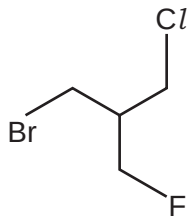
A



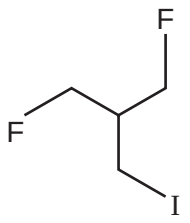
B



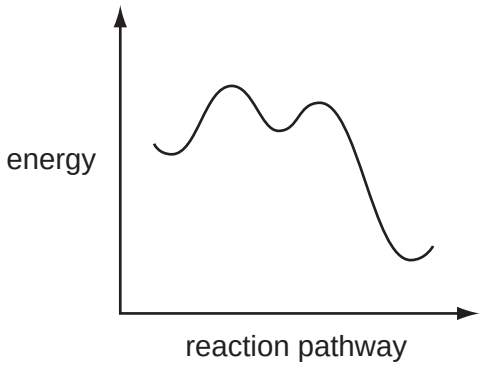
C



D



29 A reaction pathway diagram is shown.



Which reaction does **not** have such a profile?

A $CH_3CHO + HCN \xrightarrow{NaCN} CH_3CH(OH)CN$

B $C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr$

C $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

D 

30 Which statement does **not** correctly describe the polymer PVC?

A Combustion of PVC waste produces a highly acidic gas.

B PVC molecules are saturated.

C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is –(CHC*l*CHC*l*)–.

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 Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5.

Why is it **not** possible for nitrogen to form NCl_5?

1 Nitrogen's outer shell can only contain eight electrons.

2 Nitrogen cannot have oxidation state +5.

3 Nitrogen is almost inert.

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

In which pairs do both species have the same number of unpaired p electrons?

1 O and Cl^+

2 F^+ and Ga^-

3 P and Ne^+

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.

33 The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

where each symbol has its usual meaning.

Which statements are correct?

1 One mole of an ideal gas occupies the same volume under the same conditions of temperature and pressure.

2 The density of an ideal gas at constant pressure is inversely proportional to the temperature, T.

3 The volume of a given mass of an ideal gas is doubled if its temperature is raised from 25 °C to 50 °C at constant pressure.

34 Which statements are correct for all three halogens, chlorine, bromine and iodine?

1 They all form hydrides that are strong acids in aqueous solution.

2 They all react with aqueous sodium hydroxide to form oxo-anions.

3 They all require one more electron to fill the p orbitals of their outer shells.

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35 In the manufacture of sulfuric acid the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ usually takes place at 400 °C and 1 atm pressure. In one industrial plant, it is decided to change the pressure to 20 atm.

What will be the consequences of this change?

1 increased running costs

2 an increased percentage of sulfur trioxide in the equilibrium mixture

3 the rate of the backward reaction increases

36 Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Ammonia behaves as a reducing agent.

2 Ammonia behaves as a base.

3 The oxidation number of the hydrogen changes.

37 A number of alcohols with the formula $C_4H_{10}O$ are separately oxidised. Using 70 g of the alcohols a 62 % yield of organic product is achieved.

What mass of product could be obtained?

1 42.2 g of butanone

2 51.6 g of butanoic acid

3 51.6 g of 2-methyl propanoic acid

38 What is **always** involved in a carbon-carbon π bond?

1 a shared pair of electrons

2 a sideways overlap of p orbitals

3 delocalised electrons

39 How can a good yield of ethylamine be made using bromoethane as starting material?

1 by heating bromoethane with an excess of ammonia gas in a sealed tube

2 by adding dilute aqueous ammonia to bromoethane at room temperature

3 by heating bromoethane under reflux with aqueous ammonium chloride

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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.

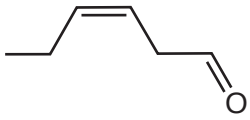
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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.

40 The compound *cis*-hex-3-enal is responsible for the characteristic smell of cut grass. The human nose is particularly sensitive to this compound, being able to detect 0.25 parts per billion in air.



cis-hex-3-enal

Which reagents will react with *cis*-hex-3-enal?

1 sodium

2 sodium borohydride

3 Fehling's reagent

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