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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

1650953752

CHEMISTRY **9701/21**

Paper 2 Structured Questions AS Core **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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Answer **all** questions.
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For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **9** printed pages and **3** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Valence Shell Electron Pair Repulsion theory (VSEPR) is a model of electron-pair repulsion (including lone pairs) that can be used to deduce the shapes of, and bond angles in, simple molecules.

(a) Complete the table below by using simple hydrogen-containing compounds. One example has been included.

number of bond pairs	number of lone pairs	shape of molecule	formula of a molecule with this shape
3	0	trigonal planar	BH_3
4	0		
3	1		
2	2		

[3]

(b) Tellurium, Te, proton number 52, is used in photovoltaic cells.

When fluorine gas is passed over tellurium at 150 °C, the colourless gas TeF_6 is formed.

(i) Draw a 'dot-and-cross' diagram of the TeF_6 molecule, showing outer electrons only.

(ii) What will be the shape of the TeF_6 molecule?

.....

(iii) What is the F–Te–F bond angle in TeF_6?

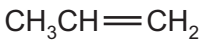
.....

[3]

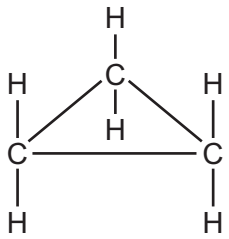
[Total: 6]

For Examiner's Use

2 The molecular formula C_3H_6 represents the compounds propene and cyclopropane.



propene



cyclopropane

(a) What is the H–C–H bond angle at the terminal $=CH_2$ group in propene?

..... [1]

(b) Under suitable conditions, propene and cyclopropane each react with chlorine.

(i) With propene, 1,2-dichloropropane, $CH_3CHCl CH_2Cl$ is formed.

State fully what type of reaction this is.

..... [1]

(ii) When cyclopropane reacts with chlorine, three different compounds with the molecular formula $C_3H_4Cl_2$ can be formed.

Draw displayed structures of **each** of these three compounds.

[3]

[Total: 5]

For Examiner's Use

3 Chlorine gas is manufactured by the electrolysis of brine using a diaphragm cell.

(a) (i) Write half-equations, including state symbols, for the reactions occurring at **each** of the electrodes of a diaphragm cell.

anode .....

cathode .....

(ii) In the diaphragm cell, the anode is made of titanium and the cathode is made of steel.

Suggest why steel is never used for the anode.

.....

..... [3]

(b) Chlorine is very reactive and will form compounds by direct combination with many elements.

Describe what you would see when chlorine is passed over separate heated samples of sodium and phosphorus.
In **each** case write an equation for the reaction.

sodium

.....

.....

.....

phosphorus

.....

.....

..... [4]

(c) Chlorine reacts with aqueous sodium hydroxide in two different ways, depending on the conditions used. In each case, water, sodium chloride and one other chlorine-containing compound are formed.

For **each** condition below, give the formula of the **other** chlorine-containing compound and state the oxidation number of chlorine in it.

condition	formula of **other** chlorine-containing compound	oxidation number of chlorine in this compound
cold dilute NaOH(aq)		
hot concentrated NaOH(aq)		

[4]

(d) Magnesium chloride, $MgCl_2$, and silicon tetrachloride, $SiCl_4$, each dissolve in or react with water.

Suggest the approximate pH of the solution formed in **each** case.

$MgCl_2$ ..... $SiCl_4$ .....

Explain, with the aid of an equation, the difference between the two values.

.....

.....

.....

..... [5]

[Total: 16]

[Turn over

For Examiner's Use

4 Compound **R** is a weak diprotic (dibasic) acid which is very soluble in water.

(a) A solution of **R** was prepared which contained 1.25 g of **R** in 250 cm^3 of solution. When 25.0 cm^3 of this solution was titrated with 0.100 mol dm^{-3} NaOH, 21.6 cm^3 of the alkali were needed for complete reaction.

(i) Using the formula H_2X to represent **R**, construct a balanced equation for the reaction between H_2X and NaOH.

.....

(ii) Use the data above to calculate the amount, in moles, of OH^- ions used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of **R** present in 25.0 cm^3 of solution.

(iv) Calculate the amount, in moles, of **R** present in 250 cm^3 of solution.

(v) Calculate M_r of **R**.

[5]

(b) Three possible structures for **R** are shown below.

S	**T**	**U**
$HO_2CCH{=}CHCO_2H$	$HO_2CCH(OH)CH_2CO_2H$	$HO_2CCH(OH)CH(OH)CO_2H$

(i) Calculate the M_r of each of these acids.

M_r of **S** = ... M_r of **T** = ... M_r of **U** = ...

(ii) Deduce which of the structures, **S**, **T** or **U**, correctly represents the structure of the acid, **R**.

R is represented by .....

[2]

It is possible to convert **S**, **T**, or **U** into one another.

(c) State the reagent(s) and essential conditions that would be used for the following conversions.

S into **T**

.....

S into **U**

.....

T into **S**

..... [5]

(d) Give the structural formula of the organic product formed in **each** of the following reactions.

T reacting with an excess of Na

U reacting with an excess of Na_2CO_3

[2]

(e) The acid **S** shows stereoisomerism. Draw structures to show this isomerism.
Label each isomer.

[2]

(f) When one of the isomers of **S** is heated at 110 °C in the absence of air, a cyclic compound **V**, with molecular formula $C_4H_2O_3$, is formed.
The other isomer of **S** does not react at this temperature.

Suggest the displayed formula of **V**.

[2]

[Total: 18]

For Examiner's Use

5 Propane, C_3H_8, and butane, C_4H_{10}, are components of Liquefied Petroleum Gas (LPG) which is widely used as a fuel for domestic cooking and heating.

(a) (i) To which class of compounds do these two hydrocarbons belong?

.....

(ii) Write a balanced equation for the complete combustion of butane.

.....
[2]

(b) When propane or butane is used in cooking, the saucepan may become covered by a solid black deposit.

(i) What is the chemical name for this black solid?

.....

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.....
[2]

(c) Propane and butane have different values of standard enthalpy change of combustion.

Define the term *standard enthalpy change of combustion*.

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.....

..... [2]

(d) A 125 cm^3 sample of propane gas, measured at 20 °C and 101 kPa, was completely burnt in air.
The heat produced raised the temperature of 200 g of water by 13.8 °C.
Assume no heat losses occurred during this experiment.

(i) Use the equation $pV = nRT$ to calculate the mass of propane used.

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(e) The boiling points of methane, ethane, propane, and butane are given below.

compound	CH_4	CH_3CH_3	$CH_3CH_2CH_3$	$CH_3(CH_2)_2CH_3$
boiling point / K	112	185	231	273

(i) Suggest an explanation for the increase in boiling points from methane to butane.

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(ii) The isomer of butane, 2-methylpropane, $(CH_3)_3CH$, has a boiling point of 261 K. Suggest an explanation for the difference between this value and that for butane in the table above.

.....

.....

.....

[4]

[Total: 15]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3576889954

CHEMISTRY **9701/22**

Paper 2 Structured Questions AS Core **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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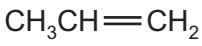
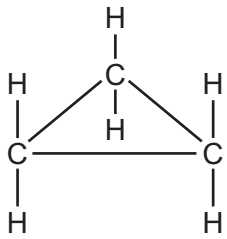


propene



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(i) Suggest an explanation for the increase in boiling points from methane to butane.

.....

.....

.....

(ii) The isomer of butane, 2-methylpropane, $(CH_3)_3CH$, has a boiling point of 261 K. Suggest an explanation for the difference between this value and that for butane in the table above.

.....

.....

.....

[4]

[Total: 15]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
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CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

6138594413

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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UNIVERSITY of CAMBRIDGE International Examinations

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Ammonia, NH_3, and methane, CH_4, are the hydrides of elements which are next to one another in the Periodic Table.

(a) In the boxes below, draw the 'dot-and-cross' diagram of a molecule of **each** of these compounds. Show outer electrons only.
State the shape of **each** molecule.

NH_3	CH_4
shape	shape

[3]

(b) Ammonia is polar whereas methane is non-polar. The physical properties of the two compounds are different.

(i) Explain, using ammonia as the example, the meaning of the term *bond polarity*.

.....

.....

.....

(ii) Explain why the ammonia molecule is polar.

.....

.....

(iii) State **one** physical property of ammonia which is caused by its polarity.

.....

.....

[4]

For Examiner's Use

(c) When ammonia gas is mixed with hydrogen chloride, white, solid ammonium chloride is formed.

State **each type** of bond that is present in one formula unit of ammonium chloride and how many of each type are present.
You may draw diagrams.

.....

.....

.....

.....

..... [3]

[Total: 10]

For Examiner's Use

2 Petrol and diesel fuel are both used in internal combustion engines.
Petrol may be regarded as having the formula C_9H_{20} and diesel fuel as having the formula $C_{14}H_{30}$.

(a) (i) To which class of compounds do these two hydrocarbons belong?

.....

(ii) Write a balanced equation for the complete combustion of petrol.

.....
[2]

(b) When petrol or diesel fuel are used in internal combustion engines, several different products of the incomplete combustion of the fuel may be formed.

(i) Name **two** of these products that do not contain hydrogen.

..... and .....

(ii) Choose one of these and state a hazard it causes.

product .....

hazard .....

(iii) Write a balanced equation for the formation of **one** of the products in **(i)** from diesel fuel.

.....
[4]

(c) Define the term *standard enthalpy change of combustion*.

.....

.....

..... [2]

(d) A 1.00 cm^3 sample of $C_{14}H_{30}$ was completely burnt in air.
The heat produced raised the temperature of 250 g of water by 34.6 °C.
Assume no heat losses occurred during this experiment.
The density of $C_{14}H_{30}$ is 0.763 g cm^{-3}.

(i) Use relevant data from the *Data Booklet* to calculate the amount of heat released in this experiment.

(ii) Use the data above and your answer to **(i)** to calculate the energy produced by the combustion of 1 mol of $C_{14}H_{30}$.

[5]

[Total: 13]

[Turn over

3 The elements of Group VII of the Periodic Table show variation in their properties.

(a) (i) Complete the table below, stating the colour of each element in its normal state at room temperature.

halogen	melting point / °C	colour
chlorine	–101	
bromine	–7	
iodine	114	

(ii) Briefly explain why the melting points of the halogens increase from chlorine to iodine.

.....

.....

.....

[4]

(b) The halogens form many interhalogen compounds in which two different halogens are combined. One such compound is bromine monochloride, BrC*l*.

(i) Complete the electronic configurations of chlorine and bromine.

chlorine	$1s^2 2s^2 2p^6$
bromine	$1s^2 2s^2 2p^6$

(ii) Draw a 'dot-and-cross' diagram of the BrC*l* molecule.
Show outermost electrons only.

[2]

For Examiner's Use

(c) Interhalogen compounds like BrCl have similar properties to the halogens.

(i) By considering your answers to **(a)** and **(b)**, predict the physical state of BrCl at room temperature. Explain your answer.

physical state .....

explanation .....

.....

.....

(ii) Suggest the colour of BrCl.

.....

[4]

(d) Cl_2 and BrCl each react with aqueous KI.

(i) Describe what would be seen when Cl_2 is bubbled through aqueous KI for several minutes.

initially .....

.....

after several minutes .....

.....

(ii) Construct an equation for the reaction that occurs.

.....

(iii) Suggest an equation for the reaction that occurs between BrCl and aqueous KI.

.....

(iv) How do Cl_2 and BrCl behave in these reactions?

.....

[5]

[Total: 15]

For Examiner's Use

4 Compound **Q** is a viscous liquid which is very soluble in water.
The M_r of **Q** is 90.0.

Three possible structures for **Q** are shown below.

R	**S**	**T**
$HOCH_2CH_2CO_2H$	$HOCH_2CO_2CH_3$	$HCO_2CH_2CH_2OH$

(a) (i) What type of isomerism do **R**, **S** and **T** show?

.....

(ii) What oxygen-containing functional groups are present in **R**, **S** and **T**?
Give their **full names**.

R ..... and .....

S ..... and .....

T ..... and .....

(iii) Which functional group(s) in **(ii)** will react with sodium carbonate?

.....

(iv) Which functional group(s) in **(ii)** will react with sodium metal?

.....

[6]

(b) When 0.002 mol of **Q** is reacted with an excess of solid sodium carbonate, Na_2CO_3, 24 cm^3 of carbon dioxide, measured at room temperature and pressure, is produced.

(i) Calculate the amount, in moles, of carbon dioxide produced in this reaction.

(ii) Hence calculate the amount, in moles, of carbon dioxide produced by 1 mol of **Q**.

[2]

When 0.002 mol of **Q** is reacted with an excess of metallic sodium, 48 cm^3 of hydrogen, measured at room temperature and pressure, is produced.

(c) (i) Calculate the amount, in moles, of hydrogen molecules produced in this reaction.

(ii) Hence calculate the amount, in moles, of hydrogen molecules produced by 1 mol of **Q**.

[2]

(d) Use your answers to **(b)** and **(c)** to deduce which structure, **R**, **S** or **T**, corresponds to the structure of **Q** and write balanced equations for the reactions that occurred.

identity of **Q** is .....

equation for reaction with sodium carbonate

.....

equation for reaction with sodium metal

..... [5]

[Total: 15]

[Turn over

5 The molecular formula C_4H_9OH represents four different alcohols, **W**, **X**, **Y** and **Z**.

W	X	Y	Z
$CH_3CH_2CH_2CH_2OH$	$CH_3CH_2CH(OH)CH_3$	$(CH_3)_2CHCH_2OH$	$(CH_3)_3COH$

(a) Draw the **skeletal formula** of **Z**.

[1]

(b) Acidified potassium dichromate(VI) is used as an oxidising agent in organic chemistry.

Give the **structural formula** of the organic product formed when **each** of the four alcohols above is heated under reflux with acidified potassium dichromate(VI).
If you believe that no reaction occurs, write 'no reaction' in the box.

W	
X	
Y	
Z	

[4]

(c) One of the alcohols, **W**, **X**, **Y** or **Z**, can be dehydrated to give more than one organic product.

Identify this alcohol and give the structural formulae of **two** of the products.

alcohol	
product 1	
product 2	

[2]

[Total: 7]

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