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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

2045742995

CHEMISTRY **9701/02**

Paper 2 Structured Questions AS Core **October/November 2008**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and candidate number on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE ON ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, fasten all your work securely together.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **10** printed pages and **2** blank pages.

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

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1 Most submarines travel under water using electrical power from batteries. The German engineer Helmut Walter designed a diesel engine that could be used to propel a submarine beneath the surface of the sea. Instead of taking air from above the surface of the sea, Walter's engine used hydrogen peroxide, H_2O_2, to provide oxygen for a conventional diesel engine.

Hydrogen peroxide may be catalytically decomposed to give water and oxygen.

(a) (i) What is meant by the term *catalyst*?

.....

.....

(ii) Construct a balanced equation for the decomposition of H_2O_2.

..... [3]

Diesel fuel may be considered to consist of the hydrocarbon $C_{15}H_{32}$ which reacts completely with oxygen according to the following equation.

$$C_{15}H_{32} + 23O_2 \rightarrow 15CO_2 + 16H_2O$$

(b) (i) To which homologous series does $C_{15}H_{32}$ belong?

.....

(ii) Use the equation above and your answer to **(a)(ii)** to calculate the amount, in moles, of H_2O_2, that will provide sufficient oxygen for the complete oxidation of one mole of $C_{15}H_{32}$.

amount of H_2O_2 = ... mol

[3]

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A submarine equipped with a Walter engine used 212 tonnes of diesel fuel during an underwater voyage. The submarine also carried concentrated aqueous H_2O_2.
[1 tonne = 10^6 g]

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(c) (i) Calculate the amount, in moles, of diesel fuel used during the underwater voyage.

amount of diesel fuel = ... mol

(ii) Use your answers to **(b)(ii)** and **(c)(i)** to calculate the mass, in tonnes, of hydrogen peroxide used during the underwater voyage.

mass of H_2O_2 = ... tonnes
[4]

(d) The exhaust products of the Walter engine were passed into the sea.

What would happen to them?

..... [1]

[Total: 11]

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2 Ketene, C_2H_2O, is a member of a class of unsaturated organic compounds that is widely used in pharmaceutical research for the synthesis of organic compounds.

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$CH_2=C=O$

ketene

(a) (i) Suggest values for the H-C-H and C=C=O bond angles in ketene.

H-C-H …… C=C=O ……

(ii) By considering the structure of the molecule, suggest why the name *ketene* is used.

.....

..... [3]

(b) Ketene burns completely in air to form carbon dioxide and water.

(i) Write a balanced equation for this reaction.

.....

(ii) Use your equation to calculate the volume of CO_2, in dm^3, measured at room temperature and pressure, which will be formed when 3.5 g of ketene are burned in an excess of air.

Give your answer to **two** significant figures.

volume of CO_2 = ... dm^3 [4]

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

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.....

.....

.....

(ii) Use the data below to calculate the standard enthalpy change of formation of ketene.

	$\Delta H^{\ominus}$/kJ mol^{-1}
standard enthalpy change of formation of CO_2	–395
standard enthalpy change of combustion of H_2	–286
standard enthalpy change of combustion of CH_2=C=O	–1028

[6]

(d) Ketene can be converted directly into ethanoic acid, CH_3CO_2H, by reaction with a compound **A**.

Suggest the identity of **A**.

.....

[1]

[Total: 14]

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

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

anode .....

cathode ..... [2]

(b) 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.

.....

..... [1]

(c) One important product made in the diaphragm cell is formed in aqueous solution.

(i) What substance is produced in aqueous solution in the diaphragm cell?

.....

(ii) Explain, with the aid of appropriate half-equation(s), how this compound is formed by electrolysis.

.....

.....

..... [3]

(d) 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]

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

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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: 15]

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4 Organic chemistry is the chemistry of carbon compounds. The types of organic reactions that you have studied are listed below.

addition	elimination	hydrolysis
oxidation	reduction	substitution

Addition and substitution reactions are further described as follows.

electrophilic	nucleophilic	free radical

Complete the table below.

Fill in the central column by using **only** the types of reaction given in the lists above. Use **both** lists when appropriate.

In the right hand column give the name(s) or formula(e) of the reagent(s) you would use to carry out the reaction given.

organic reaction	type of reaction	reagent(s)
$CH_3CHO \rightarrow CH_3CH(OH)CN$		
$CH_3CH_2CH_2CH_3 \rightarrow CH_3CH_2CHBrCH_3$		
$CH_3CH(OH)CH_3 \rightarrow CH_3CH{=}CH_2$		
$CH_3CH{=}CH_2 \rightarrow CH_3CH(OH)CH_2OH$		

[Total: 10]

5 An organic ester, **B**, has the empirical formula C_2H_4O. An experiment by a student in a college gave a value of 87.5 for M_r of **B**.

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(a) What is the molecular formula of **B**?

…… [1]

(b) In the boxes below, draw the structural formulae of **four** isomers of **B** that are esters.

W	**X**
Y	**Z**

[4]

The student hydrolysed his sample of **B** by heating with aqueous mineral acid and then separating the alcohol, **C**, that was formed. He heated the alcohol **C** under reflux with acidified dichromate(VI) ions and collected the product **D**.

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A sample of **D** gave an orange precipitate with 2,4-dinitrophenylhydrazine reagent. A second sample of **D** gave no reaction with Tollens' reagent.

(c) (i) What group does the reaction with 2,4-dinitrophenylhydrazine reagent show to be present in **D**?

……

(ii) What does the result of the test with Tollens' reagent show about **D**?

……

(iii) What is the structural formula of the alcohol **C**?

(iv) Which of your esters, **W**, **X**, **Y**, or **Z** has the same structure as that of the ester **B**?

…… [4]

(d) Which, if any of your esters, **W**, **X**, **Y**, or **Z** is chiral? Explain your answer.

.....

..... [1]

[Total: 10]

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