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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

7524377035

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **May/June 2010**

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 **11** printed pages and **1** blank page.

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

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1 Hydrazine, N_2H_4, can be used as a rocket fuel and is stored as a liquid. It reacts exothermically with oxygen to give only gaseous products.

The enthalpy change of a reaction such as that between hydrazine and oxygen may be calculated by using standard enthalpy changes of formation.

(a) Define the term *standard enthalpy change of formation*, $\Delta H_f^{\ominus}$.

.....

.....

..... [3]

(b) Hydrazine reacts with oxygen according to the following equation.

$$N_2H_4(l) + O_2(g) \longrightarrow N_2(g) + 2H_2O(g)$$

(i) Use the data in the table to calculate the standard enthalpy change of this reaction.

compound	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$N_2H_4(l)$	50.6
$H_2O(g)$	–241.8

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

(ii) Although the above reaction is highly exothermic, hydrazine does not burn spontaneously in oxygen.
Suggest a reason for this.

.....

.....

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(iii) Suggest why using hydrazine as a rocket fuel could be regarded as being 'environmentally friendly'.

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.....

.....

[4]

(c) The bonding in hydrazine is similar to that in ammonia.

(i) Showing outer-shell electrons only, draw a 'dot-and-cross' diagram of an ammonia molecule.

(ii) Draw a diagram to show the three-dimensional shape of an ammonia molecule.

(iii) Draw a diagram to show the shape of a hydrazine molecule.
Show clearly which atom is joined to which and show clearly the value of **one** bond angle.

[4]

(d) Deduce the oxidation state of nitrogen in hydrazine.

..... [1]

[Total: 12]

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[Turn over

2 The alkali metals are a series of six elements in Group I of the Periodic Table. The first ionisation energy of these elements shows a marked trend as the Group is descended.

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(a) Define the term *first ionisation energy*.

.....

.....

..... [2]

(b) **(i)** State and explain the trend in first ionisation energy as Group I is descended.

.....

.....

.....

(ii) Suggest how this trend helps to explain the increase in the reactivity of the elements as the Group is descended.

.....

..... [3]

(c) In a redox reaction, 0.83 g of lithium reacted with water to form 0.50 dm^3 of aqueous lithium hydroxide.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

(i) Calculate the amount, in moles, of lithium that reacted.

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(ii) Calculate the volume of hydrogen produced at room temperature and pressure.

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(iii) Calculate the concentration, in mol dm^{-3}, of the LiOH(aq) formed.

[5]

(d) When heated in chlorine, all of the alkali metals react to form the corresponding chloride.

Describe what you see when sodium is heated in chlorine and write a balanced equation for the reaction.

description

.....

.....

.....

equation

.....

[2]

[Total: 12]

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[Turn over

3 This question refers to the elements shown in the section of the Periodic Table below.

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							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

(a) From this list of elements, identify in **each** case **one** element that has the property described. Give the symbol of the element.

(i) an element that sinks in cold water and reacts readily with it

.....

(ii) an element that forms an oxide that is a reducing agent

.....

(iii) the element that has the largest first ionisation energy

.....

(iv) the metal in Period 3 (Na to Ar) that has the smallest cation

.....

(v) the element which has a giant molecular structure **and** forms an oxide which also has a giant molecular structure

.....

(vi) the element in Period 3 (Na to Ar) with the greatest electrical conductivity

.....

[6]

(b) From the section of the Periodic Table above, identify **two** elements whose hydrides form hydrogen bonds between their molecules.

..... and ..... [1]

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(c) Use the elements in Period 3 (Na to Ar) in the section of the Periodic Table opposite to identify the oxide(s) referred to below.
In **each** case, give the formula of the oxide(s).

(i) an oxide which has no reaction with water

.....

(ii) **two** acidic oxides formed by the same element

..... and .....

(iii) an oxide which dissolves readily in water to give a strongly alkaline solution

.....

(iv) an oxide which is amphoteric

.....

[5]

[Total: 12]

4 Organic reactions involve substances which may be

atoms, *molecules*, *ions* or *free radicals*.

We also apply the terms

electrophilic, *nucleophilic*, *addition*, *elimination* and *substitution*

to organic reactions.

Consider the following reactions.

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ reaction 1

$CH_3CH_2OH \rightarrow CH_2{=}CH_2 + H_2O$ reaction 2

$CH_3I + OH^- \rightarrow CH_3OH + I^-$ reaction 3

$CH_3COCH_3 + HCN \rightarrow CH_3C(OH)(CN)CH_3$ reaction 4

(a) Using the terms mentioned above, state as clearly as you can the nature of each of the following reactions.

reaction 1 .....

reaction 2 ..... [2]

(b) By considering the four reactions above, suggest a formula for **each** of the following substances.
In **each** case, state which reaction you are considering.

(i) **one** substance that is an addition product

reaction..... addition product

(ii) **one** substance that is a leaving group

reaction..... leaving group

(iii) **one** substance that behaves as an electrophile

reaction..... electrophile

[3]

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(c) What is meant by the term *nucleophile*?

For Examiner's Use

.....

..... [1]

(d) Reactions 3 and 4 involve nucleophiles.

For **each** reaction, give the formula of the nucleophile.

reaction 3

reaction 4

[2]

(e) One characteristic reaction of ethene is its ability to decolourise bromine.

$$CH_2{=}CH_2 + Br_2 \longrightarrow BrCH_2CH_2Br$$

In this reaction, ethene behaves as a nucleophile.

Suggest an explanation for how ethene can behave in this way.

.....

..... [1]

[Total: 9]

5 Lactic acid, 2-hydroxypropanoic acid, $CH_3CH(OH)CO_2H$, occurs naturally in sour milk and in our muscles when we take hard exercise.
Lactic acid is chiral and shows stereoisomerism.

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(a) Draw fully displayed structures of the two optical isomers of lactic acid.
Indicate with an asterisk (*) the chiral carbon atom in the lactic acid molecule.

[3]

(b) Lactic acid may be synthesised from ethanol by the following route.

$$CH_3CH_2OH \xrightarrow{\text{step 1}} CH_3CHO \xrightarrow{\text{step 2}} CH_3CH(OH)CN \xrightarrow{\text{step 3}} CH_3CH(OH)CO_2H$$

Give the reagent(s) and essential condition(s) for **each** step.

	reagent(s)	condition(s)
step 1		
step 2		
step 3		

[6]

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During exercise, lactic acid is produced in our muscles from pyruvic acid, CH_3COCO_2H. This reaction occurs in the presence of the enzyme lactic acid dehydrogenase.

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(c) (i) What type of chemical compound is the enzyme lactic acid dehydrogenase?

.....

(ii) How would you detect a small quantity of pyruvic acid in a sample of lactic acid?

State the reagent(s) you would use and what would be seen in your test.

reagent(s) .....

observation .....

(iii) How would you detect a small quantity of lactic acid in a sample of pyruvic acid?

State the reagent(s) you would use and what would be seen in your test.

reagent(s) .....

observation .....

(iv) What chemical reagent would be used to convert pyruvic acid into lactic acid?

$$CH_3COCO_2H \rightarrow CH_3CH(OH)CO_2H$$

.....

[6]

[Total: 15]

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