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

| | |
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| 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.

*For Examiner's Use*

**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'.

*For Examiner's Use*

.....

.....

[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]

**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.

*For Examiner's Use*

**(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]

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

*For Examiner's Use*

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | H | | | | | | | | | | He |
| Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | | | | | | | | | | | A*l* | Si | P | S | C*l* | 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).

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**(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.

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

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

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

$CH_3COCH_3 + HCN \longrightarrow CH_3C(OH)(CN)CH_3$ 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]

*For Examiner's Use*

**(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.

*For Examiner's Use*

**(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]

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.

*For Examiner's Use*

**(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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