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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3660957283

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **May/June 2011**

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 Methanoic acid, HCO_2H, was formerly known as formic acid because it is present in the sting of ants and the Latin name for ant is *formica*. It was first isolated in 1671 by John Ray who collected a large number of dead ants and extracted the acid from them by distillation.

In this question, you should give all numerical answers to <u>two</u> significant figures.

At room temperature, pure methanoic acid is a liquid which is completely soluble in water.

When we are stung by a 'typical' ant a solution of methanoic acid, **A**, is injected into our skin.

Solution **A** contains 50% by volume of pure methanoic acid.

A 'typical' ant contains $7.5 \times 10^{-6}\,dm^3$ of solution **A**.

(a) (i) Calculate the volume, in cm^3, of solution **A** in one ant.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the volume, in cm^3, of pure methanoic acid in one ant.

volume = ... cm^3

(iii) Use your answer to **(ii)** to calculate how many ants would have to be distilled to produce $1\,dm^3$ of pure methanoic acid.

number = ...
[3]

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When we are stung by an ant, the amount of solution **A** injected is 80% of the total amount of solution **A** present in one ant.

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The density of pure methanoic acid is $1.2\,g\,cm^{-3}$.

(b) (i) Calculate the volume, in cm^3, of **pure** methanoic acid injected in one ant sting.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the mass of methanoic acid present in one ant sting.

mass = ... g
[3]

Bees also sting us by using methanoic acid. One simple treatment for ant or bee stings is to use sodium hydrogencarbonate, $NaHCO_3$.

(c) (i) Construct a balanced equation for the reaction between methanoic acid and sodium hydrogencarbonate.

.....

(ii) In a typical bee sting, the mass of methanoic acid injected is $5.4 \times 10^{-3}\,g$.
Calculate the mass of $NaHCO_3$ needed to neutralise one bee sting.

mass = ... g
[3]

[Total: 9]

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2 The kinetic theory of gases is used to explain the large scale (macroscopic) properties of gases by considering how individual molecules behave.

(a) State **two** basic assumptions of the kinetic theory as applied to an ideal gas.

(i) .....

.....

(ii) .....

.....
[2]

(b) State **two** conditions under which the behaviour of a real gas approaches that of an ideal gas.

(i) .....

(ii) .....
[2]

(c) Place the following gases in decreasing order of ideal behaviour.

ammonia, neon, nitrogen

most ideal ..... **least ideal**

Explain your answer.

.....

.....
[3]

(d) By using the kinetic-molecular model, explain why a liquid eventually becomes a gas as the temperature is increased.

.....

.....

.....

.....[2]

(e) Ethane, CH_3CH_3, and fluoromethane, CH_3F are *iso*-electronic, that is they have the same total number of electrons in their molecules.

For Examiner's Use

Calculate the **total** number of electrons in one molecule of CH_3F.

[1]

(f) The boiling points of these two compounds are given below.

compound	bp/K
CH_3CH_3	184.5
CH_3F	194.7

Suggest explanations for the following.

(i) the close similarity of the boiling points of the two compounds

.....

.....

(ii) the slightly higher boiling point of CH_3F

.....

.....

[2]

[Total: 12]

3 Elements in the same period of the Periodic Table show trends in physical and chemical properties. The grids on this page and on the opposite page refer to the elements of the third period, Na to C*l*.

On **each** of these grids, draw a clear sketch to show the variation of the stated property.

Below **each** grid, briefly explain the variation you have described in your sketch.

For each explanation you should refer to the important factors that cause the differences in the property you are describing.

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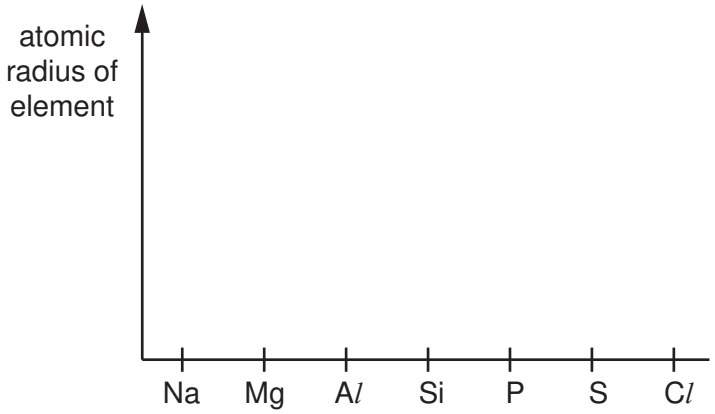
(a)



explanation .....

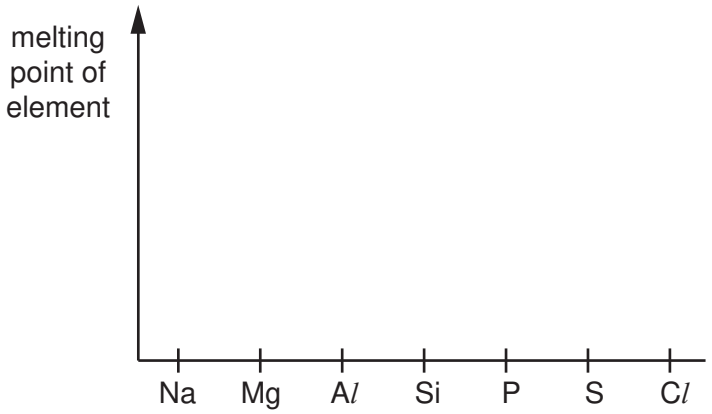
.....

.....

.....

[3]

(b)



explanation .....

.....

.....

.....

[4]

(c)

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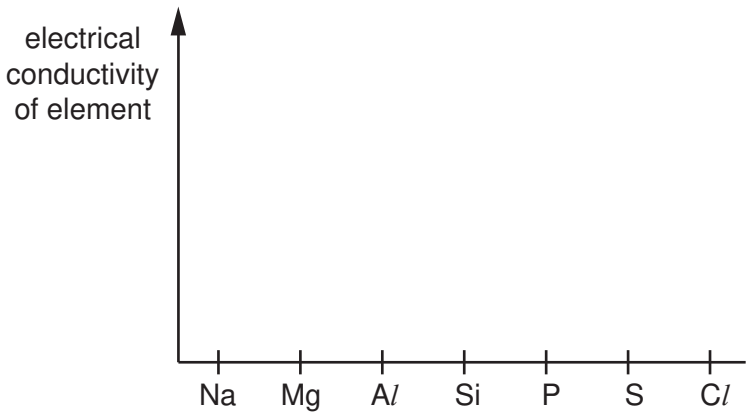

explanation .....

.....

.....

.....

[4]

(d) The melting points of some of the oxides of the elements sodium to sulfur are given in the table below.

compound	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6	SO_2
mp/K	1193	3173	2313	1883	297	198

(i) What type of bond is broken when **each** of the following compounds is melted?

Na_2O .....

SiO_2 .....

P_4O_6 .....

(ii) Identify **one** of these six oxides that has no reaction at all with water.

.....

[4]

[Total: 15]

4 The compound *trans*-4-hydroxy-2-nonenal (HNE) is thought to lead to infections of the lung when cigarettes are smoked.

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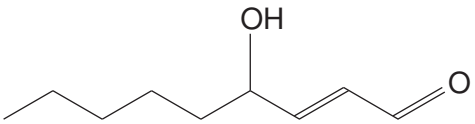

$CH_3(CH_2)_4CH(OH)CH=CHCHO$

***trans*-4-hydroxy-2-nonenal**

(a) What is the empirical formula of *trans*-4-hydroxy-2-nonenal?

..... [1]

(b) **(i)** HNE contains an alkene group. Name as fully as you can **two** other functional groups which are present in the HNE molecule.

.....

.....

(ii) How would you confirm the presence of the alkene group in HNE?
State the reagent used and the observation you would make.

reagent .....

observation .....
[5]

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HNE is a reactive compound.

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(c) Give the structural formulae of all of the carbon-containing compounds formed in each case when HNE is reacted separately with the following reagents.

(i) hot concentrated manganate(VII) ions in acid solution

(ii) hot phosphorus trichloride, PCl_3

(iii) sodium tetrahydridoborate(III), $NaBH_4$

[4]

[Total: 10]

5 Fermentation of sugars by bacteria or moulds produces many different organic compounds.

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One compound present in fermented molasses is 2-ethyl-3-methylbutanoic acid which gives a distinctive aroma to rum.

$(CH_3)_2CHCH(C_2H_5)CO_2H$

2-ethyl-3-methylbutanoic acid

(a) (i) What is the molecular formula of 2-ethyl-3-methylbutanoic acid?

(ii) How many chiral carbon atoms are present in a molecule of 2-ethyl-3-methylbutanoic acid? If none write 'none'.

.....

[2]

A sample of 2-ethyl-3-methylbutanoic acid may be prepared in a school or college laboratory by the oxidation of 2-ethyl-3-methylbutan-1-ol, $(CH_3)_2CHCH(C_2H_5)CH_2OH$.

(b) (i) State the reagent(s) that would be used for this oxidation.
Describe what colour change would be seen.

reagent(s) .....

colour change from ..... to .....

This reaction is carried out by heating the reacting chemicals together.

(ii) What could be the main organic impurity present in the sample of the acid?

Explain your answer.

.....

.....

.....

(iii) State whether a distillation apparatus or a reflux apparatus should be used.

Explain your answer.

.....

.....

.....

[6]

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(c) A structural isomer of 2-ethyl-3-methylbutan-1-ol is 2-ethyl-3-methylbutan-2-ol, $(CH_3)_2CHC(OH)(C_2H_5)CH_3$.

What colour change would be seen if this were heated with the reagents you have given in **(b)(i)**?
Explain your answer as clearly as you can.

.....

.....

.....[3]

An isomer of 2-ethyl-3-methylbutanoic acid which is an ethyl ester is a very strong smelling compound which is found in some wines.

(d) This ethyl ester contains a branched hydrocarbon chain and is chiral.

Draw the displayed formula of this ethyl ester.

Identify the chiral carbon atom with an asterisk (*).

[3]

[Total: 14]

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