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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

9395074405

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **May/June 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.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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

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

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **11** printed pages and **1** blank page.

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

For Examiner's Use

1 Carbon disulfide, CS_2, is a volatile, flammable liquid which is produced in small quantities in volcanoes.

(a) The sequence of atoms in the CS_2 molecule is sulfur to carbon to sulfur.

(i) Draw a 'dot-and-cross' diagram of the carbon disulfide molecule.
Show outer electrons only.

(ii) Suggest the shape of the molecule and state the bond angle.

shape .....

bond angle .....
[3]

(b) Carbon disulfide is readily combusted to give CO_2 and SO_2.

(i) Construct a balanced equation for the complete combustion of CS_2.

.....

(ii) Define the term *standard enthalpy change of combustion*, $\Delta H_c^{\ominus}$.

.....

.....

.....
[3]

For Examiner's Use

(c) Calculate the standard enthalpy change of formation of CS_2 from the following data. Include a sign in your answer.

standard enthalpy change of combustion of CS_2 = $-1110\,kJ\,mol^{-1}$

standard enthalpy change of formation of CO_2 = $-395\,kJ\,mol^{-1}$

standard enthalpy change of formation of SO_2 = $-298\,kJ\,mol^{-1}$

[3]

(d) Carbon disulfide reacts with nitrogen monoxide, NO, in a 1:2 molar ratio.
A yellow solid and two colourless gases are produced.

(i) Construct a balanced equation for the reaction.

.....

(ii) What is the change in the oxidation number of sulfur in this reaction?

from ..... to .....

[3]

[Total: 12]

For Examiner's Use

2 Methanol, CH_3OH, can be produced industrially by reacting carbon monoxide, CO, with hydrogen, H_2.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\,kJ\,mol^{-1}$$

The process is carried out at 4×10^3 kPa (40 atmospheres) and 1150 K.

(a) (i) State Le Chatelier's Principle.

.....

.....

..... [2]

(ii) From your understanding of Le Chatelier's Principle, state the conditions of temperature and pressure that could be used in order to produce an increased yield of methanol in this process.
In **each** case, explain why the yield would increase.

temperature .....

explanation .....

.....

pressure .....

explanation .....

.....
[4]

(b) The carbon monoxide for use in the production of methanol may be formed by reacting carbon dioxide with hydrogen.

$$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g) \qquad K_c = 1.44 \text{ at } 1200\,K$$

A mixture containing 0.70 mol of CO_2, 0.70 mol of H_2, 0.30 mol of CO and 0.30 mol of H_2O was placed in a 1 dm^3 flask and allowed to come to equilibrium at 1200 K.

Calculate the amount, in moles, of each substance present in the equilibrium mixture at 1200 K.

	CO_2	+	H_2	$\rightleftharpoons$	CO	+	H_2O
initial moles	0.70		0.70		0.30		0.30

[4]

[Total: 10]

For Examiner's Use

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

		H						He
Li	Be		B	C	N	O	F	Ne
Na	Mg		Al	Si	P	S	Cl	Ar
K	Ca	..... transition elements	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 has molecules which consist of single atoms.

.....

(ii) An element that has a molecule which contains exactly four atoms.

.....

(iii) The element that is a liquid at room temperature and pressure.

.....

(iv) The element in Period 3 (Na to Ar) that has the largest atomic radius.

.....

(v) The element in Period 3 (Na to Ar) that has the highest melting point.

.....

(vi) The element in Period 3 (Na to Ar) that forms the largest anion.

.....

(vii) An element that reacts with water to give a solution that can behave as an oxidising agent.

.....

[7]

(b) The formulae and melting points of some of the oxides of the elements in Period 3, Na to C*l*, are given in the table.

formula of oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6	SO_2	Cl_2O_7
m.p. / °C	1132	2830	2054	1710	24	–73	–92

(i) Give the formulae of **two** of these oxides that have simple molecular structures.

..... and .....

(ii) Give the formula of one of these oxides that will give no reaction with water when placed in it for a long time.

.....

(iii) Give the formula of the product formed when MgO is reacted with SO_2.

.....

[4]

(c) The melting points of the elements Si to C*l* are given in the table.

element	Si	P	S	C*l*
m.p. / °C	1414	44	115	–102

(i) Explain why the melting point of Si is very much greater than those of the other three elements.

.....

.....

(ii) Suggest why the melting points of the other three elements are in the order S > P > C*l*.

.....

.....

.....

.....

[4]

[Total: 15]

For Examiner's Use

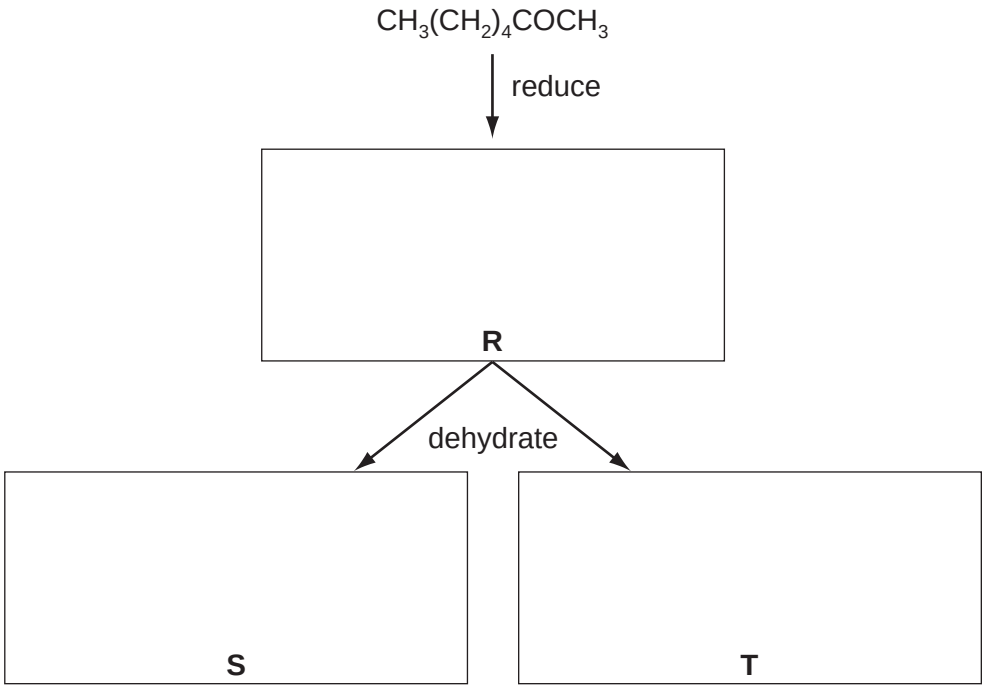
4 Compound **Q**, heptan-2-one, is found in some blue cheeses.

$CH_3(CH_2)_4COCH_3$

compound **Q**

(a) Compound **Q** may be reduced to **R**.
Compound **R** may be dehydrated to give two different products, **S** and **T**.

(i) In the boxes below, draw the **structural formulae** of **R**, **S**, and **T**.



(ii) State the reagents that would be used for **each** of these reactions in a school or college laboratory.

reduction .....

dehydration .....

[5]

For Examiner's Use

(b) In the boxes below, write the **structural formula** of the organic compound formed when **Q** is reacted separately with each reagent under suitable conditions.
If you think no reaction occurs, write 'NO REACTION' in the box.

Tollens' reagent	
HCN	
$K_2Cr_2O_7 / H^+$	

[3]

(c) The first stage of cheese making is to produce 2-hydroxypropanoic acid (lactic acid) from milk.

$CH_3CH(OH)CO_2H$

lactic acid

Other than the use of a pH indicator, what reagent could you use to confirm the presence of some lactic acid in a sample of heptan-2-one?
State what observation you would make.

reagent .....

observation ..... [2]

[Total: 10]

For Examiner's Use

5 Compounds containing the allyl group, $CH_2=CHCH_2–$, have pungent smells and are found in onions and garlic.
Allyl alcohol, $CH_2=CHCH_2OH$, is a colourless liquid which is soluble in water.

(a) Allyl alcohol behaves as a primary alcohol and as an alkene.

Give the structural formula of the organic compound formed when allyl alcohol is reacted separately with each of the following reagents.

(i) acidified potassium dichromate(VI), heating under reflux

(ii) bromine in an inert organic solvent

(iii) cold, dilute, acidified potassium manganate(VII)

(iv) hot, concentrated, acidified potassium manganate(VII)

[5]

(b) Allyl alcohol undergoes the following reactions.

(i) When reacted with concentrated HC*l* at 100 °C, $CH_2=CHCH_2Cl$ is formed.

State as fully as you can what *type of reaction* this is.

.....

(ii) When reacted with MnO_2 at room temperature, $CH_2=CHCHO$ is formed.

What *type of reaction* is this?

.....
[2]

(c) Allyl alcohol can be converted into propanal in two steps.

$$CH_2{=}CHCH_2OH \xrightarrow{\text{step I}} CH_3CH_2CH_2OH \xrightarrow{\text{step II}} CH_3CH_2CHO$$

(i) What reagents and conditions would be used for **each** step?

step I

reagent(s) .....

condition(s) .....

step II

reagent(s) .....

condition(s) .....

(ii) Allyl alcohol and propanal are isomers.

What form of isomerism do they display?

.....

[5]

(d) Allyl alcohol may also be converted into propanal by using a ruthenium(IV) catalyst in water.

$$CH_2{=}CHCH_2OH \xrightarrow{\text{ruthenium(IV) catalyst}} CH_3CH_2CHO$$

Suggest what is unusual about this single step reaction.

.....

..... [1]

[Total: 13]

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