



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

CANDIDATE  
NAME

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CENTRE  
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**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,  $\text{CS}_2$ , is a volatile, flammable liquid which is produced in small quantities in volcanoes.

(a) The sequence of atoms in the  $\text{CS}_2$  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  $\text{CO}_2$  and  $\text{SO}_2$ .

- (i) Construct a balanced equation for the complete combustion of  $\text{CS}_2$ .

.....

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

.....

.....

.....

[3]

- (c) Calculate the standard enthalpy change of formation of  $\text{CS}_2$  from the following data. Include a sign in your answer.

standard enthalpy change of combustion of  $\text{CS}_2 = -1110 \text{ kJ mol}^{-1}$

standard enthalpy change of formation of  $\text{CO}_2 = -395 \text{ kJ mol}^{-1}$

standard enthalpy change of formation of  $\text{SO}_2 = -298 \text{ kJ mol}^{-1}$

[3]

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

- (i) Construct a balanced equation for the reaction.

.....

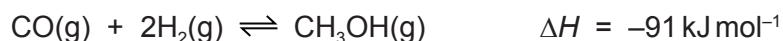
- (ii) What is the change in the oxidation number of sulfur in this reaction?

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

[3]

[Total: 12]

- 2 Methanol,  $\text{CH}_3\text{OH}$ , can be produced industrially by reacting carbon monoxide,  $\text{CO}$ , with hydrogen,  $\text{H}_2$ .



The process is carried out at  $4 \times 10^3 \text{ kPa}$  (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 .....

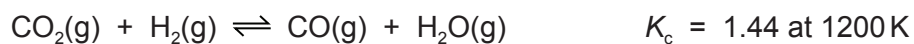
.....

pressure .....

explanation .....

..... [4]

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



A mixture containing 0.70 mol of  $\text{CO}_2$ , 0.70 mol of  $\text{H}_2$ , 0.30 mol of  $\text{CO}$  and 0.30 mol of  $\text{H}_2\text{O}$  was placed in a  $1 \text{ dm}^3$  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.

|                  |               |   |              |                      |             |   |                      |
|------------------|---------------|---|--------------|----------------------|-------------|---|----------------------|
|                  | $\text{CO}_2$ | + | $\text{H}_2$ | $\rightleftharpoons$ | $\text{CO}$ | + | $\text{H}_2\text{O}$ |
| initial<br>moles | 0.70          |   | 0.70         |                      | 0.30        |   | 0.30                 |

[4]

[Total: 10]

- 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 Cl, are given in the table.

|                  |                   |      |                                |                  |                               |                 |                                |
|------------------|-------------------|------|--------------------------------|------------------|-------------------------------|-----------------|--------------------------------|
| formula of oxide | Na <sub>2</sub> O | MgO  | Al <sub>2</sub> O <sub>3</sub> | SiO <sub>2</sub> | P <sub>4</sub> O <sub>6</sub> | SO <sub>2</sub> | Cl <sub>2</sub> O <sub>7</sub> |
| 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<sub>2</sub>.

.....

[4]

- (c) The melting points of the elements Si to Cl are given in the table.

|         |      |    |     |      |
|---------|------|----|-----|------|
| element | Si   | P  | S   | Cl   |
| 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 > Cl.

.....

.....

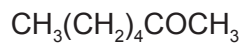
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.....

[4]

[Total: 15]

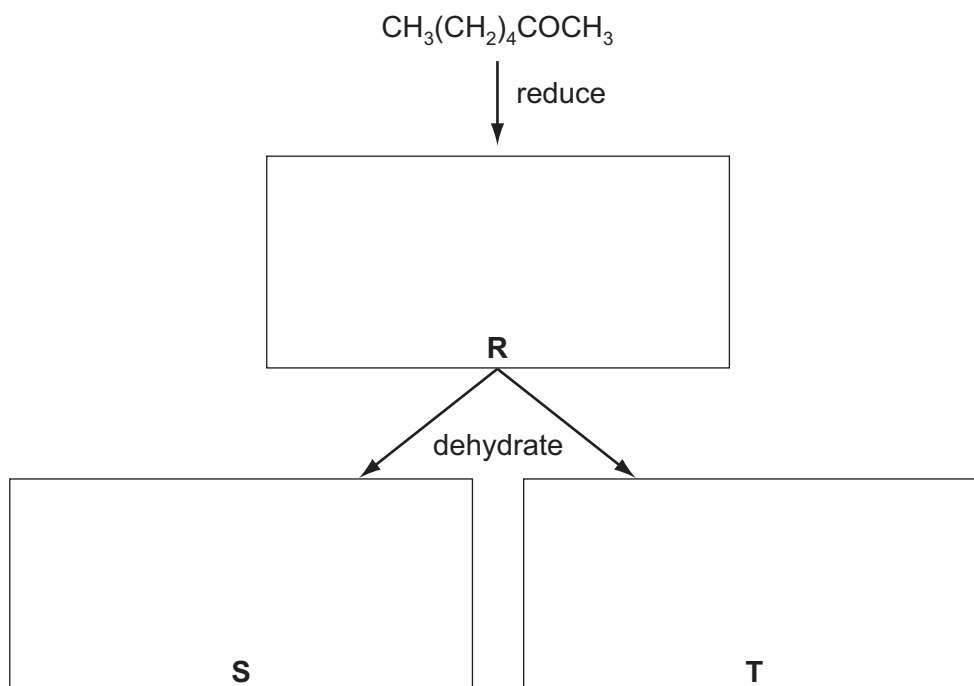
- 4 Compound **Q**, heptan-2-one, is found in some blue cheeses.



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]

- (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.



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]

- 5 Compounds containing the allyl group,  $\text{CH}_2=\text{CHCH}_2-$ , have pungent smells and are found in onions and garlic.  
Allyl alcohol,  $\text{CH}_2=\text{CHCH}_2\text{OH}$ , 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  $\text{HCl}$  at  $100^\circ\text{C}$ ,  $\text{CH}_2=\text{CHCH}_2\text{Cl}$  is formed.

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

.....

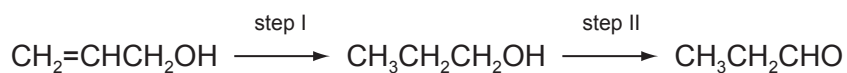
(ii) When reacted with  $\text{MnO}_2$  at room temperature,  $\text{CH}_2=\text{CHCHO}$  is formed.

What *type of reaction* is this?

.....

[2]

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



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

**step I**

reagent(s) .....

condition(s) .....

**step II**

reagent(s) .....

condition(s) .....

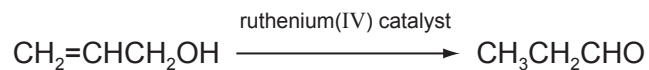
(ii) Allyl alcohol and propanal are isomers.

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.



Suggest what is unusual about this single step reaction.

.....

..... [1]

[Total: 13]

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