Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

7469726555

CHEMISTRY **9701/21**

Paper 2 Structured Questions AS Core **October/November 2015**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.

This document consists of **8** printed pages.

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

1 Aluminium is a metal in Period 3 and Group III of the Periodic Table.

(a) Describe the structure of solid aluminium.

.....

.....

..... [2]

(b) A common use of aluminium is to make the conducting cables in long distance overhead power lines.

(i) Suggest two properties of aluminium that make it suitable for this use.

.....

.....

..... [2]

The cables are attached to pylons by ceramic supports.

(ii) Describe the structure of a ceramic material.

.....

..... [1]

(iii) State the property of a ceramic material that makes it suitable for this use.

.....

..... [1]

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(c) Aluminium reacts with chlorine to form a white, solid chloride that contains 79.7% chlorine and sublimes (changes straight from a solid to a gas) at 180 °C.

(i) Describe the structure and bonding in this compound. Suggest how it explains the low sublimation temperature.

.....

.....

.....

.....

..... [2]

(ii) Calculate the empirical formula of the chloride. You must show your working.

empirical formula = ... [2]

At 200 °C and 100 kPa, a 1.36 g sample of this chloride occupied a volume of 200 cm^3.

(iii) Calculate the relative molecular mass, M_r, of the chloride. Give your answer to **three** significant figures.

M_r = ... [2]

(iv) Deduce the molecular formula of this chloride at 200 °C.

..... [1]

[Total: 13]

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[Turn over

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2 **(a)** **(i)** Explain the meaning of the term *enthalpy change of formation*.

.....

.....

..... [2]

(ii) Give the equation for the reaction for which the enthalpy change corresponds to the standard enthalpy change of formation of liquid sulfur trioxide, SO_3. Include state symbols.

..... [1]

(b) Ammonia is manufactured by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) Use bond energies from the *Data Booklet* to calculate the enthalpy change of reaction for the Haber process. Include a sign in your answer.

enthalpy change ..... $kJ\,mol^{-1}$ [3]

(ii) State the essential operating conditions for the Haber process.

.....

.....

..... [3]

(iii) Explain the choices of temperature and pressure for the Haber process.

.....

.....

.....

.....

..... [4]

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(c) One of the major uses of ammonia is in the manufacture of fertilisers such as diammonium hydrogen phosphate, $(NH_4)_2HPO_4$.

(i) Write an equation for the formation of diammonium hydrogen phosphate by the reaction between ammonia and phosphoric acid, H_3PO_4.

..... [1]

(ii) Explain this reaction in terms of the Brønsted-Lowry theory.

.....

.....

.....

..... [2]

(d) The use of nitrate fertilisers can give rise to environmental consequences in terms of effects on both rivers and the atmosphere.

(i) Explain how the uncontrolled use of nitrate fertilisers can result in a severe reduction in water quality in rivers.

.....

.....

.....

..... [3]

(ii) Oxides of nitrogen are produced by the action of bacteria on nitrate fertilisers.

Explain the problems associated with the release of oxides of nitrogen into the atmosphere. Include an equation in your answer.

.....

.....

..... [2]

[Total: 21]

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3 Heptane, C_7H_{16}, is an undesirable component of petrol as it burns explosively causing 'knocking' in an engine.

(a) There are nine structural isomers with the formula C_7H_{16}, only two of which contain chiral centres.

(i) Explain the meanings of the terms *structural isomers* and *chiral*.

structural isomers .....

.....

.....

chiral .....

.....

.....

[2]

(ii) Give the structures and names of the two structural isomers of C_7H_{16} which contain a chiral centre.

[4]

(b) (i) Write an equation for the complete combustion of heptane.

..... [1]

(ii) Write an equation for the incomplete combustion of heptane leading to the production of a solid pollutant.

..... [1]

(iii) Incomplete combustion can also lead to emission of unburnt hydrocarbons.

State one environmental consequence of this.

..... [1]

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(c) The reaction of heptane with chlorine in the presence of UV light produces a wide variety of products.

Formation of the monochloroheptanes can be represented by the following equation.

$$C_7H_{16} + Cl_2 \rightarrow C_7H_{15}Cl + HCl$$

(i) Name the mechanism of the reaction between heptane and chlorine in the presence of UV light.

..... [1]

(ii) Describe this mechanism, using suitable equations and including the names of each stage in the process.

.....

.....

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.....

.....

.....

..... [5]

[Total: 15]

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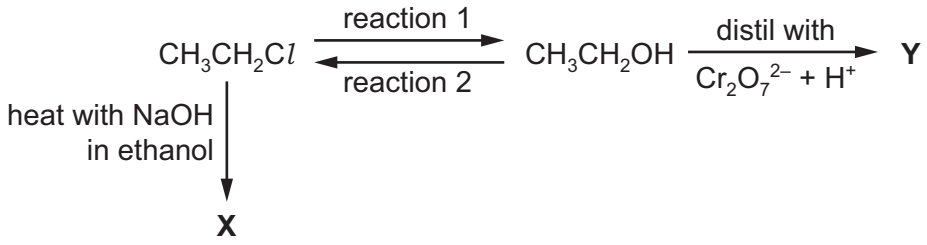
4 Some reactions involving ethanol are shown.



(a) (i) Give an equation for reaction 2 including the reagent needed for the conversion.

..... [2]

(ii) State the reagent and conditions required for reaction 1.

..... [2]

(b) (i) Identify the organic product **X**.

..... [1]

(ii) Nitric acid is added to the products of reaction of CH_3CH_2Cl with NaOH in ethanol. Silver nitrate solution is then added to this mixture.

State what you would observe.

..... [1]

(iii) Write an ionic equation, including state symbols, for the reaction responsible for the observation in **(ii)**.

..... [1]

(c) (i) Identify the organic product **Y** which is distilled out of the reaction mixture.

..... [1]

(ii) Explain, in terms of the properties of and intermolecular forces in CH_3CH_2OH and **Y**, why the chosen conditions for the reaction ensure that **Y** is the product.

.....

.....

..... [3]

[Total: 11]

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