Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3280296283

CHEMISTRY **9701/23**

Paper 2 AS Level Structured Questions **May/June 2016**

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 **9** printed pages and **3** blank pages.

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

1 An experiment was carried out to determine the percentage of iron in a sample of iron wire.

(a) A 3.35 g piece of the wire was reacted with dilute sulfuric acid, in the absence of air, so that all of the iron atoms were converted to iron(II) ions. The resulting solution was made up to 250 cm^3.

(i) Write a balanced equation for the reaction between the iron in the wire and the sulfuric acid.

..... [1]

A 25.0 cm^3 sample of this solution was acidified and titrated with 0.0250 mol dm^{-3} potassium dichromate(VI). 32.0 cm^3 of the potassium dichromate(VI) solution was required for complete reaction with the iron(II) ions in the sample.

The relevant half-equations are shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

(ii) Use the half-equations to write an equation for the reaction between the iron(II) ions and the acidified dichromate(VI) ions.

..... [1]

(iii) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(iv) Calculate the amount, in moles, of iron(II) ions in the 25.0 cm^3 sample of solution.

amount = ... mol [1]

(v) Calculate the amount, in moles, of iron in the 3.35 g piece of wire.

amount = ... mol [1]

(vi) Calculate the mass of iron in the 3.35 g piece of wire.

mass = ... g [1]

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(vii) Calculate the percentage of iron in the iron wire.

percentage = ... % [1]

(b) Some electronegativity values are shown.

element	electronegativity
aluminium	1.5
chlorine	3.0
iron	1.8

(i) Use the data to suggest the nature of the bonding in iron(III) chloride. Explain your answer.

.....

.....

..... [2]

(ii) Suggest an equation for the reaction between iron(III) chloride and water.

..... [1]

[Total: 10]

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[Turn over

2 Ammonium nitrate is an important fertiliser made by the acid-base reaction between ammonia and nitric acid.

(a) Write an equation for the production of ammonium nitrate from ammonia and nitric acid.

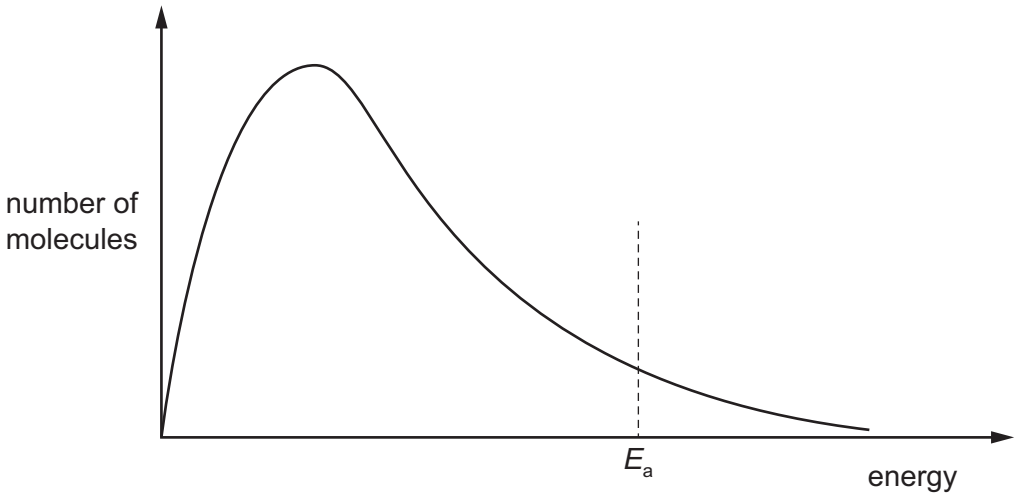
..... [1]

The ammonia for this reaction is produced by the Haber process and the nitric acid is produced by oxidation of ammonia.

(b) The Haber process involves a reaction between nitrogen and hydrogen at a temperature of 450 °C and a pressure of 20 000 kPa. At a higher reaction temperature, the rate of production of ammonia would be greater.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3 \qquad \Delta H = -92\,kJ\,mol^{-1}$$

The Boltzmann distribution curve shows the distribution of energies in a mixture of nitrogen and hydrogen at 450 °C.



(i) Sketch a second line onto the axes above to show the distribution of energies in the same mixture of gases at a higher temperature. [2]

(ii) With reference to the two curves, explain why the rate of production of ammonia would be greater at a higher temperature.

.....

.....

..... [2]

(iii) Add a suitable label to the horizontal axis above and use it to explain why a catalyst is used in the Haber process.

.....

.....

..... [2]

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(iv) Explain why a higher temperature is **not** used despite the fact that it would increase the rate of production of ammonia.

.....

.....

..... [2]

(c) The first stage in the production of nitric acid involves the reaction of ammonia with oxygen to form nitrogen monoxide, NO, and water.

Suggest an equation for this reaction and use oxidation numbers to show that it is a redox reaction.

.....

.....

.....

..... [3]

(d) **(i)** Draw a dot-and-cross diagram of the ammonium ion. Show the outer electrons only. Use the following code for your electrons.

- • electrons from nitrogen
- × electrons from hydrogen

[2]

(ii) State the shape of an ammonium ion and give the H–N–H bond angle.

shape .....

bond angle .....
[2]

(e) State and explain the problems that arise from the overuse of ammonium nitrate fertiliser when the excess is washed into rivers.

.....

.....

.....

..... [3]

[Total: 19]

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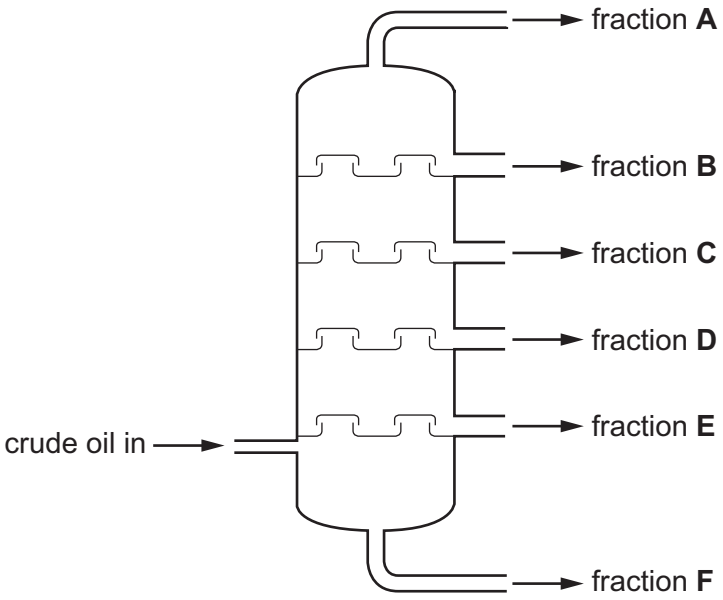
[Turn over

3 Crude oil is a mixture of hydrocarbons and provides many useful chemicals when processed.

Two of the stages involved in the processing of crude oil are fractional distillation and cracking.

(a) The diagram is a simplified representation of a fractional distillation column.



(i) What has to be done to the crude oil before it enters the column?

..... [1]

(ii) What trend in **structure** is there from fraction **A** to fraction **F**?

.....

..... [1]

(iii) State the trends in **two** properties of the fractions from **A** to **F**.

.....

.....

..... [2]

(b) The naphtha fraction from fractional distillation of crude oil is used as a starting material for cracking.

(i) Write an equation for the cracking of $C_{12}H_{26}$ to form the products ethene and one other hydrocarbon in a 2 : 1 mole ratio.

..... [1]

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(ii) Suggest a use for each of the products from your equation in **(i)**. Explain what makes each product from **(i)** suitable for the use you suggest.

use of ethene .....

.....

explanation .....

.....

use of other product .....

.....

explanation .....

.....

[4]

(c) Burning hydrocarbons can cause a number of environmental problems.

The products of internal combustion engines can include oxides of nitrogen and oxides of carbon.

Sulfur dioxide is a by-product of burning coal in power stations.

(i) Explain how and why oxides of nitrogen are produced in internal combustion engines.

.....

.....

..... [2]

(ii) Write an equation for the reaction between nitrogen monoxide and carbon monoxide in a catalytic converter.

..... [1]

(iii) Write equations to show the involvement of nitrogen monoxide in the formation of acid rain from atmospheric sulfur dioxide.

.....

.....

..... [3]

(iv) Describe two of the problems associated with acid rain.

.....

.....

..... [2]

[Total: 17]

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[Turn over

4 Acetoin, $CH_3COCH(OH)CH_3$, and diacetyl, $CH_3COCOCH_3$, are two of the compounds that give butter its characteristic flavour. Their skeletal formulae are shown.



acetoin diacetyl

(a) Give the systematic name for acetoin.

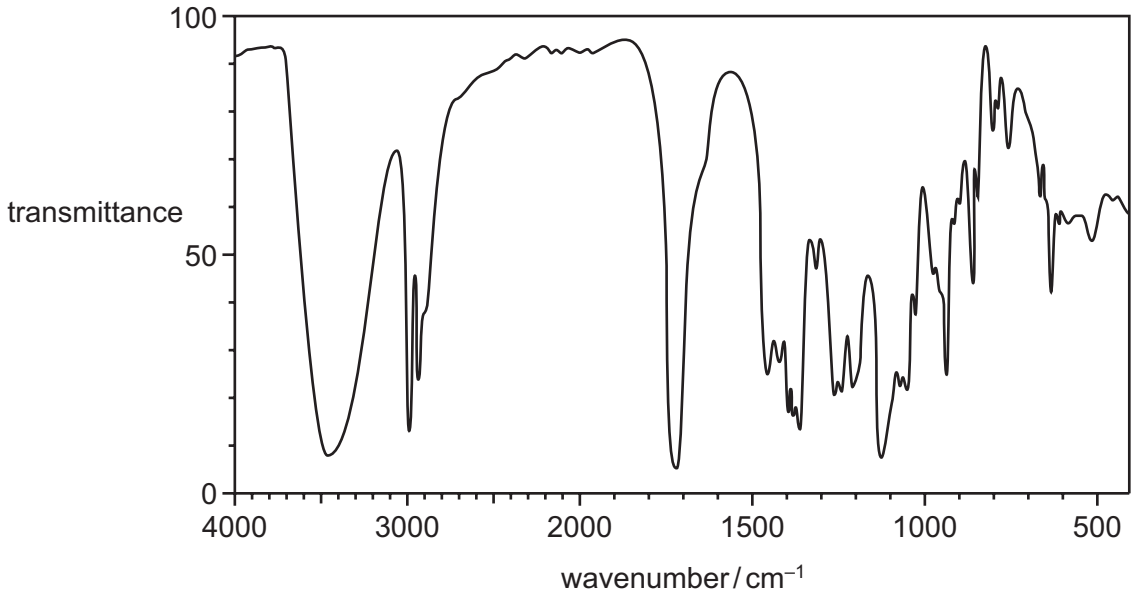
..... [1]

(b) Identify the reagents and conditions necessary for the conversion of acetoin into diacetyl.

.....

..... [2]

(c) The infra-red spectrum for acetoin is shown.



(i) Explain the main features of this spectrum, with reference to the peaks with wavenumbers greater than 1500 cm^{-1}.

.....

.....

.....

.....

..... [3]

(ii) State and explain how the infra-red spectrum for diacetyl would differ from the infra-red spectrum for acetoin.

.....

.....

..... [2]

(d) If a sample of acetoin is reacted with concentrated sulfuric acid, a single product is formed that does **not** exhibit stereoisomerism.

However, if a sample of acetoin is reacted with HBr, a mixture of a pair of stereoisomers is produced.

(i) Give the structural formula of the product of the reaction of acetoin with concentrated sulfuric acid.

..... [1]

(ii) Explain why the product in **(i)** does **not** exhibit stereoisomerism.

.....

.....

..... [2]

(iii) Explain why the product of reaction of acetoin with HBr **does** exhibit stereoisomerism.

.....

.....

..... [1]

(iv) Draw the two stereoisomers from **(iii)** using the conventional representation.

[2]

[Total: 14]

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