Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6002972519

CHEMISTRY **9701/22**

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 **10** printed pages and **2** blank pages.

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[Turn over

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

1 **(a)** Fill the gaps in the table for each of the given particles.

name of isotope	type of particle	charge	symbol	electron configuration
carbon-13				$1s^2 2s^2 2p^2$
		–1	${}^{37}_{17}Cl^-$	
sulfur-34	atom	0		
iron-54	cation			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

[5]

(b) One of the factors that determines the type of bonding present between the particles of a substance is the relative electronegativities of the bonded particles.

(i) Explain the meaning of the term *electronegativity*.

....

....

.... [2]

(ii) Name and describe the type of bonding you would expect to find between particles with equal electronegativities.

....

....

.... [2]

(iii) Name and describe the type of bonding you would expect to find between particles with very different electronegativities.

....

....

.... [2]

(c) The boiling points of some molecules with equal numbers of electrons are given.

substance	fluorine	argon	hydrogen chloride	methanol
formula	F_2	Ar	HCl	CH_3OH
boiling point / K	85	87	188	338

(i) Explain why the boiling points of fluorine and argon are so similar.

....

....

.... [2]

(ii) Explain why the boiling point of hydrogen chloride is higher than that of fluorine.

....

....

.... [2]

(iii) Explain why methanol has the highest boiling point of all these molecules.

....

....

.... [2]

[Total: 17]

2 Chemical reactions are accompanied by enthalpy changes.

(a) Explain the meaning of the term *standard enthalpy change* of reaction.

....

....

.... [2]

(b) The enthalpy change of hydration of anhydrous magnesium sulfate, ΔH_{hyd} $MgSO_4$, can be calculated by carrying out two separate experiments.

In the first experiment 45.00 g of water was weighed into a polystyrene cup and 3.01 g of $MgSO_4$ was added and stirred until it was completely dissolved. The temperature of the water rose from 23.4 °C to 34.7 °C.

(i) Calculate the amount of heat energy transferred to the water during this dissolving process.

You can assume that the specific heat capacity of the solution is the same as that of water, $4.18\,J\,g^{-1}\,K^{-1}$.

heat energy = ... J [1]

(ii) Calculate the amount, in moles, of $MgSO_4$ dissolved.

amount = ... mol [1]

(iii) Calculate the enthalpy change of solution, ΔH_{soln}, of $MgSO_4$(s).

You must include a sign with your answer.

ΔH_{soln}, of $MgSO_4$(s) = ... kJ mol^{-1} [1]

In the second experiment, the enthalpy change of solution for the hydrated salt, $MgSO_4.7H_2O$(s), was calculated and found to be +9.60 kJ mol^{-1}.

(iv) Use the equation below for the hydration of anhydrous magnesium sulfate to construct a suitable, fully labelled energy cycle that will allow you to calculate the enthalpy change for this reaction, ΔH_{hyd} $MgSO_4$.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4.7H_2O(s)$$

[1]

(v) Calculate the enthalpy change for this reaction, ΔH_{hyd} $MgSO_4$. Include a sign in your answer.

ΔH_{hyd} $MgSO_4$ = ... kJ mol^{-1} [1]

[Total: 7]

3 The elements in Period 3, Na, Mg, A*l*, P and S, all react with oxygen when heated in air.

(a) **(i)** Give the formula of the oxide formed when each element is heated in air. One has been completed for you.

Na = ... Mg = ... A*l* = Al_2O_3

P = ... S = ...

[2]

(ii) Describe what you would **see** when sodium and sulfur are each heated separately in air and give an equation for each reaction.

Na ....

equation ....

S ....

equation ....

[4]

(b) The oxides show variations in their behaviour when added to water, acids and alkalis.

(i) Place the symbols of the elements in **(a)(i)** in the appropriate row of the table to indicate this behaviour.

acidic	
amphoteric	
basic	

[2]

(ii) State the bonding present in acidic and basic oxides.

acidic ....

basic ....

[2]

(iii) Write equations for the reaction of aluminium oxide with each of hydrochloric acid, HC*l*, and sodium hydroxide, NaOH.

with HC*l* ....

with NaOH ....

[2]

(c) Explain how the presence of an impurity in carbonaceous fuels can give rise to acid rain.

name of impurity ....

....

.... [2]

[Total: 14]

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4 Halogenoalkanes are useful intermediates in the synthesis of a wide variety of compounds.

(a) 2-bromobutane reacts in two different ways with sodium hydroxide depending on the conditions.

When warmed with aqueous sodium hydroxide, 2-bromobutane produces an alcohol that exists as a pair of optical isomers.

(i) Give the name of the mechanism of the reaction between 2-bromobutane and aqueous sodium hydroxide.

.... [1]

(ii) Explain why the alcohol produced exists as a pair of optical isomers.

....

.... [1]

(iii) Draw the three-dimensional structure of the two optical isomers of the alcohol produced in **(ii)**.

[2]

Heating 2-bromobutane with ethanolic sodium hydroxide produces a mixture of three alkenes, two of which are a pair of geometrical isomers.

(iv) Give the name of the mechanism of the reaction between 2-bromobutane and ethanolic sodium hydroxide.

.... [1]

(v) Draw and name the structures of the pair of geometrical isomers formed by reaction of 2-bromobutane with ethanolic sodium hydroxide.

name ....

name ....

[2]

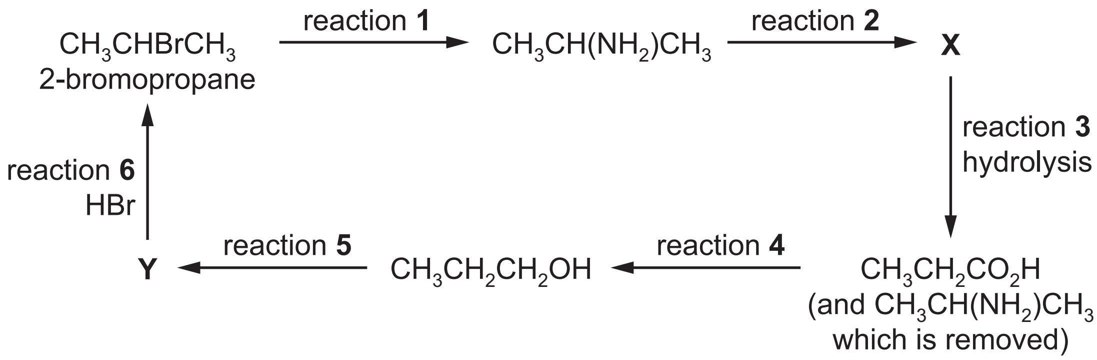
(vi) Name the third alkene produced by reaction of 2-bromobutane with ethanolic sodium hydroxide and explain why it does **not** show geometrical isomerism.

....

....

.... [2]

(b) Some reactions involving 2-bromopropane are shown.



(i) State the reagent needed for reaction **1**.

.... [1]

(ii) State the reagent needed for reaction **2**.

.... [1]

(iii) Give the structural formula of **X**.

[1]

(iv) Name the type of reaction involved in reaction **4** and suggest a suitable reagent.

....

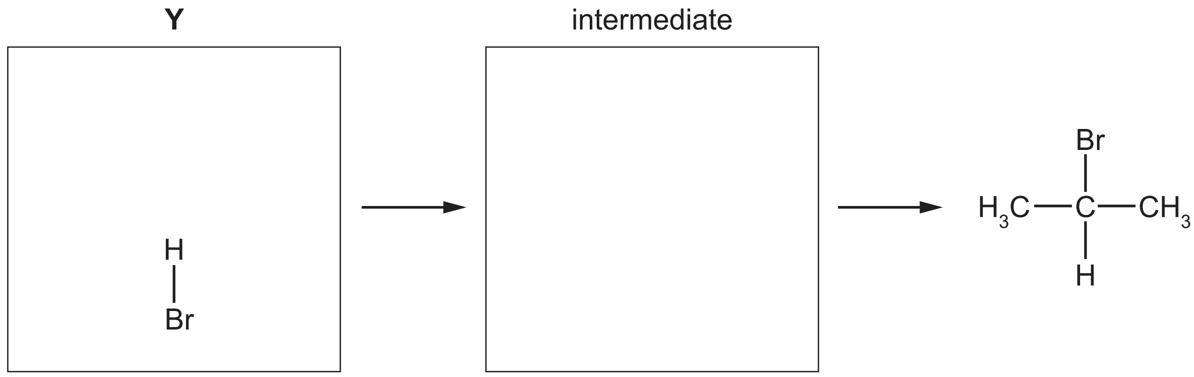
.... [2]

(v) State the name of a solid catalyst for reaction **5**.

.... [1]

(vi) Complete the mechanism for the production of 2-bromopropane from **Y** in reaction **6** shown below.

Include the structure of **Y** and any necessary lone pairs, curly arrows, charges and partial charges.



[4]

(vii) Give the name of the mechanism in **(vi)**.

.... [1]

(viii) 1-bromopropane is a minor product of reaction **6**.

Explain why 2-bromopropane is the major product of reaction **6**.

....

....

....

.... [2]

[Total: 22]

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