Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

* 3 4 7 2 9 0 8 3 1 1 *

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **May/June 2019**

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.

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This document consists of **10** printed pages and **2** blank pages.

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

1 Methylpropane, $(CH_3)_2CHCH_3$, is an isomer of butane, $CH_3(CH_2)_2CH_3$.

(a) **(i)** Explain why methylpropane and butane are a pair of isomers.

.....

..... [2]

(ii) Identify the type of isomerism shown by methylpropane and butane.

..... [1]

(b) When a sample of butane is heated to 373 K, in the presence of a catalyst, and allowed to reach equilibrium the following reaction occurs.

$$CH_3(CH_2)_2CH_3(g) \rightleftharpoons (CH_3)_2CHCH_3(g) \qquad \Delta H = -8.0\,kJ\,mol^{-1}$$

State and explain the effect on the composition of this equilibrium mixture when the temperature is increased to 473 K.

.....

.....

..... [2]

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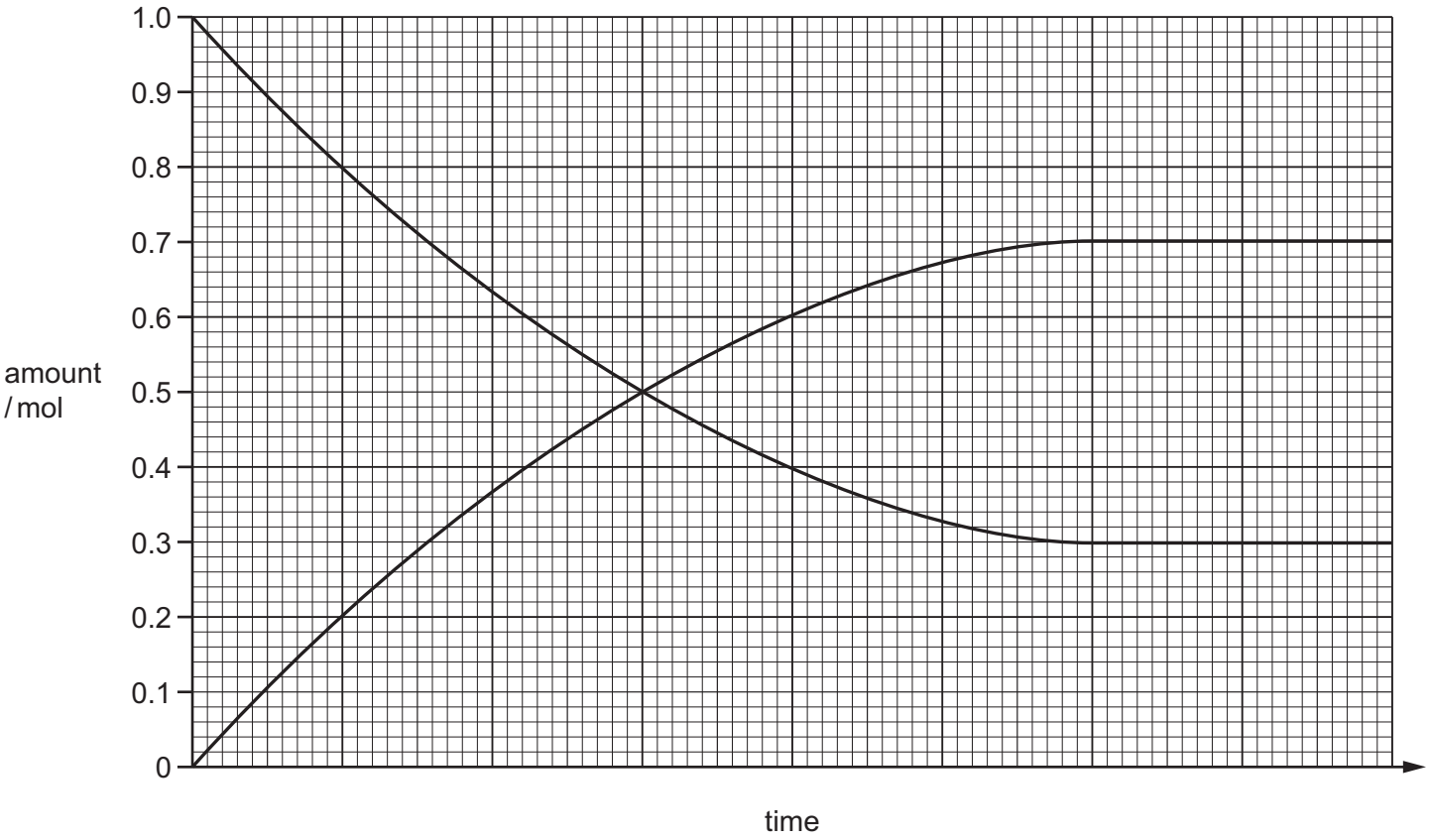
(c) 1 mole of butane gas was added to a 1 dm^3 closed system, at a constant temperature and pressure. The amount of butane and methylpropane was measured at regular time intervals.



(i) Label the graph with a *t* to show the time taken to reach dynamic equilibrium. [1]

(ii) Use the graph to find the concentration of butane and methylpropane in the mixture at equilibrium.

concentration of butane = ... $mol\,dm^{-3}$

concentration of methylpropane = ... $mol\,dm^{-3}$

[1]

(iii) Write an expression for K_c for this reaction.

[1]

(iv) Calculate a value for K_c and state its units.

K_c = ... units = ... [2]

[Total: 10]

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2 Group 17 elements are commonly referred to as the halogens.

(a) State and explain the trend in volatility of chlorine, bromine and iodine down the group.

.....

.....

.....

..... [3]

Hydrogen gas reacts with the different halogens under different conditions.

(b) (i) State the conditions required for chlorine to react with hydrogen at room temperature.

..... [1]

(ii) On heating, iodine reacts with hydrogen in a reversible reaction.

Give the equation for this reaction. Include state symbols.

..... [2]

(c) Hydrogen chloride reacts with water.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

(i) In this reaction, one of the reactants behaves as a Brønsted-Lowry acid.

What is meant by the term *Brønsted-Lowry acid*?

.....

..... [1]

(ii) Identify the reactant behaving as an acid and its conjugate base.

acid .....

conjugate base .....
[1]

(iii) Name the type of bond formed between H^+ and H_2O to make H_3O^+.

..... [1]

(iv) For H_3O^+, predict its shape and the H–O–H bond angle.

shape .....

bond angle .....
[2]

[Total: 11]

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3 Period 3 elements react with chlorine gas, Cl_2(g), to form chlorides.

(a) The table shows the differences in observations which occur when two Period 3 chlorides are added to water.

Period 3 chloride	observations when added to water	pH of solution formed with water
$NaCl$	White solid disappears. Colourless solution made.	7
$SiCl_4$	Pale yellow solution forms. Bubbles form and the test-tube feels hot. White precipitate forms.	1–2

(i) Write an equation for the reaction occurring when $SiCl_4$ is added to cold water. Include state symbols.

..... [1]

(ii) Name the type of reaction occurring when $SiCl_4$ is added to water.
Ignore the exothermic/endothermic nature of the reaction.

..... [1]

(iii) Explain, in terms of bonding, why $NaCl$ and $SiCl_4$ behave differently when added to water.

.....

.....

..... [2]

(iv) Explain, in terms of electronegativity, why the bonding in $NaCl$ is different from the bonding in $SiCl_4$.

.....

.....

.....

..... [3]

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(b) Cl_2(g) dissolves in cold water and reacts with it.

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

(i) Identify the oxidation number of chlorine in each of the chlorine-containing species in this reaction.

chlorine-containing species	Cl_2	HCl	$HClO$
oxidation number of chlorine			

[2]

(ii) Name the type of reaction occurring.

..... [1]

(iii) Explain why chlorine is used in the purification of water.

.....

..... [1]

(c) A mixture of HCl and $HClO$ is added to cold dilute NaOH. One of the products behaves as a bleach.

Suggest the equation for the reaction occurring.

..... [2]

[Total: 13]

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4 There are many different types of aliphatic and aromatic hydrocarbons.

(a) Name a naturally occurring source of aliphatic and aromatic hydrocarbons and outline how different hydrocarbons are separated from this source.

name of source .....

outline of separation of hydrocarbons .....

.....
[2]

(b) When alkanes are heated to high temperatures, in the absence of air, the molecules can break into smaller molecules.

(i) Identify the type of reaction occurring.

..... [1]

(ii) Write an equation which describes the reaction occurring when heptane, C_7H_{16}, is heated in the absence of air, to form hexane, butane and ethene only.

..... [1]

(c) The equation for the complete combustion of ethene is shown.

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

Calculate the volume, in dm^3, of carbon dioxide formed in the complete combustion of 1.00 g of ethene at room temperature and pressure.

volume of CO_2 = ... dm^3 [3]

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(d) The table compares the reactivity of alkanes and alkenes with chlorine.

	alkanes	alkenes
name of the type of reaction with chlorine	substitution	addition and substitution
name of the type of reacting species	free radical	electrophile and free radical

(i) During the first stage in the substitution reaction chlorine forms chlorine free radicals.

Explain what is meant by the term *free radical*.

..... [1]

(ii) Name and explain the type of bond breaking which occurs to form chlorine free radicals.

.....

..... [2]

(iii) Name the stage of the reaction mechanism which occurs when a methane molecule reacts with a chlorine free radical.

..... [1]

(iv) Complete the equation for the reaction which occurs when a methane molecule reacts with a chlorine free radical.

[1]

(v) Carbon atoms can form σ and π bonds within hydrocarbon molecules.

Explain the following statement with reference to σ and π bonds.

Alkenes react with electrophiles but alkanes do not.

.....

.....

.....

..... [2]

[Total: 14]

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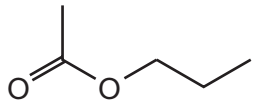
5 Many naturally occurring esters are used as flavourings in food.

(a) The structure of ester **V** is shown.



V

(i) Name **V**.

..... [1]

V reacts with a reagent to form a salt of a carboxylic acid and an alcohol.

(ii) Identify a reagent that could be used in this reaction.

..... [1]

(iii) Draw the displayed formula of the alcohol made during this reaction.

[1]

(iv) State one other possible use for **V**, apart from as a food flavouring.

..... [1]

(b) Ester **W** is made up of 54.5% carbon, 9.1% hydrogen and 36.4% oxygen.

(i) Calculate the empirical formula of **W**.

[3]

(ii) State what additional information is required to determine the molecular formula of **W**.

..... [1]

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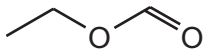
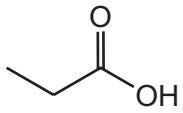
(c) Compounds **X**, **Y** and **Z** are shown. They all have the same molecular formula.

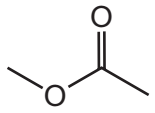
X



Y



Z



(i) Deduce the molecular formula of **X**, **Y** and **Z**.

..... [1]

(ii) In three experiments, sodium is added to separate samples of **X**, **Y** and **Z**.

Complete the table to show the observations for each of these three experiments. Ignore any temperature changes which may occur.

experiment	observations
Na + **X**	
Na + **Y**	
Na + **Z**	

[2]

(d) Sodium carbonate solution reacts with methanoic acid.

Write the equation for this reaction.

..... [1]

[Total: 12]

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