Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

3410012160

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **February/March 2018**

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 **11** printed pages and **1** blank page.

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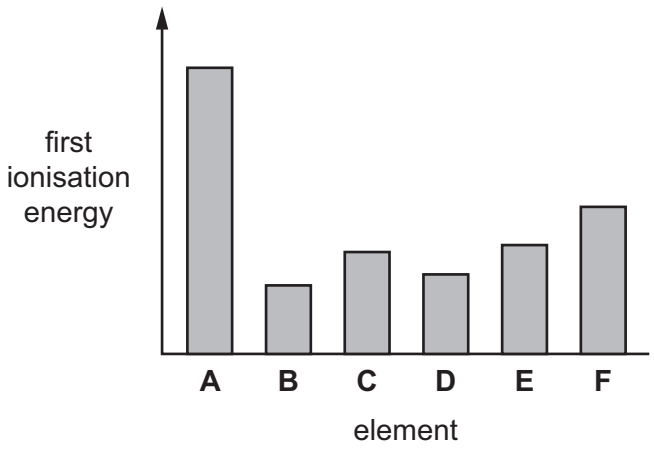
Answer **all** the questions in the spaces provided.

1 **(a)** The graph shows a sketch of the first ionisation energies of six successive elements in the Periodic Table.

The letters are **not** the symbols of the elements.



(i) Explain what is meant by the term *first ionisation energy*.

.....

.....

.....

..... [3]

(ii) Suggest why the first ionisation energy of **B** is much less than that of **A**.

.....

.....

.....

.....

..... [3]

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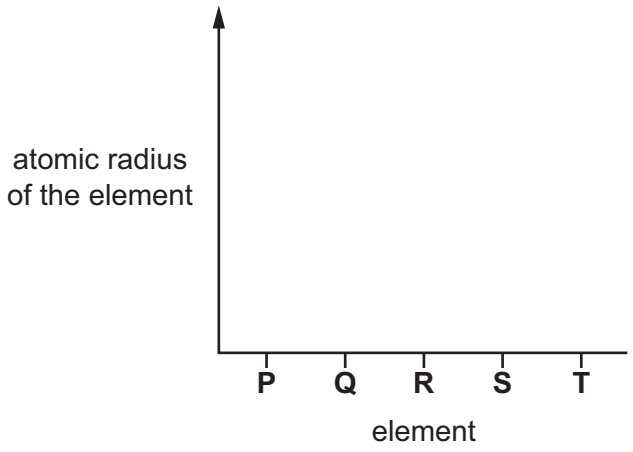
(b) **P**–**T** are successive elements in Period 3 of the Periodic Table.

The letters are **not** the symbols of the elements.

On the axes, sketch a graph to show the trend in the atomic radius of the elements **P**–**T**.

Explain your answer.



explanation .....

.....

.....

.....

.....

[3]

[Total: 9]

2 Carbon and silicon are elements in Group 14.

(a) C_{60} and diamond are allotropes of carbon.

(i) Describe the lattice structure of solid C_{60}.

.....

.....

.....

..... [2]

(ii) C_{60} sublimes (turns directly from solid to gas) at about 800 K. Diamond also sublimes but only above 3800 K.

Explain why C_{60} and diamond sublime at such different temperatures.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) C_{60} forms hydrocarbons with similar chemical properties to those of alkenes. One such hydrocarbon is $C_{60}H_{18}$.

(i) State what is meant by the term *hydrocarbon*.

.....

..... [1]

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(ii) Describe a test to indicate the presence of double bonds between carbon atoms in $C_{60}H_{18}$. Give the result of the test.

test .....

.....

result .....

.....
[2]

(c) 0.144 g of C_{60} was placed in a 100 cm^3 container of hydrogen gas at 20 °C and 1.00×10^5 Pa.

The container was heated to make the C_{60} and hydrogen gas react.

The reaction occurred as shown in the equation.

$$C_{60}(s) + xH_2(g) \rightarrow C_{60}H_{2x}(s)$$

After the reaction, the container was allowed to cool to 20 °C. The pressure decreased to 2.21×10^4 Pa. All of the C_{60} had reacted.

(i) Name the type of reaction that occurred.

..... [1]

(ii) Calculate the amount, in moles, of C_{60} that reacted.

amount of C_{60} = ... mol [1]

(iii) Calculate the amount, in moles, of hydrogen gas that reacted with the C_{60}.

amount of hydrogen gas = ... mol [2]

(iv) Use your answers from **(ii)** and **(iii)** to deduce the molecular formula of the hydrocarbon, $C_{60}H_{2x}$.

If you were unable to calculate the amount of hydrogen gas, assume that 0.00240 mol of hydrogen gas reacted. This is **not** the correct value for the amount of hydrogen gas that reacted.

molecular formula = ... [2]

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[Turn over

(d) Silicon shows the same kind of bonding and structure as diamond.

(i) State the type of bonding and structure shown by silicon.

.....

.....

..... [2]

(ii) When silicon reacts with magnesium, Mg_2Si forms. Mg_2Si is thought to contain the Si^{4-} ion.

State the full electronic configuration of the Si^{4-} ion.

$1s^2$..... [1]

(iii) Solid Mg_2Si reacts with dilute hydrochloric acid to form gaseous SiH_4 and a solution of magnesium chloride.

Write an equation to show the reaction of solid Mg_2Si with dilute hydrochloric acid.

Include state symbols.

..... [2]

(iv) Predict the shape of the SiH_4 molecule.

..... [1]

(v) SiH_4 reacts spontaneously with oxygen to produce a white solid and a colourless liquid that turns anhydrous copper(II) sulfate blue. No other products are formed.

Write an equation for the reaction of SiH_4 with oxygen.

State symbols are **not** required.

..... [1]

[Total: 22]

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3 Calcium and its compounds have a large variety of applications.

(a) Calcium metal reacts readily with most acids.

(i) Write an equation for the reaction of calcium with dilute nitric acid. State symbols are **not** required.

..... [1]

(ii) When calcium metal is placed in dilute sulfuric acid, it reacts vigorously at first.

After a short time, a crust of calcium sulfate forms on the calcium metal and the reaction stops. Some of the calcium metal and dilute sulfuric acid remain unreacted.

Suggest an explanation for these observations.

.....

.....

.....

..... [2]

(b) Calcium ethanedioate is formed when calcium reacts with ethanedioic acid, $(CO_2H)_2$. The compound contains one cation and one anion.

(i) Draw the 'dot-and-cross' diagram of the cation present in calcium ethanedioate. Show **all** electrons.

[1]

(ii) Draw the displayed formula of the anion present in calcium ethanedioate.

[2]

(c) Calcium chlorate(I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate(I), $NaClO$, in some household products.

(i) Suggest a use for calcium chlorate(I).

..... [1]

(ii) The chlorate(I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine.

Write an **ionic** equation for this reaction. State symbols are **not** required.

..... [1]

(iii) The chlorate(I) ion is unstable and decomposes when heated as shown.

Deduce the oxidation number of chlorine in each species. Complete the boxes.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

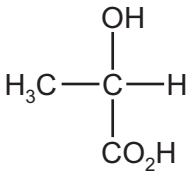
oxidation number of chlorine:	+1		

[1]

(iv) In terms of electron transfer, state what happens to the chlorine in the reaction in **(iii)**.

..... [1]

(d) Calcium lactate is used in some medicines. It forms when lactic acid (2-hydroxypropanoic acid) reacts with calcium carbonate.



lactic acid

(i) Identify the **two** other products of the reaction of lactic acid with calcium carbonate.

..... [1]

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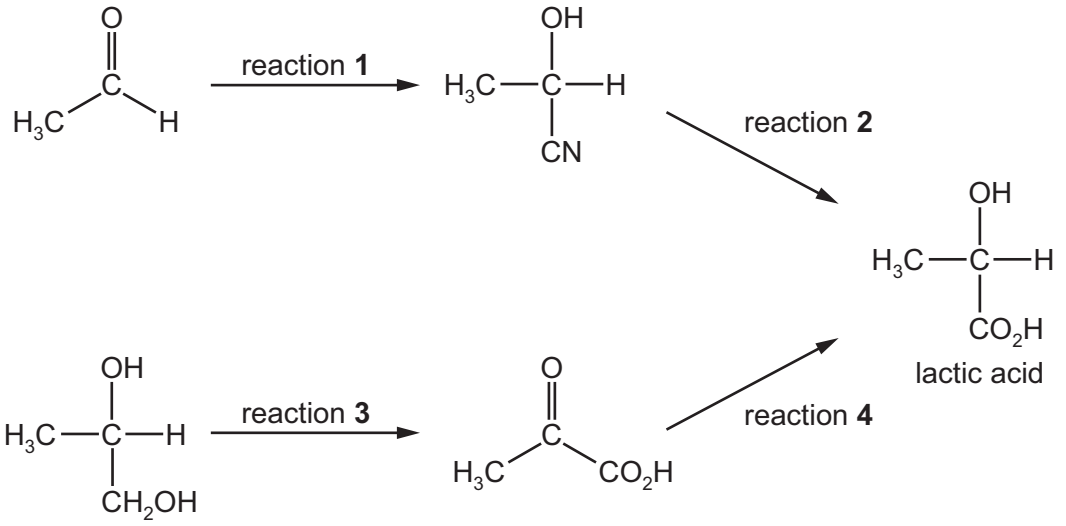
Two possible methods of making lactic acid are shown.



(ii) State suitable reagents and conditions for reactions **1** and **3**.

reaction	reagents and conditions
1	
3	

[4]

(iii) Name the type of reaction that occurs in reaction **2**.

..... [1]

(iv) Reaction **4** uses $NaBH_4$.

Identify the role of $NaBH_4$ in this reaction.

..... [1]

(v) Lactic acid has a chiral centre.

State what is meant by the term *chiral centre*.

.....

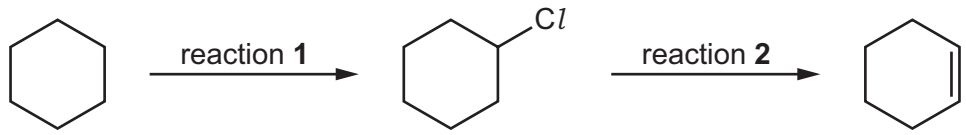
.....

..... [1]

[Total: 18]

4 Cyclohexane is a colourless liquid used in industry to produce synthetic fibres.

A reaction scheme involving cyclohexane is shown.

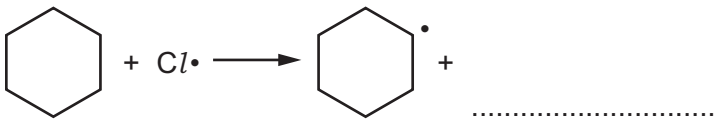
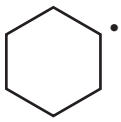
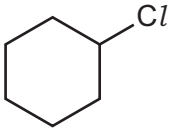
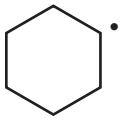


(a) Reaction **1** involves a free radical substitution mechanism.

(i) State the essential condition required for reaction **1** to occur.

..... [1]

(ii) Complete the table to give details of the mechanism in reaction **1**.

name of step	reaction
.....	$Cl_2 \longrightarrow 2Cl\bullet$
propagation	 + $Cl\bullet$ → + ...
.....	 + Cl_2 →  + $Cl\bullet$
termination	 + $Cl\bullet$ → .....

[4]

(b) Name the type of reaction that occurs in reaction **2**.

..... [1]

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(c) The product of reaction **2** is cyclohexene.

Cyclohexene can be converted into adipic acid (hexanedioic acid), $HO_2C(CH_2)_4CO_2H$.

(i) Identify the reagents and conditions for the conversion of cyclohexene into adipic acid.

.....

..... [2]

(ii) Suggest **three** main differences between the infra-red spectra of cyclohexene and adipic acid.

In each case, identify the bond responsible and its characteristic absorption range (in wavenumbers).

1 .....

.....

.....

2 .....

.....

.....

3 .....

.....

.....

[3]

[Total: 11]

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