Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 8 5 8 2 6 1 1 0 1 7 *

CHEMISTRY

9701/21

Paper 2 Structured Questions AS Core

May/June 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 **11** printed pages and **1** blank page.

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

1 **(a)** Chemists recognise that atoms are made of three types of particle.

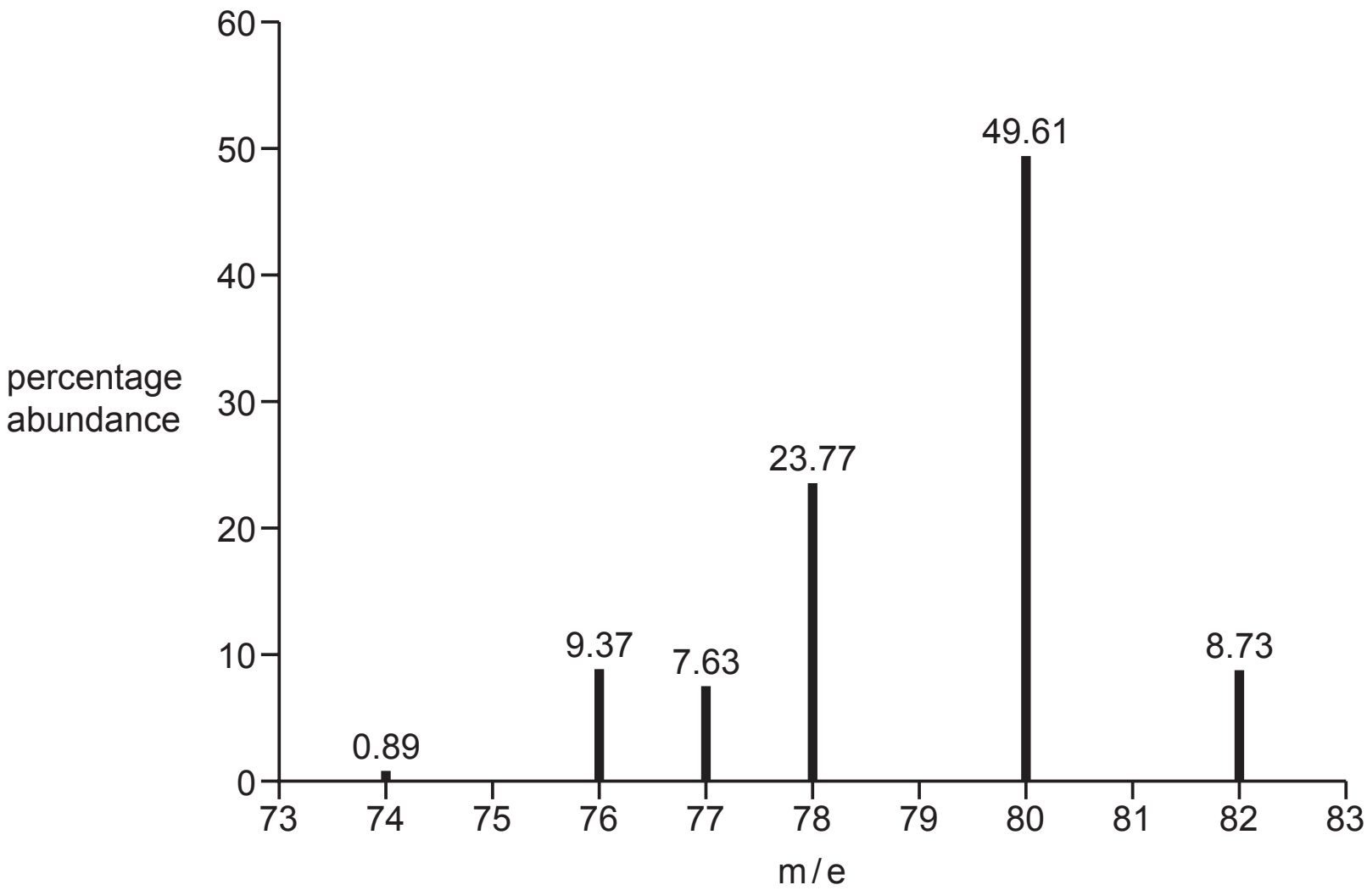
Complete the following table with their names and properties.

name of particle	relative mass	relative charge
		0
	1/1836	

[3]

(b) The relative atomic mass of an element can be determined using data from its mass spectrum.

The mass spectrum of element **X** is shown, with the percentage abundance of each isotope labelled.



(i) Define the terms *relative atomic mass* and *isotope*.

relative atomic mass .....

.....

.....

isotope .....

.....

[3]

(ii) Use the data in the mass spectrum to calculate the relative atomic mass, A_r, of **X**. Give your answer to **two** decimal places and suggest the identity of **X**.

A_r of **X** .....

identity of **X** .....
[2]

(c) The element tellurium, Te, reacts with chlorine to form a single solid product, with a relative formula mass of 270. The product contains 52.6% chlorine by mass.

(i) Calculate the molecular formula of this chloride.

molecular formula ..... [3]

(ii) This chloride melts at 224 °C and reacts vigorously with water.

State the type of bonding **and** structure present in this chloride and explain your reasoning.

.....

.....

.....

..... [2]

(iii) Suggest an equation for the reaction of this chloride with water.

..... [1]

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(d) Sodium and silicon also react directly with chlorine to produce the chlorides shown.

chloride	melting point / °C	difference between the electronegativities of the elements
NaCl	801	2.2
SiCl_4	–69	1.3

(i) Describe what you would **see** during the reaction between sodium and chlorine.

.....

.....

..... [2]

(ii) Explain the differences between the melting points of these two chlorides in terms of their structure **and** bonding. You should refer to the difference between the electronegativities of the elements in your answer.

NaCl structure **and** bonding .....

.....

SiCl_4 structure **and** bonding .....

.....

explanation .....

.....

.....

.....

.....

..... [4]

[Total: 20]

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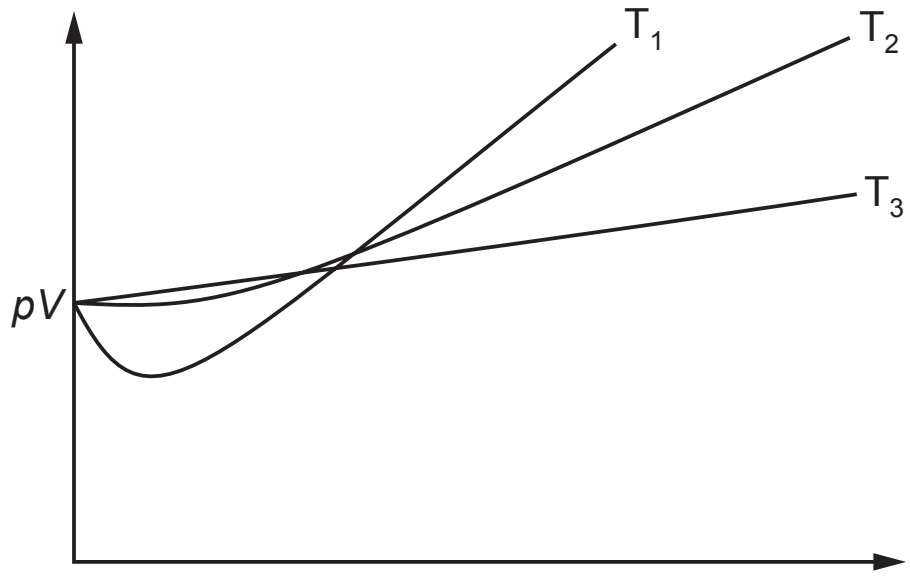
2 The relationship $pV = nRT$ can be derived from the laws of mechanics by assuming ideal behaviour for gases.

(a) The graph represents the relationship between pV and p for a real gas at three different temperatures, T_1, T_2 and T_3.



(i) Draw **one** line on the graph to show what the relationship should be for the same amount of an **ideal** gas. [1]

(ii) State and explain, with reference to the graph, which of T_1, T_2 or T_3 is the lowest temperature.

.....

..... [1]

(iii) Explain your answer to **(ii)** with reference to intermolecular forces.

.....

..... [1]

(iv) State and explain the effect of pressure on the extent to which a gas deviates from ideal behaviour.

.....

.....

.....

..... [2]

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(b) A flask with a volume of 100 cm^3 was first weighed with air filling the flask, and then with another gas, **Y**, filling the flask. The results, measured at 26 °C and 1.00×10^5 Pa, are shown.

Mass of flask containing air = 47.930 g

Mass of flask containing **Y** = 47.989 g

Density of air = 0.00118 g cm^{-3}

Calculate the relative molecular mass, M_r, of **Y**.

M_r of **Y** = ... [4]

(c) Although nitrogen gas makes up about 79% of the atmosphere it does not easily form compounds.

(i) Explain why nitrogen is so unreactive.

.....

..... [1]

(ii) Explain why the conditions in a car engine lead to the production of oxides of nitrogen.

.....

..... [1]

(iii) Give an equation for a reaction involved in the removal of nitrogen monoxide, NO, from a car's exhaust gases, in the catalytic converter.

..... [1]

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One of the main reasons for reducing the amounts of oxides of nitrogen in the atmosphere is their contribution to the formation of acid rain.

(iv) Write an equation for the formation of nitric acid from nitrogen dioxide, NO_2, in the atmosphere.

..... [1]

(v) Write equations showing the catalytic role of nitrogen monoxide, NO, in the oxidation of atmospheric sulfur dioxide, SO_2.

.....

..... [2]

[Total: 15]

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3 Ethanal reacts with hydrogen cyanide, in the presence of a small amount of NaCN, as shown.

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$$

(a) Use bond energies from the *Data Booklet* to calculate the enthalpy change for this reaction. Include a sign with your answer.

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

(b) The product of this reaction shows stereoisomerism as it contains a chiral centre. This reaction produces an equimolar mixture of two optical isomers.

(i) Explain the meanings of the terms *stereoisomerism* and *chiral centre*.

stereoisomerism .....

.....

.....

chiral centre .....

.....
[2]

(ii) Suggest why the two optical isomers are produced in equal amounts by this reaction.

.....

..... [1]

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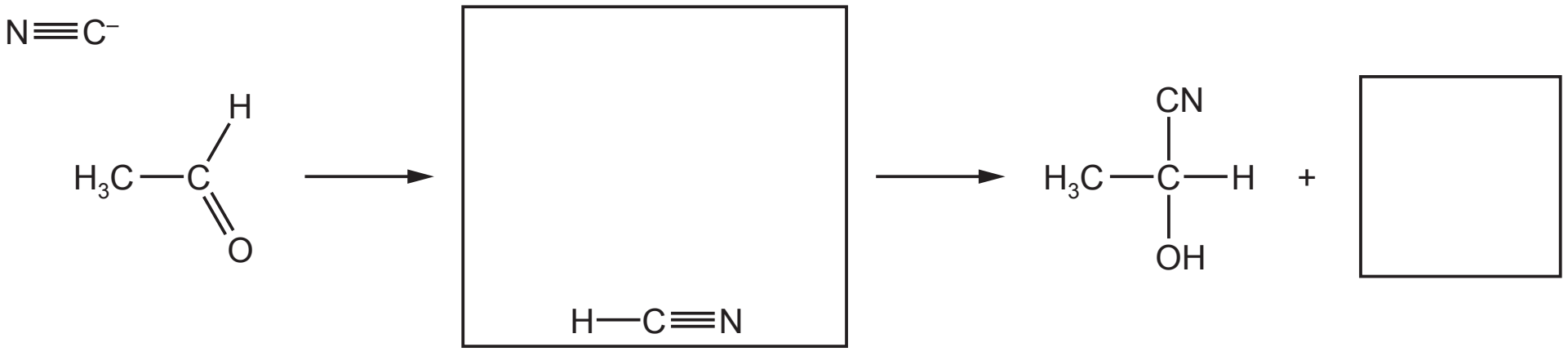
(c) (i) Complete the diagram to show the mechanism of this reaction. Include all necessary charges, partial charges, lone pairs and curly arrows and show the structure of the intermediate.



[5]

(ii) With reference to your mechanism in **(i)**, explain the role of the NaCN in this reaction.

.....

..... [1]

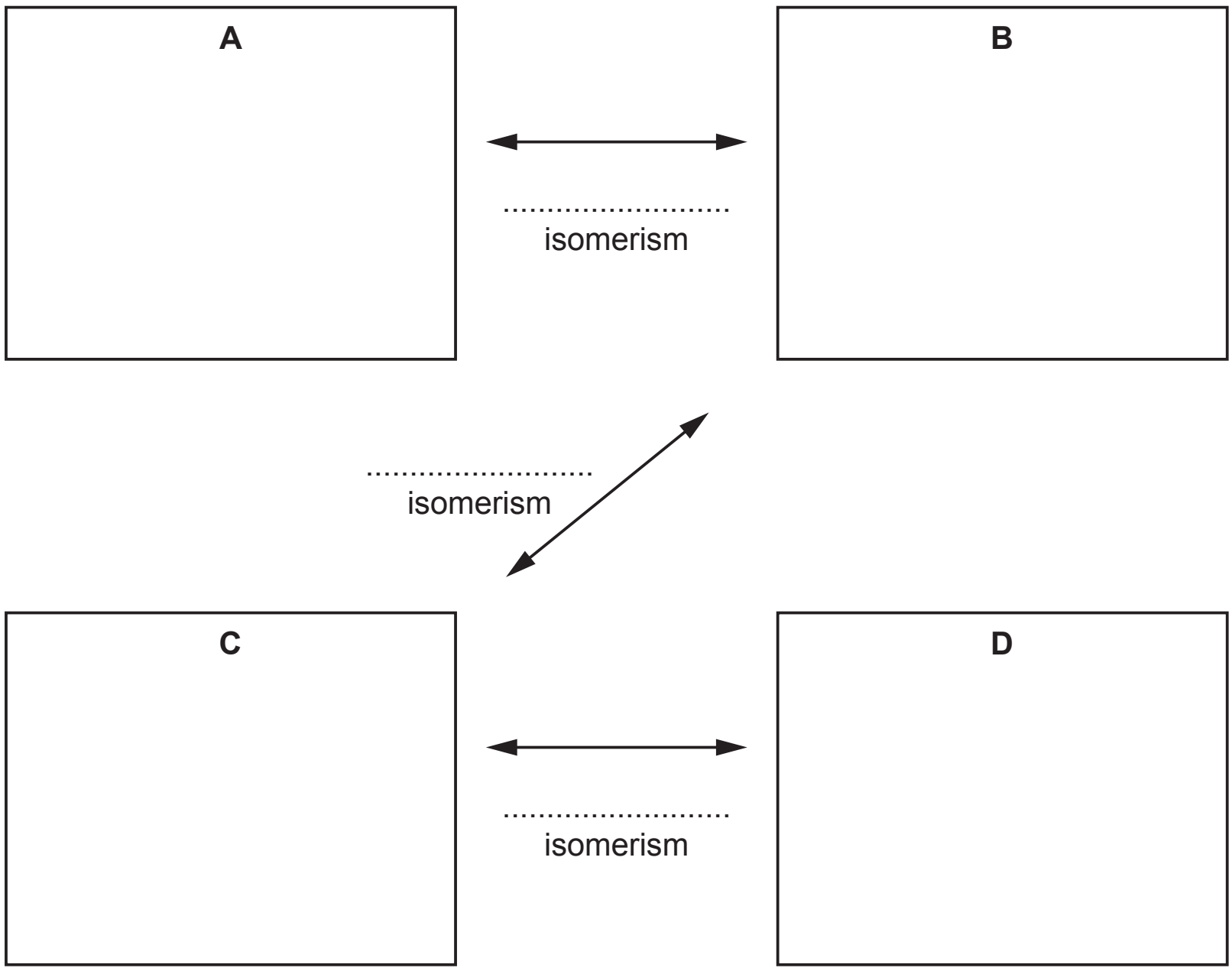
[Total: 12]

4 There are four alcohols, **A**, **B**, **C** and **D**, which are structural isomers with the molecular formula $C_4H_{10}O$.

Alcohol **A** does not react with acidified potassium dichromate(VI) solution but **B**, **C** and **D** do.

All four alcohols react with hot, concentrated sulfuric acid to form products with the molecular formula C_4H_8. **A**, **C** and **D** each give a single product in this reaction. **B** gives a mixture of two structural isomers, one of which shows stereoisomerism.

(a) Give the **skeletal** formula for each of the four alcohols and complete the diagram with the names of the types of structural isomerism shown by each linked pair of compounds.



[7]

(b) (i) Give the names of the two structural isomers produced by the reaction of **B** with hot, concentrated sulfuric acid

.... [2]

(ii) State which of these two isomers shows stereoisomerism. Explain why this molecule is capable of showing stereoisomerism.

.....

.....

.....

..... [2]

(iii) Draw **displayed** formulae to show the two stereoisomers.

stereoisomer 1	stereoisomer 2

[2]

[Total: 13]

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