Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

8530346621

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **May/June 2017**

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

1 The composition of atoms and ions can be determined from knowledge of atomic number, nucleon number and charge.

(a) Complete the table.

atomic number	nucleon number	number of electrons	number of protons	number of neutrons	symbol
3		2			$^{6}_{3}Li^{+}$
		23	26	32	

[2]

(b) Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B. The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

(i) Define the term *relative isotopic mass*.

.....

..... [2]

(ii) Calculate the relative isotopic mass of ^{11}B.

Give your answer to **six** significant figures. Show your working.

[2]

[Total: 6]

2 Nitrogen gas, N_2, is very unreactive.

(a) Explain why nitrogen gas is so unreactive.

.....

.....

..... [2]

(b) Despite the low reactivity of N_2, oxides of nitrogen occur in the atmosphere through both natural and man-made processes.

(i) Explain why oxides of nitrogen can be produced by internal combustion engines.

.....

.....

..... [2]

(ii) State and explain, using a suitable equation, how oxides of nitrogen produced by internal combustion engines can be prevented from reaching the atmosphere.

.....

..... [2]

(iii) State the role of nitrogen dioxide, NO_2, in the formation of acid rain by oxides of sulfur. Write suitable equations to explain this role.

role .....

equation 1 .....

equation 2 .....

[3]

(iv) Suggest an equation to show how NO_2 can contribute **directly** to acid rain.

..... [1]

(c) Explain how the uncontrolled use of nitrate fertilisers on land can lead to a severe reduction in water quality in rivers.

.....

.....

.....

..... [3]

[Total: 13]

[Turn over

3 The hydrogen halides, HC*l*, HBr and HI, can undergo thermal decomposition.
In a sealed container an equilibrium is established according to the equation shown.

$$2HX(g) \rightleftharpoons H_2(g) + X_2(g) \qquad \text{(where X = C}l\text{, Br or I)}$$

(a) Some bond energies are shown in the table.

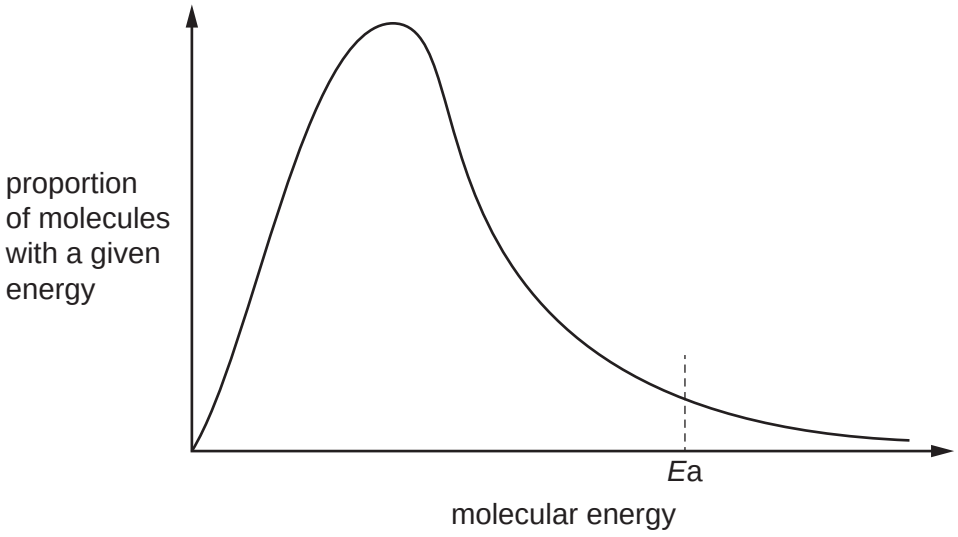
	bond energy / kJ mol^{-1}
H–Br	366
H–H	436
Br–Br	193

Use these data to calculate a value for the enthalpy change, ΔH, for the thermal decomposition of hydrogen bromide, HBr, according to the equation shown.

ΔH = ... kJ mol^{-1} [1]

(b) At a temperature of 700 K a sample of HBr is approximately 10% decomposed. Changing the temperature affects both the rate of decomposition of HBr and the percentage that decomposes.

The Boltzmann distribution for a sample of HBr at 700 K is shown. *E*a represents the activation energy for the reaction.



(i) Using the same axes, sketch a second curve to indicate the Boltzmann distribution at a higher temperature. [2]

(ii) With reference to the curves, state and explain the effect of increasing temperature on the **rate** of decomposition of HBr.

.....

.....

.....

..... [3]

(iii) The decomposition of HBr is endothermic.

State the effect of increasing temperature on the **percentage** of HBr that decomposes. Use Le Chatelier's principle to explain your answer.

.....

.....

.....

..... [3]

(iv) At 700 K HBr is approximately 10% decomposed but hydrogen iodide, HI, is approximately 20% decomposed.

Explain this difference with reference to bond strengths and the factors that affect them.

.....

.....

.....

..... [3]

[Turn over

(c) At temperatures above 1500 K, HCl will decompose.

A sample of 0.300 mol of HCl decomposed in a sealed container.

The resulting equilibrium mixture was found to contain 1.50×10^{-2} mol of Cl_2.

(i) Calculate the amounts, in mol, of H_2 and HCl present in the equilibrium mixture.

H_2 = ... mol

HCl = ... mol
[2]

(ii) Calculate the mole fraction of each gas in the equilibrium mixture.

mole fraction of HCl = ...

mole fraction of H_2 = ...

mole fraction of Cl_2 = ...
[1]

(d) In another experiment under different conditions, an equilibrium mixture was produced with mole fractions for each species as shown.

species	mole fraction
HCl	0.88
H_2	0.06
Cl_2	0.06

(i) Write the expression for the equilibrium constant, K_p, for the decomposition of HCl.

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

K_p =

[1]

(ii) Explain why the total pressure of the system does **not** need to be known for K_p to be calculated for this experiment.

.....

..... [1]

(iii) Calculate the value of K_p for this experiment.

K_p = ... [1]

[Total: 18]

4 **(a)** The hydrocarbons **A**, C_4H_{10}, and **B**, C_4H_8, are both unbranched.

A does **not** decolourise bromine.

B decolourises bromine and shows geometrical isomerism.

(i) Draw the skeletal formula of **A**.

A

[1]

(ii) The hydrocarbon **A**, C_4H_{10}, has a branched isomer.

Suggest why unbranched **A** has a higher boiling point than its branched isomer.

.....

.....

.....

.....

..... [2]

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

..... [1]

(iv) Explain why **B** shows geometrical isomerism.

.....

.....

.....

..... [2]

(v) Draw the mechanism of the reaction of **B** with bromine, Br_2.
Include all necessary charges, dipoles, lone pairs and curly arrows.

[4]

(vi) Explain the origin of the dipole on Br_2 in this mechanism.

.....

.....

..... [1]

(b) The alcohols **C** and **D** are isomers of each other with molecular formula $C_4H_{10}O$. Both isomers are branched.

When **C** is heated under reflux with acidified potassium dichromate(VI) no colour change is observed.

When **D** is heated under reflux with acidified potassium dichromate(VI) the colour of the mixture changes from orange to green and **E**, $C_4H_8O_2$, is produced.

E reacts with aqueous sodium carbonate to form carbon dioxide gas.

(i) Identify **C**, **D** and **E**.

C	**D**	**E**

[3]

(ii) Write the equation for the reaction between **E** and aqueous sodium carbonate.

..... [1]

(c) The isomers **F** and **G**, $C_5H_{10}O$, both form an orange precipitate when reacted with 2,4-DNPH.

F is unbranched and reacts with alkaline aqueous iodine to produce a yellow precipitate.

G does not react with alkaline aqueous iodine. It contains a chiral centre and produces a silver mirror when warmed with Tollens' reagent.

(i) Name the yellow precipitate produced by the reaction between **F** and alkaline aqueous iodine.

..... [1]

(ii) Give the structural formula of **F** and of **G**.

F .....

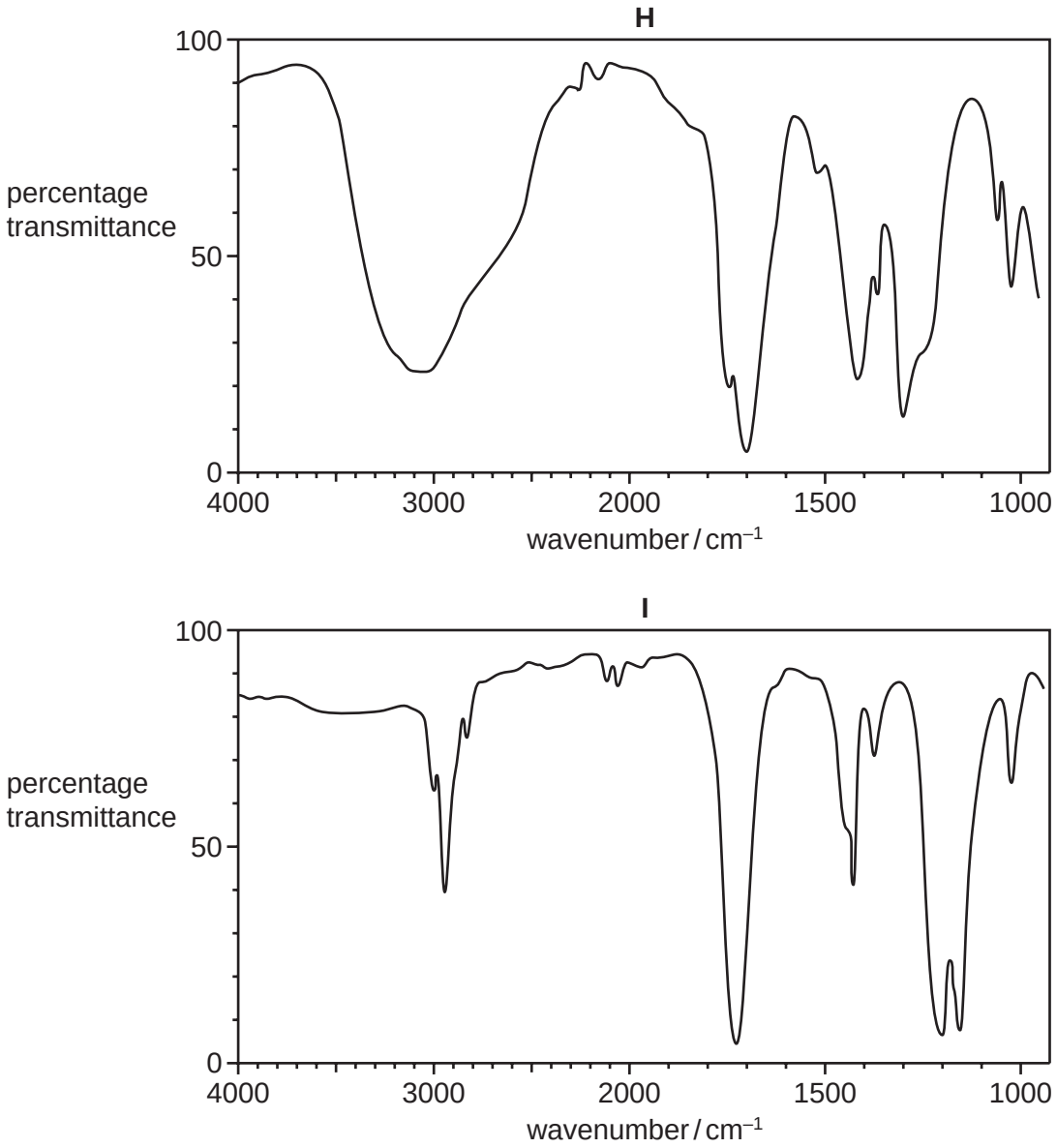
G .....
[2]

(iii) Explain the meaning of the term *chiral centre*.

.....

..... [1]

(d) **H** and **I** are isomers with molecular formula $C_2H_4O_2$. The infra-red spectra of isomers **H** and **I** are shown.



(i) Identify the bonds responsible for the principal peaks above 1500 cm^{-1} in each spectrum.

spectrum of **H** .....

.....

spectrum of **I** .....

.....

[2]

(ii) Name **H** and **I**.

H .....

I .....

[2]

[Total: 23]

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