

# Atomic Structure

## Question Paper 4

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Atomic Structure
<b>Sub-Topic</b>	
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question Paper 4

**Time Allowed:** 83 minutes

**Score:** /69

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 (a) Natural bromine consists of the two isotopes  $^{79}\text{Br}$  and  $^{81}\text{Br}$  in roughly equal proportions.

The mass spectrum of bromine consists of 5 peaks.

- (i) Suggest the mass numbers for the 5 peaks and the identities of the species responsible for them.

.....  
 .....  
 .....

- (ii) Suggest the ratios of the relative abundances of

- the three lines with the highest mass numbers,

.....

- the two lines with the lowest mass numbers.

.....

[4]

Esters of 2,3-dibromopropan-1-ol with phosphoric acid are useful flame retardants used in plastics and fibres.

2,3-dibromopropan-1-ol can be made from propenal by the following two-stage process.



(b) (i) Draw the structure of the intermediate **A** in the box opposite.

(ii) Suggest reagents and conditions for

- reaction I,

.....

- reaction II.

.....

[3]

(c) The mass spectrum of 2,3-dibromopropan-1-ol includes the following peaks.

mass number	relative abundance
31	100
106	44
108	45
185	0.3
187	0.6
189	0.3

(i) At what mass number would you expect the molecular ion to occur?

.....

(ii) Identify the molecular formula (including isotopic composition where relevant) of these 6 peaks.

mass number	molecular formula
31	
106	
108	
185	
187	
189	

[5]

[Total: 12]

2 (a) Use the general formula of a carboxylic acid,  $\text{RCO}_2\text{H}$ , to write equations to explain the following terms.

(i)  $K_a$  .....

(ii)  $\text{p}K_a$  .....

[2]

(b) The  $\text{p}K_a$  values of four carboxylic acids are listed in the table below.

acid	formula of acid	$\text{p}K_a$
1	$\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$	4.9
2	$\text{CH}_3\text{CHClCO}_2\text{H}$	2.8
3	$\text{CH}_3\text{CCl}_2\text{CO}_2\text{H}$	1.4
4	$\text{CH}_2\text{ClCH}_2\text{CO}_2\text{H}$	4.1

(i) Describe and explain the trend in acid strength shown by acids 1, 2 and 3.

.....  
 .....  
 .....  
 .....

(ii) Suggest an explanation for the difference in the  $\text{p}K_a$  values for acids 2 and 4.

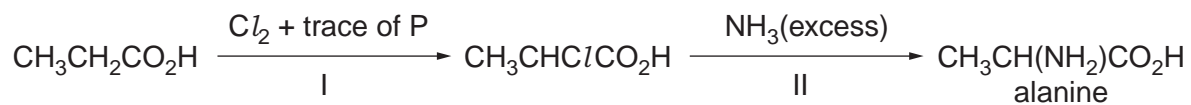
.....  
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(iii) Calculate the pH of a  $0.010 \text{ mol dm}^{-3}$  solution of propanoic acid (acid 1).

.....  
 .....  
 .....

[6]

(c) A good way of making synthetic amino acids uses chloro-acids as intermediates.



(i) Suggest the role that the trace of phosphorus plays in reaction I.

.....

(ii) Write a fully balanced equation for reaction I.

.....

(iii) State the *type of mechanism* of reaction II.

.....

(iv) When 10.0g of propanoic acid was used in this 2-stage synthesis, a yield of 9.5g of alanine was obtained.  
Calculate the overall percentage yield.

.....

[5]

(d) In the solid state and in aqueous solutions, alanine exists as a zwitterion.  
Draw the structural formula of this zwitterion.

[2]

[Total: 15]

3 Iron and cobalt are adjacent elements in the Periodic Table. Iron has three main naturally occurring isotopes, cobalt has one.

(a) Explain the meaning of the term *isotope*.

.....

.....

..... [2]

(b) The most common isotope of iron is  $^{56}\text{Fe}$ ; the only naturally occurring isotope of cobalt is  $^{59}\text{Co}$ .

Use the *Data Booklet* to complete the table below to show the atomic structure of  $^{56}\text{Fe}$  and of  $^{59}\text{Co}$ .

isotope	number of		
	protons	neutrons	electrons
$^{56}\text{Fe}$			
$^{59}\text{Co}$			

[3]

(c) A sample of iron has the following isotopic composition by mass.

isotope mass	54	56	57
% by mass	5.84	91.68	2.17

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

.....

.....

.....

.....

(ii) By using the data above, calculate the relative atomic mass of iron to **three** significant figures.

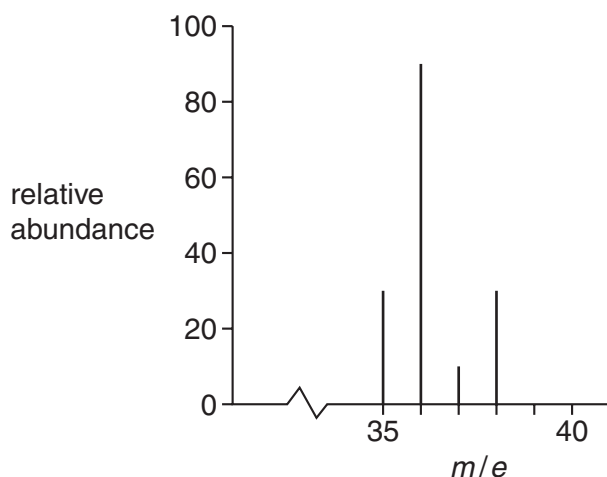
[5]

[Total: 10]

- 4 (a) Define *an isotope* in terms of its sub-atomic particles.

.....  
 .....  
 [1]

- (b) In a mass spectrometer some hydrogen chloride molecules will split into atoms. The mass spectrum of  $\text{HCl}$  is given. Chlorine has two isotopes. The hydrogen involved here is the isotope  $^1_1\text{H}$  only.



- (i) What particle is responsible for the peak at mass 35? .....
- (ii) What particle is responsible for the peak at mass 38? .....  
 [2]

- (c) Use the relative heights of the peaks to determine the proportions of the two isotopes of chlorine. Explain simply how you obtained your answer.

[2]

- (d) Use your answer to (c) to explain why chlorine has a relative atomic mass of 35.5.

[1]

[Total : 6]

5 (a) Complete the electronic configurations of the following atoms.

oxygen:  $1s^2$ .....

fluorine:  $1s^2$ .....

[1]

(b) A compound of fluorine and oxygen contains three atoms in each molecule.

(i) Predict its formula.

..... [1]

(ii) Draw a 'dot-and-cross' diagram to show its bonding.

[1]

(iii) Suggest the shape of this molecule.

..... [1]

(c) Use  $E^\ominus$  values from the *Data Booklet* to predict the relative oxidising abilities of fluorine and chlorine.

.....  
.....  
..... [2]

(ii) Predict the *type of reaction* that would occur between the interhalogen compound chlorine fluoride,  $ClF$ , and potassium bromide solution.

..... [1]

(iii) Construct an equation for this reaction.

..... [1]

[Total: 8]



6 (a) Explain what is meant by the term *ionisation energy*.

.....  
.....  
..... [3]

(b) The first seven ionisation energies of an element, **A**, in  $\text{kJ mol}^{-1}$ , are

1012 1903 2912 4957 6274 21 269 25 398.

(i) State the group of the Periodic Table to which **A** is most likely to belong. Explain your answer.

.....  
.....  
.....  
..... [2]

(ii) Complete the electronic configuration of the element in Period 2 that is in the same group as **A**.

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

(c) Another element, **Z**, in the same period of the Periodic Table as **A**, reacts with chlorine to form a compound with empirical formula  $\text{ZCl}_2$ . The percentage composition by mass of  $\text{ZCl}_2$  is **Z**, 31.13; **Cl**, 68.87.

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

.....  
.....  
..... [2]

(ii) Calculate the relative atomic mass,  $A_r$ , of **Z**.  
Give your answer to **three** significant figures.

$A_r$  of **Z** = ..... [2]

(d) The chlorides of elements in Period 3 of the Periodic Table show different behaviours on addition to water, depending on their structure and bonding.

(i) Write equations to show the behaviour of sodium chloride,  $\text{NaCl}$ , and silicon chloride,  $\text{SiCl}_4$ , when separately added to an excess of water.

$\text{NaCl}$  .....

$\text{SiCl}_4$  .....

[2]

(ii) State and explain the differences in behaviour of these two chlorides when added to water, in terms of their structure and the bonding found in the compounds.

.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

(e) Sulfur reacts with fluorine to form  $\text{SF}_6$ . State the shape and bond angle of  $\text{SF}_6$ .

shape of  $\text{SF}_6$  .....

bond angle of  $\text{SF}_6$  .....

[2]

[Total: 18]