A' Level Chemistry

Year 1

Unit 1: TOF

Summary Examination Revision Pack

The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet Classes
Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes
Keywords & Definitions
Key Concepts
Application
Key Skills

Section 1 of 2

Year 1 A' Level Chemistry : Periodicity / Group II / Group VII

Online Forms
Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

If you struggle with the questions in the pack, **STOP!** and complete some more revision.

If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

6

0 6 . 1 Explain how ions are accelerated, detected and have their abundance determined in a time of flight (TOF) mass spectrometer.

[3 marks]

0 6 . 2 Calculate the mass, in kg, of a single $^{52}Cr^{+}$ ion.
Assume that the mass of a $^{52}Cr^{+}$ ion is the same as that of a ^{52}Cr atom.

(The Avogadro constant L = 6.022×10^{23} mol^{-1})

[1 mark]

0 6 . 3 In a TOF mass spectrometer the kinetic energy (KE) of a $^{52}Cr^{+}$ ion was 1.269×10^{-13} J

Calculate the velocity of the ion using the equation.

$$KE= \frac{1}{2}mv^2$$

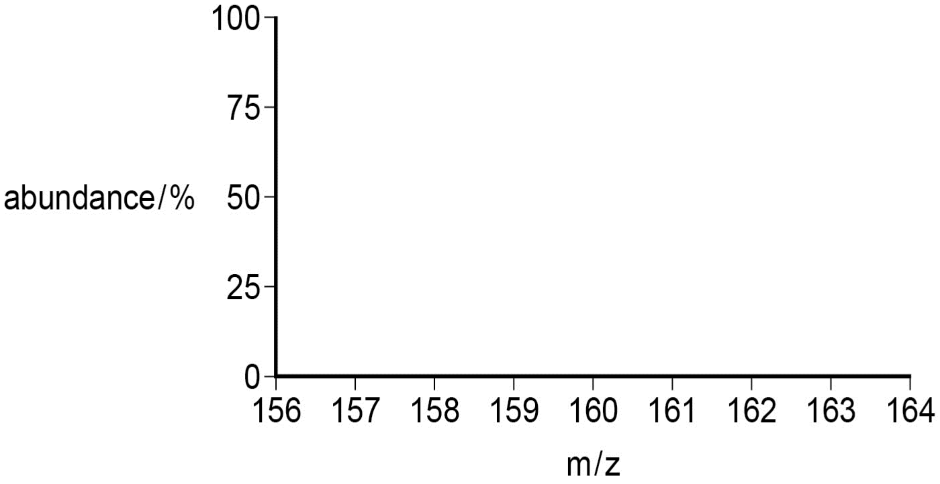
(m = mass/kg and v = velocity/ms^{-1})

[2 marks]

0 6 . 4 Bromine has two isotopes, ^{79}Br and ^{81}Br, in approximately equal abundance. In a TOF mass spectrometer bromine forms ions with formula $[Br_2]^+$

Sketch the pattern of peaks you would expect to see in the mass spectrum of a sample of bromine.

[2 marks]



0 6 . 5 A sample of xenon has A_r = 131.31. The sample consists of four isotopes. The abundances of three of the isotopes are shown in **Table 3**. The data for one of the isotopes, ^{m}Xe, is missing.

Table 3

Isotope	^{129}**Xe**	^{131}**Xe**	^{132}**Xe**	^{m}**Xe**
% abundance	28.0	25.0	27.0	To be calculated

Use the data to calculate the abundance of isotope ^{m}Xe and calculate m, the mass number of ^{m}Xe. Show your working.

[4 marks]

Question	Marking Guidance	Mark	Comments
06.1	(Ions accelerated by) attraction to negatively charged plate / electric field Ions detected by gaining electrons Abundance determined by (size) of current flowing (or amount of electrons gained) in the detector	1 1 1	Mark independently Allow the transfer of electrons Allow current is proportional to abundance
06.2	Mass = $\frac{52/1000}{6.022\text{x}10^{23}}$ Mass = $8.6(4)\text{x}10^{-26}$	1	
06.3	$V^2 = (2\text{x}1.269\text{x}10^{-13})/8.64\text{x}10^{-26}$ $V = 1.71\text{x}10^{6}\text{ms}^{-1}$	1 1	Allow correct rearrangement for V or V^2 Allow ecf from 6.2 (note if $8.6\text{x}10^{-23}$ in 6.2 leads to approx. $5.4\text{x}10^{4}\text{ ms}^{-1}$)

Question	Marking Guidance	Mark	Comments
06.4	Sketch with peaks at 158,160,162	1	Mark independently
	In ratio 25%:50%:25%	1	Allow approx. ratio 1:2:1

Question	Marking Guidance	Mark	Comments
06.5	% abundance ^{m}Xe = 20(%)	1	Working must be shown
	131.31=(0.28*129)+(0.25*131)+(0.27*132)+(0.20*m)	1	
	131.31-104.51=0.2m	1	
	Mass number = 134	1	Answer must be an integer

0 1 . 4 A sample of nickel was analysed in a time of flight (TOF) mass spectrometer. The sample was ionised by electron impact ionisation. The spectrum produced showed three peaks with abundances as set out in **Table 1.**

Table 1

m/z	Abundance / %
58	61.0
60	29.1
61	9.9

Give the symbol, including mass number, of the ion that would reach the detector first in the sample.

Calculate the relative atomic mass of the nickel in the sample.
Give your answer to one decimal place.

[3 marks]

Symbol of ion ____________________________

Relative atomic mass ____________________________

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Question	Marking Guidance	Mark	Additional Comments/Guidance
01.4	$^{58}Ni^{+}$ A_r= [(58x61.0)+(60x29.1)+(61x9.9)]/100 A_r= 58.9 must be to 1DP	1 1 1	M1 needs mass and charge – allow subscripts

0 8 A sample of bromine was analysed in a time of flight (TOF) mass spectrometer and found to contain two isotopes, ^{79}Br and ^{81}Br

After electron impact ionisation, all of the ions were accelerated to the same kinetic energy (*KE*) and then travelled through a flight tube that was 0.950 m long.

0 8 . 1 The $^{79}Br^+$ ions took 6.69 x 10^{-4} s to travel through the flight tube.

Calculate the mass, in kg, of one ion of $^{79}Br^+$
Calculate the time taken for the $^{81}Br^+$ ions to travel through the same flight tube.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

$KE = \frac{1}{2} mv^2$ where m = mass (kg) and v = speed (m s^{-1})

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

[5 marks]

Mass of one ion of $^{79}Br^+$ ______________________ kg

Time taken by $^{81}Br^+$ ions ______________________ s

0 8 . 2 Explain how ions are detected and relative abundance is measured in a TOF mass spectrometer.

[2 marks]

7

Qu	Marking Guidance		Additional Comments	Mark
8.1	$= 79 / (1000 \times 6.022 \times 10^{23}) \quad = \underline{1.31 \times 10^{-25}}$ kg			1
	either	or		
	$V_{79} = \frac{d}{t} \quad = 0.950 / 6.69 \times 10^{-4}$ $= 1420$ ms^{-1}	$m_1(d/t_1)^2 = m_2 (d/t_2)^2$ or $m_1 / t_1^2 = m_2 / t_2^2$	Do not mix and match methods In method 1, M2 can be awarded in M3	1
	$KE = ½ mv^2$ $= ½ \times 1.312 \times 10^{-25} \times (1420)^2$ $= 1.32 \times 10^{-19}$ J	$t_2^2 = t_1^2 (m_2/m_1)$ Or $t_2^2 = (6.69 \times 10^{-4})^2 \times (81/79)$	In method 1, mark consequential to their velocity and mass. Allow mass of 79 etc.	1
	$V_{81} = \sqrt{(\frac{2KE}{m})}$ $= \sqrt{1.963 \times 10^6}$ $= 1.40 \times 10^3$ ms^{-1} (allow $1.398 \times 10^3 - 1.402 \times 10^3$)	$t_2^2 = 4.59 \times 10^{-7}$	In method 1, mark consequential to their KE. Allow mass of 81 etc In method 2, mark consequential to their M3	1
	$t = \frac{d}{v} = \frac{0.950}{v_{81}}$ $= 6.80 \times 10^{-4}$ s	$t = 6.77 \times 10^{-4}$ s	In both methods, mark consequential to their M4 Accept 6.77 – 6.80 $\times 10^{-4}$ s	1

8.2	ion hits the detector / negative plate <u>and</u> gains an electron (relative) abundance is proportional to (the size of) the current	Not positive plate	1 1

0 2 Time of flight (TOF) mass spectrometry is an important analytical technique.

A mixture of three compounds is analysed using a TOF mass spectrometer.
The mixture is ionised using electrospray ionisation.

The three compounds are known to have the molecular formulas:

$C_3H_5O_2N$
$C_3H_7O_3N$
$C_3H_7O_2NS$

0 2 . 1 Describe how the molecules are ionised using electrospray ionisation.

[3 marks]

0 2 . 2 Give the formula of the ion that reaches the detector first in the TOF mass spectrometer.

[1 mark]

0 2 . 3 A sample of germanium is analysed in a TOF mass spectrometer using electron impact ionisation.

Give an equation, including state symbols, for the process that occurs during the ionisation of a germanium atom.

[1 mark]

0 2 . 4 In the TOF mass spectrometer, a germanium ion reaches the detector in 4.654×10^{-6} s
The kinetic energy of this ion is 2.438×10^{-15} J
The length of the flight tube is 96.00 cm

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2} mv^2$

where
m = mass / kg
v = speed / m s^{-1}

The Avogadro constant $L = 6.022 \times 10^{23}$ mol^{-1}

Use this information to calculate the mass, in g, of one mole of these germanium ions.
Use your answer to state the mass number of this germanium ion.

[5 marks]

Mass of one mole of germanium ions ____________________ g

Mass number of ion ____________________

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Turn over for the next question

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.1	(Sample is) dissolved (in a volatile solvent) (Injected through) needle/nozzle/capillary at high voltage/positively charged Each molecule/particle gains a proton/H^+	Allow named solvent (eg water/methanol) Ignore pressure Allow M3 from a suitable equation (ignore state symbols) Do not allow atoms gain a proton for M3 Ignore references to electron gun ionisation Mark each point independently	1 1 1
02.2	$C_3H_6O_2N^+$ / $C_3H_5O_2NH^+$	Must be charged	1
02.3	$Ge(g) + e^- \rightarrow Ge^+(g) + 2e^-$ OR $Ge(g) \rightarrow Ge^+(g) + e^-$	State symbols essential	1

02.4	M1 v = length/t = 0.96 / 4.654 x 10 $^{-6}$ v = 206274 m s^{-1} m = 2*KE*/v^2 M2 mass of one ion = 1.146 x 10^{-25} kg M3 mass of 1 mole ions = 1.146 x 10^{-25} x 6.022 x 10^{23} = (0.06901 kg) M4 = 69(.01) g M5 mass number = 69	Notes: M1 = working (or answer) M2 = answer conseq on M1 M3 = M2 x 6.022 x 10^{23} M4 = M3 x 1000 M3/M4 could be in either order M5 must have whole number for mass no	1 1 1 1 1

0 3 This question is about chromium and its compounds.

0 3 . 1 Complete the full electron configuration of a chromium atom.

[1 mark]

$1s^2$ ____________________

0 3 . 2 An atom has 2 more protons and 3 more neutrons than an atom of ^{52}Cr.

Deduce the symbol, including the mass number and the atomic number, for this atom.

[1 mark]

____

0 3 . 3 A sample of chromium contains four isotopes and has a relative atomic mass of 52.09

Table 2 shows the mass number and the percentage abundance of three of these isotopes.

Table 2

Mass number	52	53	54
Abundance (%)	82.8	10.9	2.7

Determine the percentage abundance of the fourth isotope.
Show by calculation that the mass number of this isotope is 50

[3 marks]

Percentage abundance ____________________

Calculation

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ Or $(1s^2) 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$	Ignore commas Do not penalise capitals and subscripts	1
03.2	${}^{57}_{26}Fe$	Allow mass number and atomic number on RHS of Fe	1
03.3	% of 4th isotope = 3.6 M2: $\frac{(52 \times 82.8) + (53 \times 10.9) + (54 \times 2.7) + (3.6x)}{100} = 52.09$ M3: $x = 49.97$ OR $179.9 = 3.6x$ and $x = 50$ (evidence of working)	Allow alternative methods M2 (52 x 82.8) + (53 x 10.9) + (54 x 2.7) + (50 x 3.6) =5209 M3 A_r = 5209/100 = 52.09 Or M2 $\frac{(52 \times 82.8) + (53 \times 10.9) + (54 \times 2.7) + (50x)}{100} = 52.09$ M3 awarded for $50x = 179.9$ and then $x = 3.6$ (evidence of working)	1 1 1

0 3 This question is about time of flight (TOF) mass spectrometry.

0 3 . 1 Define the term relative atomic mass.

[2 marks]

____

____

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____

0 3 . 2 A sample of krypton is ionised using electron impact.

The mass spectrum of this sample of krypton has four peaks.

Table 2 shows data from this spectrum.

Table 2

m/z	82	83	84	86
Relative intensity	6	1	28	8

Calculate the relative atomic mass (A_r) of this sample of krypton.

Give your answer to 1 decimal place.

[2 marks]

A_r ______________________________

0 3 . 3 In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (*KE*).

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$

Where:
KE = kinetic energy / J
m = mass / kg
v = speed / m s^{-1}

In a TOF mass spectrometer, each $^{84}Kr^+$ ion is accelerated to a kinetic energy of 4.83×10^{-16} J and the time of flight is 1.72×10^{-5} s

Calculate the length, in metres, of the TOF flight tube.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

[4 marks]

Length of flight tube ____________________ m

8

Turn over for the next question

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1	The average mass of an atom of an element Compared to 1/12th the mass of an atom of carbon-12	(Weighted) average mass of all isotopes of an element	1 1
03.2	R.A.M. = $\frac{(82 \times 6) + (83 \times 1) + (84 \times 28) + (86 \times 8)}{43}$ = 3615 / 43 = 84.1	M1 for working M2 for answer to 1 decimal place 36.2 scores 1/2	1 1
03.3	M1 m = (84/1000)/6.02 x 10^{23} (= 1.395 x 10^{-25} kg) M2 v^2 = 2ke/m = 2 x (4.83 × 10^{-16}) / (1.395 x 10^{-25}) M3 v = √(6924731183) = 83214.97 M4 d = v x t = 83214.97 x 1.72 × 10^{-5} = 1.43 (m)	Alternative method M1: m = (84/1000)/6.02 x 10^{23} (= 1.395 x 10^{-25} kg) M2: $d^2 = 2\ ke\ t^2/m$ M3: d^2 = 2 x (4.83 × 10^{-16}) x (1.73 x 10^{-5})^2 / 1.395 x 10^{-25} d^2 = 2.07 M4 = 1.44 (m) Allow answers in range 1.43 – 1.44 m If m not converted to kg, then d = 0.045m for max 3	4

0 5 A sample of antimony is analysed in a time of flight (TOF) mass spectrometer and is found to contain two isotopes, ^{121}Sb and ^{123}Sb

After electron impact ionisation, all of the ions are accelerated to the same kinetic energy (*KE*) and then travel through a flight tube that is 1.05 m long. A ^{121}Sb^{+} ion takes 5.93×10^{-4} s to travel through the flight tube.

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$

KE = kinetic energy / J
m = mass / kg
v = speed / m s^{-1}

Calculate the mass, in kg, of one ^{121}Sb^{+} ion.

Calculate the time taken for a ^{123}Sb^{+} ion to travel through the same flight tube.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

[5 marks]

Mass of one ^{121}Sb^{+} ion ______________________ kg

Time taken by a ^{123}Sb^{+} ion ______________________ s

5

Question	Marking guidance	Additional Comments/Guidelines	Mark
05	Mass of one ion of $^{121}Sb^{+}$ $= 121 / (1000 \times 6.022 \times 10^{23})$ $= 2.009 \times 10^{-25}$ kg		1
	$V = d/t$ $= 1.050 / 5.93 \times 10^{-4}$ $= 1770.658$ (m s^{-1})	Alternative method $KE = ½\, m\, d^2/t^2$	1
	$KE = ½\, m\, v^2$ $= ½ \times 2.009 \times 10^{-25} \times (M2)^2$ (or $= ½ \times M1 \times (M2)^2$) $= 3.1493 \times 10^{-19}$ (J)	$m_{121}/t_{121}{}^2 = m_{123}/t_{123}{}^2$	1
	$V_{123} = \sqrt{\left(\frac{2KE}{m}\right)}$ $= \sqrt{[2(M3) / 2.0425 \times 10^{-25}]}$ $= \sqrt{3083769.889}$ $= 1756.07$ (m s^{-1})	$t_{123}{}^2 = 123/121 \text{ x } t_{121}{}^2$ $= 3.57 \text{ x } 10^{-7}$ (s^2)	1
	$t = d / v$ $= 1.050 / (M4)$ $= 5.98 \times 10^{-4}$ s	$t_{123} = \sqrt{M4}$	1 (5 x AO2)