AS-Level Chemistry Notes

1st Edition

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PREFACE

Chemistry is a fascinating subject that explores the composition and behavior of matter and its interactions with energy. AS Level Chemistry is an exciting journey into the world of chemical reactions, elements, compounds, and their applications in various fields.

We are thrilled to present this comprehensive AS Level Chemistry textbook, co-authored by **Ibrahim Khalid** and **Talha Iqbal** and authored by **Mr Muhammad Ali**. This book provides a clear and thorough understanding of the fundamental principles of Chemistry and their applications in everyday life. The content has been carefully crafted to meet the needs of AS Level students and covers all the essential topics, including but not limited to atomic structure, chemical bonding, organic chemistry, and analytical techniques.

The authors have taken great care to ensure that the language and presentation of the material are accessible and engaging, making the subject more approachable and less intimidating. The text is supported by numerous illustrations, diagrams, and examples to help students visualize and comprehend the concepts.

We hope that this book will serve as a valuable resource for AS Level students and inspire them to pursue their interest in Chemistry further. We are confident that it will serve as an exceptional resource for both students and teachers alike, providing a strong foundation for further studies in the field of chemistry.

We would like to extend our gratitude to **Mr Muhammad Ali** for his guidance and support during the development of this book. We would also like to thank **MS Books** for their commitment to publishing high-quality educational materials.

Ibrahim Khalid, Talha Iqbal, and Mr Muhammad Ali

Atomic Structure

Atom is composed of sub-atomic particles

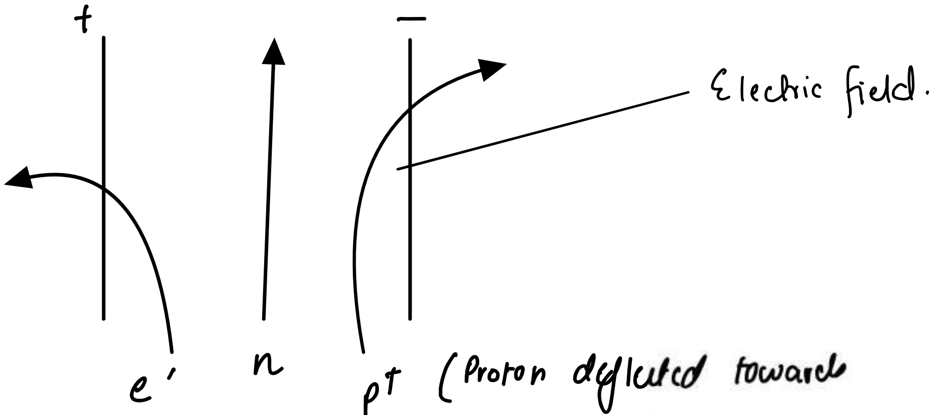
		Relative mass	Relative charge
99% of atom is made of these 3.	Protons	1 amu	+1
	Neutrons	1 amu	0
	Electrons	1/1840 amu	-1

> Electron charge: -1.6×10^{-19} C
>
> Proton charge: $+1.6 \times 10^{-19}$ C

Atom is electrically neutral

∴ # of protons = # of electrons

The following experiment is done to observe the relative charge and mass of subatomic particles.



(Proton deflected towards -ve plate therefore it has +ve charge)

(electron deflects towards +ve because of which we know that electron is -vely charged)

As mass is less of electron deflection is more.

Deflection pattern shows

1. charge of particle
2. Relative mass of particle.

$^{23}_{11}Na$

- 23 → Atomic mass / mass # / nucleon #
- 11 → Atomic number / proton #

↓

Always write Atomic No. on the left.

Number of protons, electrons and neutrons in polyatomic ions

	OH^-	NH_4^{+1}	SO_4^{-2}
p^+	9	11	48
e^-	10	10	50
n	8	7	48

Importance of Sub-atomic particles

Protons

→ Any change in Proton number will change the element.

Electron

→ Any change in electrons results in formation of ions.

	+ve ion	-ve ion
Physical	Cation	Anion
Inorganic	Cation	Anion/Ligand
Organic	Electrophile	Nucleophile.

Neutrons

→ Any change in neutrons will result in formation of Isotopes.

Isotopes

→ Atoms of same elements which have same # of protons but different number of neutrons.

e.g

① $^{35}_{17}Cl$ $^{37}_{17}Cl$

	$^{35}_{17}Cl$	$^{37}_{17}Cl$
p^+	17	17
e^-	17	17
n	18	20

② $^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

proteam deuterium tritium

③ $^{23}_{11}Na$ $^{24}_{11}Na$

④ $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

→ Isotopes have diff physical but same chemical properties

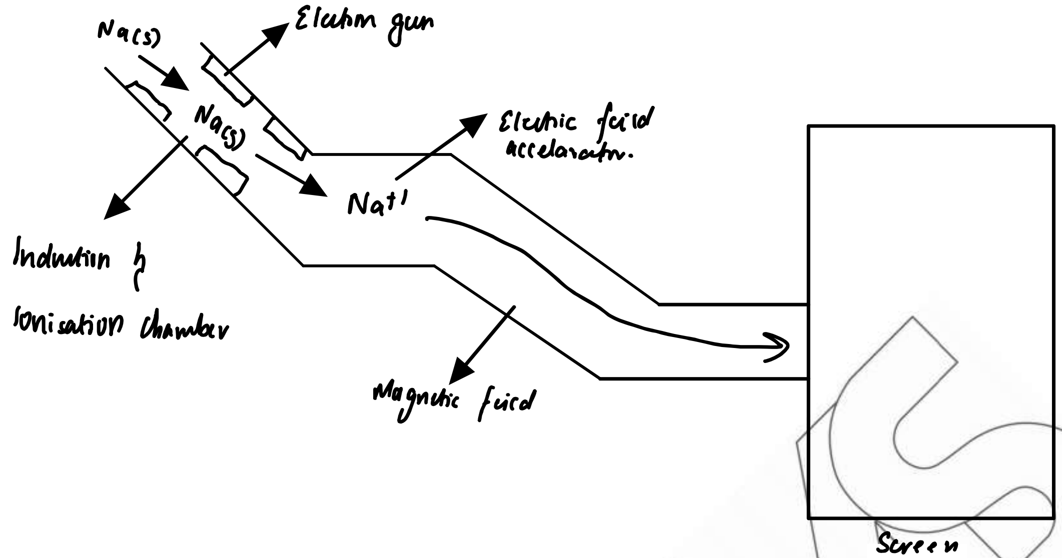
Mass spetometry (Mass spectroscopy)

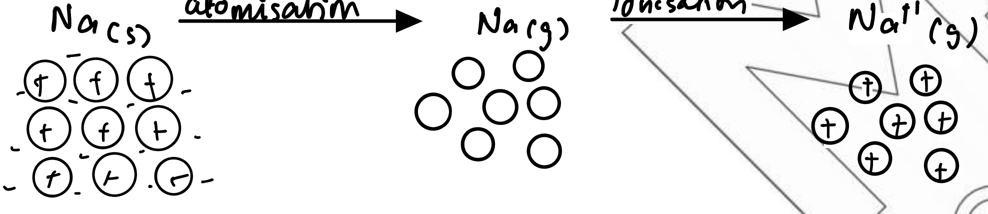
→ It can read upto 10^{-12} g (spectrometer)

AS
1. This is used to identify # of isotopes of an element
2. The percentage abundance of each isotope
3. Relative atomic mass calculation
4. Molar mass determination

A_2
5. Determination of M peak, M+1 peak, M+2 peak, M+4 peak, M+6 peak
6. Fragmenation

Working of mass spectometer (not in syllabus)





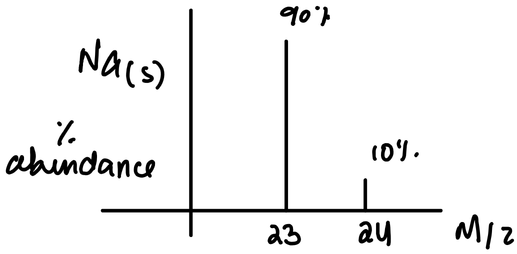
Note: Every Element forms monoatomic positive ions because only one electron knocked out.

Screen of mass spectometer

- M = mass
- e or z = charge on ion

As charge is one so x-axis is mass axis.

Monoatomic elements



# of sticks = # of isotopes

Relative Atomic mass (Ar)

→ It is the weighted average mass of an element compared to 1/12th the mass of C-12 atom

Note : Mass of carbon to 6 s.f is 12.0000

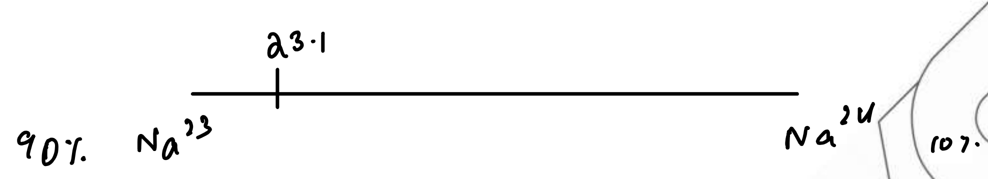
$$Ar = \frac{\Sigma(\%\ abundance \times isotopic\ mass)}{\Sigma(\%\ abundance)}$$

$$= \frac{(90 \times 23 + 10 \times 24)}{100} = 23.1$$

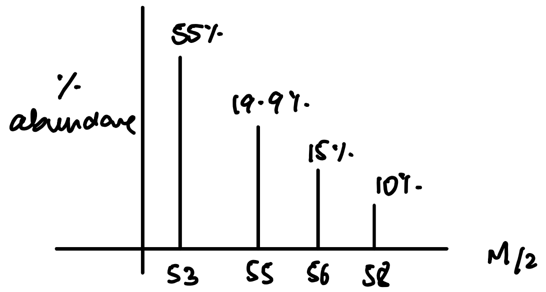
Relative isotopic mass

→ It is the mass of an atom of isotope compared to 1/12th mass of C-12 atom.

When there are two isotopes Ar can be calculated using a number line.



Q



a) Suggest how many isotopes element X has?

4 = number of peaks

b) Calculate Ar

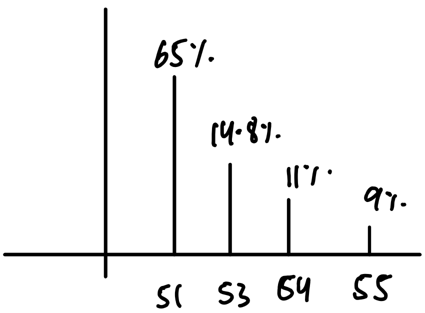
$$= \frac{(55 \times 53) + (19.9 \times 55) + (15 \times 56) + (10 \times 58)}{99.9}$$

$= 54.34 \approx 54.3$ (3 s.f)

Q They are 150 atoms of an element, 40 atoms are of ^{42}Y & rest of ^{44}Y. Calculate Ar

$$\frac{40 \times 42 + 44 \times 110}{150} = 43.5$$

Q Element Y



→ 4 isotopes

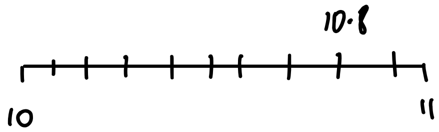
→ $Ar = \frac{(65 \times 51) + (14.8 \times 53) + (11 \times 54) + (9 \times 55)}{99.9}$

$= 51.988$

≈ 52.0

Q: There are two isotopes of Boron i.e. ^{10}B & ^{11}B. Ar of Boron is 10.8. calculate abundance of each isotope.

P1



80 — 20% ^{10}B

& 80% ^{11}B

P2

^{10}B — x %

^{11}B — 100 - x %

$$10.8 = \frac{(10n) + (100-n)11}{100}$$

$1080 = 10n + 1100 - 11n$

$n = 1100 - 1080$

$n = 20\%$

^{10}B — 20%

^{11}B — 80%

<u>Diatomic elements</u>

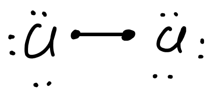
→ Cl_2 & Br_2

^{35}Cl	&	^{37}Cl
75%		25%

→ Memorise these ←

^{79}Br	^{81}Br
50%	50%

Cl_2



When thrown in mass spectrometer two things can happen

1. One non-bonding electron is kicked out & a molecular ion is formed Cl_2^+
2. The bond is broken forming 2Cl after which electrons are kicked out forming atomic ions.

$^{35}Cl^+$ $^{37}Cl^+$

$$Cl_{2(g)} \xrightarrow{\text{atomisation}} 2Cl_{(g)} \xrightarrow{\text{ionisation}} Cl^+_{(g)}$$

Cl_2^+

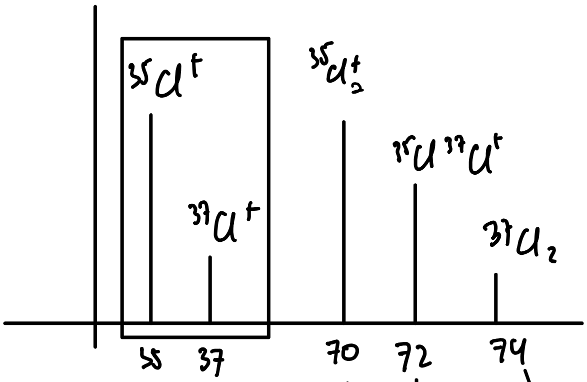
$^{35}Cl_2^+$	$^{35}Cl^{37}Cl^+$	$^{37}Cl_2^+$
↓	↓	↓
70	72	74

molecular ions

$^{35}Cl^+$	$^{37}Cl^+$
↓	↓
35	37

atomic ions

→ for molecular ions the smallest mass is known as M peak



70 → M peak
72 → M+2 peak
74 → M+4 peak.

<u>Probability</u>

$^{35}Cl : {}^{37}Cl$

$3/4 : 1/4$

$3 : 1$

<u>Probability</u>

$^{35}Cl_2 : {}^{35}Cl\,^{37}Cl : {}^{37}Cl_2$

$(3/4 \times 3/4) : (3/4 \times 1/4) \times 2 : (1/4 \times 1/4)$

$9/16 : 6/16 : 1/16$

$9 : 6 : 1$

^{79}Br ^{81}Br

① Br_2^+

$^{81}Br_2^+$ → 162

$^{81}Br\,^{79}Br^+$ → 160

$^{79}Br_2^+$ → 158

molecular ions

$^{79}Br_2^+ : {}^{79}Br\,^{81}Br^+ : {}^{81}Br_2^+$

$1/2 \times 1/2 : 2(1/2 \times 1/2) : 1/2 \times 1/2$

$1/4 : 1/2 : 1/4$

$1 : 2 : 1$

$^{79}Br^+$ → 79

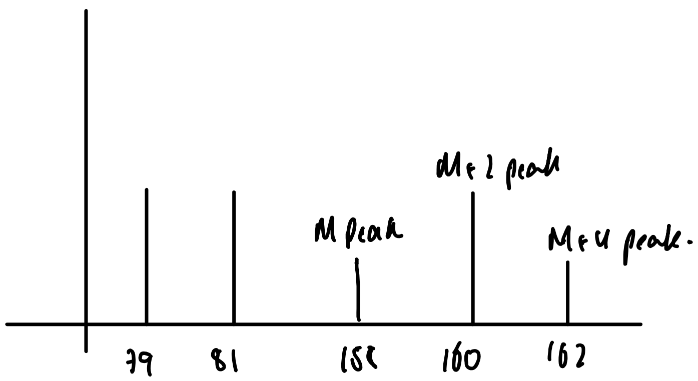
$^{81}Br^+$ → 81

atomic ions

$^{79}Br : {}^{81}Br$

$1/2 : 1/2$

$1 : 1$



Hydrogen Halides

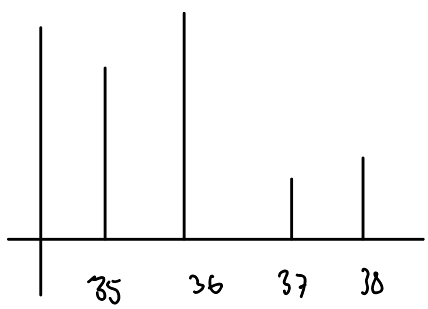
→ HCl & HBr

Interesting fact: If a molecule contains n number of halogen atoms then the number of molecular ion peak is n+1

HCl

HCl^+ → $H^{35}Cl^+$ → 36

HCl^+ → $H^{37}Cl^+$ → 38



$^1H^+$ — Ignored as a peak

$^{35}Cl^+$ — 35

$^{37}Cl^+$ — 37

$H^{35}Cl^+ : H^{37}Cl^+$

$3/4 : 1/4$

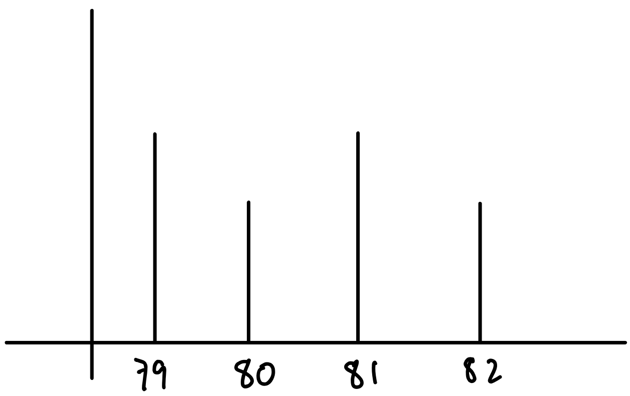
$3 : 1$

(Ignore hydrogen probability)

HBr

HBr^+ < $H^{79}Br^+$ — 80 50%
$H^{81}Br^+$ — 82 50%

$^1H^+$ — Ignored as a peak
$^{79}Br^+$ — 79 50%
$^{81}Br^+$ — 81 50%

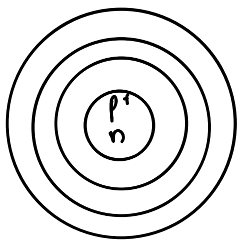


Note:

Q: How to find number of carbon atoms?

$$\# \text{ of } C = \frac{100}{1.1} \times \frac{\text{Abundance of } M+1}{\text{Abundance of } M}$$

Atomic Structure



1st shell : 2e'
2nd shell : 8e'
3rd shell : 18e'
4th shell : 32e'

\# of e' in a shell : $2n^2$
where n = no. of shells.

- If you have to find a person you should know their address.

City → town → house # → person.

For electrons:

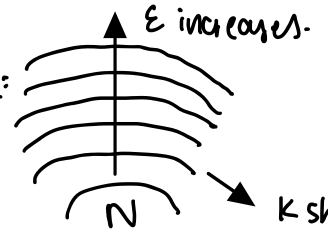
city (n) = Shell # (Also known as: Principle quantum #)

Town (l) = Shubshell # (Also known as: Azimuthal quantum #)

house = orbital

person = $\bar{e}$

Note:



— Anything at a lower energy is more stable than something at higher energy.

— lower shell fills first because it is more stable as you go further from nucleus potential energy increases

Shell # (Principle Quantum #)	Subshell # (Azimuthal Quantum #)	Orbital	e'
1	has 1 subshell	1	2
2	has 2 subshells	4	8
3	has 3 subshells	9	18
4	has 4 subshells	16	32

4 subshells

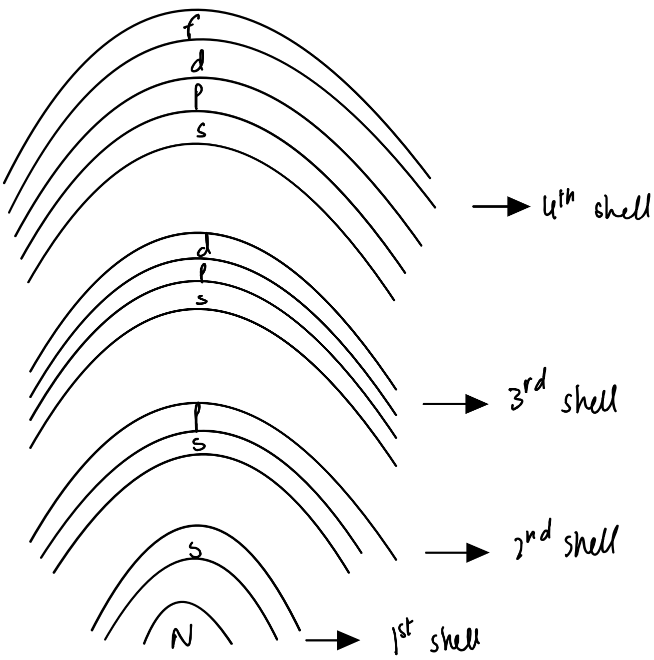
Energy increases ↑

f	—	fundamental	[↑↓][↑↓][↑↓][↑↓][↑↓][↑↓][↑↓]	14
d	—	diffused	[↑↓][↑↓][↑↓][↑↓][↑↓]	10
p	—	principle	[↑↓][↑↓][↑↓]	6
s	—	simple or spherical	[↑↓]	2

Key [↑↓] one orbital (houses two electrons max)

It is the region of space where maximum probability of finding an e⁻ exists

Shell #	subshell
1	1s
2	2s & 2p
3	3s, 3p & 3d
4	4s, 4p, 4d & 4f



Paulis Exclusion Principle

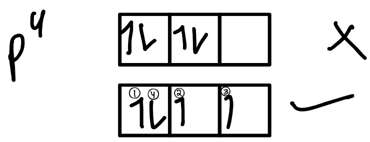
Two e' reside in one orbital due to opposite spin

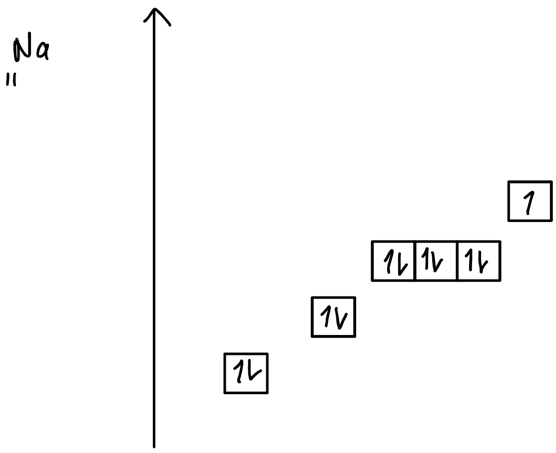
One moves clockwise & the other moves anticlockwise.

→ Both electrons produce magnetic flux which allows them to overcome electrostatic repulsion & have attractive forces

Hund's Rule

→ Electrons are added one by one in degenerate orbitals
↓ at same energy level





$_{11}Na$ $1s^1 2s^2 2p^6 3s^1$