ATOMIC STRUCTURE : INTRO & REVIEW
& Mass Spectroscopy

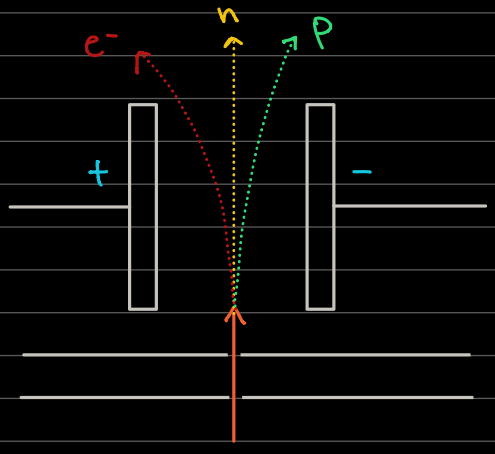
REVIEW:

Atom: The smallest particle of an element which can take part in a chemical reaction.

Name	Symbol	Approx. Ar.	Relative Charge
Protons	p	1	+1
Neutrons	n	1	0
Electrons	e	$\frac{1}{1840}$	-1

→ Important to write "0" and not "no charge"

BEHAVIOUR OF SUBATOMIC PARTICLES IN AN ELECTRICAL FIELD



n = no deflection : no charge

p = deflected towards (-) because positively charged
↳ to a lesser extent due to greater mass

e = deflected towards (+) because negatively charged
↳ To a greater extent, because lesser mass.

Atoms of the same element are NOT always the same

↳ ISOTOPES

Atoms of the same element with the same atomic number but a different nucleon number / number of neutrons

Mass Spectroscopy: Used to measure the relative masses of atoms and their relative abundance.

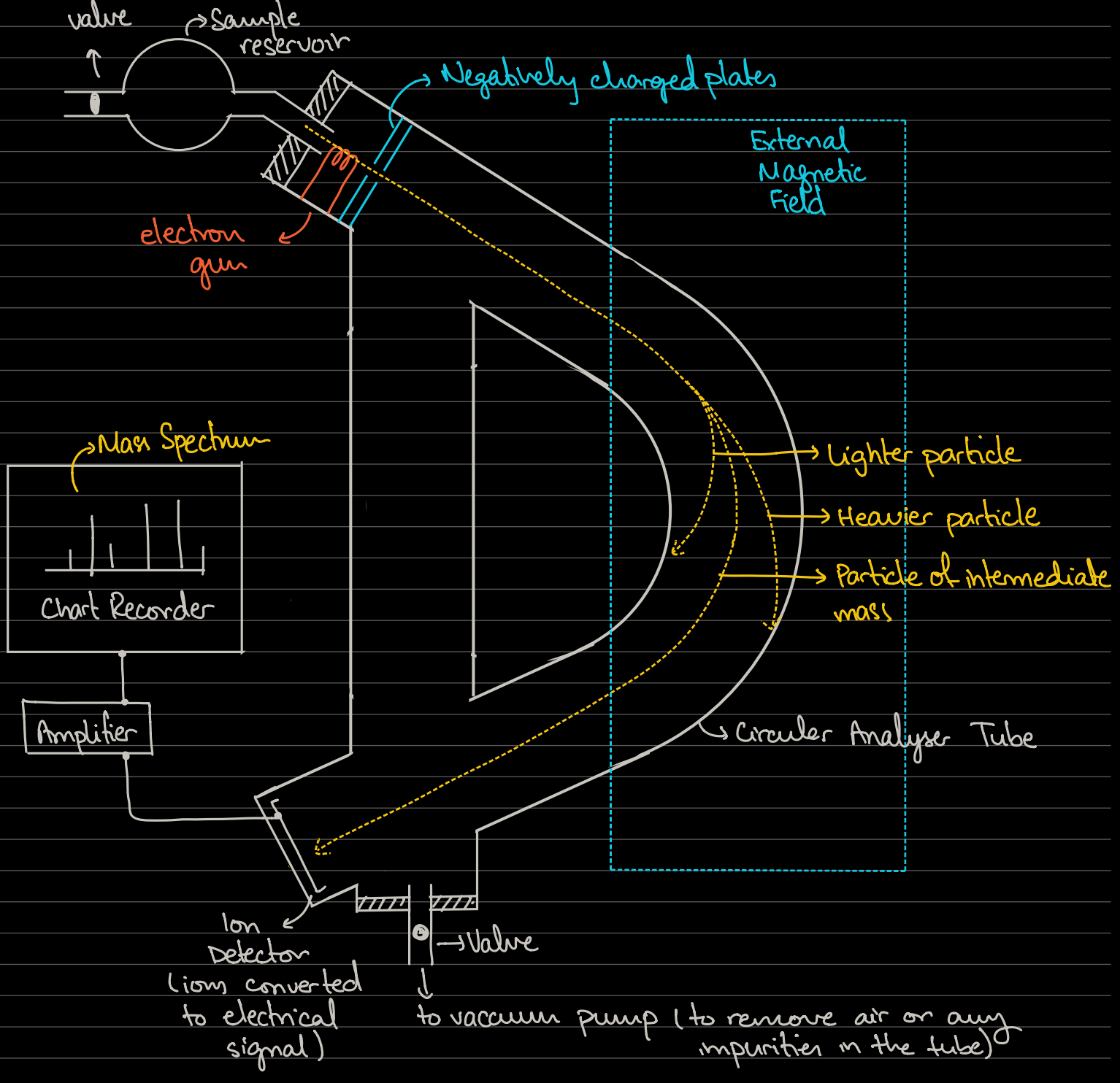
Relative masses

- Isotopic mass
- Abundance (%) of the isotope

} Used to calculate Ar (Relative Atomic Mass) of an element

MASS SPECTROSCOPY

↳ Measures the relative mass of atoms and their relative abundance



5 processes that take places in the mass spectrometer (VIADD)

1. Vaporise — The sample is vaporised by the heating element + temp. control

2. Ionise It is then ionised by the high energy electrons emitted by the electron gun.

3. Accelerate This is done by the negatively charged plates

4. Deflect Done by the external magnetic field

5. Detect The ions are detected by the ion detector in the end.

IONISATION OF A SAMPLE :

- When a sample, ie Sample M, is hit by a high energy electron, it loses one or more electron to become an ion

↳ non bonding e^- that is removed

$$M^{\bullet} + e^- \longrightarrow M^+ + 2e^-$$

TEACHER'S NOTES :

- The inside is pumped down to a near perfect vacuum to remove air particles and any impurities
- The vaporised sample is subjected to high energy electrons
  - ↳ These electrons knock off other electrons from the vaporised atoms to form positively charged ions (molecular ion)
    - ↳ $(M + e^- \longrightarrow M^+ + 2e^-)$
- The gaseous ions are accelerated by passing through an electric field
- They are deflected after passing through the external magnetic field
- The path which the particles follow depends on it's mass / charge ratio

$$\frac{\text{mass}}{\text{charge}} \rightarrow \frac{m}{e} \text{ or } \frac{m}{z} \qquad e \text{ or } z = \text{charge}$$

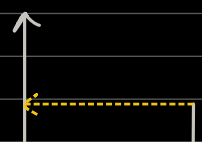
- A mass spectrum gives us the following information:

① The number of lines / peaks represents the number of different isotopes

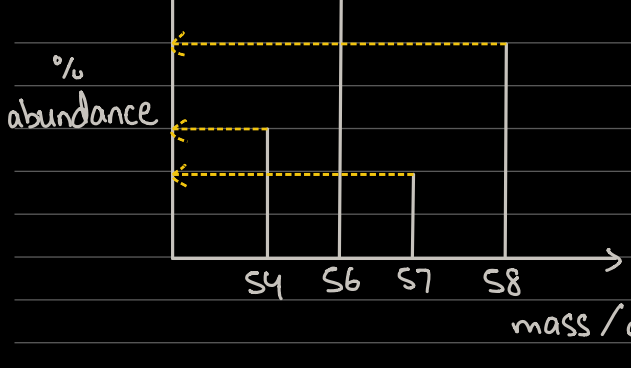
② The relative atomic mass of each isotope (exact mass ; 4 to 5 decimal places)

③ The % abundance of each isotope → given by the height of the peak

Example of a mass spectrum :



Isotope	Ar	% abundance
^{54}Fe	53.9396	5.82



^{56}Fe	55.9349	91.66
^{57}Fe	56.9354	2.19
^{58}Fe	57.9333	0.33

Use the exact relative isotopic masses and their % abundances to calculate the Ar

Ar = weighted Avg. Mass

$$Ar = \frac{5.82(53.9396) + 91.66(55.9349) + 2.19(56.9354) + 0.33(57.9333)}{100}$$

Ar = 55.8

MORE EXAMPLES:

Relative Atomic Mass

Example 2 of ~~Mass Spectroscopy~~ / Spectrum 09/09/20

Cl₂ has two isotopes: ^{35}Cl — 75.53%
^{37}Cl — 24.47%.

$= \frac{(35 \times 75.53) + (37 \times 24.47)}{100}$

$= 35.48$

Ar = 35.5

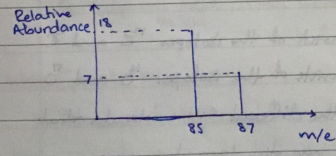
Example 3 — Calculating Ar / Reading mass spectrum

Q. The mass spectrum of rubidium (Rb) is given.

a) what isotopes are present in Rubidium?

b) What is the percentage abundance of each isotope?

c) Calculate the relative atomic mass (Ar) of rubidium.



a) ~~Ru~~ rubidium-85
~~rubi~~ rubidium-87

b) rubidium-85 = 72%
rubidium-87 = 28%

c) Ar = $(85 \times 0.72) + (87 \times 0.28)$

Ar = 85.56

≈ 85.6

Example 4 - June 2014 P2 Q1

Q. Using the relative atomic mass of Bromine (79.90), calculate the relative/percentage isotopic abundance of bromine-79 and bromine-81 if their accurate isotopic masses 78.92 and 80.92, respectively.

A. $79.90 = \frac{79 \times 78.9\,(78.92 \times x) + (80.92 \times (100-x))}{100}$

$7990 = 78.92 \times x + 80.92 \times 100 - x$

$7990 = x(78.92) + (100-x)(80.92)$

$7990 = 78.92x + 8092 - 80.92x$

$\frac{2x}{2} = \frac{102}{2}$

$x = 51\%$ for bromine-79

$100 - x = 49\%$ for bromine-81

Q. A sample of carbon consists of the isotopes ^{12}C and ^{13}C
A sample of oxygen consists of the isotopes ^{16}O and ^{17}O
Write the formulae of all the different CO_2 molecules that can be. Which molecule has the largest mass?

A. Possible combinations.

$^{12}C\,^{16}O\,^{17}O$, $^{13}C\,^{16}O_2$, $^{12}C\,^{16}O_2$, $^{12}C\,^{16}O\,^{18}O$, $^{12}C\,^{17}O_2$, $^{13}C\,^{17}O_2$ largest

DEFINITIONS:

Relative Isotopic Mass
The relative isotopic mass is the mass of an isotope relative to 1/12 of the mass of one atom of carbon-12.
↳ why carbon? By convention.

Relative Atomic Mass (Ar)
The Ar of an element is the weighted average of all the isotopic masses of all it's natural isotopes

Relative Molecular Mass (Mr)
The sum of all the relative atomic masses of all the atoms present/shown in the molecular formula (relative to 1/12 of carbon-12)
↳ Mr is used for covalent compounds

Relative Formula Mass
Is the sum of all the atoms in the formula of an ionic compound relative to 1/12th the mass of ^{12}C

Mole
One mole of a substance contains the same number of particles as the number of atoms in exactly 12g of ^{12}C.

Avogadro's Constant
The number of particles in one mole of any substance is a constant known as Avogadro's constant (L) and is equal to 6.022×10^{23} particles/mol.