THE STRUCTURE OF ATOMS

ATOMS Atoms consist of a number of fundamental particles, the most important are ...

	Mass / kg	*Charge / C*	*Relative mass*	*Relative Charge*
PROTON				
NEUTRON				
ELECTRON				

MASS NUMBER & ATOMIC NUMBER

Atomic Number (Z) Number of protons in the nucleus of an atom

Mass Number (A) Sum of the protons and neutrons in the nucleus

$^{23}_{11}Na$

Mass number (protons + neutrons) — 23

Atomic number (protons) — 11

Q.1

	Protons	*Neutrons*	*Electrons*	*Charge*	*Atomic No.*	*Mass No.*	*Symbol*
A	19	21	19				
B	20			Neutral		40	
C				+	11	23	
D	6	6		Neutral			
E	92			Neutral		235	
F	6		6			13	
G		16		2-	16		
H							$^{27}Al^{3+}$

Relative Atomic Mass (A_r) The mass of an atom relative to the ^{12}C isotope having a value of 12.000

$$A_r = \frac{\text{average mass per atom of an element} \times 12}{\text{mass of one atom of carbon-12}}$$

Relative Isotopic Mass Similar, but uses the mass of an isotope ^{238}U

Relative Molecular Mass (M_r) Similar, but uses the mass of a molecule CO_2, N_2

Relative Formula Mass Used for any formula of a species or ion $NaCl$, OH^-

ISOTOPES

Definition Atoms with ... the **same atomic number** but **different mass number** or the **same number of protons** but **different numbers of neutrons**.

Properties Chemical properties of isotopes are identical

Theory Relative atomic masses measured by chemical methods rarely produce whole numbers but they should do (allowing for the low relative mass of the electron). This was explained when the mass spectrograph revealed that **atoms of the same element could have different masses** due to the **variation in the number of neutrons** in the nucleus. The observed mass was a consequence of the abundance of each type of isotope.

	P	N
$^{1}_{1}H$	1	0
$^{2}_{1}H$	1	1
$^{3}_{1}H$	1	2

Example *There are two common isotopes of chlorine.*

Calculate the average relative atomic mass of chlorine atoms

	P	N	%
$^{35}_{17}Cl$	17	18	75
$^{37}_{17}Cl$	17	20	25

Method 1 *Three out of every four atoms will be chlorine-35*

$$\text{Average} = \frac{35 + 35 + 35 + 37}{4} = 35.5$$

Method 2 *Out of every 100 atoms* *75 are ^{35}Cl*
25 are ^{37}Cl

$$\text{Average} = \frac{(75 \times 35) + (25 \times 37)}{100} = 35.5$$

Q.2 *Calculate the average relative atomic mass of sulphur from the following isotopic percentages...* *^{32}S 95%* *^{33}S 1%* *^{34}S 4%*

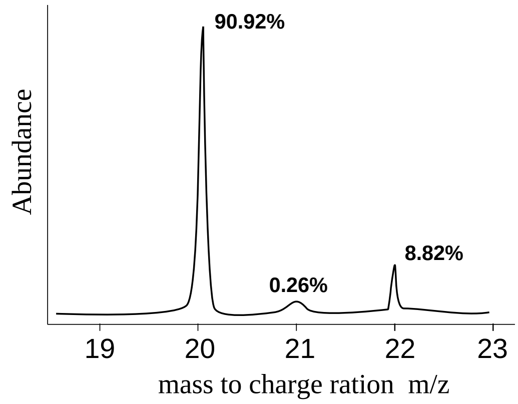
Q.3 *Bromine has isotopes with mass numbers 79 and 81. If the average relative atomic mass is 79.908, calculate the percentage of each isotope present.*

Need help:- See example calculation on the next page

Mass spectra An early application was the demonstration by Aston, (Nobel Prize, 1922), that naturally occurring neon consisted of three isotopes ...

^{20}Ne, ^{21}Ne and ^{22}Ne.

- positions of peaks gives atomic mass
- peak intensity gives relative abundance
- highest abundance is scaled up to 100% - other values are adjusted accordingly.



CALCULATIONS

Example 1 *Calculate the average relative atomic mass of neon using the above information.*

Out of every 100 atoms 90.92 are ^{20}Ne , 0.26 are ^{21}Ne and 8.82 are ^{22}Ne

$$\text{Average} = \frac{(90.92 \times 20) + (0.26 \times 21) + (8.82 \times 22)}{100} = 20.179$$

Ans. = 20.18

Example 2 *Naturally occurring potassium consists of potassium-39 and potassium-41. Calculate the percentage of each isotope present if the average is 39.1.*

Assume there are x nuclei of ^{39}K in every 100; there will then be (100-x) of ^{41}K.

so $\frac{39x + 41(100-x)}{100} = 39.1$ *therefore* $39x + 4100 - 41x = 3910$

thus $-2x = -190$ so $x = 95$ ANSWER **95% ^{39}K and 5% ^{41}K**

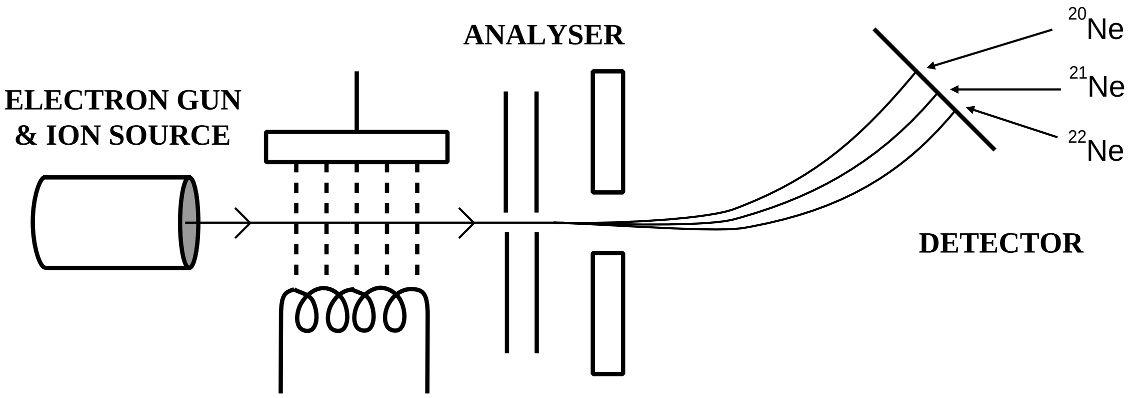
Q.4 *Calculate the average relative atomic mass of an element producing the following peaks in its mass spectrum...*

m/z	*62*	*63*	*64*	*65*
Relative intensity	*20*	*25*	*100*	*5*

Mass spectra can also be used to find the relative molecular mass of compounds

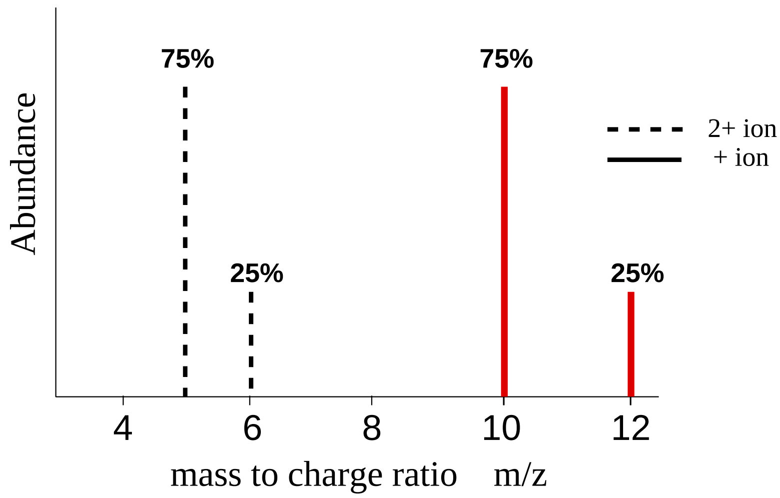
MASS SPECTROMETER

A mass spectrometer consists of ... an **ion source**, an **analyser** and a **detector**.



Ion source
- gaseous atoms are bombarded by electrons from a gun and are **IONISED**
- sufficient energy is given to form ions of 1+ charge
- resulting ions can be **ACCELERATED** out of the ion source by an electric field

Analyser
- charged particles will be **DEFLECTED** by a magnetic or electric field
- the radius of the path depends on the value of their mass/charge ratio (**m/z**)
- **ions of heavier isotopes with larger m/z values follow a larger radius curve**
- as most ions are singly charged (1+), the path depends on their mass
- if an ion acquires a **2+ charge** it will be deflected more; its **m/z value is halved**



Changes when the ion is 2+
- **M/Z VALUE IS HALVED**
- **ABUNDANCE IS THE SAME**

Detector
- by electric or photographic **DETECTION** methods
- mass spectra record the **mass/charge** values *and* **relative abundance** of each ion

ANSWERS TO QUESTIONS

Q.1

	Protons	Neutrons	Electrons	Charge	Atomic No.	Mass No.	Symbol
A	19	21	19	Neutral	19	40	^{40}K
B	20	20	20	Neutral	20	40	^{40}Ca
C	11	12	10	+	11	23	$^{23}Na^{+}$
D	6	6	6	Neutral	6	12	^{12}C
E	92	143	92	Neutral	92	235	^{235}U
F	6	7	6	Neutral	6	13	^{13}C
G	16	16	18	2-	16	32	$^{32}S^{2-}$
H	13	14	10	3+	13	27	$^{27}Al^{3+}$

Q.2 *32.49*

Q.3 ^{79}Br *54.6%* ^{81}Br *46.4%*

Q.4 *63.6*