How would you define matter?

Anything that has mass and occupies space (volume)

$\frac{\text{mass}}{\text{volume}}$ = density

All matter can be characterized by its density

- Three important phases of matter
  - solid (ICE) → compact and dense
  - liquid (water) → fluid are less dense than solid (usually)
  - gas (steam) → spread out over a large volume (low density)

Matter → pure substance → element → matter made up of a single element

Most elements are $\boxed{\text{monoatomic}}$

Fe, C, Mg, etc

But some are stable diatomics:

H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

Know these!

pure substance → compound

two or more DIFFERENT elements combine to form a bond

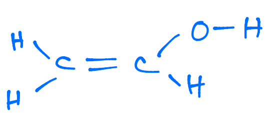
Matter → Mixture

combination of two or more pure substances

CO_2 → compound b/c more than one type of atom

O=C=O

How would I write this as a chemical formula?



2 carbons
1 oxygen
4 Hydrogens

C_2H_4O

by convention, C 1st, H 2nd then the rest

Dalton's Theory of the atom:

1. Composed of small, invisible particles (ATOMS)
2. Atoms w/i an element are identical
3. Compounds are composed of two or more atoms
4. New substances can be formed ONLY through a chemical reaction

3 sub-atomic particles:

	Location	relative charge	mass (kg)
protons	nucleus	+1	1.673×10^{-27}
neutrons	nucleus	$\emptyset$	1.675×10^{-27}
electrons	"cloud"	−1	9.109×10^{-31}

note that P+N are ~1000x heavier than e

The number of protons in the nucleus define an atom!

\# of protons is called the atomic number → designated Z

Z □ ← element symbol

Z + element symbol MUST agree! In fact, we commonly omit Z b/c it is redundant

\# of e^- must equal the number of protons in a neutral atom

neutral ≡ $\emptyset$ charge, so (+) must equal (−)

Identify the element: (name and symbol)

Z = 7 → Nitrogen (N)

Z = 28 → Nickel (Ni)

Z = 60 → Neodymium

new twin element

- extracted from didymium (used in safety glasses + glass blowing)

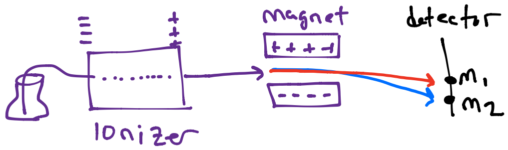
← means twin element

made of two elements

^{15}N → how many protons, neutrons + electrons?

(7 (15−7=8) 7

Mass Spectrometry allows scientist to measure the mass of atoms



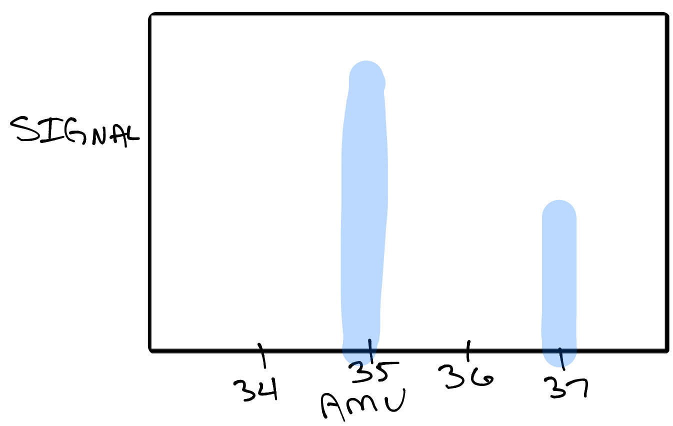
- removes one e^- from an atom

the more mass an atom has, the less influence the magnet has ($\uparrow$mass = not bendy)

smaller atoms (less mass) are more bendy

- based on where it hits the detector, the mass can be determined

If we take a sample of chlorine and run it through the mass spec



35 AMU = total number of nuclear particles = protons + neutrons

We define this as the Mass Number and designate it A

35 AMU

37 AMU

Both of these are Cl, so Z = 17

MUST have a different number of neutrons

${}^{35}_{17}Cl$ → Chlorine-35 ${}^{35}Cl$

${}^{37}_{17}Cl$ → can also be written Chlorine-37 or ${}^{37}Cl$

This is represented symbolically using symbol, Z, + A

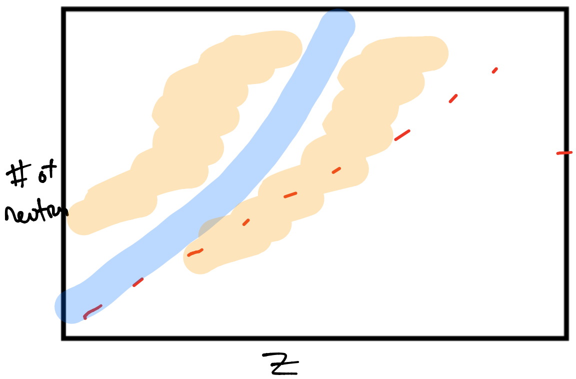
${}^{A}_{Z}\square$

These are called $\boxed{\text{isotopes}}$

Chlorine has 2 naturally occuring isotopes ${}^{35}Cl + {}^{37}Cl$

- Each isotope has different chemical properties
- The ratio of protons to neutrons is rarely 1:1
- As the number of protons in the nucleus increase, more neutrons are needed to create a stable nucleus

  - b/c more (+) charge needs to be separated



Orange = unstable nuclei

blue = stable

--- = 1:1

they will decompose to produce a stable nucleus

* we'll talk about nuclear chem this term IF time permits *

For each of the following isotopes, determine #P, N, + e⁻

$^{15}_{7}N$ $\quad Z = 7 = \#P \quad e^- = P = 7 \quad \#N = A - P = 15 - 7 = 8$

^{26}Mg $\quad Z = 12 = P = e^- \quad N = 26 - 12 = 14$

Zirconium-93 $\quad Z = 40 \quad e = 40 \quad P = 40 \quad N = 93 - 40 = 53$

^{93}Zr

What would happen if the number of electrons didn't match the number of P?

Ion is formed

$^{35}Cl \rightarrow$ 17 protons + 17 electrons

$+17 + -17 = \varnothing \equiv$ neutral

17 protons + 18 electrons

The atom has a charge of -1

$+17 + {}^-18 = -1$

$^{35}Cl^{-1}$

We can actually calculate the % abundance of each isotope IF given info about each isotope

Bromine has two naturally occurring isotopes, ^{79}Br & ^{81}Br, which have atomic masses of 78.9183 amu and 80.9163 amu, respectively.

Determine the % abundance of each isotope.

This is a weighted distribution:

mass of 1st isotope

Average = %A (A) + % B(B) + ...

comes from periodic table

this is what we need to calculate

mass of 2nd isotope

$79.904 = x(78.9183) + y(80.9163)$

ALSO: the % Abund must add up to 100%

$x + y = 1$

$y = 1 - x$

$79.904 = 78.9183x + 80.9163(1-x)$

$79.904 = 78.9183x + 80.9163 - 80.9163x$

$-1.0123 = -1.998x$

$x = 0.5067$ so ^{79}Br has a 50.67% natural abundance

$y = 1 - 0.5067$

$y = 0.4933$

^{81}Br = 49.33% Abundant

other examples:

Copper has two naturally occurring isotopes: ^{63}Cu and ^{65}Cu

If a sample of Cu is 30.83% ^{65}Cu (64.9278 amu), calculate the molar mass and abundance of ^{63}Cu.

$100\% = 30.83\% + x$

$x = 69.17\% = 0.6917$

$63.546 = 0.6917(M_{63}) + 0.3083(64.9278)$

from Periodic table

$63.546 = 0.6917 M_{63} + 20.02$

$43.53 = 0.6917 M_{63}$

$M_{63} = 62.93$ amu

Important things to note about the Periodic Table:

- Periodic Table is arranged with smallest Z @ top left → increases as you would read a book

row 1 small →
row 2 →
row 3 →

Rows are called periods + we will see later this week that they are meaningful

- Elements are grouped together in columns based on similar chemical + physical properties

columns are called "groups"

* For now, the most important thing to remember about groups is the common charges + names of element groupings

Group 1A = Alkali metals → +1 charge

Group 2A = Alkali Earth metals → +2 charge

Group 3B → 12B = Transition metals → Group 12B has common charge of +2

5A (under Nitrogen) → −3

6A (under oxygen) → −2

7A (under fluorine) = halogens → −1

8A = noble gas → never charged

Also, be familiar with the common diatomic molecules: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2