



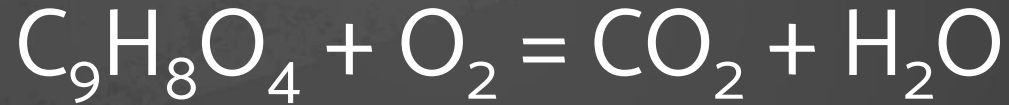
Chemistry - 101

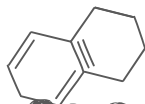
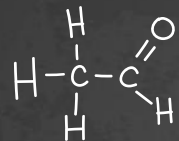
Let's continue the journey – day 2



HW 1

How many molecules of oxygen (O₂) will be necessary to turn one molecule of aspirin into carbon dioxide (CO₂) and water (H₂O)?





What are the building blocks and the building rules?



- What the difference between different atoms?
- Why do the atoms connect the way they connect and not in some different way?
- Why did the atoms of oxygen and nitrogen connect by two and argon stay alone in the air?
- Can the carbon dioxide atoms be connected differently?
- How do atom attach to each other?



$$a_{n+1} - a_n = 0_n$$

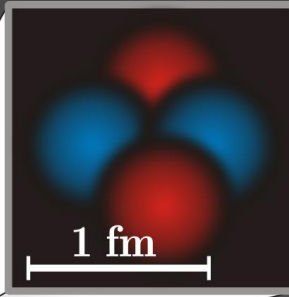
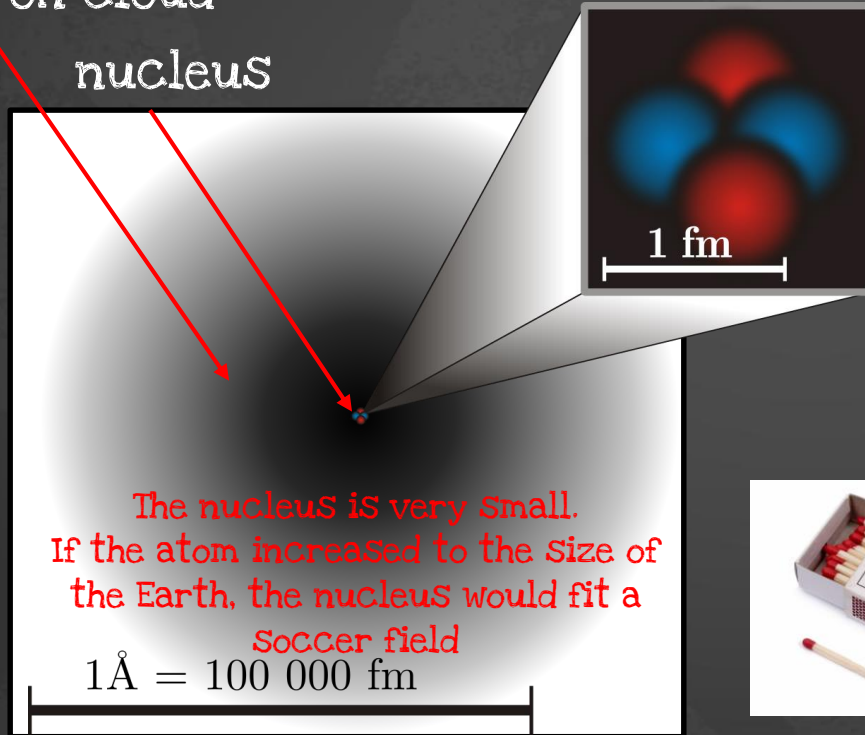


Atomic composition

- Atoms are made up of even smaller particles, which define properties of elements
- If you change the arrangement of these particles or the number of these particles you will change the properties of the element or the element itself

Electron cloud

nucleus



- Almost all atomic mass is in the nucleus
- The density of matter in the nucleus is enormous - 10^{13} - 10^{14} g/cm^3
- The atoms are tiny, classical physics cannot accurately predict their behavior (quantum effects)



2.5×10^9 tons ~ 200
Egyptian pyramids

Atomic composition

- Atoms are made of nucleus and an electron cloud around it
 - The electron cloud has a negative charge, protons in the nucleus have positive charge.
- In each atom the number of protons is equal to the number of electrons so as a whole an atom is neutral
 - (An atom can loose or acquire electrons, getting charged)
 - In addition to protons a nucleus contains neutrons. The neutrons do not have any charge
 - Electrons, protons and neutrons are subatomic particles

The size of the atom

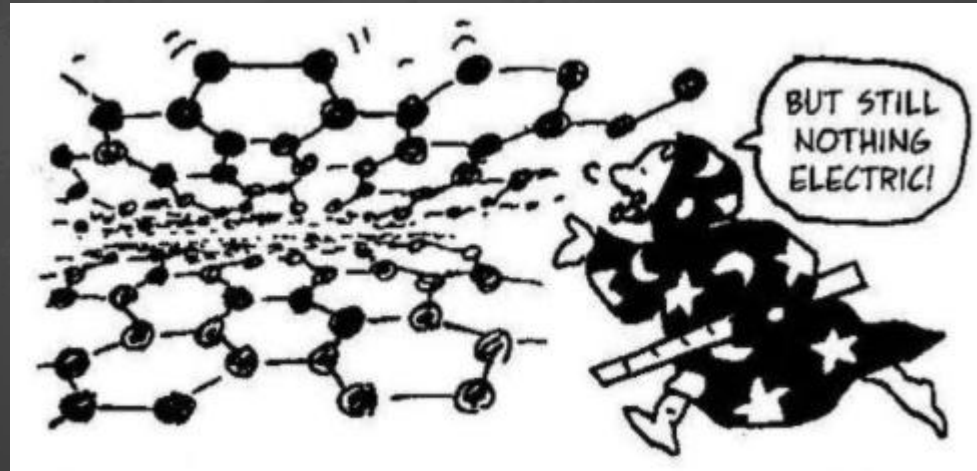


If we shrink a million times...

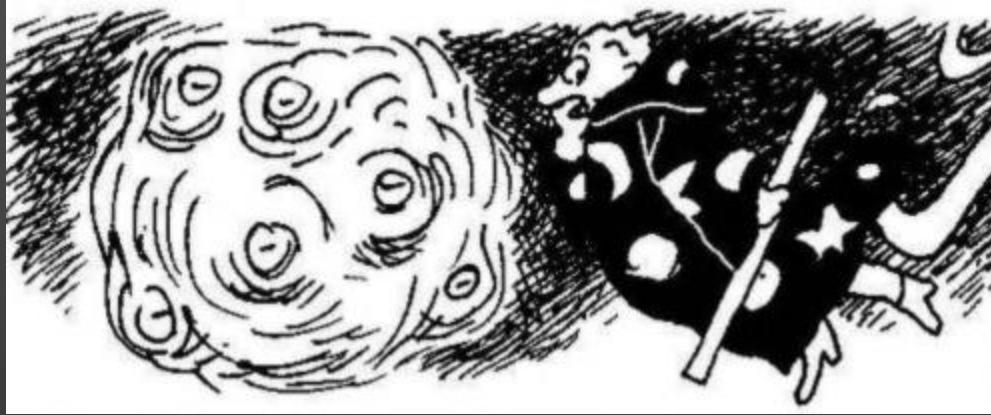
A human hair is now thirty stories
thick...

Bacteria are the size of torpedoes...
And atoms are just barely visible as
tiny specks.

Shrink another thousand times
brings us to NANOMETER (10^{-9} meter)
scale. The little man is about 2 nm
tall and the atoms are about $1/10^{\text{th}}$ of
his size



Let's shrink 10 more times to atomic size - 10^{-10} meter and look at a single carbon atom. Some electrons are humming around... but where are positive charges?

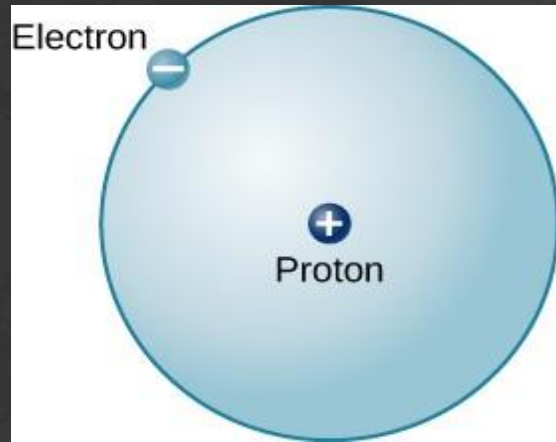


Now the man is a hundred times smaller, PICOMETER scale. That is a million of a millionth, or 10^{-12} actual size.

If the diameter of the atom were the length of a football field, then the nucleus would be smaller than a pea.



The atom is mostly empty space!



This is hydrogen atom

- The number of protons defines the element
- The elements in the periodic table are written in the order of their atomic numbers, which is the number of protons

1

H

Hydrogen

Nonmetal

2

He

Helium

Noble Gas

3

Li

Lithium

Alkali Metal

4

Be

Beryllium

Alkaline Earth Metal

11

Na

Sodium

Alkali Metal

12

Mg

Magnesium

Alkaline Earth Metal

19

K

Potassium

Alkali Metal

20

Ca

Calcium

Alkaline Earth Metal

27

Co

Cobalt

Transition Metal

28

Ni

Nickel

Transition Metal

31

Ga

Gallium

Metal

32

Ge

Germanium

Metalloid

39

Y

Yttrium

Transition Metal

40

Zr

Zirconium

Transition Metal

45

Rh

Rhodium

Transition Metal

46

Pd

Palladium

Transition Metal

51

Sb

Antimony

Metalloid

52

Te

Tellurium

Metalloid

57

La

Lanthanum

Lanthanide

58

Ce

Cerium

Lanthanide

63

Eu

Europium

Lanthanide

64

Gd

Gadolinium

Lanthanide

69

Tm

Thulium

Lanthanide

70

Yb

Ytterbium

Lanthanide

75

Re

Rhenium

Transition Metal

76

Os

Osmium

Transition Metal

81

Tl

Thallium

Metal

82

Pb

Lead

Metal

87

Fr

Francium

Alkali Metal

88

Ra

Radium

Alkaline Earth Metal

93

Np

Neptunium

Actinide

94

Pu

Plutonium

Actinide

99

Es

Einsteinium

Actinide

100

Fm

Fermium

Actinide

105

Db

Dubnium

Transition Metal

106

Sg

Seaborgium

Transition Metal

111

Rg

Roentgenium

Transition Metal

112

Cn

Copernicium

Transition Metal

117

Ts

Tennessine

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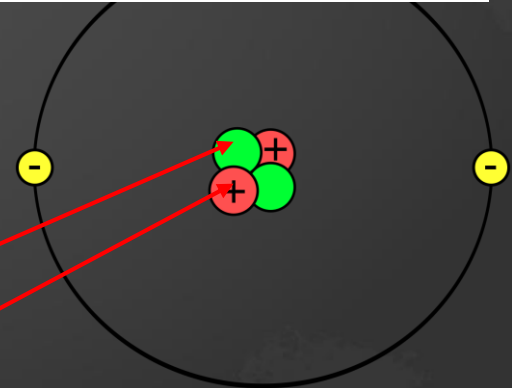
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356

electron
neutron
proton



1 H Hydrogen Nonmetal	
3 Li Lithium Alkali Metal	4 Be Beryllium Alkaline Earth Metal
11 Na Sodium Alkali Metal	12 Mg Magnesium Alkaline Earth Metal
19 K Potassium Alkali Metal	20 Ca Calcium Alkaline Earth Metal
37 Rb Rubidium Alkali Metal	38 Sr Strontium Alkaline Earth Metal
55 Cs Cesium Alkali Metal	56 Ba Barium Alkaline Earth Metal
87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth Metal

1 H Hydrogen Nonmetal

Atomic Number

Symbol

Name

Chemical Group Block

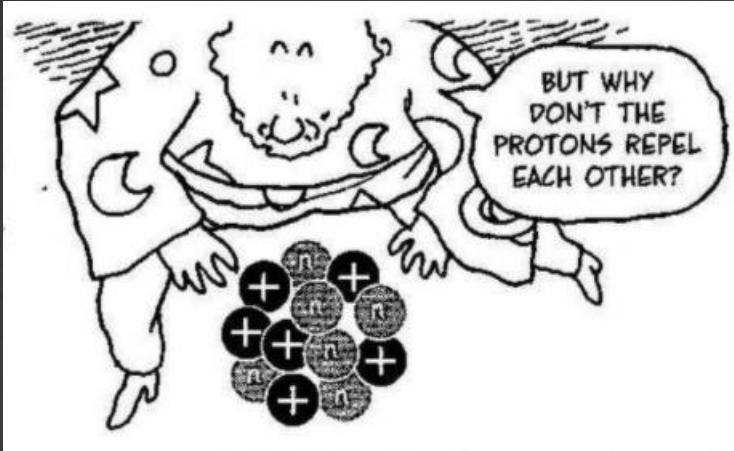
Pub**C**hem

2 He Helium Noble Gas
10 Ne Neon Noble Gas
18 Ar Argon Noble Gas
36 Kr Krypton Noble Gas
54 Xe Xenon Noble Gas
86 Rn Radon Noble Gas
118 Og Oganesson Noble Gas

5 B Boron Metalloid	6 C Carbon Nonmetal	7 N Nitrogen Nonmetal	8 O Oxygen Nonmetal	9 F Fluorine Halogens	10 Ne Neon Noble Gas
13 Al Aluminum Post-Transition Metal	14 Si Silicon Metalloid	15 P Phosphorus Nonmetal	16 S Sulfur Nonmetal	17 Cl Chlorine Halogens	18 Ar Argon Noble Gas
31 Ga Gallium Post-Transition Metal	32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogens	36 Kr Krypton Noble Gas
49 In Indium Post-Transition Metal	50 Sn Tin Post-Transition Metal	51 Sb Antimony Metalloid	52 Te Tellurium Metalloid	53 I Iodine Halogens	54 Xe Xenon Noble Gas
81 Tl Thallium Post-Transition Metal	82 Pb Lead Post-Transition Metal	83 Bi Bismuth Post-Transition Metal	84 Po Polonium Metalloid	85 At Astatine Halogens	86 Rn Radon Noble Gas
113 Nh Nihonium Post-Transition Metal	114 Fl Flerovium Post-Transition Metal	115 Mc Moscovium Post-Transition Metal	116 Lv Livermorium Post-Transition Metal	117 Ts Tennessine Halogens	118 Og Oganesson Noble Gas

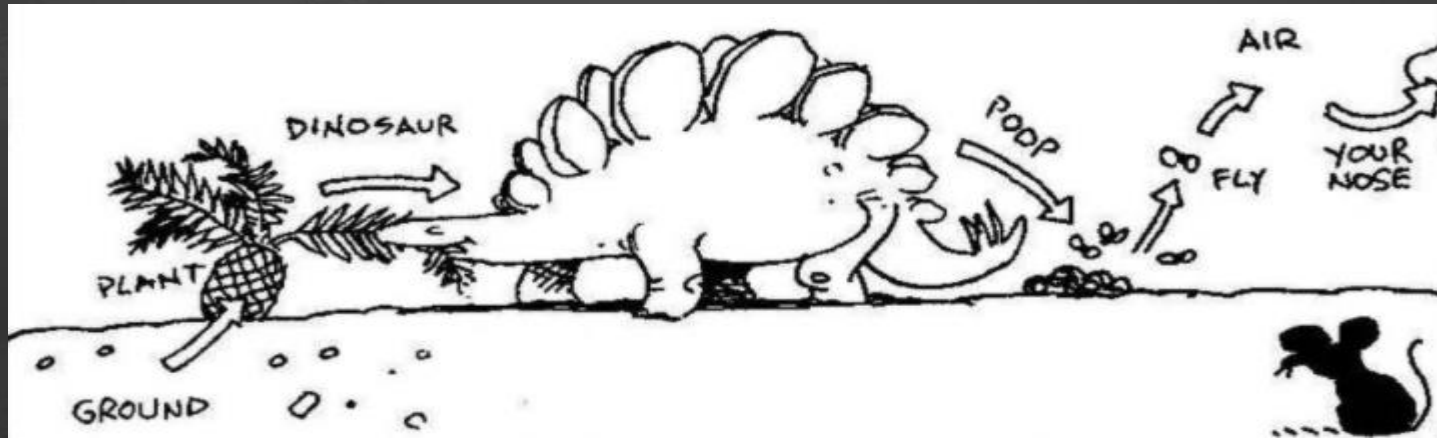
57 La Lanthanum Lanthanide	58 Ce Cerium Lanthanide	59 Pr Praseodymium Lanthanide	60 Nd Neodymium Lanthanide	61 Pm Promethium Lanthanide	62 Sm Samarium Lanthanide	63 Eu Europium Lanthanide	64 Gd Gadolinium Lanthanide	65 Tb Terbium Lanthanide	66 Dy Dysprosium Lanthanide	67 Ho Holmium Lanthanide	68 Er Erbium Lanthanide	69 Tm Thulium Lanthanide	70 Yb Ytterbium Lanthanide	71 Lu Lutetium Lanthanide
89 Ac Actinium Actinide	90 Th Thorium Actinide	91 Pa Protactinium Actinide	92 U Uranium Actinide	93 Np Neptunium Actinide	94 Pu Plutonium Actinide	95 Am Americium Actinide	96 Cm Curium Actinide	97 Bk Berkelium Actinide	98 Cf Californium Actinide	99 Es Einsteinium Actinide	100 Fm Fermium Actinide	101 Md Mendelevium Actinide	102 No Nobelium Actinide	103 Lr Lawrencium Actinide

Atoms



The nucleus is held together by a powerful short-range force attraction called THE STRONG FORCE, which overcomes electrical repulsion.

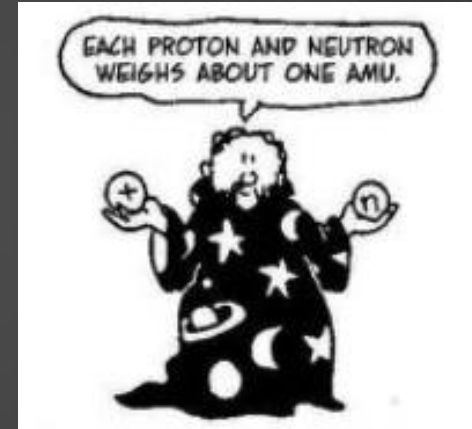
This intense pull makes most nuclei virtually indestructible.



Atomic mass

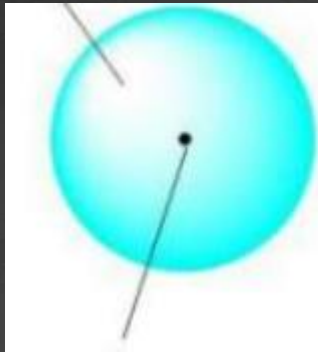
- **Atomic number** – is the number of protons in nucleus
 - Atomic number of C?
- **Atomic mass ?** Each proton and neutron has 1840 times the mass of an electron

Particle	Mass
PROTON	$1.673 \times 10^{-24} \text{g}$
NEUTRON	$1.675 \times 10^{-24} \text{g}$
ELECTRON	$0.00091 \times 10^{-24} \text{g}$



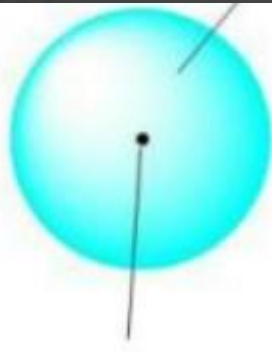
- Chemists define an atomic mass unit, or AMU, to be precisely one-twelfth the mass of a ^{12}C atom. The common carbon atom has a mass of exactly 12.000000 AMU, by definition.
- All other atomic masses are computed relative to this reference.

6 electrons



6 protons and
6 neutrons

6 electrons



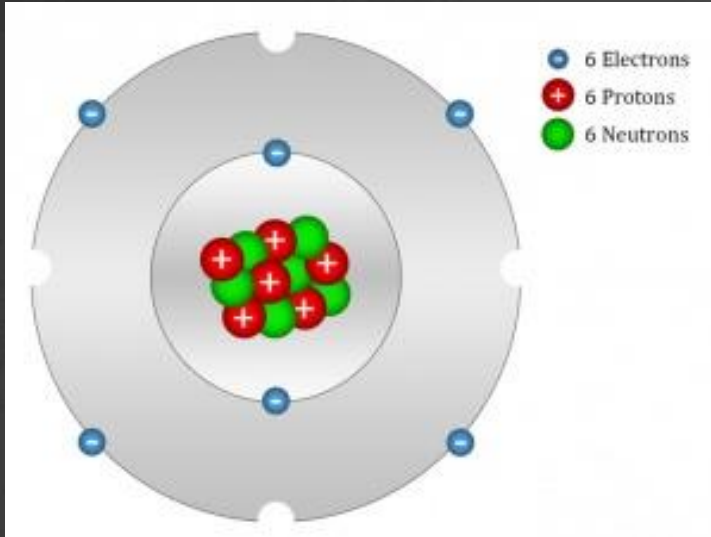
6 protons and
7 neutrons



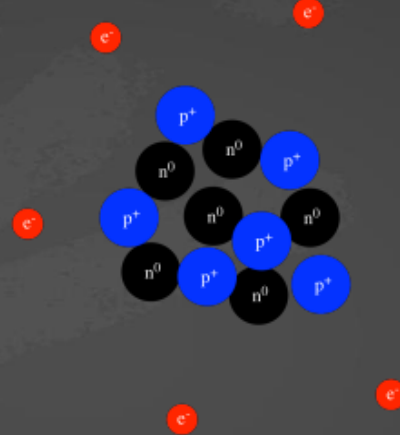
$$\begin{aligned}\text{Atomic mass of C} &= \\ (0.989 \times 12) &+ (0.011 \times 13) = 12.011\end{aligned}$$

$$\begin{aligned}\text{atomic mass of} & \\ \text{an element} &= \left(\begin{array}{l} \text{*fractional} \\ \text{abundance of} \\ \text{isotope 1} \end{array} \times \begin{array}{l} \text{mass of} \\ \text{isotope 1} \end{array} \right) + \left(\begin{array}{l} \text{fractional} \\ \text{abundance of} \\ \text{isotope 2} \end{array} \times \begin{array}{l} \text{mass of} \\ \text{isotope 2} \end{array} \right) + \dots\end{aligned}$$

Isotopes



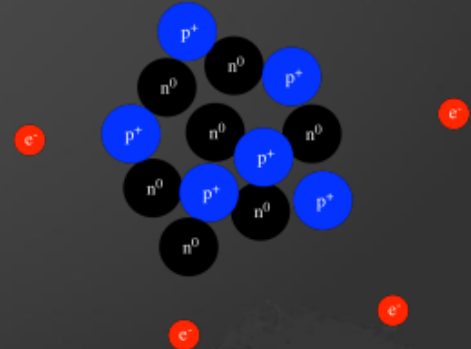
We can write it as ^{12}C



This atom has
6 protons
6 neutrons
6 electrons

This is carbon ("C") atom
It has :
6 protons
6 neutrons
6 electrons

It is still a carbon atom
We can write it as ^{13}C
In the natural carbon it is
present at ~1%



Isotopes

Isotope - each of two or more forms of element that contain equal number of protons but different number of neutrons in their nuclei, and hence differ in relative atomic mass but no in chemical properties.

Most natural isotopes are stable
The unstable ones fall apart releasing subatomic particles and electromagnetic waves. This is called radioactivity

A Special element Hydrogenium

- Hydrogen is the only element that has different symbols and names for its isotopes:
 - ^1H – protonium
 - ^2D – deuterium
 - ^3T – tritium

