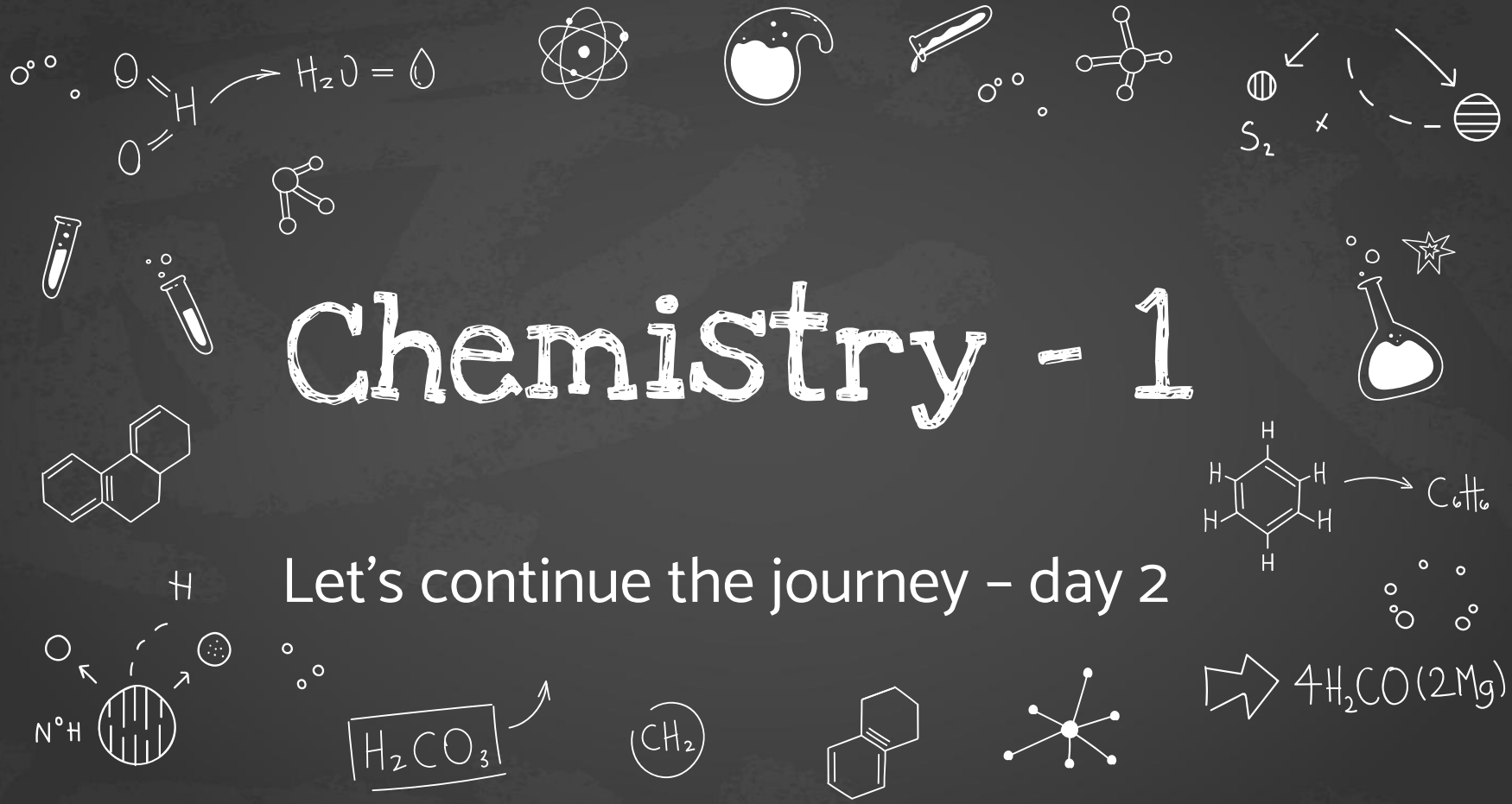
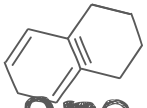
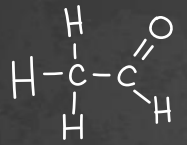

Chemistry - 1
Let's continue the journey – day 2
H_2O
S_2
C_6H_6
H_2CO_3
CH_2
$4H_2CO(2Mg)$



What are the building blocks and the building rules?



$Ca(HO)_2$

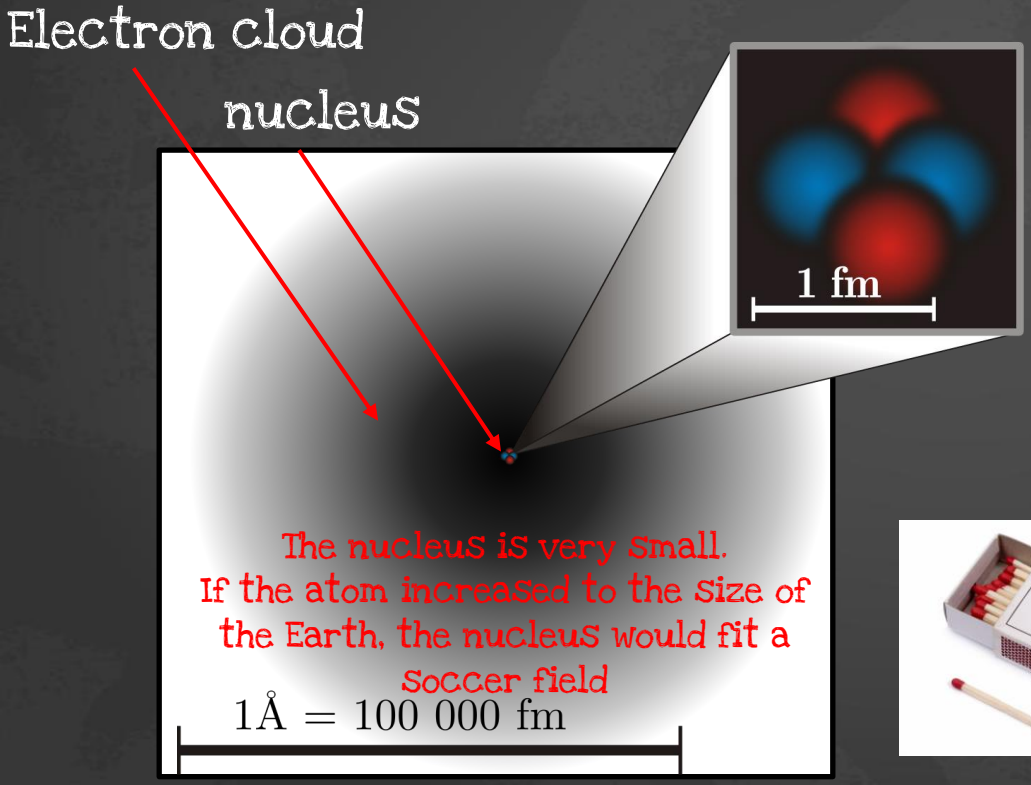
Ng^3

What is 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 atoms attach to each other?

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

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



- Almost all atomic mass is in the nucleus
- The density of matter in the nucleus is enormous - 10^{13}-10^{14} g/cm^3 (density of lead is 11.29 g/cm^3)
- The atoms are tiny, classical physics cannot accurately predict their behavior (quantum effects)

2.5×10^9 tons ~ 200 Egyptian pyramids

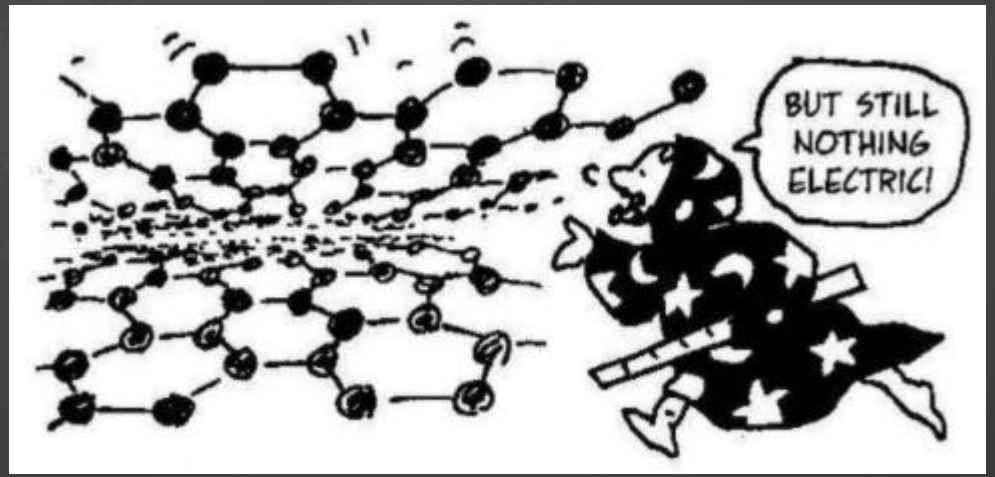
Atomic Composition

- 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

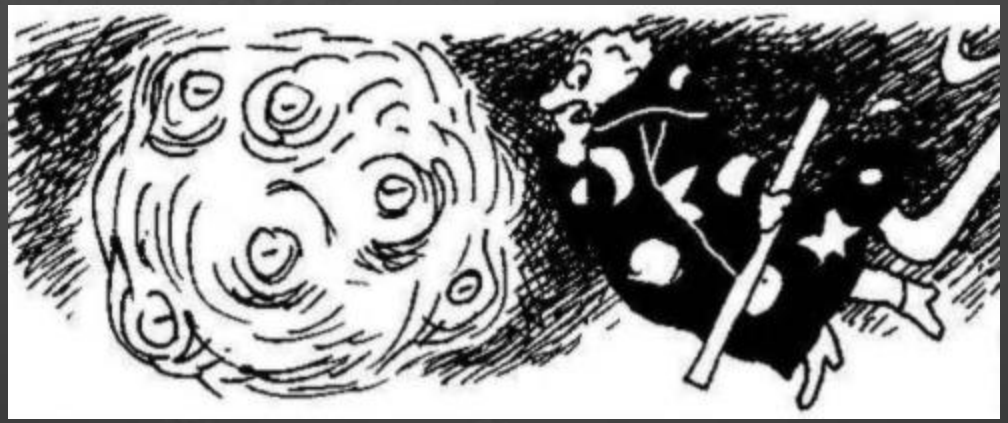
The Size of the atom

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 1/10th of his size



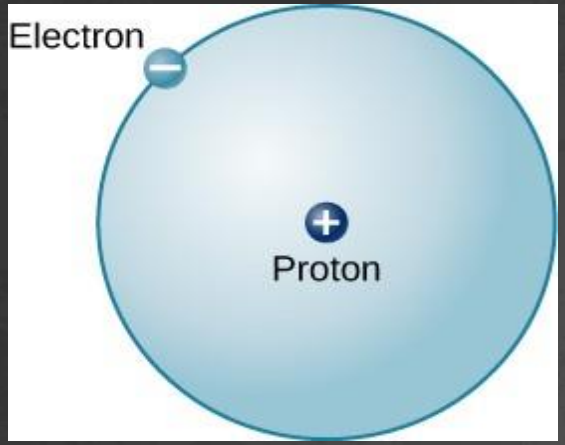
Let's shrink 10 more times to atomic size - 10^{-10} meter and look at a single carbon atom. Some electrons are humming around... but where are positive charges?



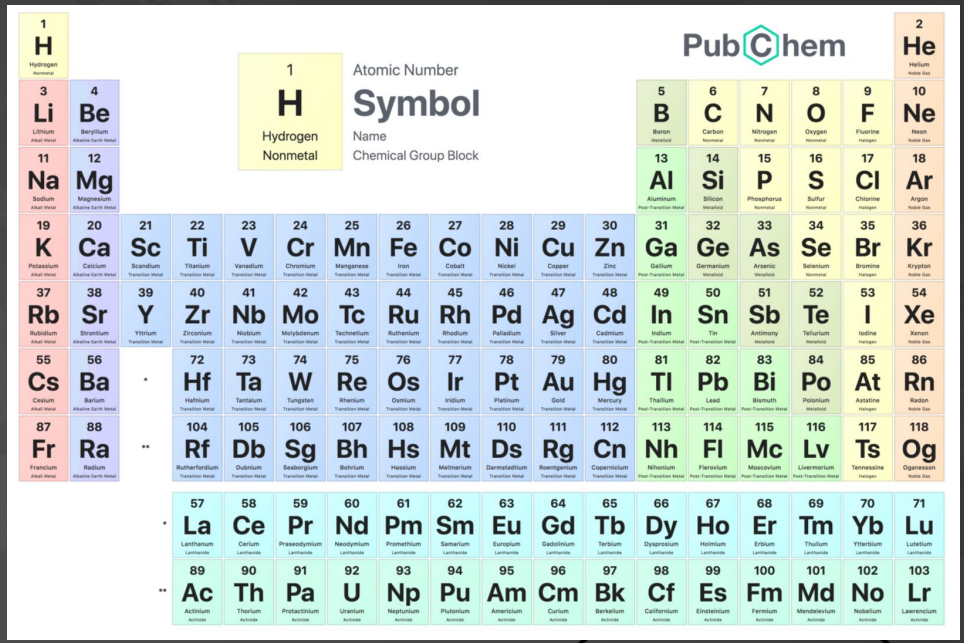
Now the man is a hundred times smaller, PICOMETER scale. That is a million of a millionth, or 10^{-12} actual size.

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

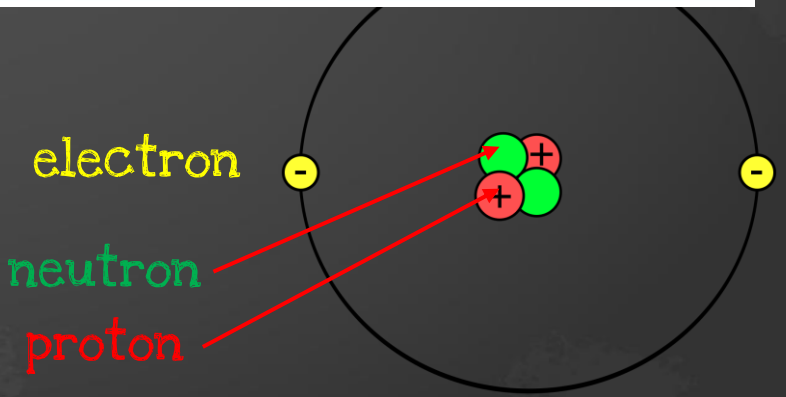
The atom is mostly empty space!

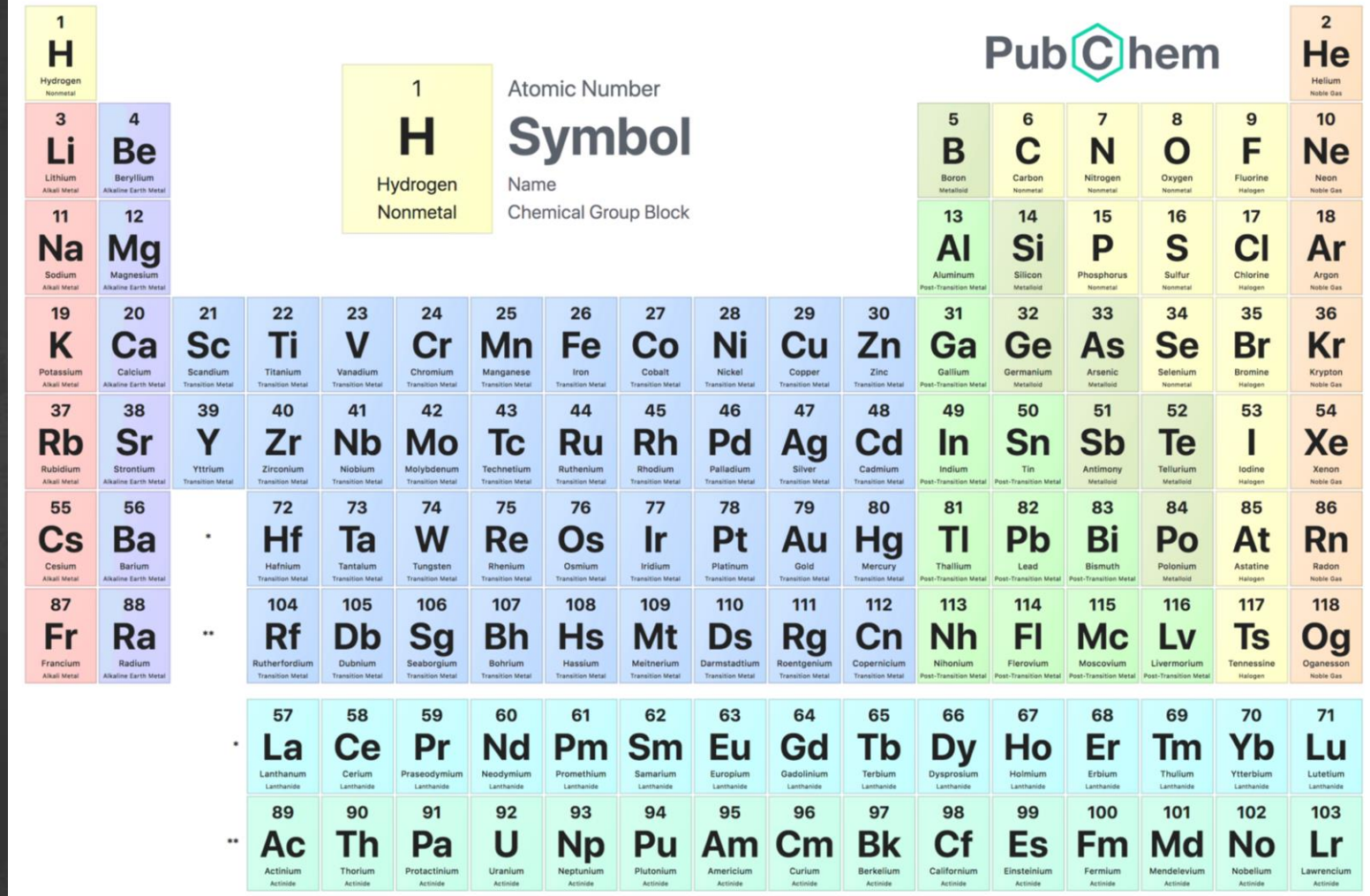


This is hydrogen atom

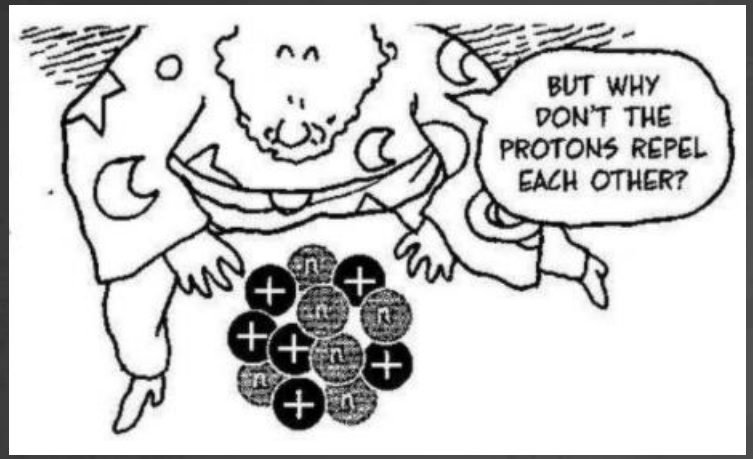


- The number of protons defines the element
- The elements in the periodic table are written in the order of their <u>atomic numbers, which is the number of protons</u>



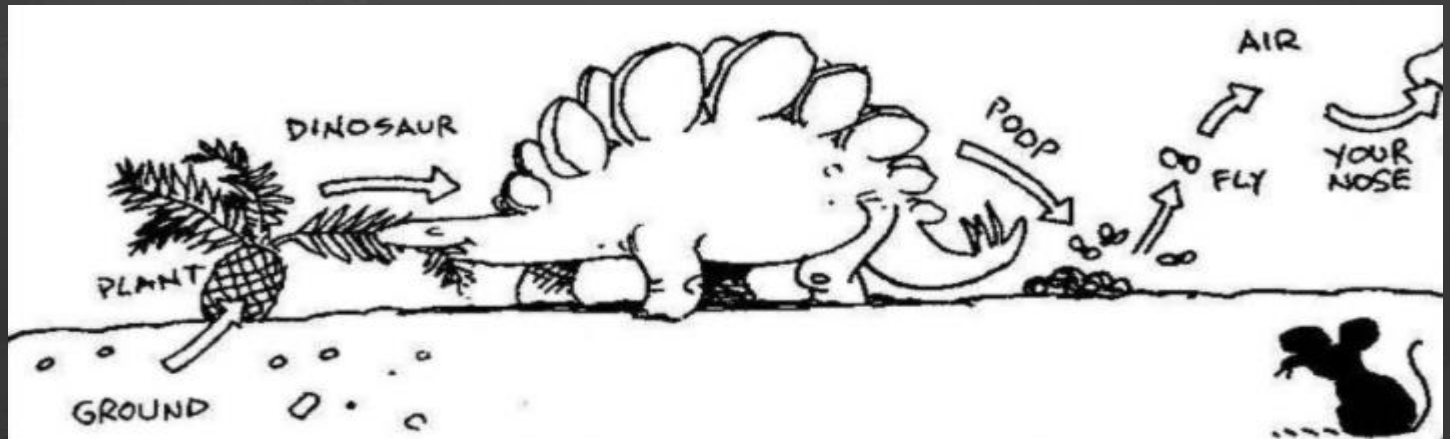

PubChem
1
H
Hydrogen
Nonmetal
Atomic Number
Symbol
Name
Chemical Group Block
1 H Hydrogen Nonmetal
2 He Helium Noble Gas
3 Li Lithium Alkali Metal
4 Be Beryllium Alkaline Earth Metal
5 B Boron Metalloid
6 C Carbon Nonmetal
7 N Nitrogen Nonmetal
8 O Oxygen Nonmetal
9 F Fluorine Halogen
10 Ne Neon Noble Gas
11 Na Sodium Alkali Metal
12 Mg Magnesium Alkaline Earth Metal
13 Al Aluminum Post-Transition Metal
14 Si Silicon Metalloid
15 P Phosphorus Nonmetal
16 S Sulfur Nonmetal
17 Cl Chlorine Halogen
18 Ar Argon Noble Gas
19 K Potassium Alkali Metal
20 Ca Calcium Alkaline Earth Metal
21 Sc Scandium Transition Metal
22 Ti Titanium Transition Metal
23 V Vanadium Transition Metal
24 Cr Chromium Transition Metal
25 Mn Manganese Transition Metal
26 Fe Iron Transition Metal
27 Co Cobalt Transition Metal
28 Ni Nickel Transition Metal
29 Cu Copper Transition Metal
30 Zn Zinc Transition Metal
31 Ga Gallium Post-Transition Metal
32 Ge Germanium Metalloid
33 As Arsenic Metalloid
34 Se Selenium Nonmetal
35 Br Bromine Halogen
36 Kr Krypton Noble Gas
37 Rb Rubidium Alkali Metal
38 Sr Strontium Alkaline Earth Metal
39 Y Yttrium Transition Metal
40 Zr Zirconium Transition Metal
41 Nb Niobium Transition Metal
42 Mo Molybdenum Transition Metal
43 Tc Technetium Transition Metal
44 Ru Ruthenium Transition Metal
45 Rh Rhodium Transition Metal
46 Pd Palladium Transition Metal
47 Ag Silver Transition Metal
48 Cd Cadmium Transition Metal
49 In Indium Post-Transition Metal
50 Sn Tin Post-Transition Metal
51 Sb Antimony Metalloid
52 Te Tellurium Metalloid
53 I Iodine Halogen
54 Xe Xenon Noble Gas
55 Cs Cesium Alkali Metal
56 Ba Barium Alkaline Earth Metal
72 Hf Hafnium Transition Metal
73 Ta Tantalum Transition Metal
74 W Tungsten Transition Metal
75 Re Rhenium Transition Metal
76 Os Osmium Transition Metal
77 Ir Iridium Transition Metal
78 Pt Platinum Transition Metal
79 Au Gold Transition Metal
80 Hg Mercury Transition Metal
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 Halogen
86 Rn Radon Noble Gas
87 Fr Francium Alkali Metal
88 Ra Radium Alkaline Earth Metal
104 Rf Rutherfordium Transition Metal
105 Db Dubnium Transition Metal
106 Sg Seaborgium Transition Metal
107 Bh Bohrium Transition Metal
108 Hs Hassium Transition Metal
109 Mt Meitnerium Transition Metal
110 Ds Darmstadtium Transition Metal
111 Rg Roentgenium Transition Metal
112 Cn Copernicium Transition Metal
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 Halogen
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.

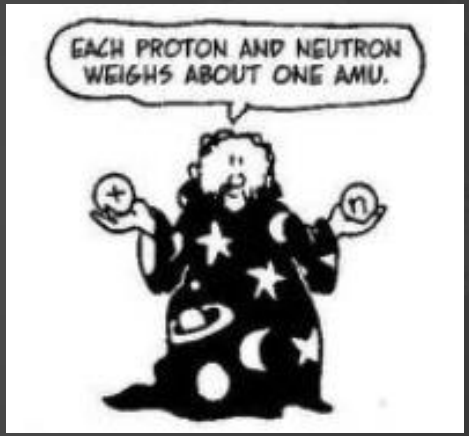
This intense pull makes most nuclei virtually indestructible.



Atomic mass

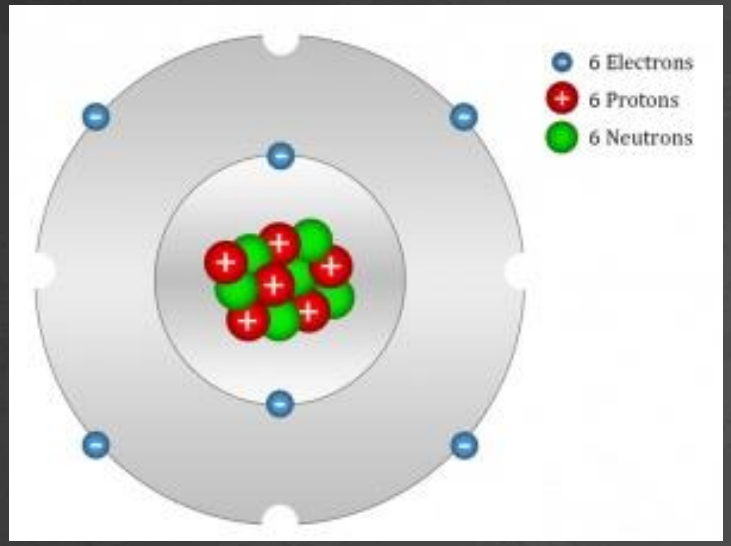
- **Atomic number** – is the number of protons in nucleus
  - Atomic number of C?
- **Atomic mass ? Each proton and neutron has 1840 times the mass of an electron**

Particle	Mass	
	kg	AMU
PROTON	1.673×10^{-24}g	1.00728
NEUTRON	1.675×10^{-24}g	1.00867
ELECTRON	0.00091×10^{-24}g	0.000549



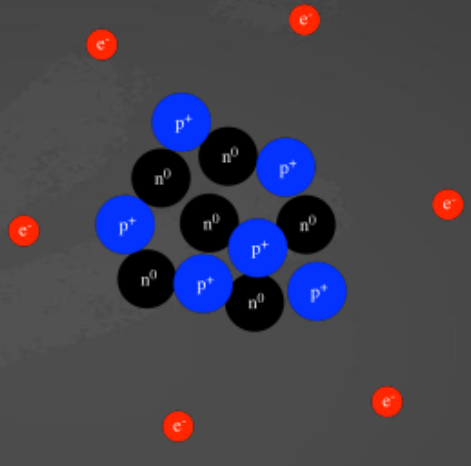
- **Chemists define an atomic mass unit, or AMU, to be precisely one-twelfth the mass of a ^{12}C atom. The common carbon atom has a mass of exactly 12.000000 AMU, by definition.**
- **All other atomic masses are computed relative to this reference.**

Isotopes



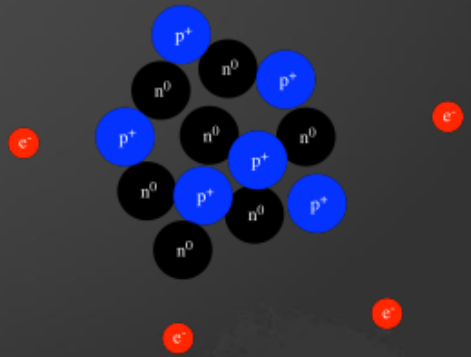
This is carbon ("C") atom
It has :
6 protons
6 neutrons
6 electrons

We can write it as ^{12}C



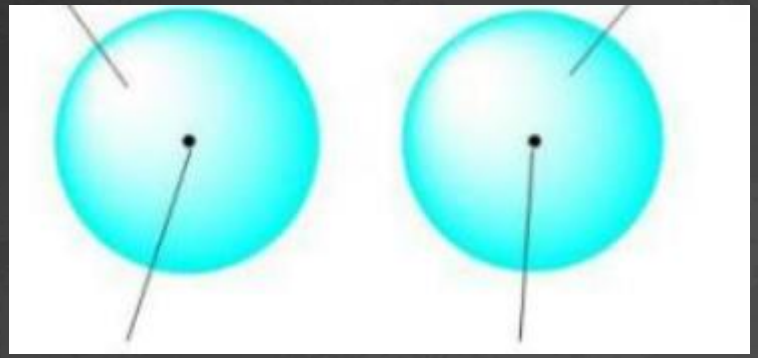
This atom has
6 protons
7 neutrons
6 electrons

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



6 electrons

6 electrons



6 protons and
6 neutrons

6 protons and
7 neutrons

$^{12}_{6}C$

$^{13}_{6}C$

Atomic mass of C=
(0.989x12)+(0.011x13) = 12.011

$$\text{atomic mass of an element} = \left(\text{fractional abundance of isotope 1} \times \text{mass of isotope 1}\right) + \left(\text{fractional abundance of isotope 2} \times \text{mass of isotope 2}\right) + \ldots$$

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

Element	Latin name	Atomic mass of the element in nature	Atomic mass of isotopes	% of isotope in the element in nature
Hydrogen $^{1}_{1}$H $^{2}_{1}$H (D)	Hydrogenium	1.0079	 1.0078 2.0140	 99.984 0.0156
Carbon $^{12}_{6}$C $^{13}_{6}$C	Carboneum	12.011	 12.000 13.00335	 98.892 1.108
Nitrogen $^{14}_{7}$N $^{15}_{7}$N	Nitrogenium	14.0067	 14.00307 15.00011	 99.635 0.365
Oxygen $^{16}_{8}$O ^{17}O $^{18}_{8}$O	Oxygenium	15.9994	 15.99491 16.9991 17.9992	 99.759 0.037 0.204
Sodium $^{23}_{11}$Na	Natrium	22.9898	 22.9898	 100
Chlorine $^{35}_{17}$Cl ^{37}Cl	Chlorium	35.453	 34.96885 36.9658	 75.53 24.47

A Special element Hydrogenium

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