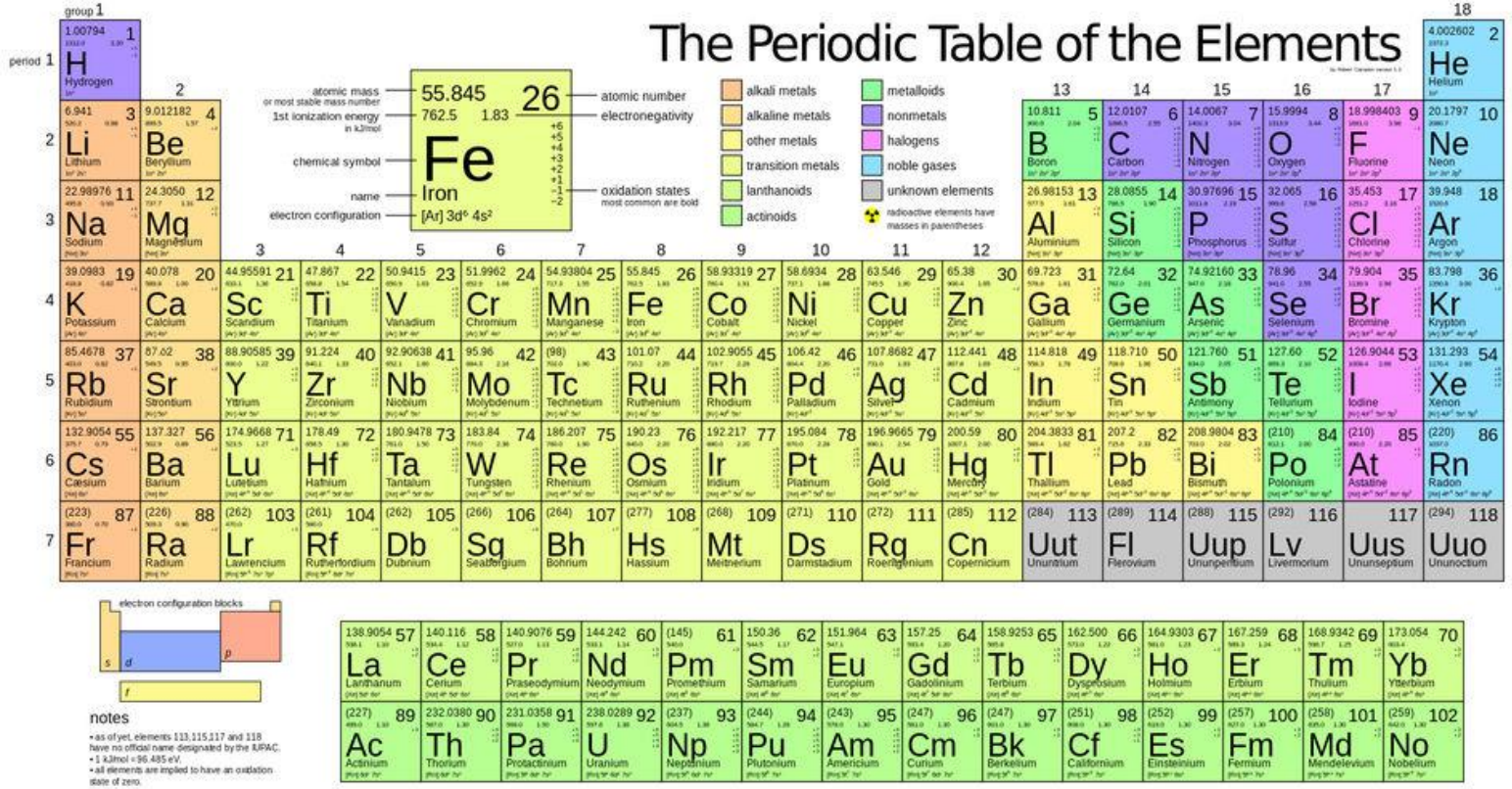
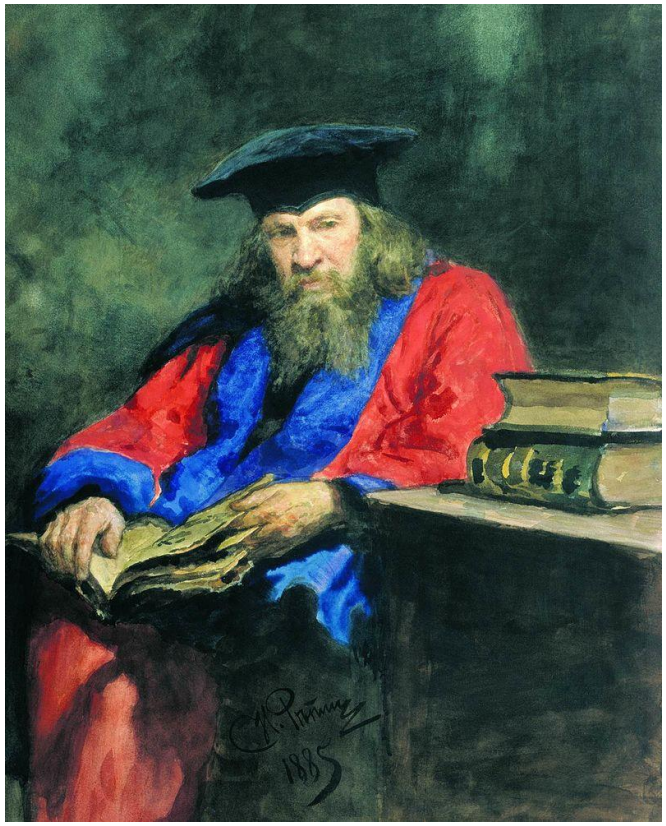
Periodic table of elements

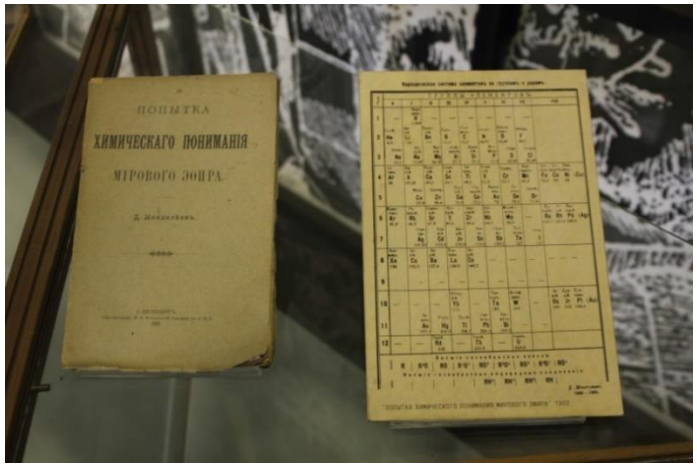


https://en.wikipedia.org/wiki/Periodic_table

DMITRI MENDELEEV – RUSSIAN CHEMIST, PHYSICIST

AN ATTEMPT TOWARDS THE CHEMICAL CONCEPTION OF THE ETHER

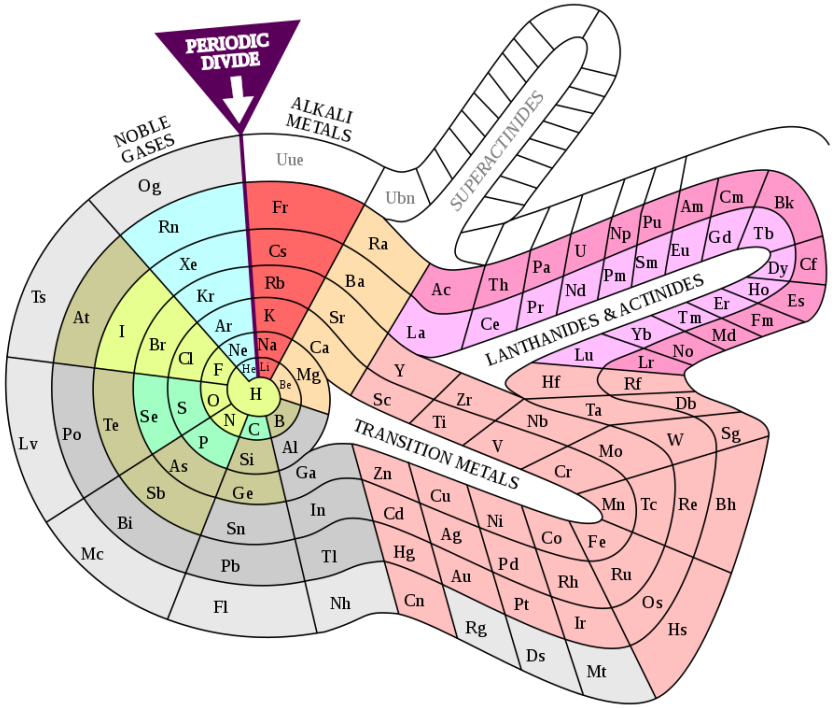




https://en.wikipedia.org/wiki/Periodic_table

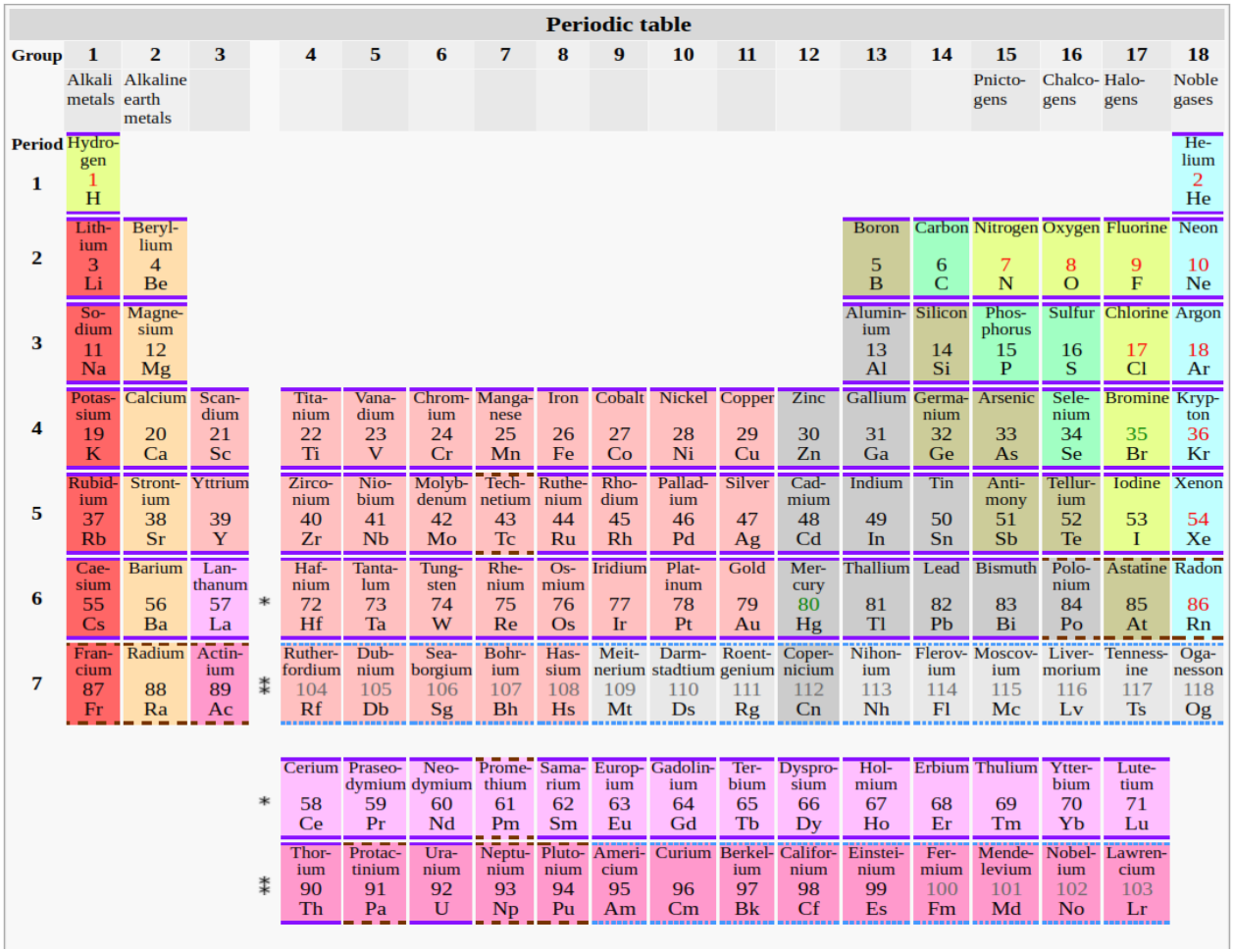
Reihen	Gruppe I. — R^2O	Gruppe II. — RO	Gruppe III. — R^2O^3	Gruppe IV. RH^4 RO^2	Gruppe V. RH^3 R^2O^5	Gruppe VI. RH^2 RO^3	Gruppe VII. RH R^2O^7	Gruppe VIII. — RO^4
1	H=1							
2	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl=35.5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Mendeleev’s second version



Theodor Benfey’S periodic table - 1964

https://en.wikipedia.org/wiki/Periodic_table



black=solid	green=liquid	red=gas	gray=unknown	**Color of the atomic number** shows state of matter (at 0 °C and 1 atm)

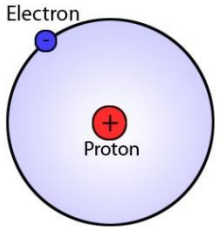
Primordial	From decay	Synthetic	**Border** shows natural occurrence of the element

Background color shows subcategory in the metal–metalloid–nonmetal trend:

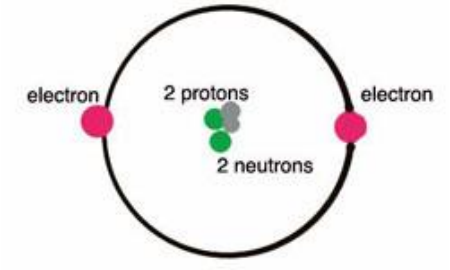
Metal						Metalloid	Nonmetal			Unknown chemical properties
Alkali metal	Alkaline earth metal	Lanthanide	Actinide	Transition metal	Post-transition metal		Polyatomic nonmetal	Diatomic nonmetal	Noble gas	

https://en.wikipedia.org/wiki/Periodic_table

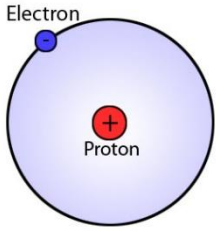
Examples


Electron
Proton

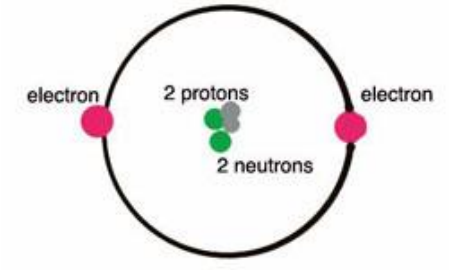

1
H
Hydrogen
1.008

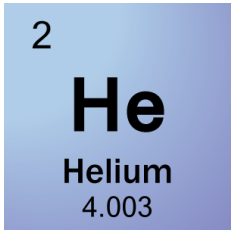

electron
2 protons
electron
2 neutrons

Examples


Electron
Proton

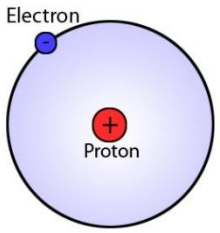

1
H
Hydrogen
1.008


electron
2 protons
electron
2 neutrons

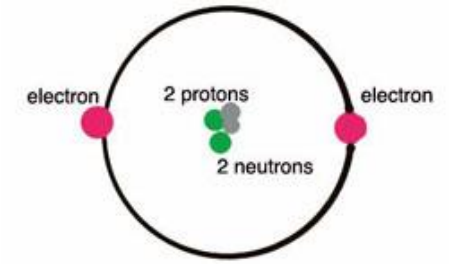

2
He
Helium
4.003

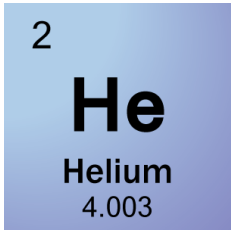
Examples

Hydrogen: 1 proton, 1 electron



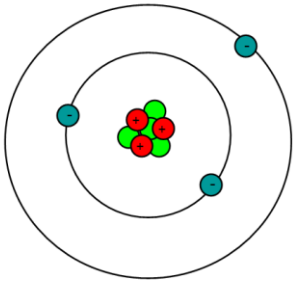
Helium: 2 electrons, 2 protons, 2 neutrons

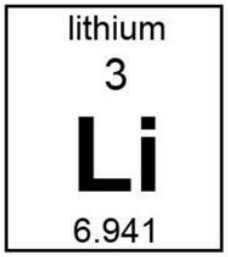




The **first energy level** can hold **a maximum of 2 electrons**

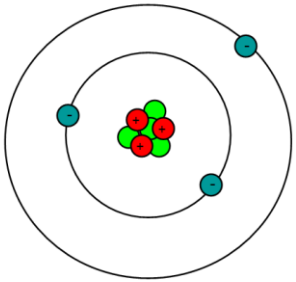
Examples

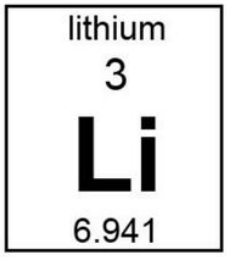




Examples

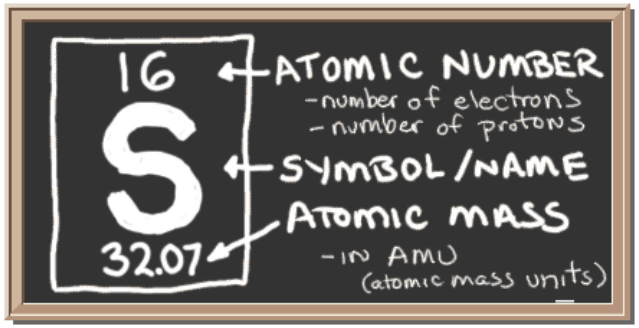
Lithium: 3 electrons, 3 protons, 4 neutrons

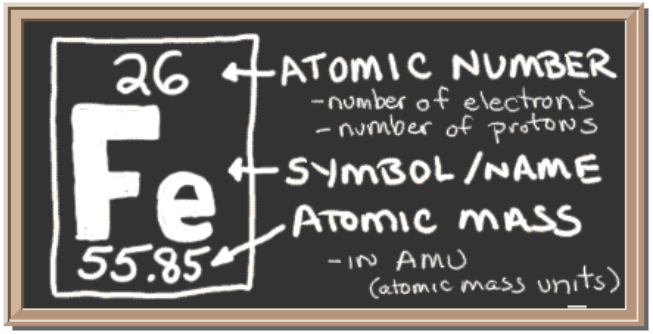




On the outher level (shell) 1 electron: the Li element is placed in the 1st Group of the periodic table

Atomic number and atomic mass





AMU: atomic mass units: one twelwth of the mass of a carbon-12 atom (1AMU =$1.66053904 \times 10^{-27}$ kilograms)

Unified atomic mass: aproximately the mass of one nucleon (proton or neutron)

S: 32 protons + neutrons

Fe: 56 protons + neutrons

Isotopes

Isotopes are variants of a particular chemical element which differ in neutron number. All isotopes of a given element have the same number of protons in each atom.

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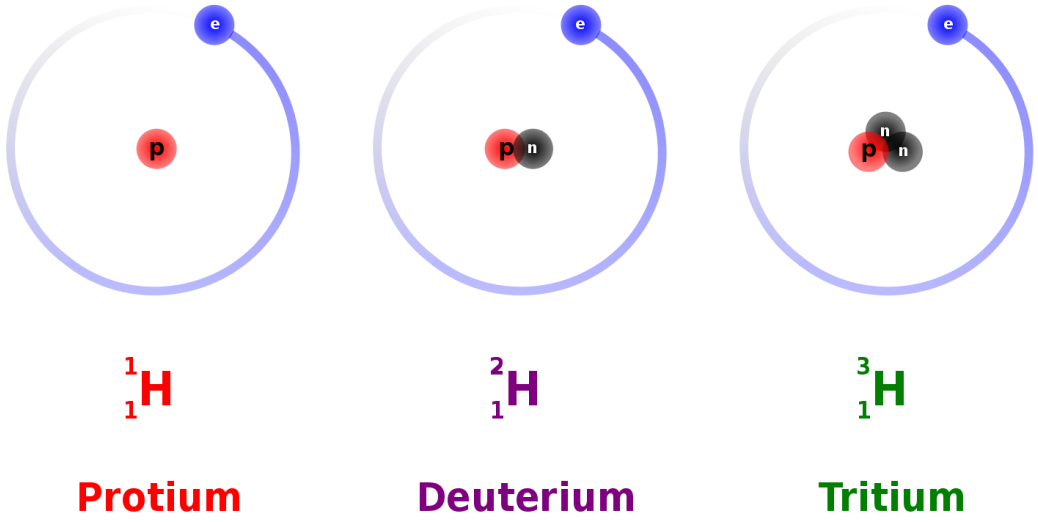
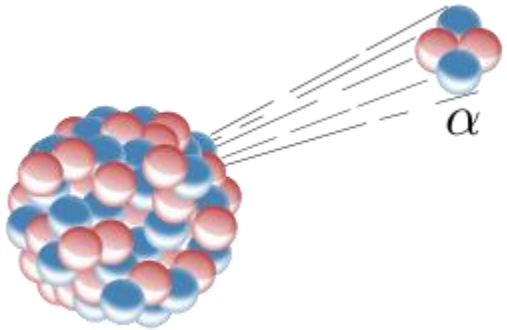


Radioactive, primordial and stable isotopes

- **Radioactive isotope**
  - **Radioactive decay** is the process by which an unstable atomic nucleus loses energy by emitting radiation, in form of an alpha particle, beta particle, neutrino. A material containing such unstable nuclei is considered **radioactive**
  - for example: alpha decay

$$\mathbf{{}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He}$$



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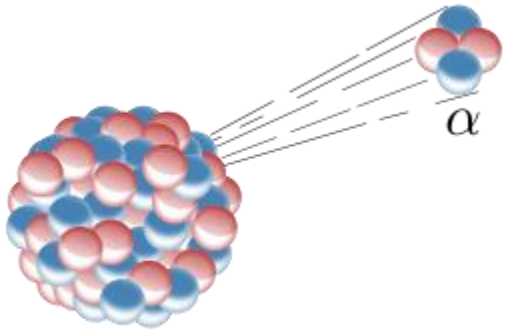


$$\boldsymbol{{}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He}$$

$${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Radioactive, primordial and stable isotopes

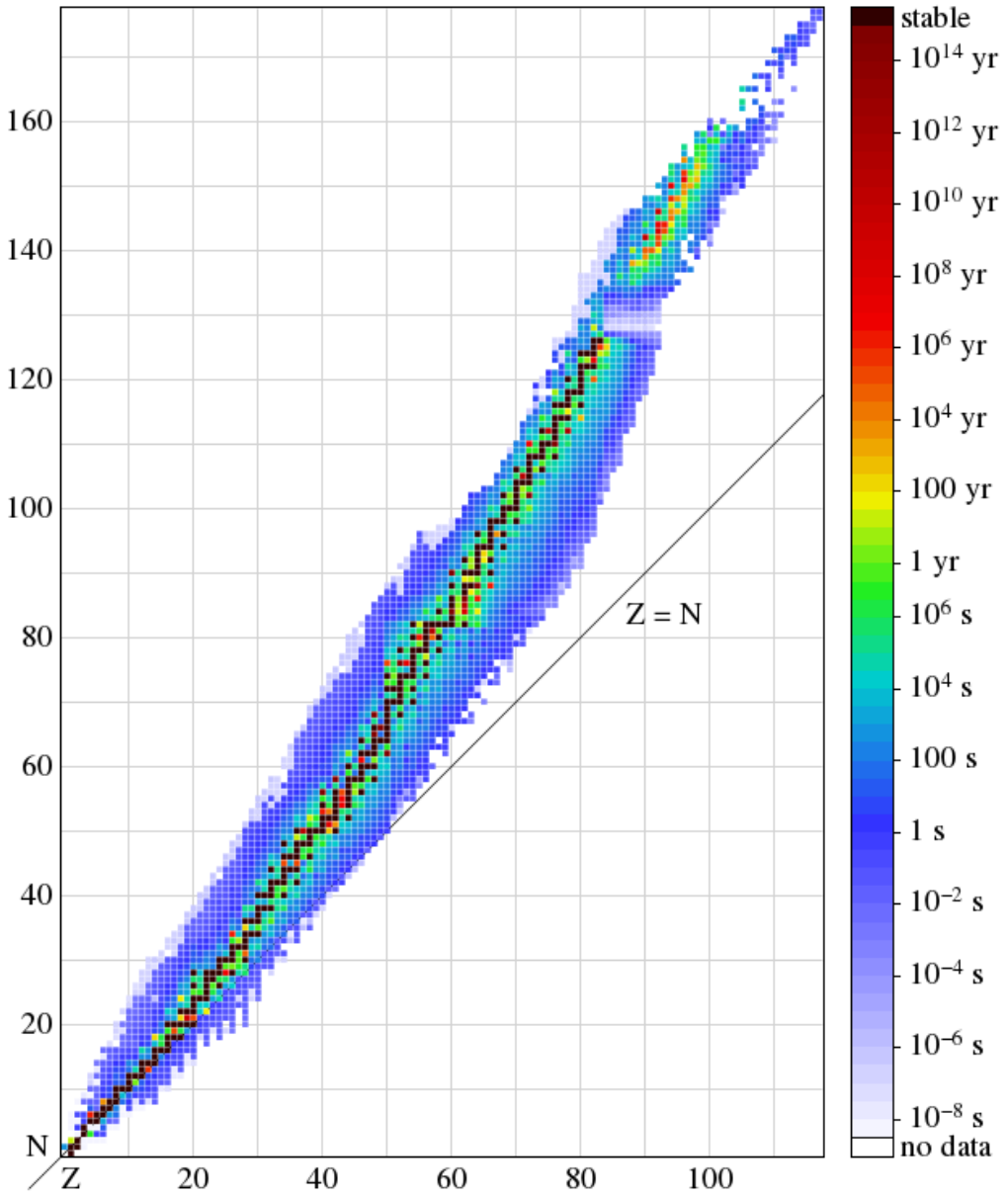
- Stable isotopes

- Primordial isotopes

Radioactive, primordial and stable isotopes

- Stable isotopes: **non-radioactive** isotopes
  - an element can have more then one stable isotope
  - eg. ^{35}Cl and ^{37}Cl
  - Hydrogen and Deuterium
  - different stable isotopes show similar chemical properties
- Primordial isotopes: **nuclides found on Earth that have existed in their current form since before Earth was formed**
  - were formed in the Big Bang
  - they are the **stable nuclides** plus the **long-lived** fraction of radionuclides (half-life longer than the age of the Earth: 4.6 billion years)
  - only 286 such nuclides are known (253 + 33)

Nuclides


160
140
120
100
80
60
40
20
N
Z
20
40
60
80
100
Z = N
stable
10^{14} yr
10^{12} yr
10^{10} yr
10^{8} yr
10^{6} yr
10^{4} yr
100 yr
1 yr
10^{6} s
10^{4} s
100 s
1 s
10^{-2} s
10^{-4} s
10^{-6} s
10^{-8} s
no data

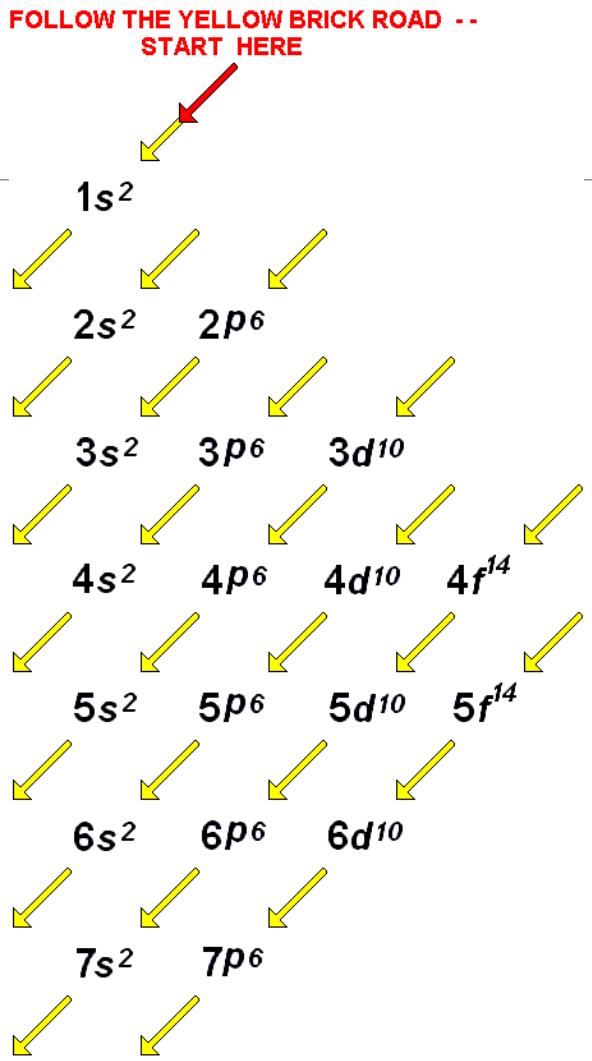
Periodically changing characteristics

- Electron configuration
- Atomic radii
- Ionization energy
- Electronegativity
- Electron affinity
- Metallic character

- Linking or bridging groups

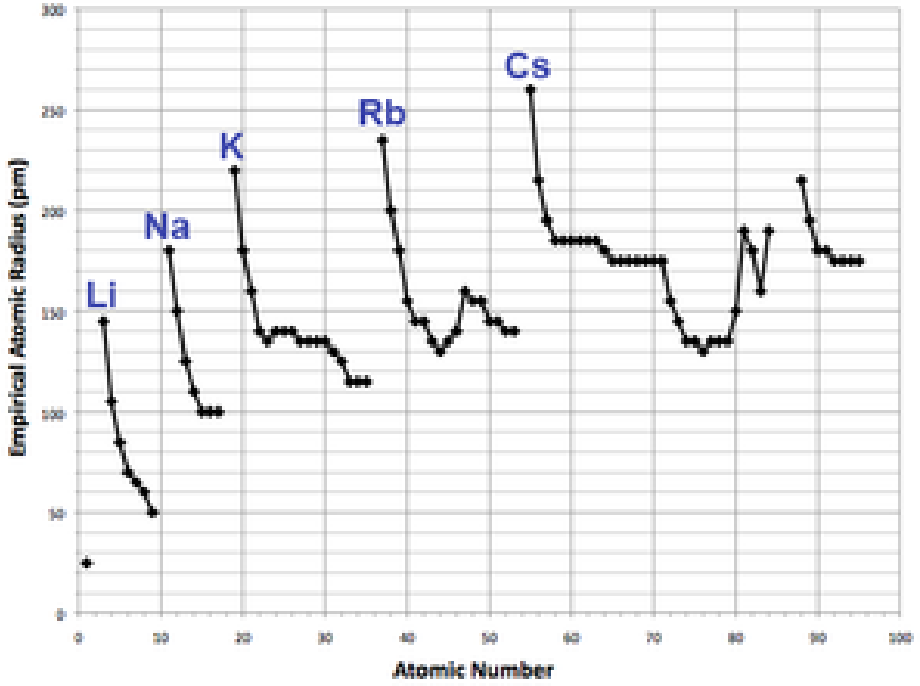
Electron configuration

- organization of electrons on electron shells
- the number of electrons and shells is increasing with the number of rows, and columns
- the filling up of the electron shells and subshells with electrons takes place according to the Madelung rule
- shells/subshells/nr. of electrons on a shell → see Quantum mechanical atomic modell



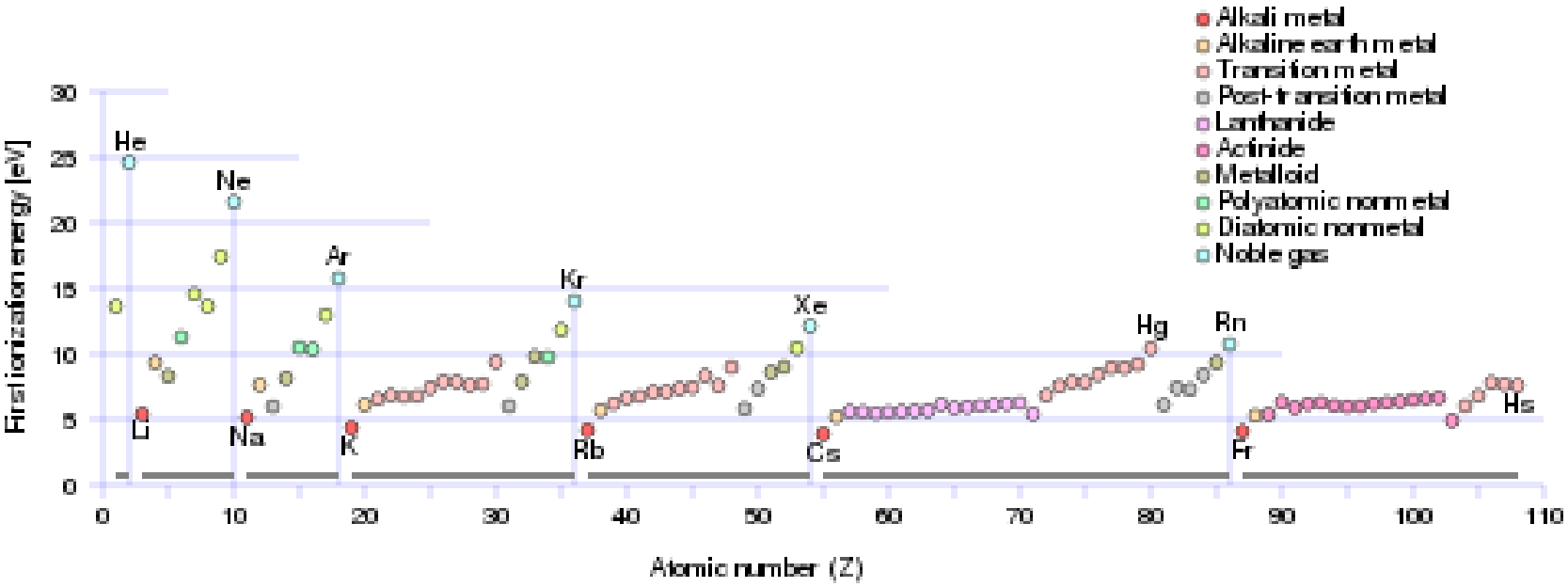
Atomic radius

- decrease along the period
- increase along each group
- ! provide important evidence for the Quantum theory
- it is explained by the weak interaction between the nucleus and the electron shell (the characteristics of the electron shell – subshells/nr of electrons on shells energy levels – affect the interaction between the nucleus and the electron shell)



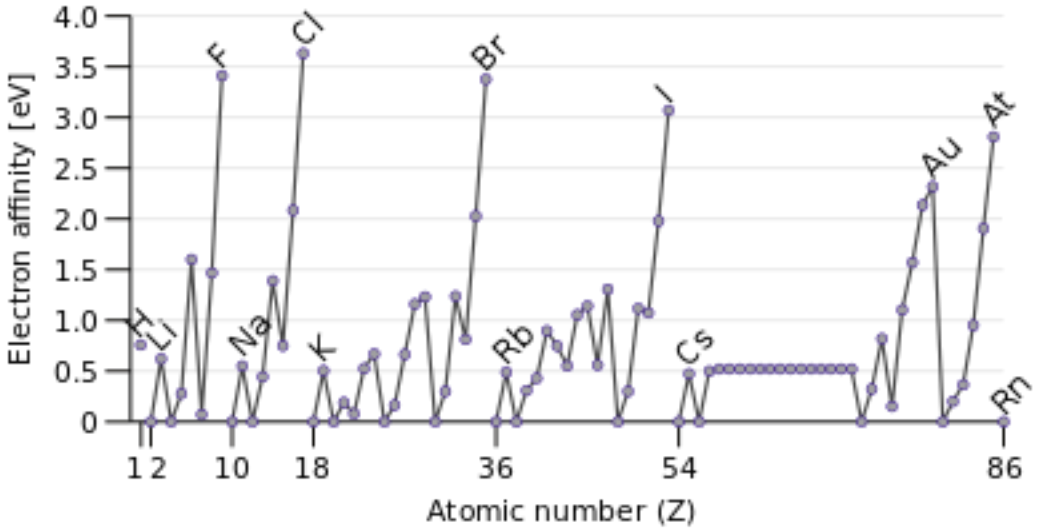
Ionization energy

- the first ionization energy is the necessary energy for removing one electron from the electron shell (second for removing a second electron)
- great jumps occur at ionizing the noble gas atoms



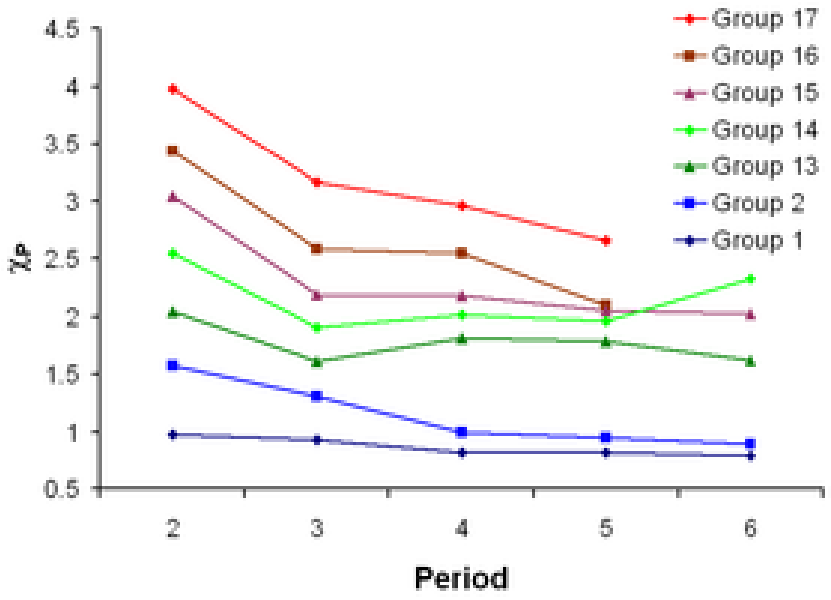
Electron affinity

- the amount of the energy released, when an electron is added to the neutral atom to form a negative ion
- when a shell is completed, the amount of released energy is increased



Electronegativity

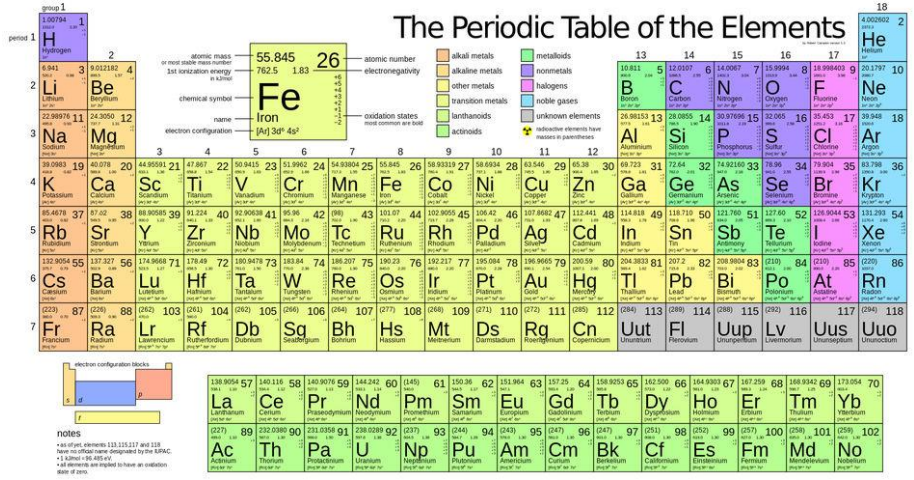
- is the tendency of an atom to attract electrons
- affected by the **atomic radii** and the **number of electrons**
- affected by the number of electrons on the last shell – **valence electrons**
- F is the most electronegative
- Cs is the least electronegative

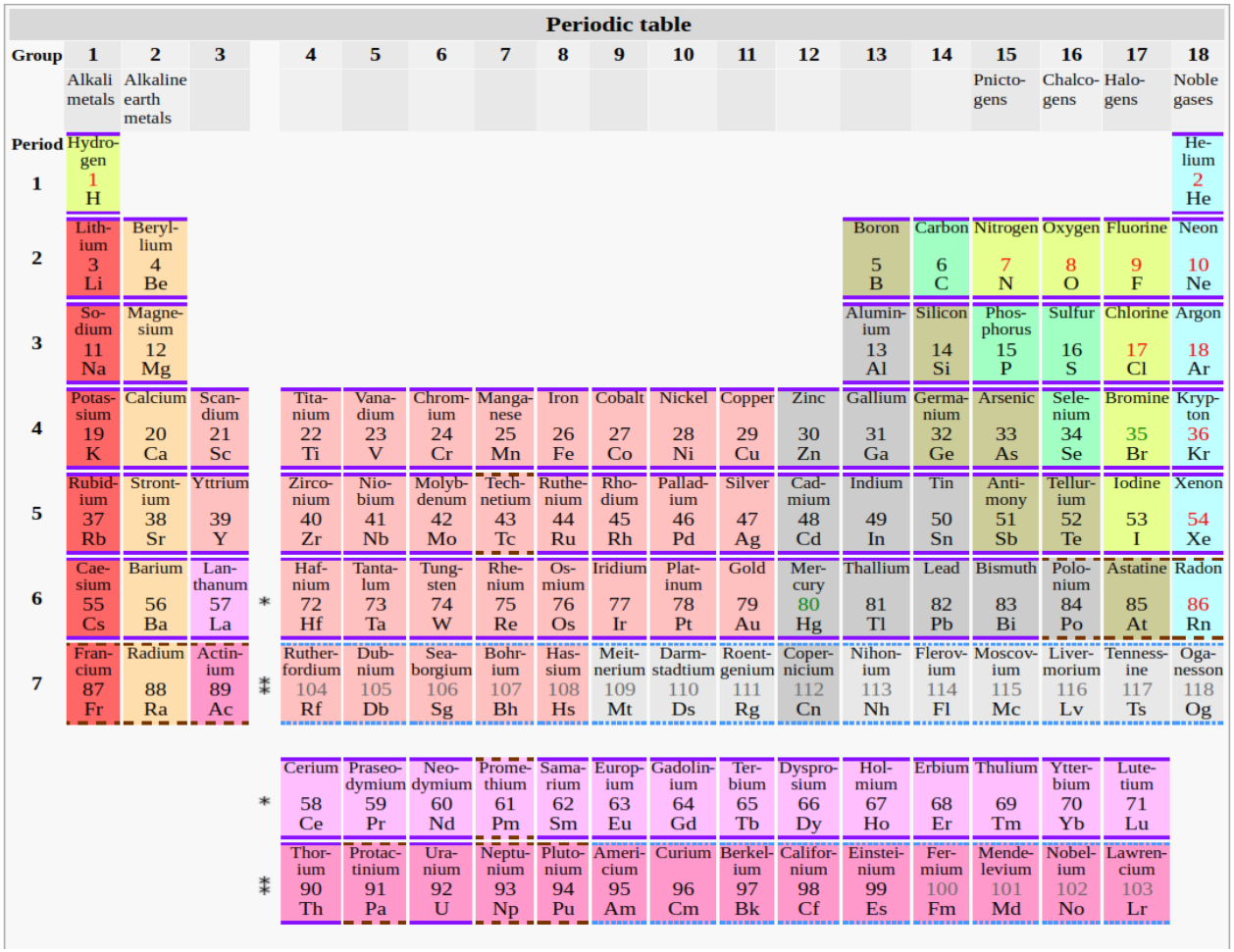


Metallic character

- the lower is the
  - electronegative character
  - electron affinity

the more METALLIC character the element has





black=solid	green=liquid	red=gas	gray=unknown	**Color of the atomic number** shows state of matter (at 0 °C and 1 atm)

Primordial	From decay	Synthetic	**Border** shows natural occurrence of the element

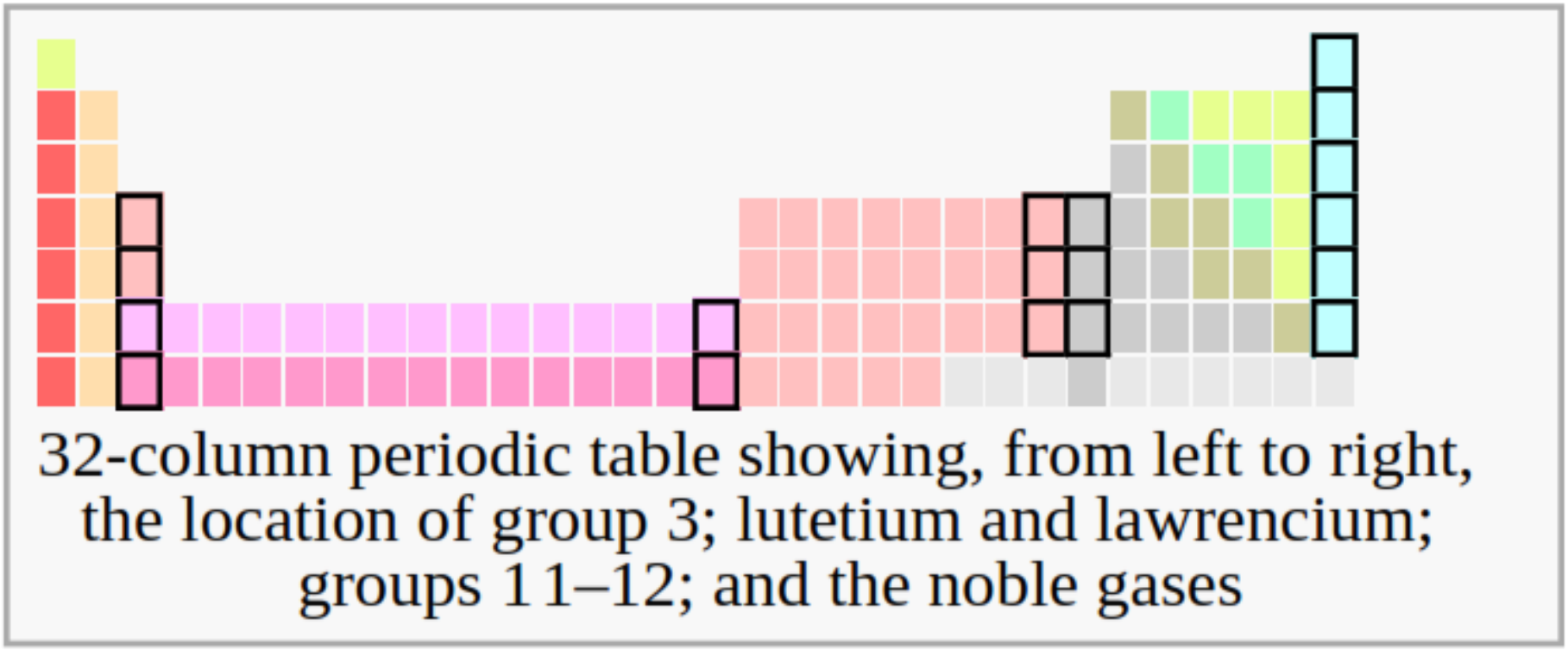
Background color shows subcategory in the metal–metalloid–nonmetal trend:

Metal						Metalloid	Nonmetal			Unknown chemical properties
Alkali metal	Alkaline earth metal	Lanthanide	Actinide	Transition metal	Post-transition metal		Polyatomic nonmetal	Diatomic nonmetal	Noble gas	

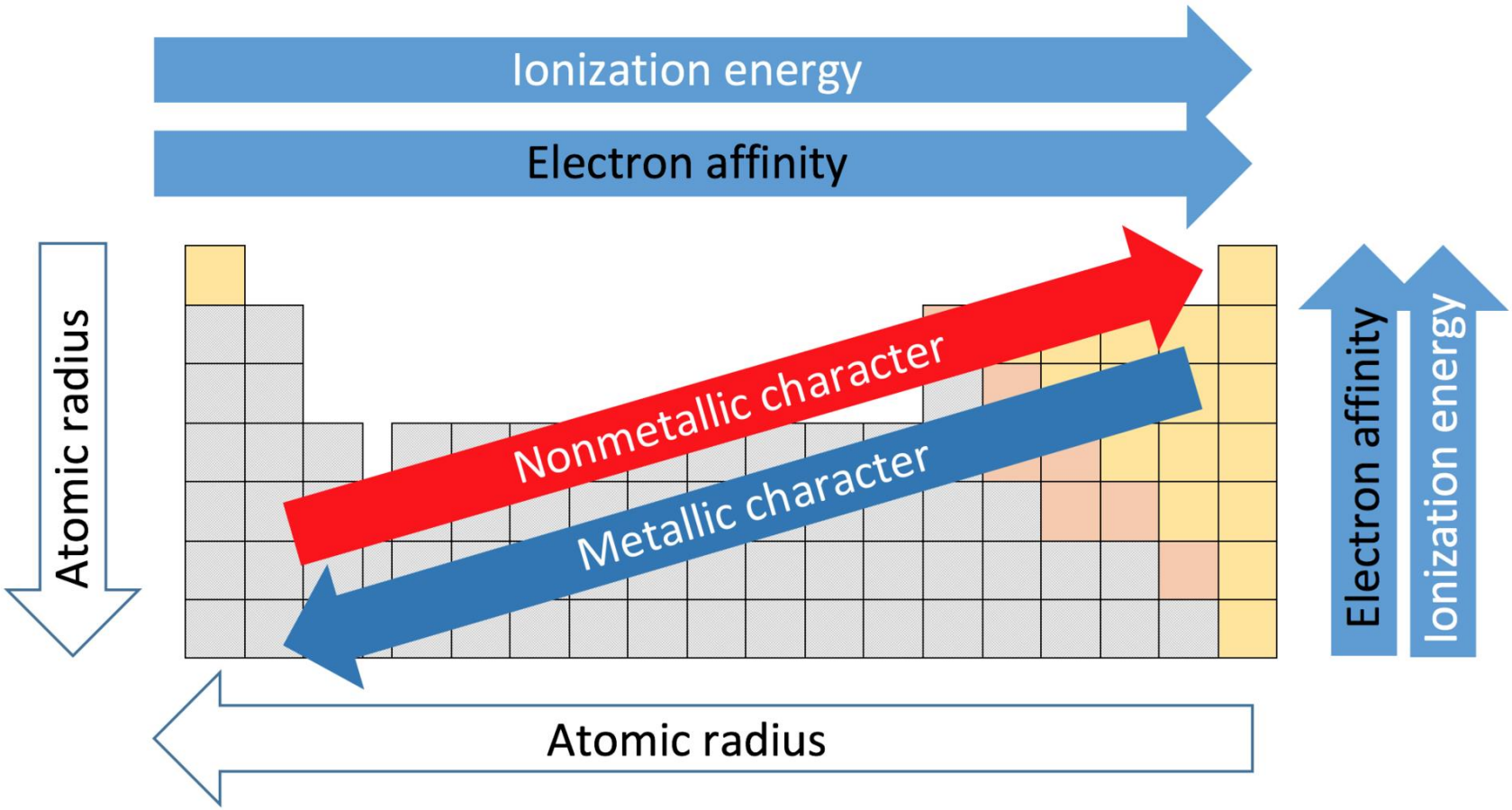
https://en.wikipedia.org/wiki/Periodic_table

Linking or bridging groups

- show characteristics in-between the two blocks that link



32-column periodic table showing, from left to right, the location of group 3; lutetium and lawrencium; groups 11–12; and the noble gases


Ionization energy
Electron affinity
Atomic radius
Nonmetallic character
Metallic character
Electron affinity
Ionization energy
Atomic radius

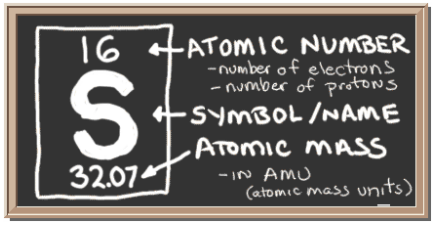
Elements, compounds, mixtures

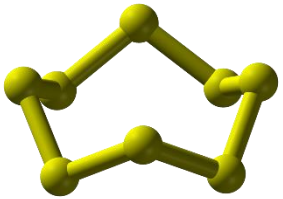
Elements

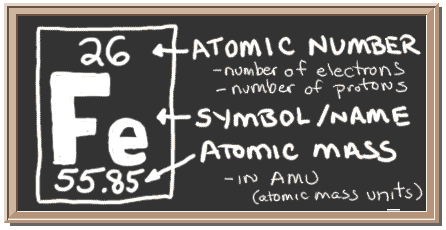
Element: a chemical element is a species of atom having the same number of protons in their atomic nuclei (that is, the same atomic number, or Z)

Example: sulphur (S), iron (Fe).

All elements have a symbol

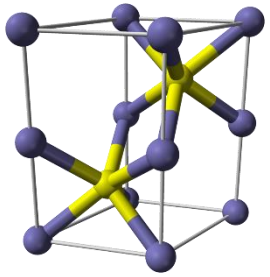


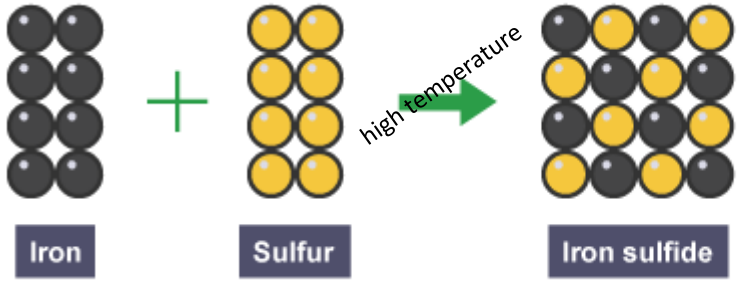




Compounds

Compounds: more than one element, **chemically combined** in a fixed number





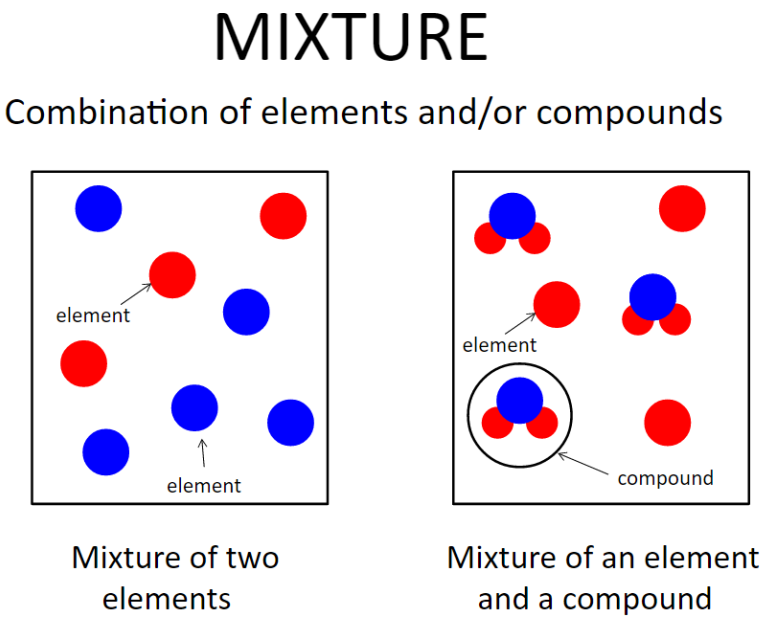
high temperature

$$Fe + S = FeS$$

for separating them we need chemical reactions

Mixtures

Mixture: different elements **not chemically combined** together



for separation we use physical methods (filtration, chrystallization, distillation)