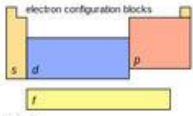
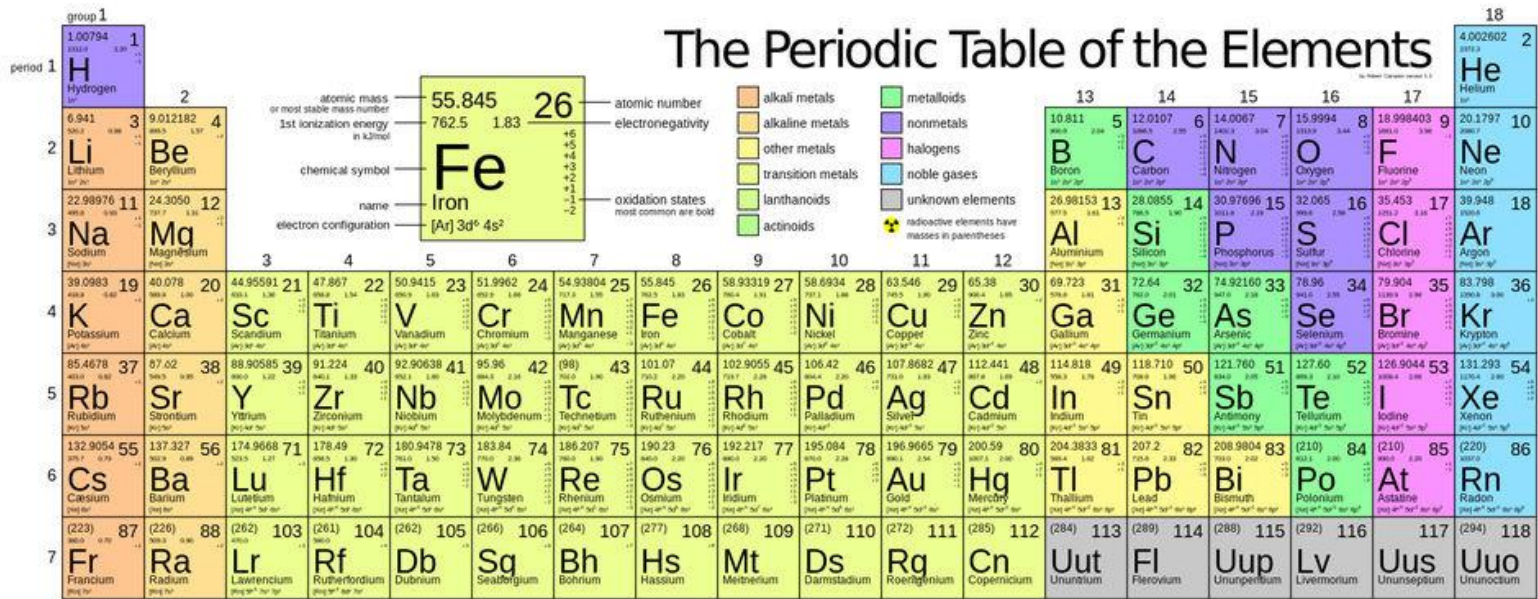


Periodic table of elements



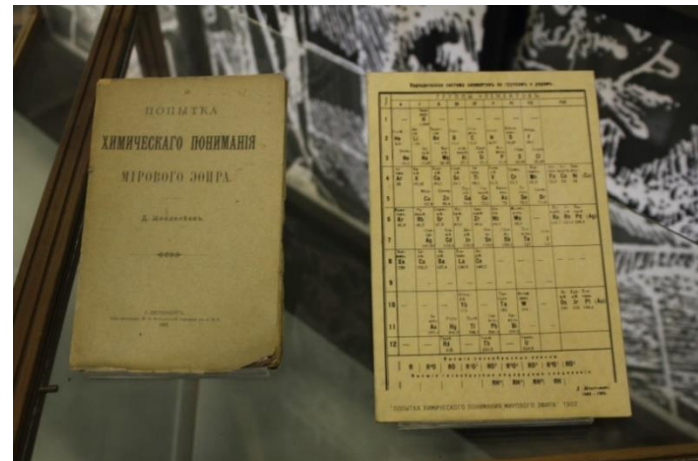
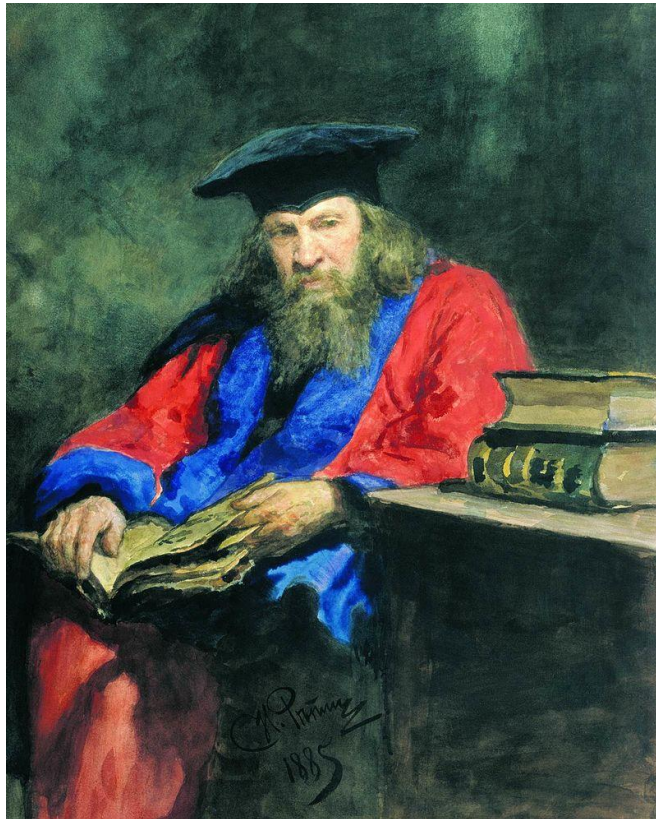
notes

- *as of yet, elements 113,115,117 and 118 have no official name designated by the IUPAC.
- +1 kJ/mol = 96.485 eV.
- +all elements are implied to have an oxidation state of zero.

138.9054 La Lanthanum	140.116 Ce Cerium	140.9076 Pr Praseodymium	144.242 Nd Neodymium	(145) Pm Promethium	150.36 Sm Samarium	151.964 Eu Europium	157.25 Gd Gadolinium	158.9253 Tb Terbium	162.500 Dy Dysprosium	164.9303 Ho Holmium	167.259 Er Erbium	168.9342 Tm Thulium	173.054 Yb Ytterbium	175.000 Lu Lutetium
(227) Ac Actinium	232.0380 Th Thorium	231.0358 Pa Protactinium	238.0289 U Uranium	(237) Np Neptunium	(244) Pu Plutonium	(243) Am Americium	(247) Cm Curium	(247) Bk Berkelium	(251) Cf Californium	(252) Es Einsteinium	(257) Fm Fermium	(258) Md Mendelevium	(259) No Nobelium	

DMITRI MENDELEEV – RUSSIAN CHEMIST, PHYSICIST

AN ATTEMPT TOWARDS THE CHEMICAL CONCEPTION OF THE ETHER



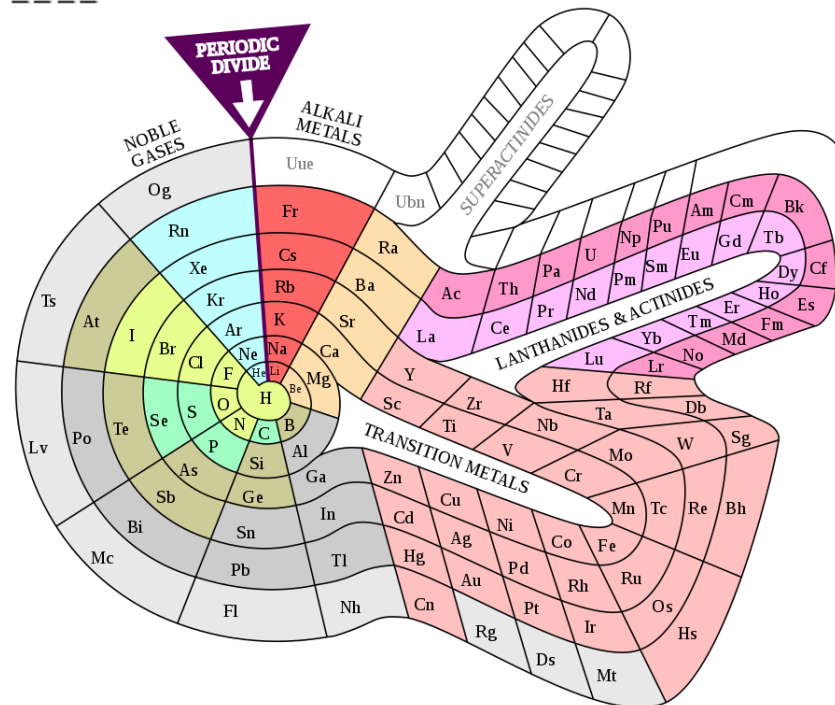
https://en.wikipedia.org/wiki/Periodic_table

Reihen	Gruppe I. — R ²⁰	Gruppe II. — RO	Gruppe III. — R ²⁰ ³	Gruppe IV. RH ⁴ RO ²	Gruppe V. RH ⁵ R ²⁰ ⁵	Gruppe VI. RH ⁶ RO ³	Gruppe VII. RH R ²⁰ 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	?Lu=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



Periodic table																																														
Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																												
	Alkali metals	Alkaline earth metals													Pnictogens	Chalcogens	Halogens	Noble gases																												
Period																																														
1	Hydrogen 1 H																	Helium 2 He																												
2	Lithium 3 Li	Beryllium 4 Be											Boron 5 B	Carbon 6 C	Nitrogen 7 N	Oxygen 8 O	Fluorine 9 F	Neon 10 Ne																												
3	Sodium 11 Na	Magnesium 12 Mg											Aluminum 13 Al	Silicon 14 Si	Phosphorus 15 P	Sulfur 16 S	Chlorine 17 Cl	Argon 18 Ar																												
4	Potassium 19 K	Calcium 20 Ca	Scandium 21 Sc	Titanium 22 Ti	Vanadium 23 V	Chromium 24 Cr	Manganese 25 Mn	Iron 26 Fe	Cobalt 27 Co	Nickel 28 Ni	Copper 29 Cu	Zinc 30 Zn	Gallium 31 Ga	Germanium 32 Ge	Arsenic 33 As	Selenium 34 Se	Bromine 35 Br	Krypton 36 Kr																												
5	Rubidium 37 Rb	Strontium 38 Sr	Yttrium 39 Y	Zirconium 40 Zr	Niobium 41 Nb	Molybdenum 42 Mo	Technetium 43 Tc	Ruthenium 44 Ru	Rhodium 45 Rh	Palladium 46 Pd	Silver 47 Ag	Cadmium 48 Cd	Indium 49 In	Tin 50 Sn	Antimony 51 Sb	Tellurium 52 Te	Iodine 53 I	Xenon 54 Xe																												
6	Cesium 55 Cs	Barium 56 Ba	Lanthanum 57 La	Hafnium 72 Hf	Tantalum 73 Ta	Tungsten 74 W	Rhenium 75 Re	Osmium 76 Os	Iridium 77 Ir	Platinum 78 Pt	Gold 79 Au	Mercury 80 Hg	Thallium 81 Tl	Lead 82 Pb	Bismuth 83 Bi	Polonium 84 Po	Astatine 85 At	Radon 86 Rn																												
7	Francium 87 Fr	Radium 88 Ra	Actinium 89 Ac	Rutherfordium 104 Rf	Dubnium 105 Db	Seaborgium 106 Sg	Bohrium 107 Bh	Hassium 108 Hs	Meitnerium 109 Mt	Darmstadtium 110 Ds	Roentgenium 111 Rg	Copernicium 112 Cn	Nihonium 113 Nh	Flerovium 114 Fl	Moscovium 115 Mc	Livermorium 116 Lv	Tennessee 117 Ts	Oganesson 118 Og																												
				<table border="1"> <tr> <td>Cerium 58 Ce</td> <td>Praseodymium 59 Pr</td> <td>Neodymium 60 Nd</td> <td>Promethium 61 Pm</td> <td>Samarium 62 Sm</td> <td>Europium 63 Eu</td> <td>Gadolinium 64 Gd</td> <td>Terbium 65 Tb</td> <td>Dysprosium 66 Dy</td> <td>Holmium 67 Ho</td> <td>Erbium 68 Er</td> <td>Thulium 69 Tm</td> <td>Ytterbium 70 Yb</td> <td>Lutetium 71 Lu</td> </tr> <tr> <td>Thorium 90 Th</td> <td>Protactinium 91 Pa</td> <td>Uranium 92 U</td> <td>Neptunium 93 Np</td> <td>Plutonium 94 Pu</td> <td>Americium 95 Am</td> <td>Curium 96 Cm</td> <td>Berkelium 97 Bk</td> <td>Californium 98 Cf</td> <td>Einsteinium 99 Es</td> <td>Fermium 100 Fm</td> <td>Mendelevium 101 Md</td> <td>Nobelium 102 No</td> <td>Lawrencium 103 Lr</td> </tr> </table>															Cerium 58 Ce	Praseodymium 59 Pr	Neodymium 60 Nd	Promethium 61 Pm	Samarium 62 Sm	Europium 63 Eu	Gadolinium 64 Gd	Terbium 65 Tb	Dysprosium 66 Dy	Holmium 67 Ho	Erbium 68 Er	Thulium 69 Tm	Ytterbium 70 Yb	Lutetium 71 Lu	Thorium 90 Th	Protactinium 91 Pa	Uranium 92 U	Neptunium 93 Np	Plutonium 94 Pu	Americium 95 Am	Curium 96 Cm	Berkelium 97 Bk	Californium 98 Cf	Einsteinium 99 Es	Fermium 100 Fm	Mendelevium 101 Md	Nobelium 102 No	Lawrencium 103 Lr
Cerium 58 Ce	Praseodymium 59 Pr	Neodymium 60 Nd	Promethium 61 Pm	Samarium 62 Sm	Europium 63 Eu	Gadolinium 64 Gd	Terbium 65 Tb	Dysprosium 66 Dy	Holmium 67 Ho	Erbium 68 Er	Thulium 69 Tm	Ytterbium 70 Yb	Lutetium 71 Lu																																	
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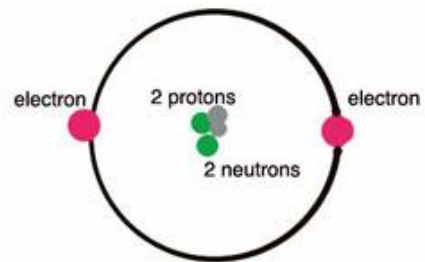
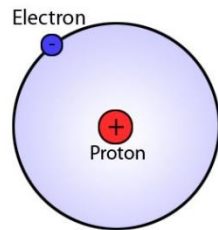
black=solid
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Color of the atomic numbers shows state of matter (at 0 °C and 1 atm)

Primordial
From decay
Synthetic
Border shows natural occurrence of the element

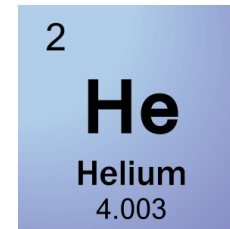
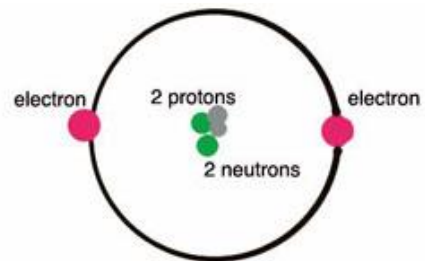
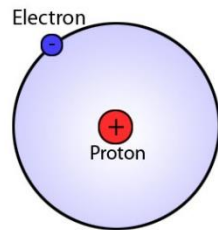
Background color shows subcategory in the metal–metalloid–nonmetal trend:

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

Examples

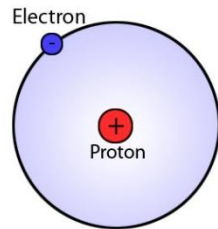


Examples

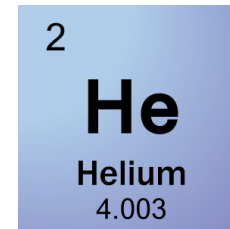
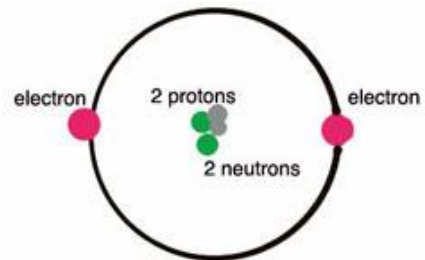


Examples

Hydrogen: 1 proton, 1 electron

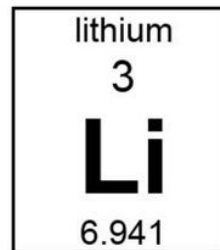
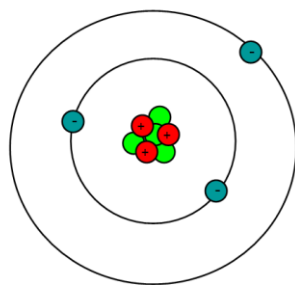


Helium: 2 electrons, 2 protons, 2 neutrons



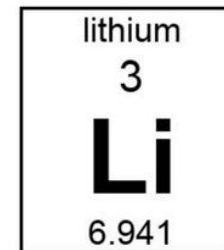
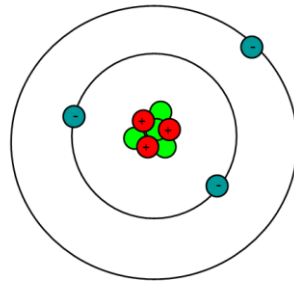
The **first energy level** can hold a **maximum of 2 electrons**

Examples



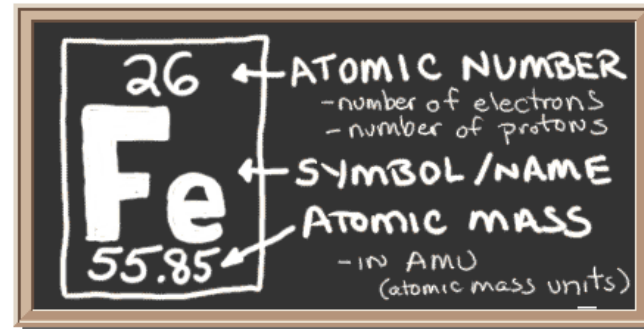
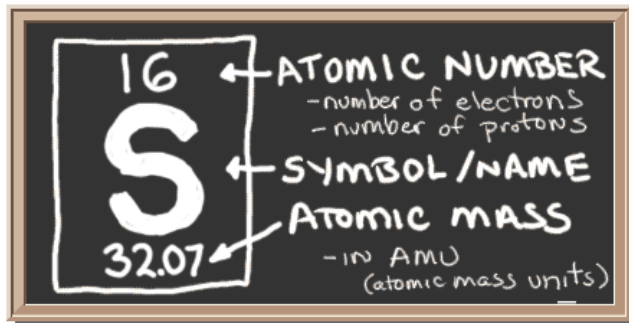
Examples

Lithium: 3 electrons, 3 protons, 4 neutrons



On the outer 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 twelfth of the mass of a carbon-12 atom
($1\text{AMU} = 1.66053904 \times 10^{-27}$ kilograms)

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

S: 32 protons + neutrons

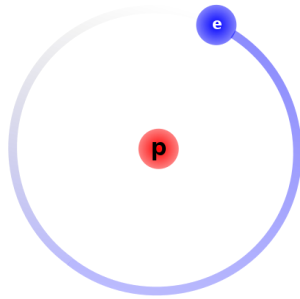
Fe: 56 protons + neutrons

Isotopes

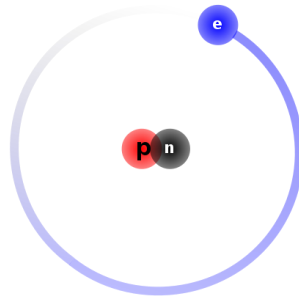
Isotopes are variants of a particular chemical element which differ in neutron number. All isotopes of a given element have the same number of protons in each atom.

Isotopes

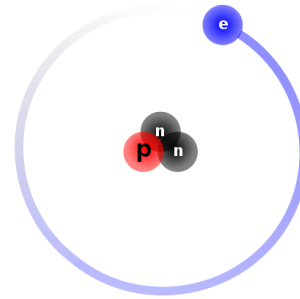
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Protium



Deuterium



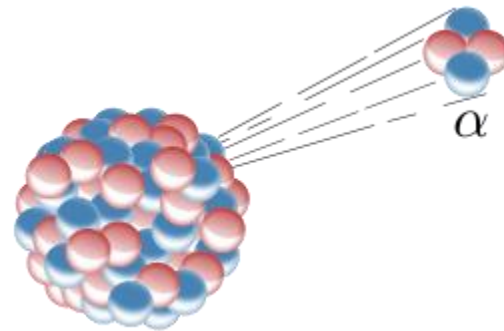
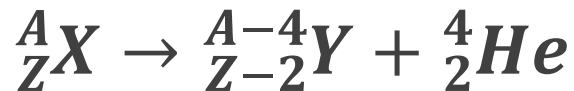
Tritium

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

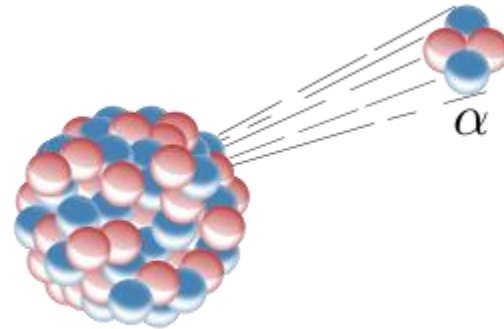
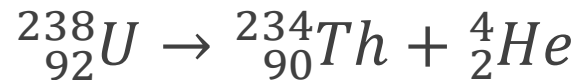
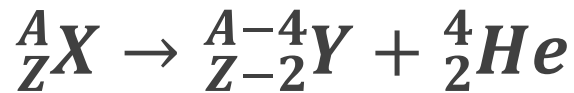


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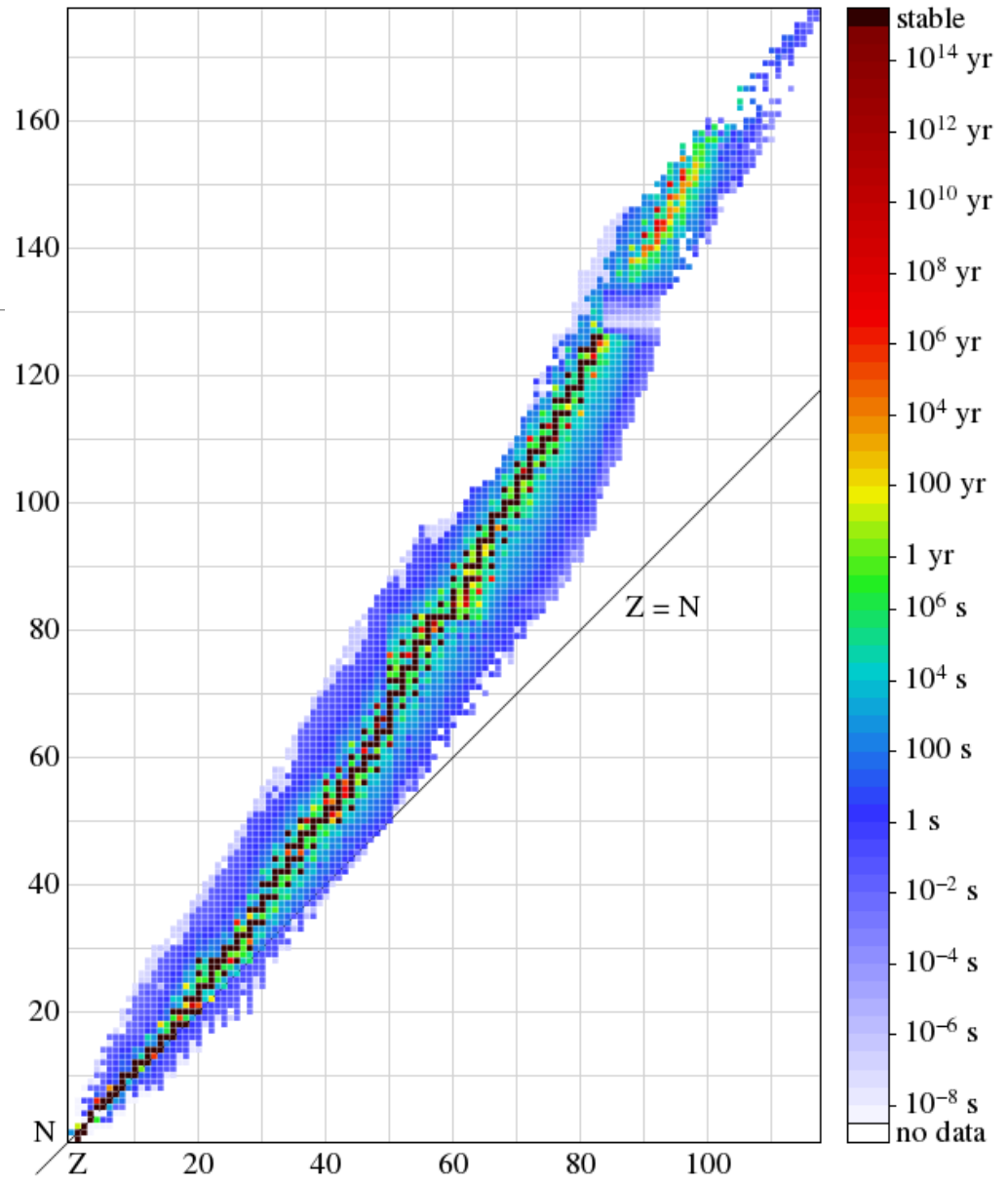
Stable isotopes

Primordial isotopes

Radioactive, primordial and stable isotopes

- Stable isotopes: **non-radioactive** isotopes
 - an element can have more than 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



Periodically changing characteristics

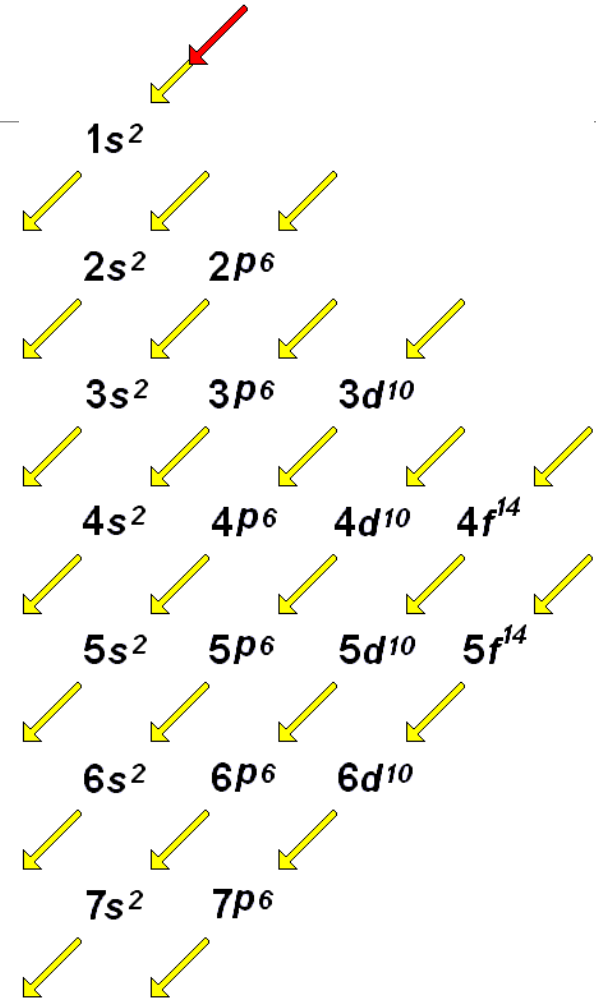
- Electron configuration
- Atomic radii
- Ionization energy
- Electronegativity
- Electron affinity
- Metallic character

- Linking or bridging groups

Electron configuration

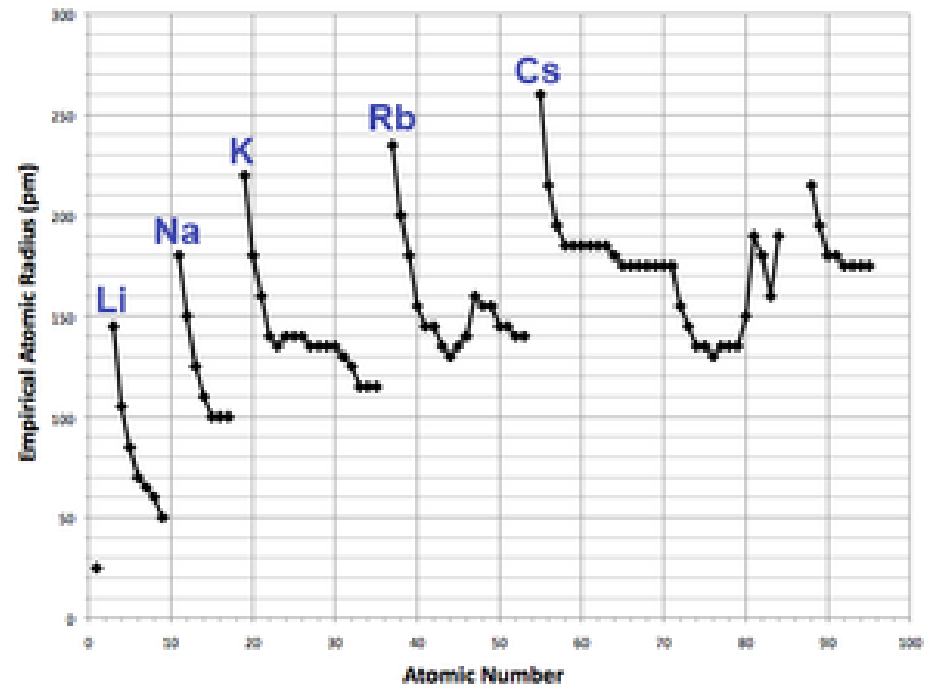
- organization of electrons on electron shells
- the number of electrons and shells is increasing with the number of rows, and columns
- the filling up of the electron shells and subshells with electrons takes place according to the Madelung rule
- shells/subshells/nr. of electrons on a shell → see Quantum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

FOLLOW THE YELLOW BRICK ROAD --
START HERE



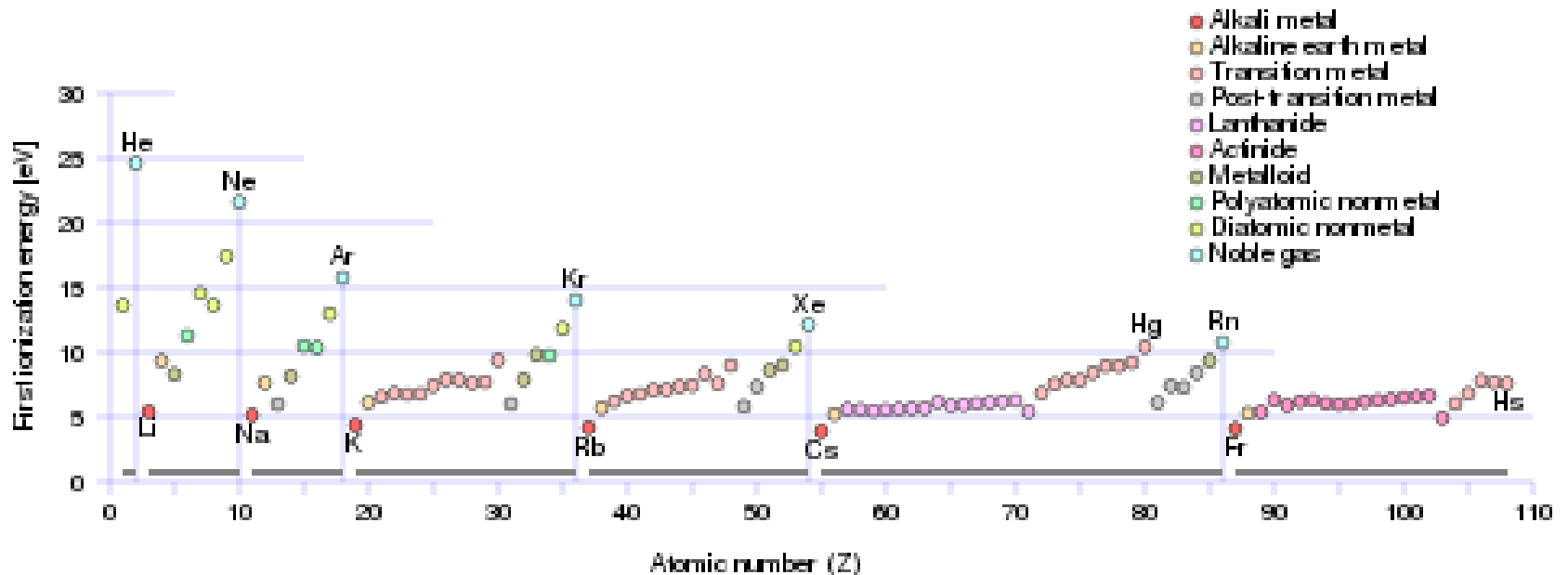
Atomic radius

- ❑ 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)



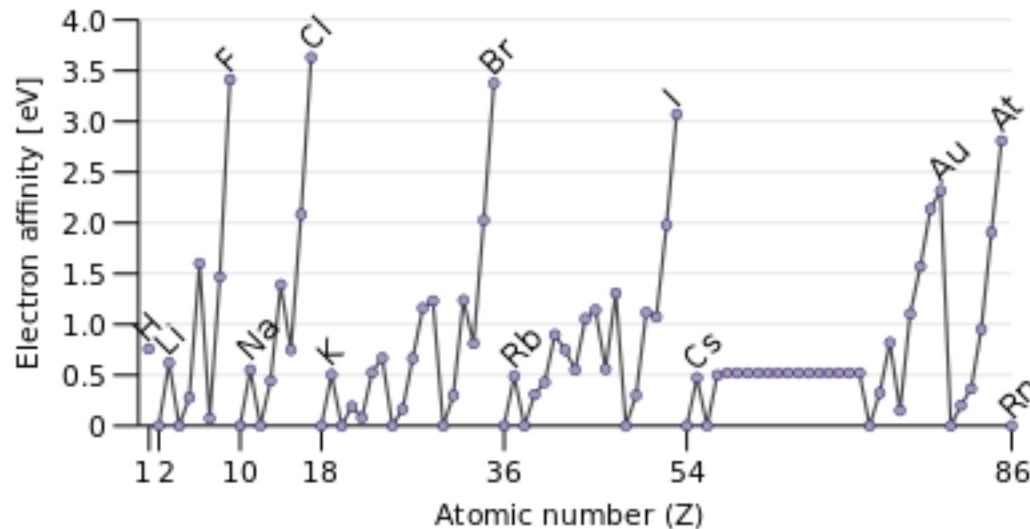
Ionization energy

- 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



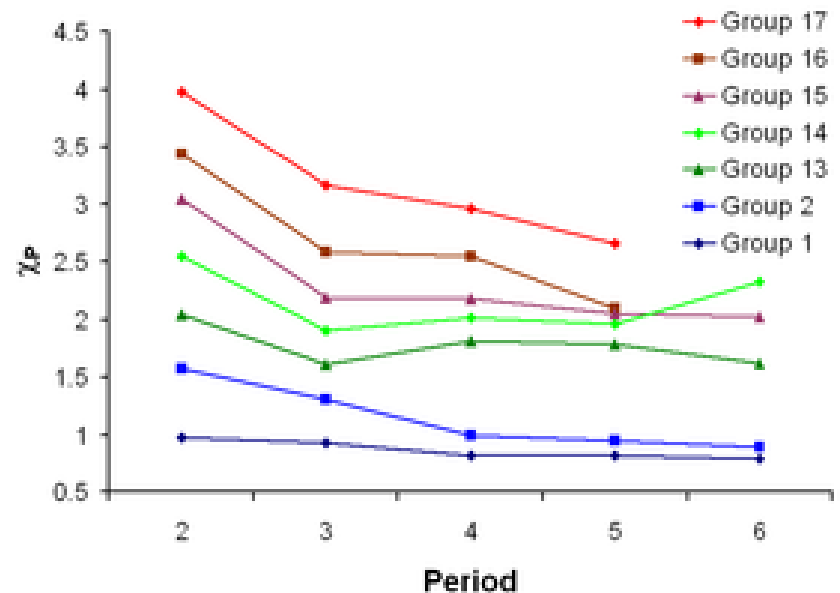
Electron affinity

- ❑ 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

The Periodic Table of the Elements

Legend:

- alkali metals
- alkaline earth metals
- transition metals
- lanthanoids
- actinoids
- metalloids
- nonmetals
- halogens
- noble gases
- unknown elements

Legend:

- s
- p
- d
- f

Notes:

- * s and p block elements 113, 115, 117 and 119 have no electron configuration assigned by IUPAC.
- * 1 block - 86 AEs + f
- * 14 elements are implied to have an oxidation state of zero.

Periodic table

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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Color of the atomic numbers shows state of matter (at 0 °C and 1 atm)

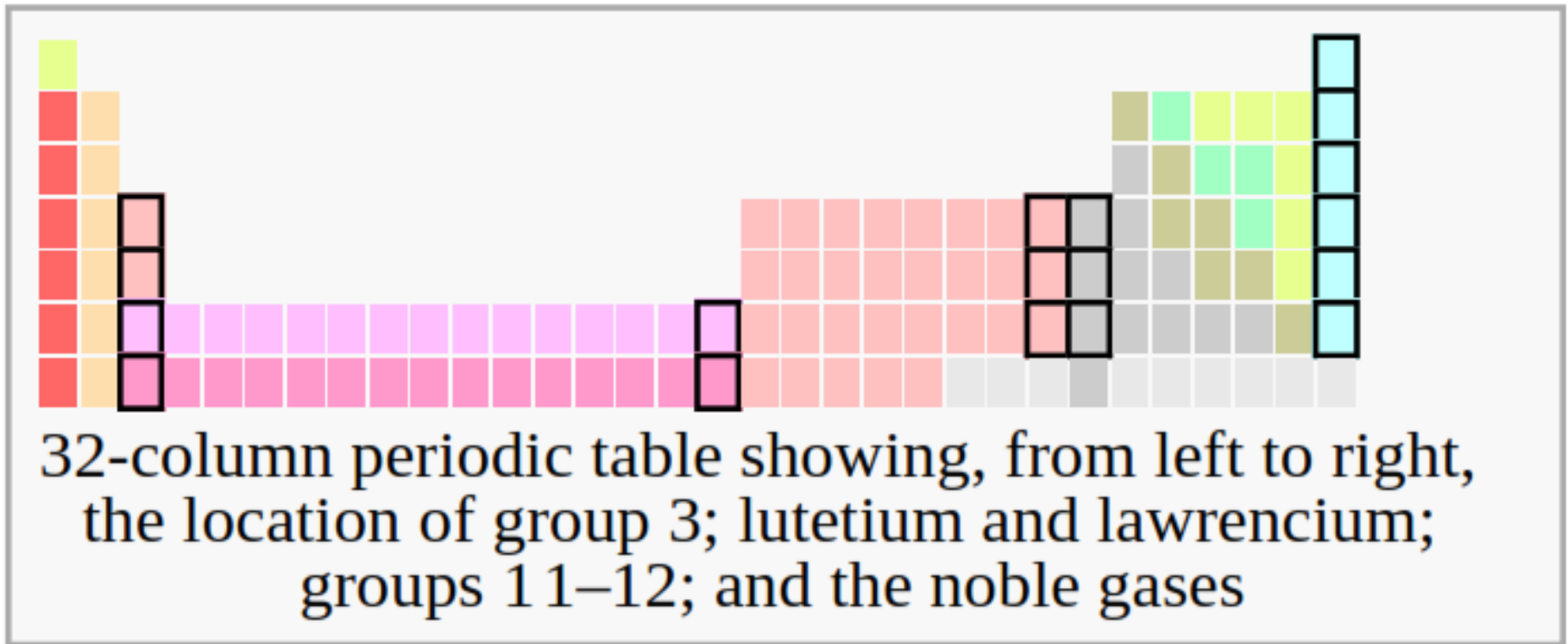
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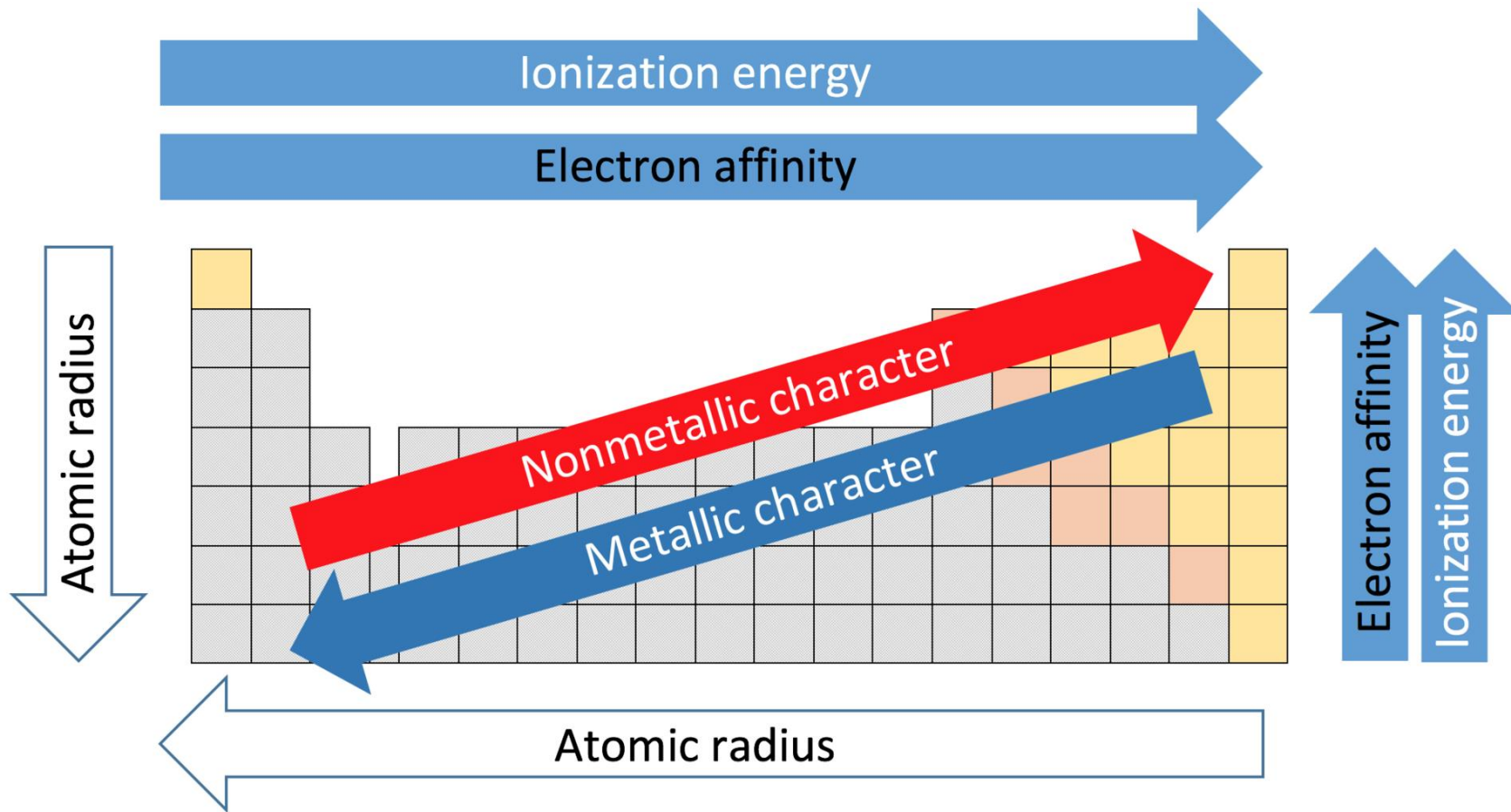
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Linking or bridging groups

- show characteristics in-between the two blocks that link





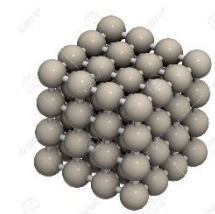
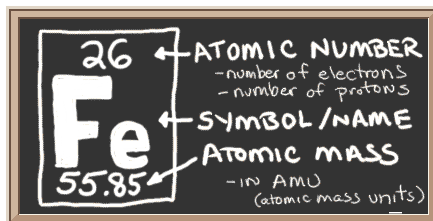
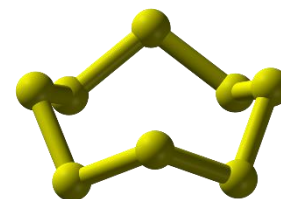
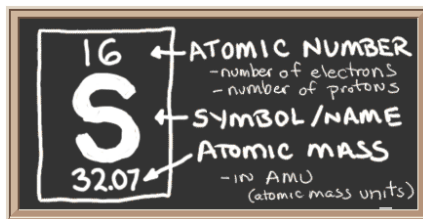
Elements,
compounds,
mixtures

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)

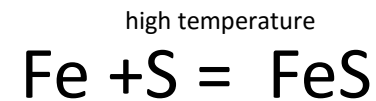
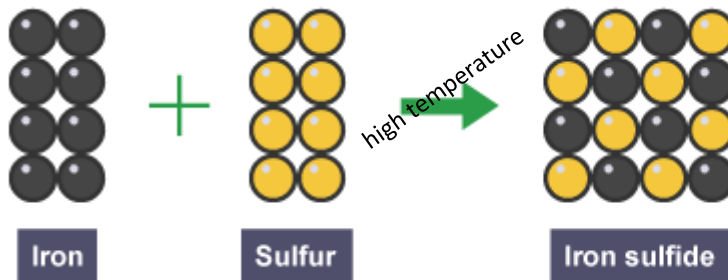
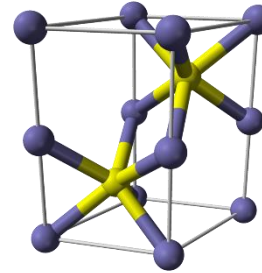
Example: sulphur (S), iron (Fe).

All elements have a symbol



Compounds

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



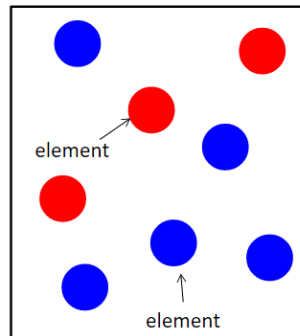
for separating them we need chemical reactions

Mixtures

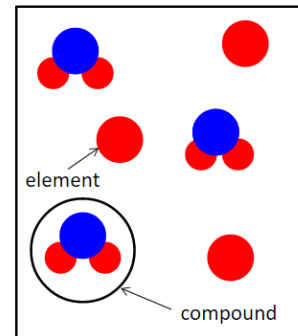
Mixture: different elements **not chemically combined** together

MIXTURE

Combination of elements and/or compounds



Mixture of two
elements



Mixture of an element
and a compound

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