Atomes et molécules

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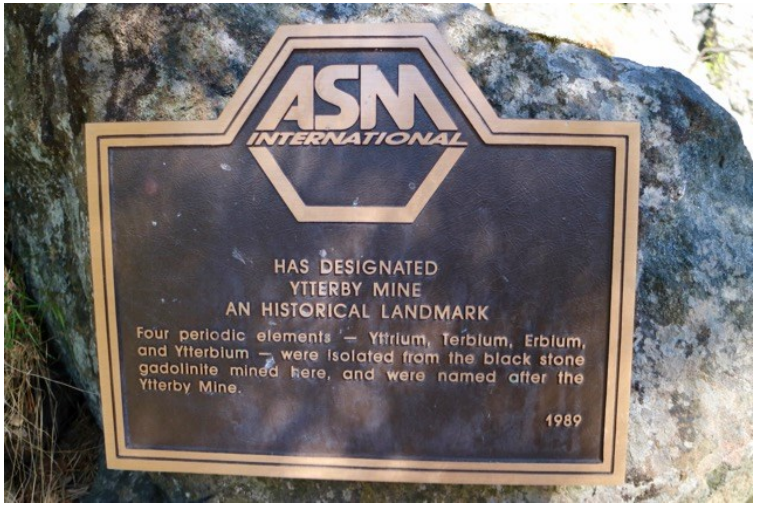
Chapter 4 : Periodic classification of elements



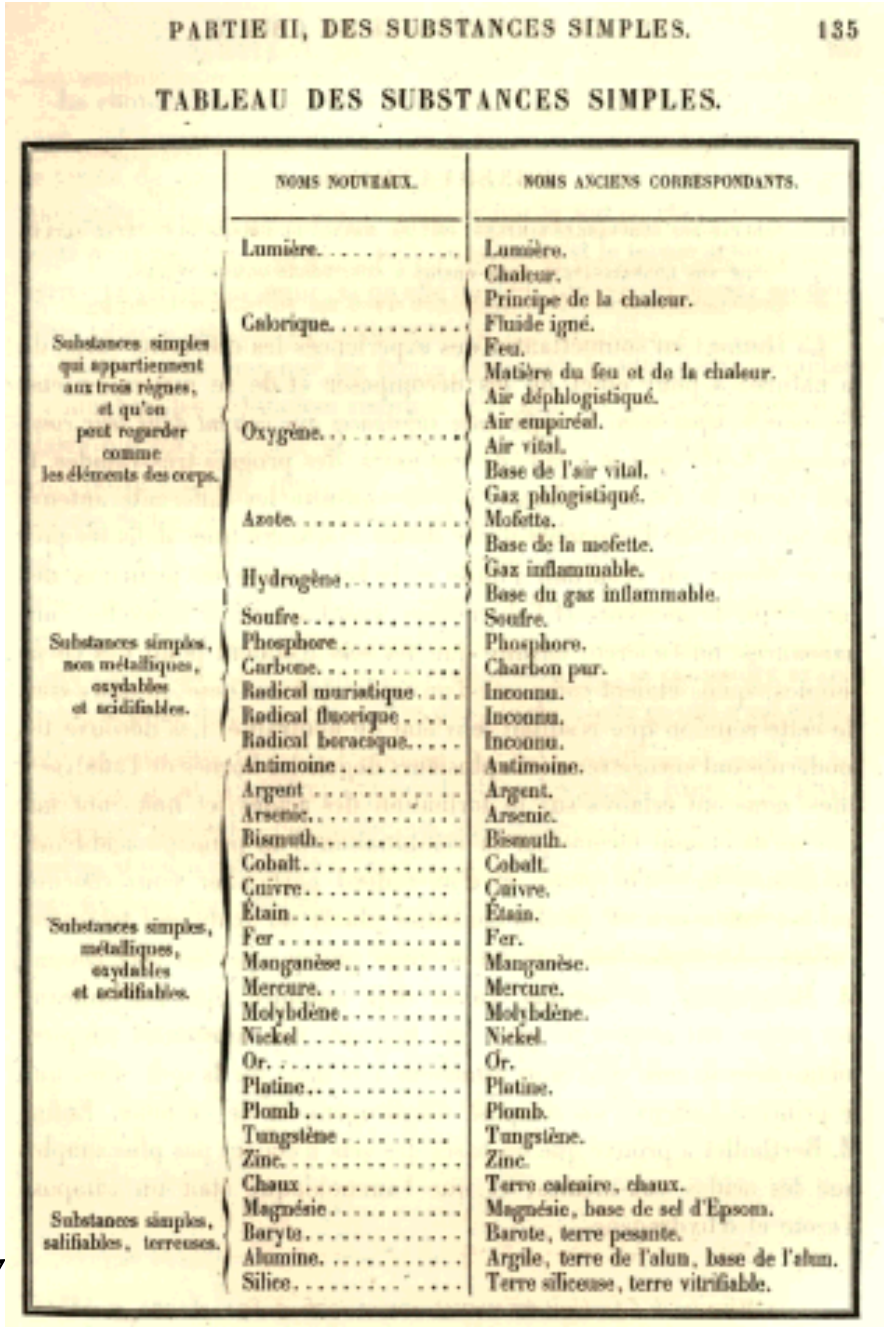
.. To all of the elements for a happy birthday to Dmitri Mendeleev, whose 1869 version of the periodic table helped us order and understand our world.

Chapter 4 – Index

Introduction:

1 – Modern periodic classification – relation with electronic configuration

2 – Metals and nonmetals



PARTIE II, DES SUBSTANCES SIMPLES. 135

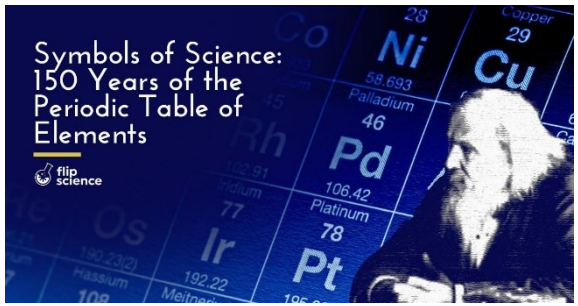
TABLEAU DES SUBSTANCES SIMPLES.

	NOMS NOUVEAUX.	NOMS ANCIENS CORRESPONDANTS.
Substances simples qui appartiennent aux trois règnes, et qu'on peut regarder comme les éléments des corps.	Lumière	Lumière.
	Calorique	Chaleur.
		Principe de la chaleur.
		Fluide igné.
		Feu.
		Matière du feu et de la chaleur.
	Oxygène	Air déphlogistiqué.
		Air empiréal.
		Air vital.
		Base de l'air vital.
	Azote	Gaz phlogistiqué.
		Mofette.
		Base de la mofette.
	Hydrogène	Gaz inflammable.
		Base du gaz inflammable.
Substances simples, non métalliques, oxydables et acidifiables.	Soufre	Soufre.
	Phosphore	Phosphore.
	Carbone	Charbon pur.
	Radical muriatique	Inconnu.
	Radical fluorique	Inconnu.
	Radical boracique	Inconnu.
Substances simples, métalliques, oxydables et acidifiables.	Antimoine	Antimoine.
	Argent	Argent.
	Arsenic	Arsenic.
	Bismuth	Bismuth.
	Cobalt	Cobalt.
	Cuivre	Cuivre.
	Étain	Étain.
	Fer	Fer.
	Manganèse	Manganèse.
	Mercure	Mercure.
	Molybdène	Molybdène.
	Nickel	Nickel.
	Or	Or.
	Platine	Platine.
	Plomb	Plomb.
	Tungstène	Tungstène.
	Zinc	Zinc.
Substances simples, salifiables, terreuses.	Chaux	Terre calcaire, chaux.
	Magnésie	Magnésie, base de sel d'Epsom.
	Baryte	Barote, terre pesante.
	Alumine	Argile, terre de l'alun, base de l'alun.
	Silice	Terre siliceuse, terre vitrifiable.

La liste de Lavoisier. 1787

United Nations Educational, Scientific and Cultural Organization

2019 IYPT International Year of the Periodic Table of Chemical Elements



INTERNATIONAL YEAR OF THE PERIODIC TABLE 2019

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ,

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ

			Ti=50	Zr= 90	?=180.
			V=51	Nb= 94	Ta=182.
			Cr=52	Mo= 96	W=186.
			Mn=55	Rh=104,4	Pt=197,1
			Fe=56	Ru=104,4	Ir=198.
			Ni=Co=59	Pd=106,6	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be= 9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,3	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Д. Менделѣевъ

Mendeleev's 1869 periodic table: *An experiment on a system of elements. Based on their atomic weights and chemical similarities.*

Introduction

Reihen	Gruppe I. — R^1O	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	—	— — — —

Le tableau périodique de Mendeleïev (1869)

Introduction

XIX century: by means of experimental observations, chemists have tried to find analogies and relations among the chemical species (about 60 had been discovered up to that moment) with the aim of classifying and grouping them in 'families', based on their chemical properties.

The first classification was proposed by **Mendeleev**. It was based on increasing atomic mass (the laws dictating the electronic distribution around the nucleus, i.e., the electronic structure of atoms, was yet unknown)

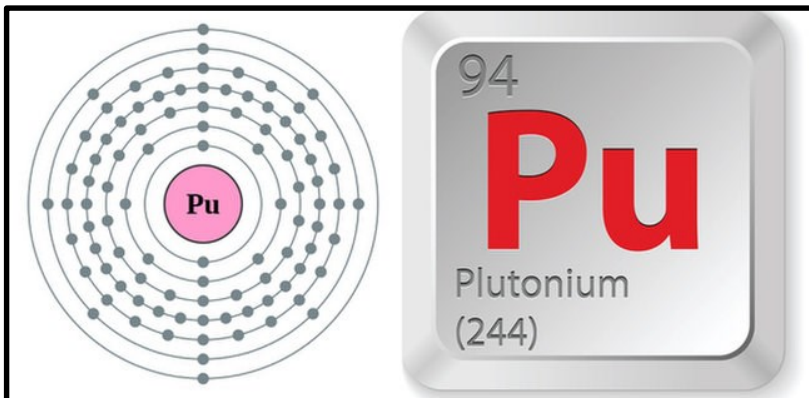
Nowadays the elements are arranged by increasing atomic number, Z.

A **chemical element** is a pure chemical substance consisting of one type of atom.

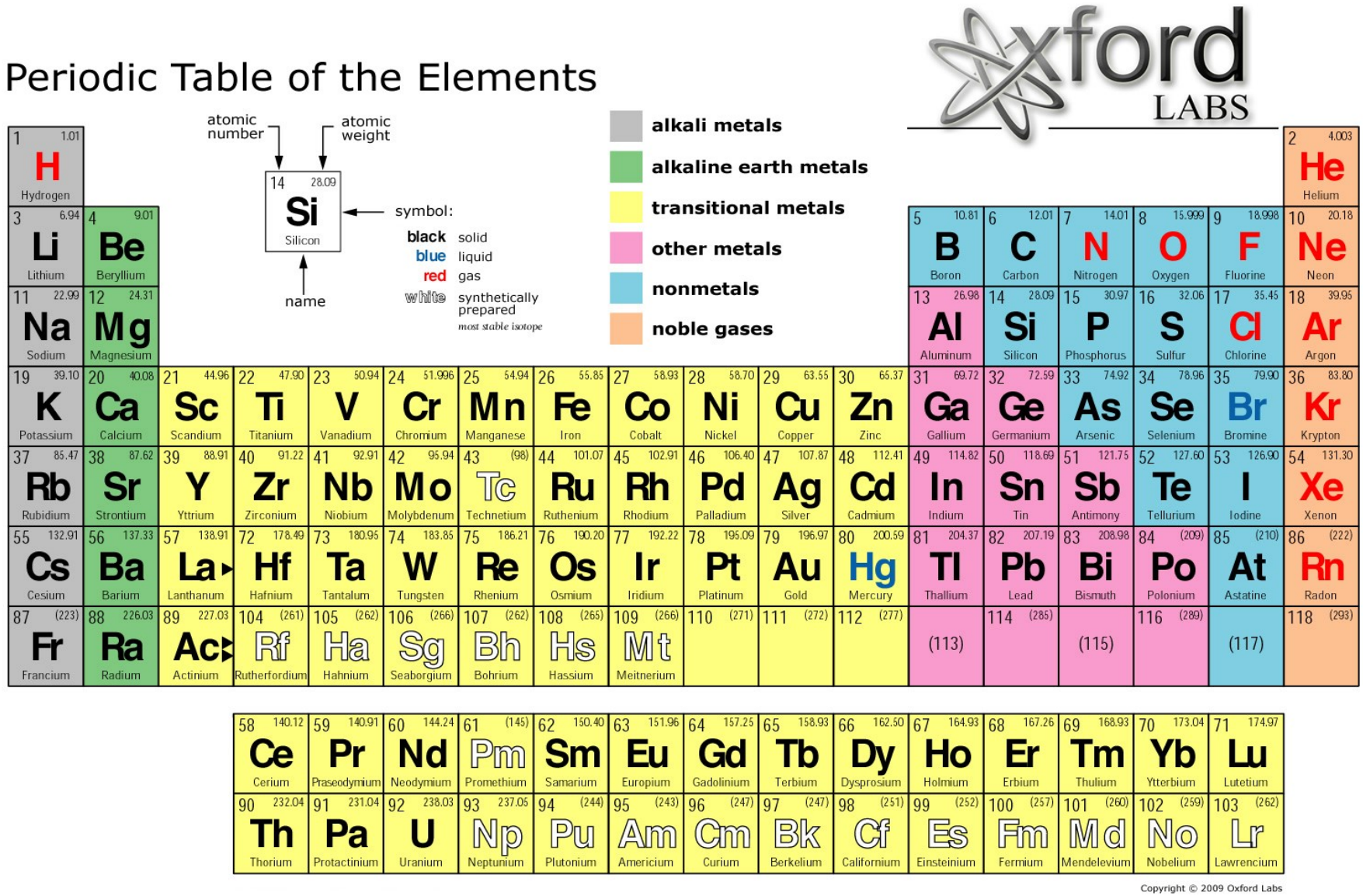
- 118 elements have been identified.
- 94 occur naturally on Earth.
- 24 are artificial.
- 80 of them are stable, while the others 38 are radioactive.

Evolution de la découverte des éléments chimiques

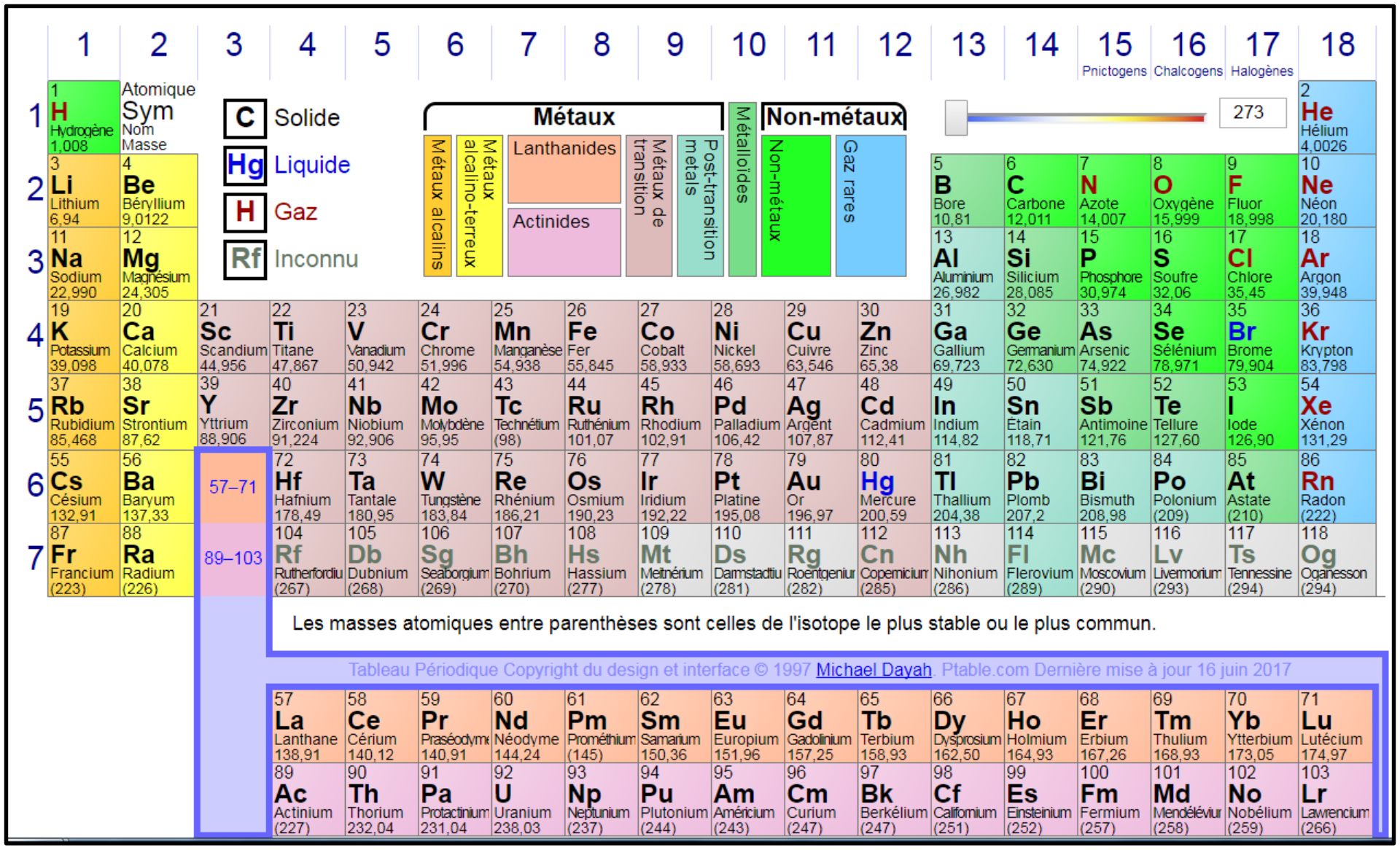
Avant 1700	1700-1799	1800-1849	1850-1899
Antimoine	Azote	Aluminium	Actinium
Argent	Béryllium	Baryum	Argon
Arsenic	Bismuth	Bore	Cesium
Carbone	Chlore	Brome	Dysprosium
Cuivre	Chrome	Cadmium	Gadolinium
Etain	Cobalt	Calcium	Gallium
Fer	Fluor	Cérium	Germanium
Mercure	Hydrogène	Erbium	Hélium
Or	Manganèse	Iode	Holmium
Phosphore	Molybdène	Lanthane	Indium
Plomb	Nickel	Iridium	Krypton
Soufre	Oxygène	Lithium	Néodyme
	Platine	Magnésium	Néon
	Strontium	Niobium	Polonium
	Tellure	Osmium	Praséodyme
	Titane	Palladium	Radium
	Tungstène	Potassium	Rhodium
	Uranium	Rubidium	Ruthénium
	Yttrium	Sélénium	Samarium
	Zinc	Silicium	Scandium
	Zirconium	Sodium	Thallium
		Tantale	Thulium
		Thorium	Xénon
		Vanadium	Ytterbium
(12)	(21)	(24)	(24)

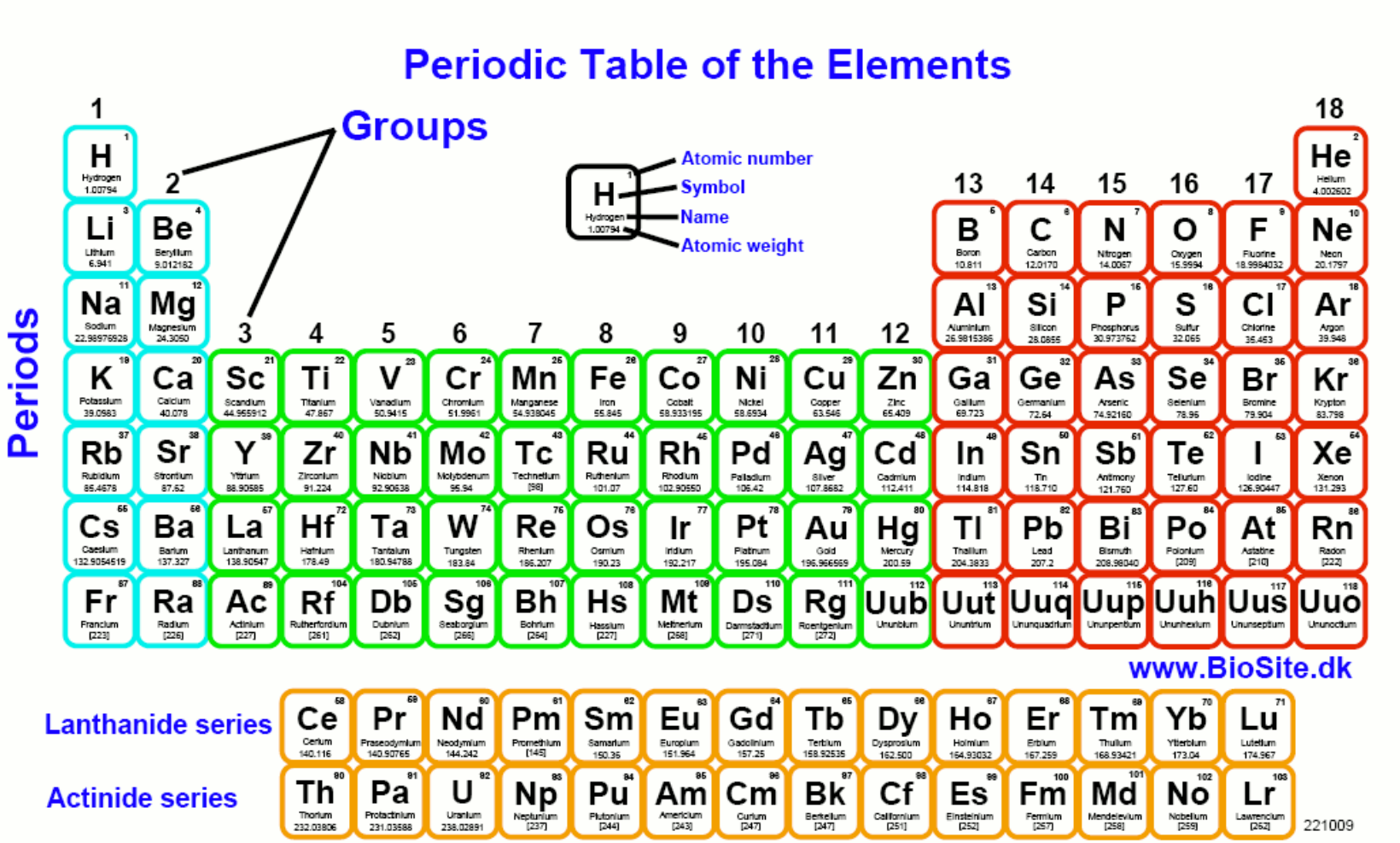


Periodic table:

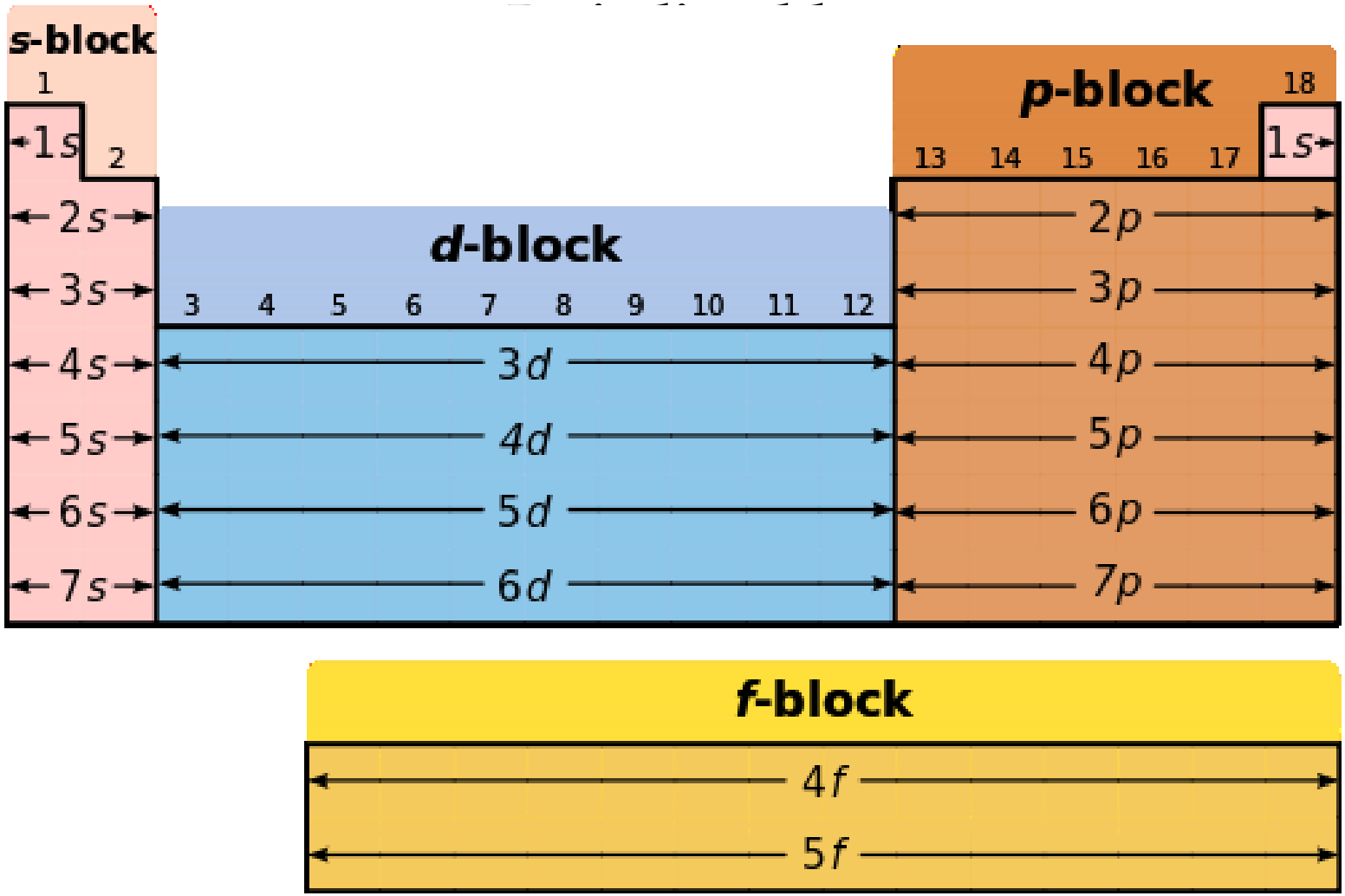


Periodic table:Version 2017





4 blocks of elements are determined according to the nature (s, p, d, f) of the layer being filled.



4 blocks of elements are determined according to the nature (s, p, d, f) of the layer being filled.

1 - Modern periodic classification – relation with electronic configuration

Periodic table organization ⟷ direct and systematic correspondence ⟷ Electronic levels filling order

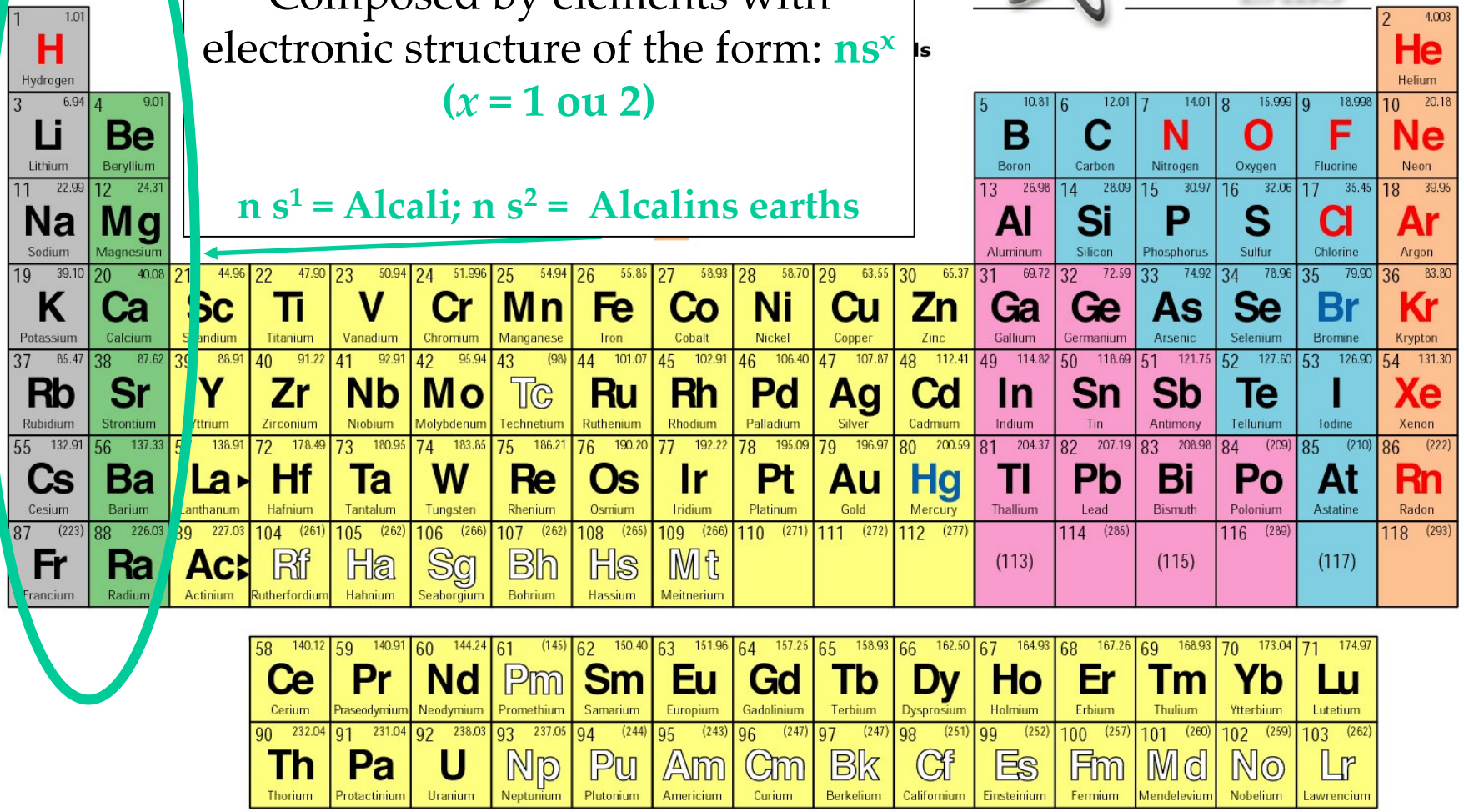
Base rule: return to first column every time a new layer is started

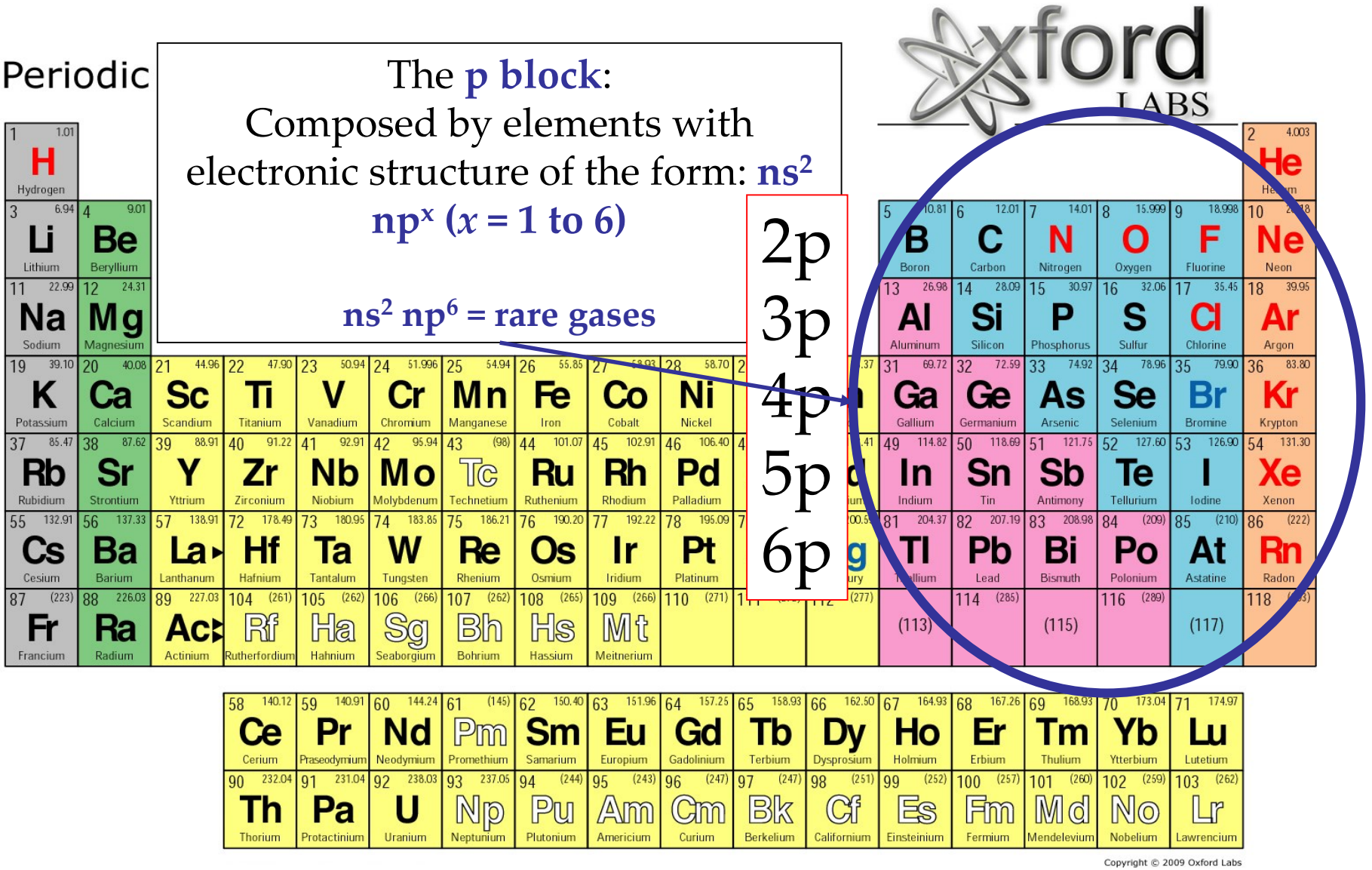
Elements in the same **row**	→ **PERIOD** →	Are ordered from left to right according to increasing atomic number Z Have their peripheric electrons in the same layer
Elements in the same **column**	↘ **FAMILY Or group** →	Have an identical electronic configuration in the external layer, Same number of valence electrons

The **s block**:
Composed by elements with electronic structure of the form: ns^x
($x = 1$ ou 2)

$n\,s^1$ = Alcali; $n\,s^2$ = Alcalins earths

1s
2s
3s
4s
5s
6s
7s




Periodic
The p block:
Composed by elements with electronic structure of the form: ns2 npx (x = 1 to 6)
ns2 np6 = rare gases
2p
3p
4p
5p
6p
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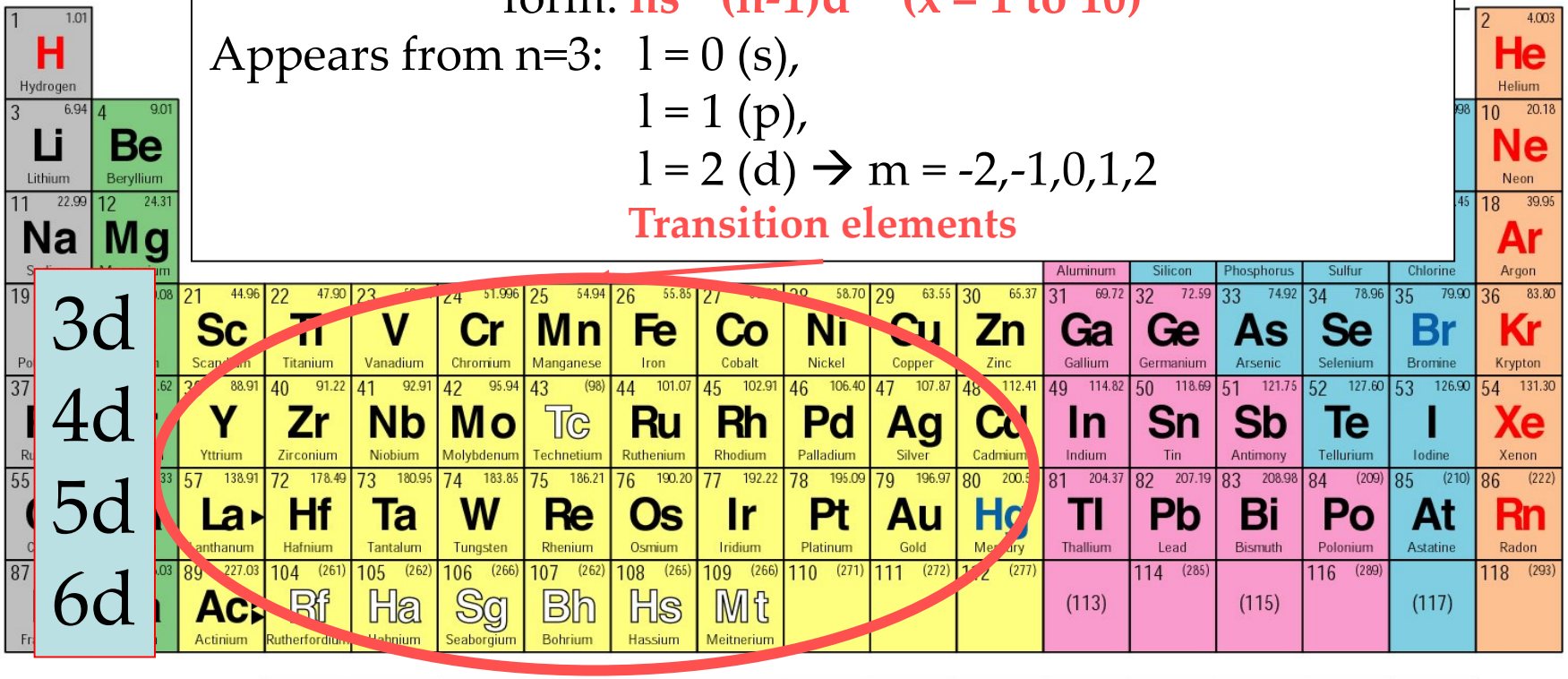
The **d block**:

Composed by elements with electronic structure of the form: ns^2 $(n-1)d^x$ $(x = 1 \text{ to } 10)$

Appears from n=3: l = 0 (s),
l = 1 (p),
l = 2 (d) → m = -2,-1,0,1,2

Transition elements



Sc z=21 $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^1$

Ti z=22 $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^2$

…

1 - Modern periodic classification – relation with electronic configuration

The **f block**:

Composed by elements with electronic structure of the form:

Appears from n=4:

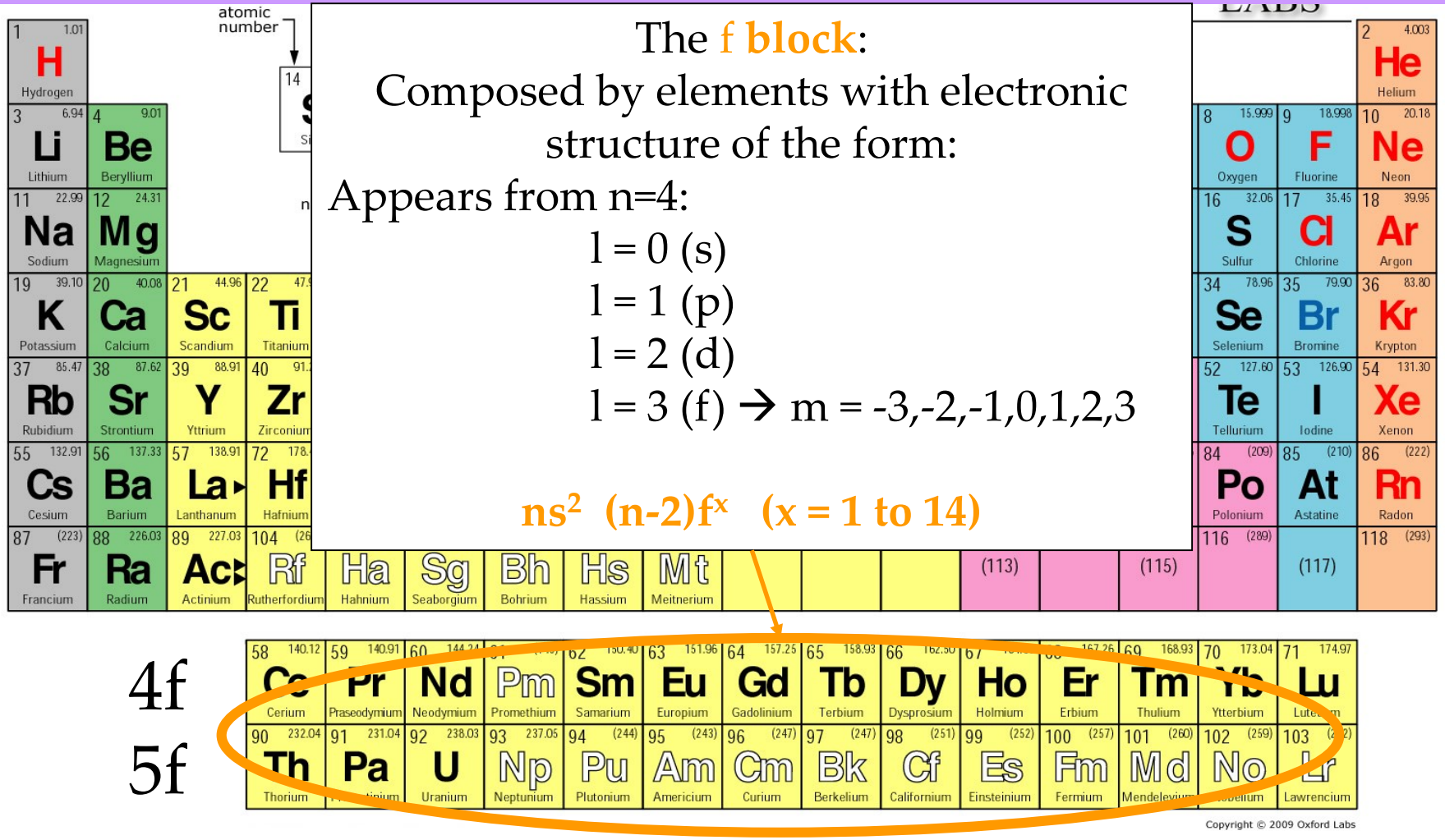
l = 0 (s)

l = 1 (p)

l = 2 (d)

l = 3 (f) → m = -3,-2,-1,0,1,2,3

ns^2 $(n-2)f^x$ (x = 1 to 14)

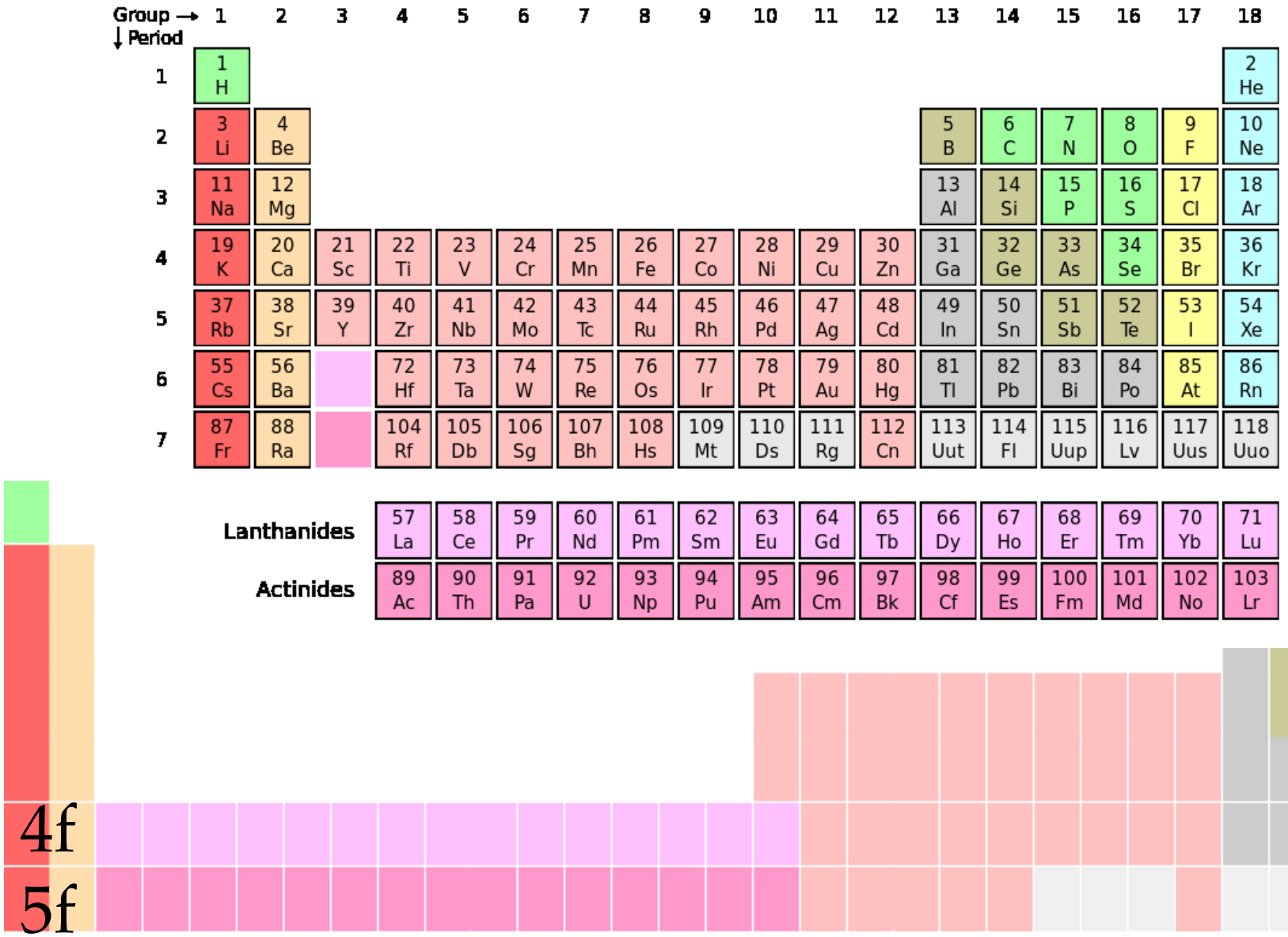


14 columns should be included between columns 3 and 4:

Z = 58 (Ce : Cerium) to Z = 71 (Lu : Lutetium) : **lanthanides**

Z = 90 (Th : Thorium) to z=103 (Lawrencium) **: actinides**

1 - Modern periodic classification – relation with electronic configuration



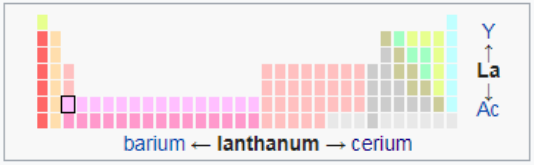
1 - Modern periodic classification – relation with electronic configuration

Lanthanum, $_{57}$La

General properties

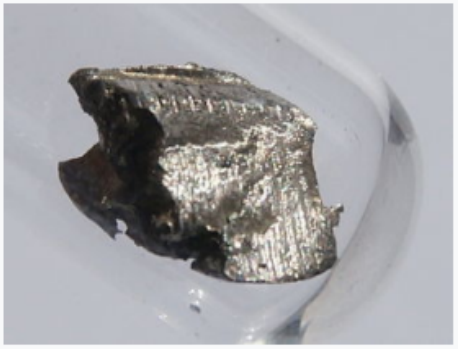
Pronunciation	/ˈlænθənəm/
Appearance	silvery white
Standard atomic weight (A_r)	138.905 47(7)[1]

Lanthanum in the periodic table



Atomic number (Z)	57
Group, period	group 3, period 6
Block	d-block
Element category	lanthanide, sometimes considered a transition metal
Electron configuration	[Xe] $5d^1\ 6s^2$
Electrons per shell	2, 8, 18, 18, 9, 2

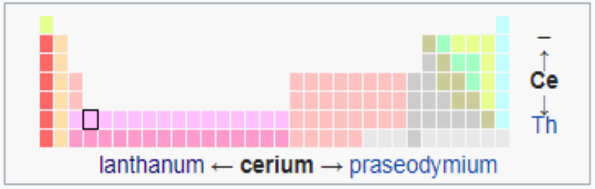
Cerium, $_{58}$Ce



General properties

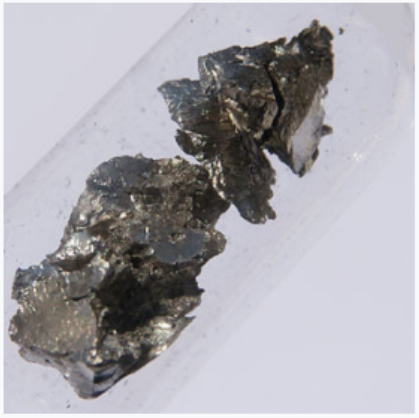
Pronunciation	/ˈsɪəriəm/
Appearance	silvery white
Standard atomic weight (A_r)	140.116(1)[1]

Cerium in the periodic table



Atomic number (Z)	58
Group, period	group n/a, period 6
Block	f-block
Element category	lanthanide
Electron configuration	[Xe] $4f^1\ 5d^1\ 6s^2$[2]
Electrons per shell	2, 8, 18, 19, 9, 2

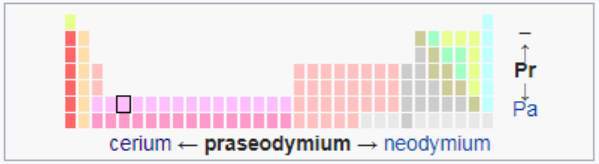
Praseodymium, $_{59}$Pr



General properties

Pronunciation	/preɪziːəˈdɪmiəm/[1] *pray-zee-ə-DIM-ee-əm*
Appearance	grayish white
Standard atomic weight (A_r)	140.907 66(2)[2]

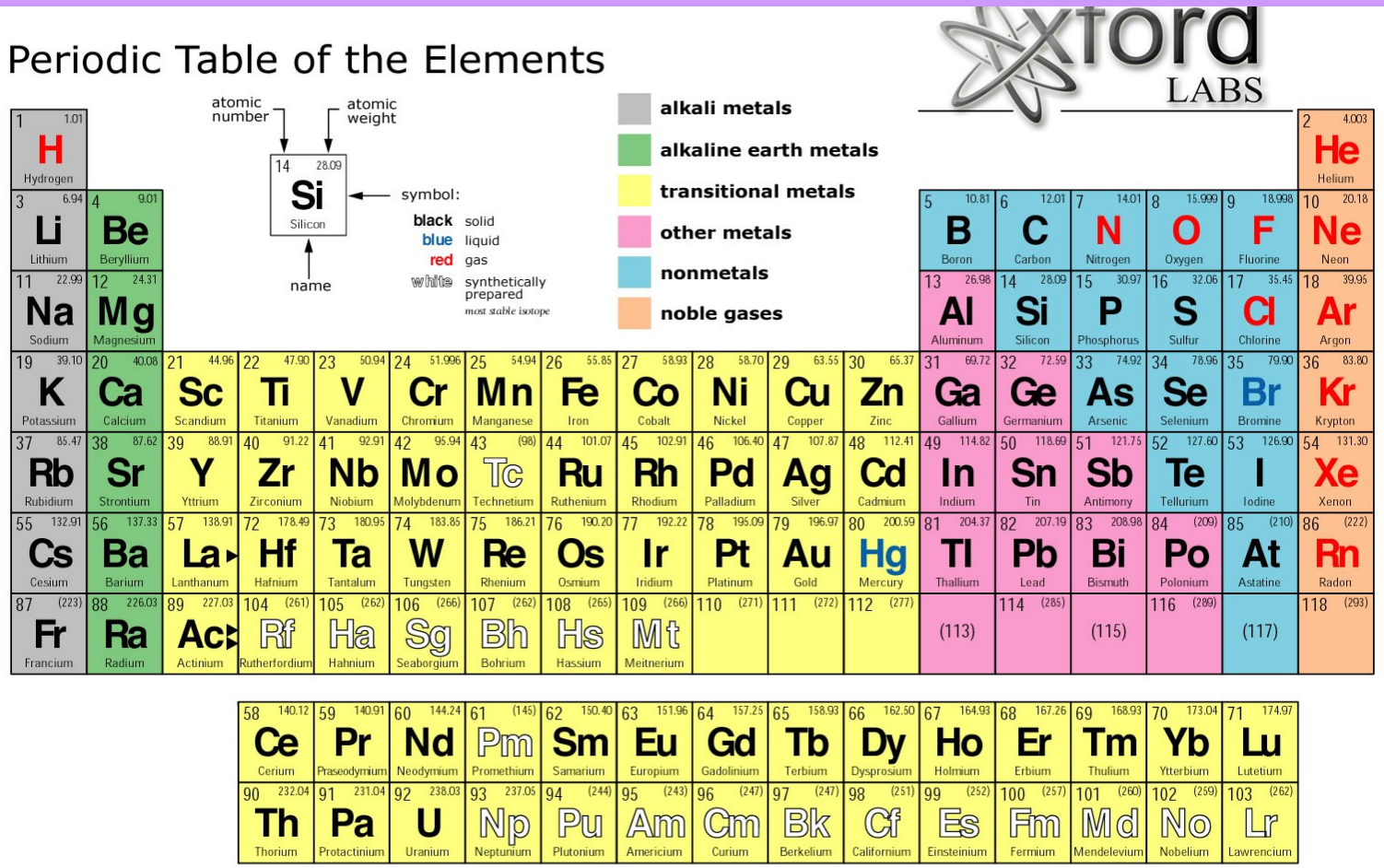
Praseodymium in the periodic table



Atomic number (Z)	59
Group, period	group n/a, period 6
Block	f-block
Element category	lanthanide
Electron configuration	[Xe] $4f^3\ 6s^2$
Electrons per shell	2, 8, 18, 21, 8, 2

Why 15 lanthanide elements?
Exception to the rule
5d and 4f subshells are very close in energy

Chemical element	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Atomic number	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Atomic electron configuration*	$5d^1$	$4f^15d^1$	$4f^3$	$4f^4$	$4f^5$	$4f^6$	$4f^7$	$4f^75d^1$	$4f^9$	$4f^{10}$	$4f^{11}$	$4f^{12}$	$4f^{13}$	$4f^{14}$	$4f^{14}5d^1$



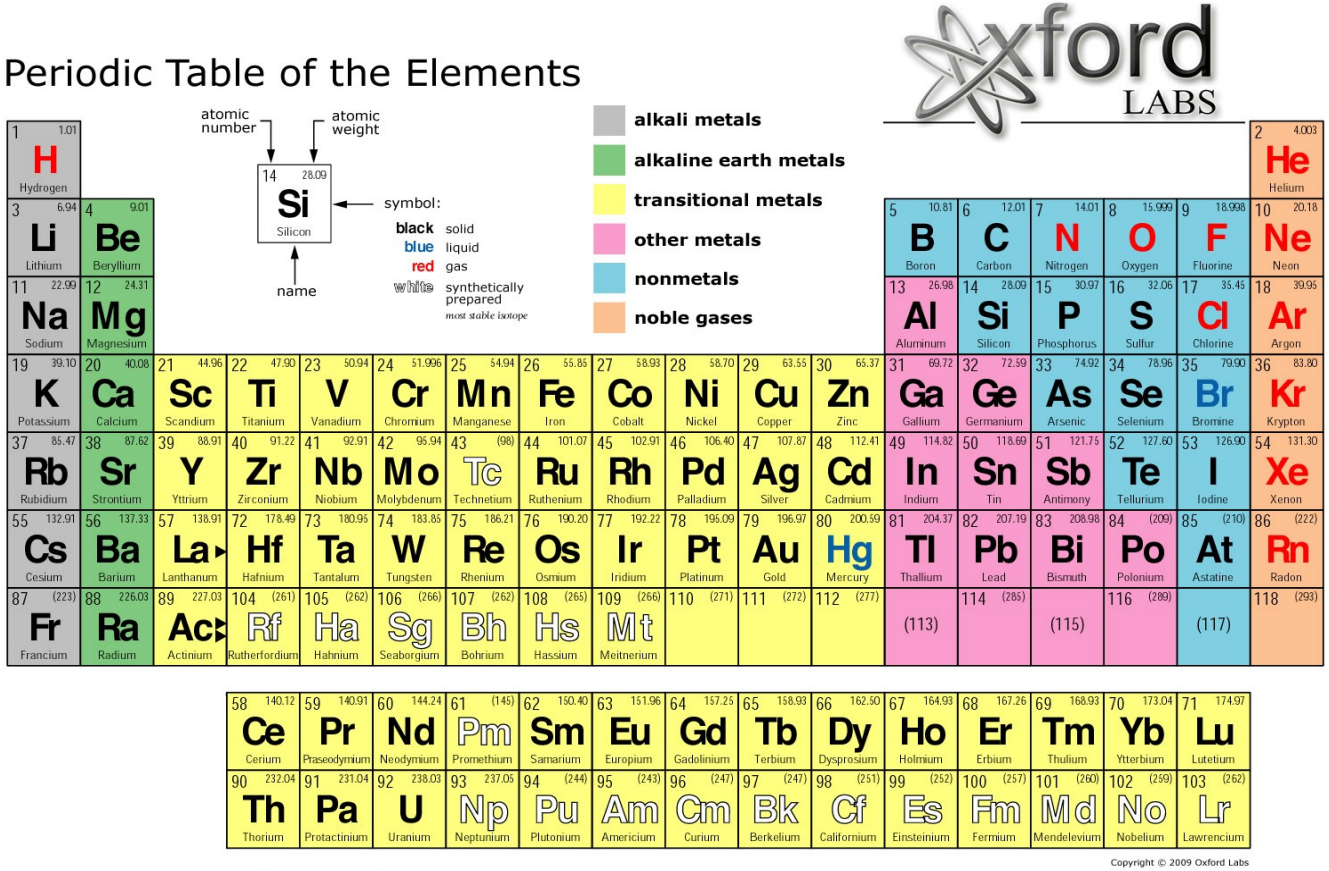
Metals

_ They occupy the center and left wing (except for the H) of the periodic classification

_ They are in general solids (NCTP, except Hg)

_ Conductors

_ Cation donors



Nonmetals

_ They occupy the upper right part of the periodic classification (except for the noble gases)

_ Solid or gas in NCPT (except Br)

_ Non-conductors

_ Anion donors

Is 'X' a metal or a nonmetal

Sanderson's rule:

An element is a METAL if the number of electrons (a) in the highest layer is <= to the period number (n)

Examples

Al

a = 3 (3 e- in the layer n=3)

n= 3 (3rd period)

a = n

It is a metal!

Si

a = 4 (4 e- in the layer n=3)

n = 3 (3rd period)

a > n

It is a nonmetal!

ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ALKALI METAL | ALKALINE EARTH METAL | TRANSITION METAL | GROUP 13 | GROUP 14 | GROUP 15 | GROUP 16 | HALOGEN | LANTHANIDE

SCREEN

49 In Indium
8 O Oxygen
50 Sn Tin

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium
14 Si Silicon
8 O Oxygen
19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium
57 La Lanthanum
65 Tb Terbium
59 Pr Praseodymium
63 Eu Europium
66 Dy Dysprosium
64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

29 Cu Copper
47 Ag Silver
79 Au Gold
73 Ta Tantalum

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

28 Ni Nickel
66 Dy Dysprosium
59 Pr Praseodymium
65 Tb Terbium
60 Nd Neodymium
64 Gd Gadolinium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

14 Si Silicon
8 O Oxygen
51 Sb Antimony
33 As Arsenic
15 P Phosphorus
31 Ga Gallium

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

50 Sn Tin
82 Pb Lead

BATTERY

3 Li Lithium
27 Co Cobalt
8 O Oxygen
6 C Carbon
13 Al Aluminium

The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon
12 Mg Magnesium
35 Br Bromine
28 Ni Nickel