

## Electron cloud

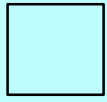
This presentation was created for the students of technical lyceum originally.

Some years ago the presentation was introduced during a science lessons for students in apprenticeship course because of their big interest in this topic. Surprisingly, these students understood this subject very well and they were able to discuss the topic on the same professional level as their colleagues in 4year course.

## ELECTRON

electron behaves like an EM wave and like a solid corpuscle at the same time. It is not possible to locate an accurate position of an electron in a given time because of above mentioned dualism. We can describe a space of an electron occurrence only, this space is called orbital

## ORBITAL



an energy of an orbital is characterized by largeness, shape, orientations and number of electrons. These are quantum physical quantities, they can't grow continuously and they are characterized by four atomic quantum numbers

## ELECTRON CLOUD

...is organized into the layers. Each layer has its own word K, L, M,... which corresponds with number of a period in a periodical system

## principal quantum number (n)

It describes a largeness of an orbital. It depends on number of a period in a periodical system and it is also number from 1 to 7.

## azimuthal quantum number (l)

It describes a shape of an orbital. Its value depends on the  $n$  and it can be from 0 to  $n-1$

$l = 0$  mark **s-orbital**       $l = 1$  mark **p-orbital**       $l = 2$  mark **d-orbital**  
 $l = 3$  mark **f-orbital**       $l = 4$  mark **g-orbital**

## magnetic quantum number (m)

For a given **principal** and **azimuthal** quantum number there are more orbitals with various **magnetic quantum numbers**  $m$  ranging from **-l** to **+l**. Simply,  $m$  describes the whole number of orbitals with a given  $n$  and  $l$  and their orientation in a space

## spin quantum number (s)

Spin is one of the characterizations of an electron wave function and it can only be  $+1/2$  or  $-1/2$

here we can see a math models of the orbitals

$n = 1$

$l = 0$  s-orbit

$m = 0$



$n = 1$

$l = 0$  s-orbit

$m = 0$

$n = 2$

$l = 0$  s-orbit

$m = 0$

$l = 1$  p-orbit

$m = -1$   $0$   $1$

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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$n = 1$

$l = 0$  s-orbit

$m = 0$

$n = 2$

$l = 0$  s-orbit

$m = 0$

$l = 1$  p-orbit

$m = -1 \ 0 \ 1$

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$n = 3$

$l = 0$  s-orbit

$m = 0$

$l = 1$  p-orbit

$m = -1 \ 0 \ 1$

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$l = 2$  d-orbit

$m = -2 \ -1 \ 0 \ 1 \ 2$

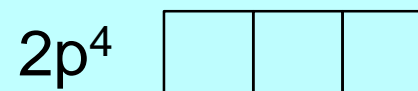
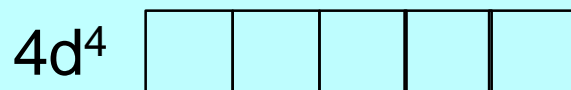
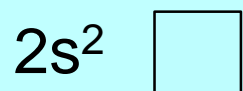
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The electron configuration is based on three principles:

Pauli exclusion principle: for (no more than) two electron occupying the same orbital (means with the same  $n$ ,  $l$  - orbitals of the subshell) the spin must be different

Hund's rule: the orbitals of the subshell are each occupied singly with electrons of parallel spin before double occupation occurs



Aufbau principle: electrons are put into orbitals in the order of increasing orbital energy

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f

[electronic configuration of the elements in periodic table here](#)

[electron configuration here](#)

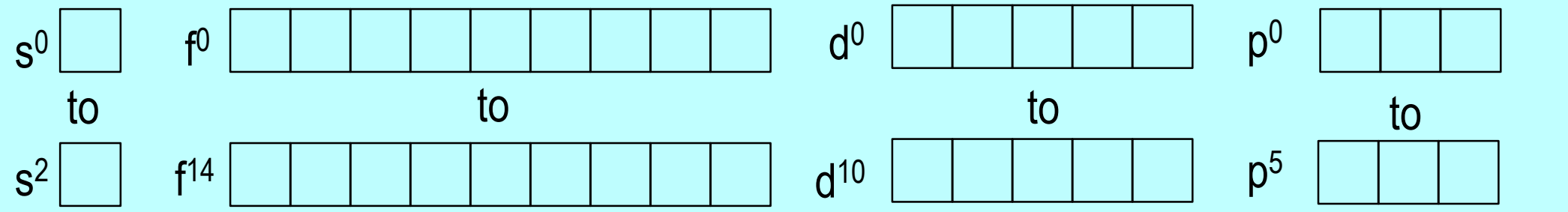
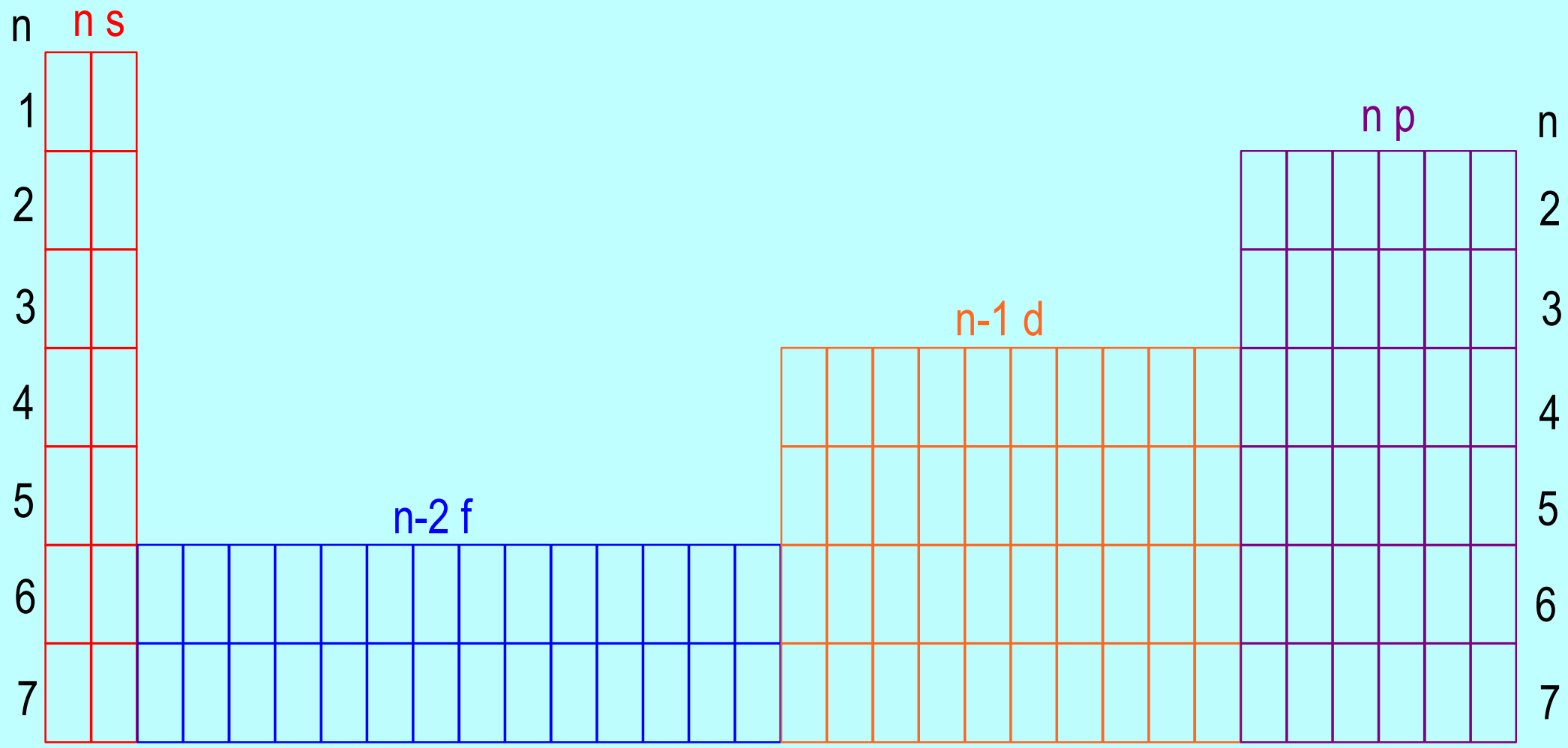


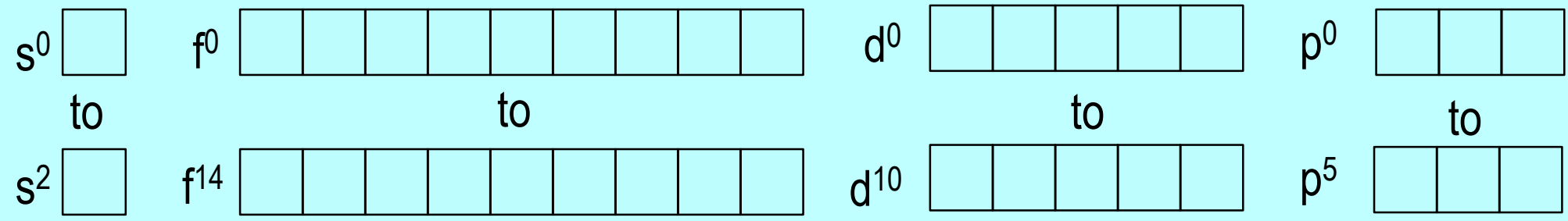
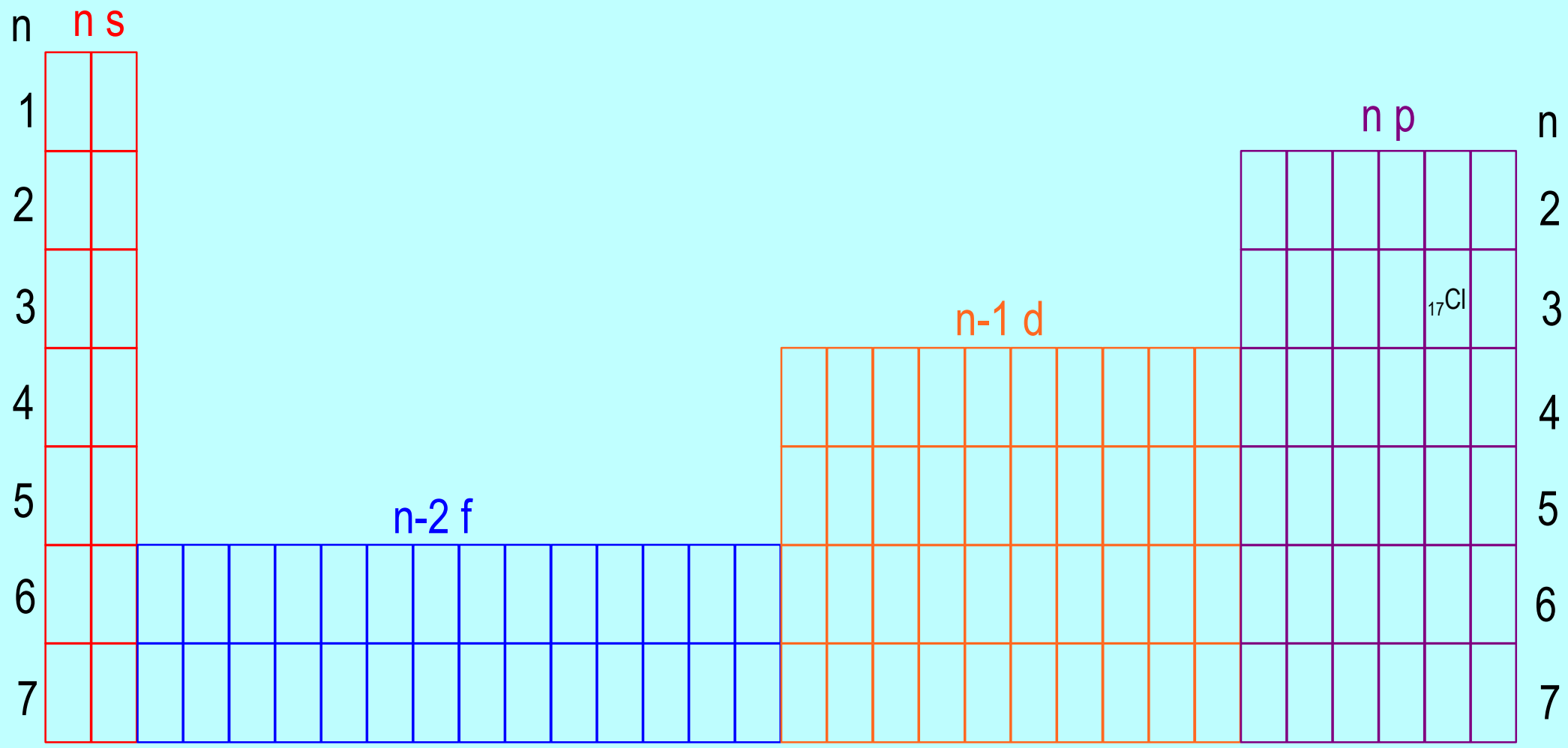
1 <b>H</b> Hydrogen																	2 <b>He</b> Helium						
3 <b>Li</b> Lithium	4 <b>Be</b> Beryllium																	5 <b>B</b> Boron	6 <b>C</b> Carbon	7 <b>N</b> Nitrogen	8 <b>O</b> Oxygen	9 <b>F</b> Fluorine	10 <b>Ne</b> Neon
11 <b>Na</b> Sodium	12 <b>Mg</b> Magnesium																	13 <b>Al</b> Aluminium	14 <b>Si</b> Silicon	15 <b>P</b> Phosphorus	16 <b>S</b> Sulfur	17 <b>Cl</b> Chlorine	18 <b>Ar</b> Argon
19 <b>K</b> Potassium	20 <b>Ca</b> Calcium	21 <b>Sc</b> Scandium	22 <b>Ti</b> Titanium	23 <b>V</b> Vanadium	24 <b>Cr</b> Chromium	25 <b>Mn</b> Manganese	26 <b>Fe</b> Iron	27 <b>Co</b> Cobalt	28 <b>Ni</b> Nickel	29 <b>Cu</b> Copper	30 <b>Zn</b> Zinc	31 <b>Ga</b> Gallium	32 <b>Ge</b> Germanium	33 <b>As</b> Arsenic	34 <b>Se</b> Selenium	35 <b>Br</b> Bromine	36 <b>Kr</b> Krypton						
37 <b>Rb</b> Rubidium	38 <b>Sr</b> Strontium	39 <b>Y</b> Yttrium	40 <b>Zr</b> Zirconium	41 <b>Nb</b> Niobium	42 <b>Mo</b> Molybdenum	43 <b>Tc</b> Technetium	44 <b>Ru</b> Ruthenium	45 <b>Rh</b> Rhodium	46 <b>Pd</b> Palladium	47 <b>Ag</b> Silver	48 <b>Cd</b> Cadmium	49 <b>In</b> Indium	50 <b>Sn</b> Tin	51 <b>Sb</b> Antimony	52 <b>Te</b> Tellurium	53 <b>I</b> Iodine	54 <b>Xe</b> Xenon						
55 <b>Cs</b> Cesium	56 <b>Ba</b> Barium	57 <b>La</b> Lanthanum	72 <b>Hf</b> Hafnium	73 <b>Ta</b> Tantalum	74 <b>W</b> Tungsten	75 <b>Re</b> Rhenium	76 <b>Os</b> Osmium	77 <b>Ir</b> Iridium	78 <b>Pt</b> Platinum	79 <b>Au</b> Gold	80 <b>Hg</b> Mercury	81 <b>Tl</b> Thallium	82 <b>Pb</b> Lead	83 <b>Bi</b> Bismuth	84 <b>Po</b> Polonium	85 <b>At</b> Astatine	86 <b>Rn</b> Radon						
87 <b>Fr</b> Francium	88 <b>Ra</b> Radium	89 <b>Ac</b> Actinium	104 <b>Rf</b> Rutherfordium	105 <b>Db</b> Dubnium	106 <b>Sg</b> Seaborgium	107 <b>Bh</b> Bohrium	108 <b>Hs</b> Hassium	109 <b>Mt</b> Meitnerium															

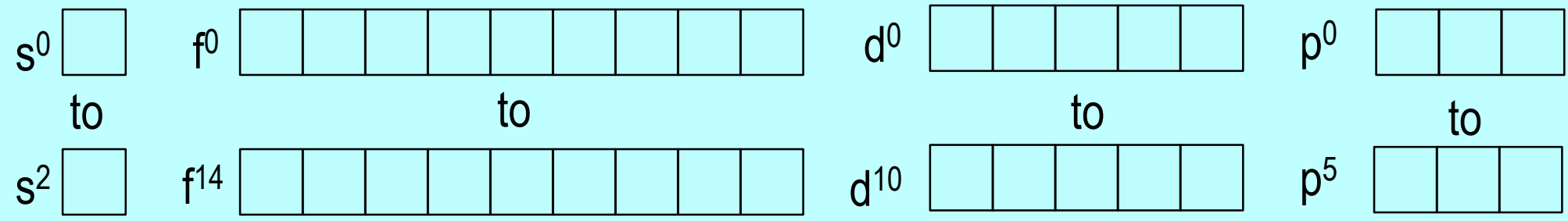
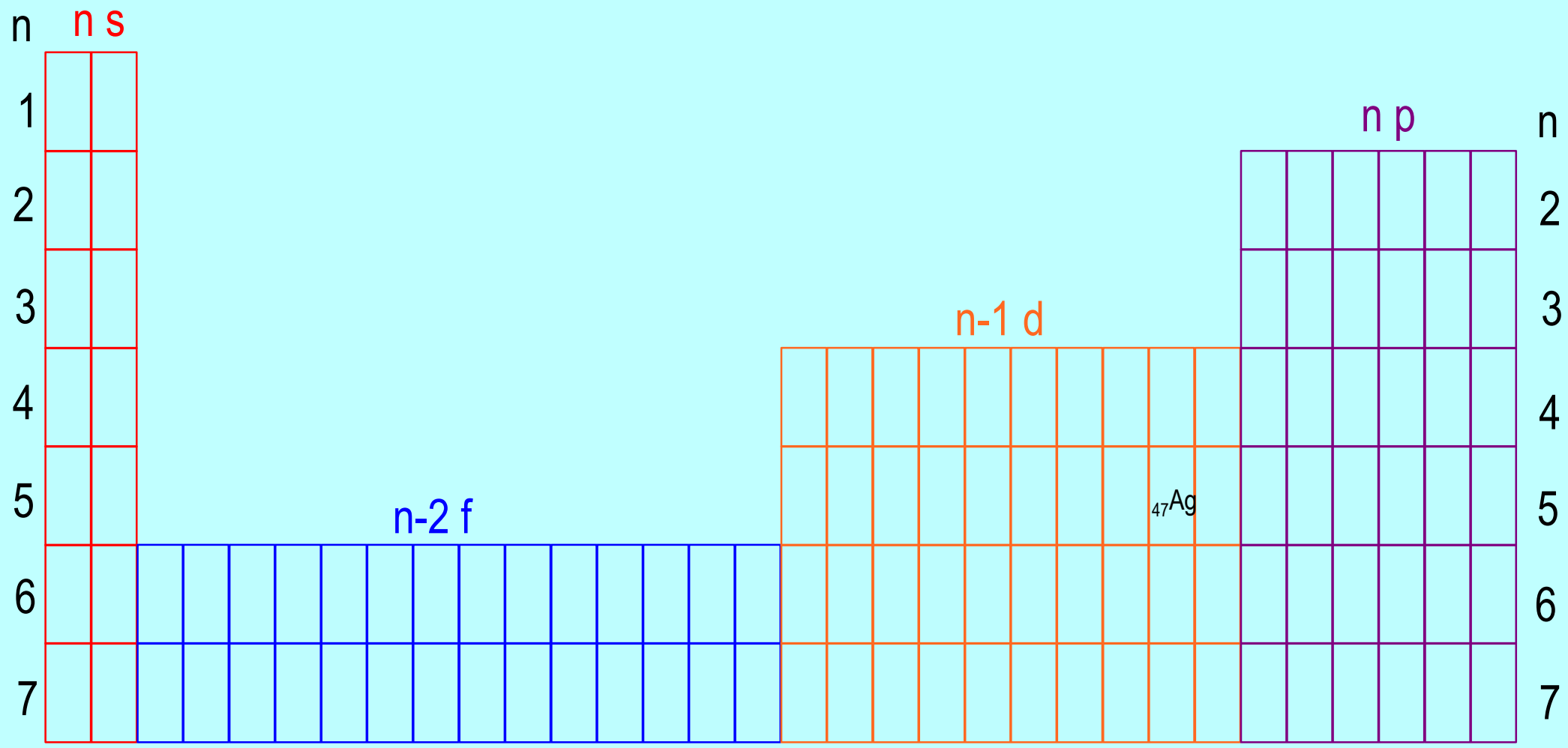
We are used to see the periodic system like this

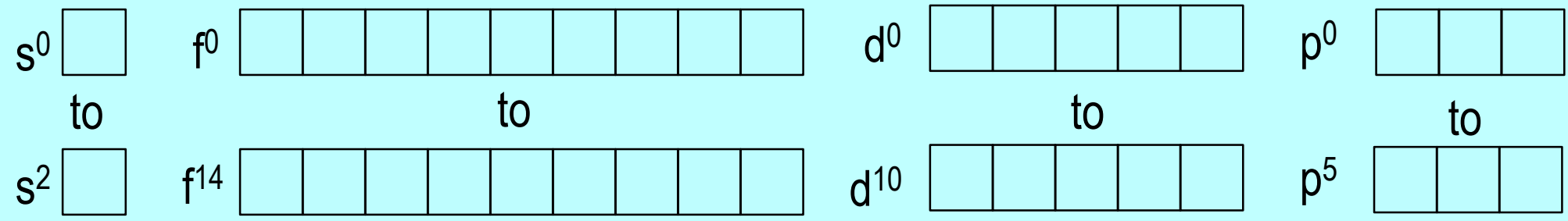
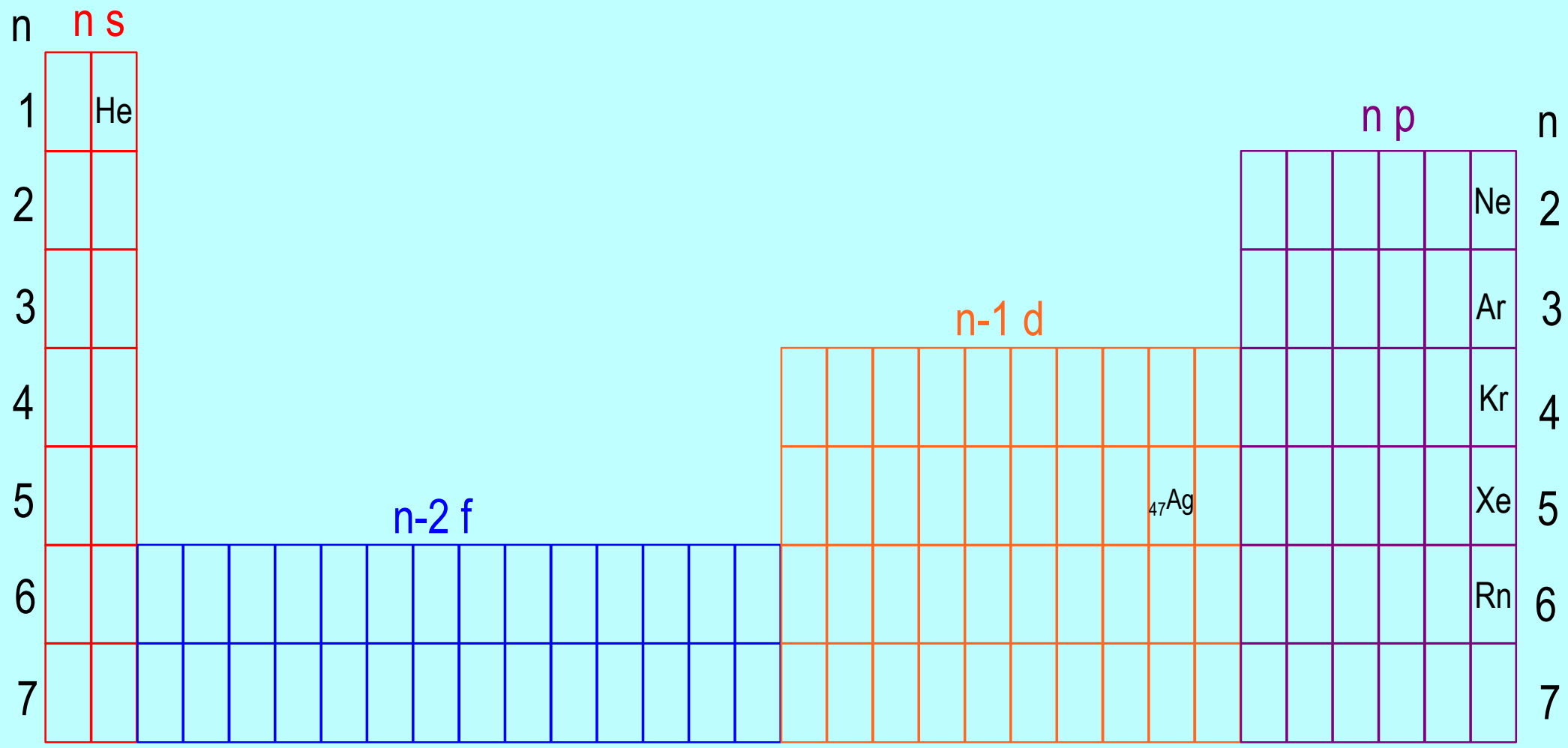
58 <b>Ce</b> Cerium	59 <b>Pr</b> Praseodymium	60 <b>Nd</b> Neodymium	61 <b>Pm</b> Promethium	62 <b>Sm</b> Samarium	63 <b>Eu</b> Europium	64 <b>Gd</b> Gadolinium	65 <b>Tb</b> Terbium	66 <b>Dy</b> Dysprosium	67 <b>Ho</b> Holmium	68 <b>Er</b> Erbium	69 <b>Tm</b> Thulium	70 <b>Yb</b> Ytterbium	71 <b>Lu</b>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

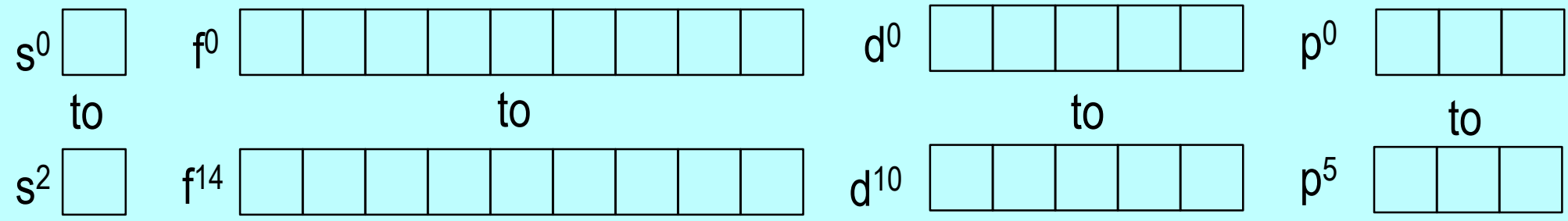
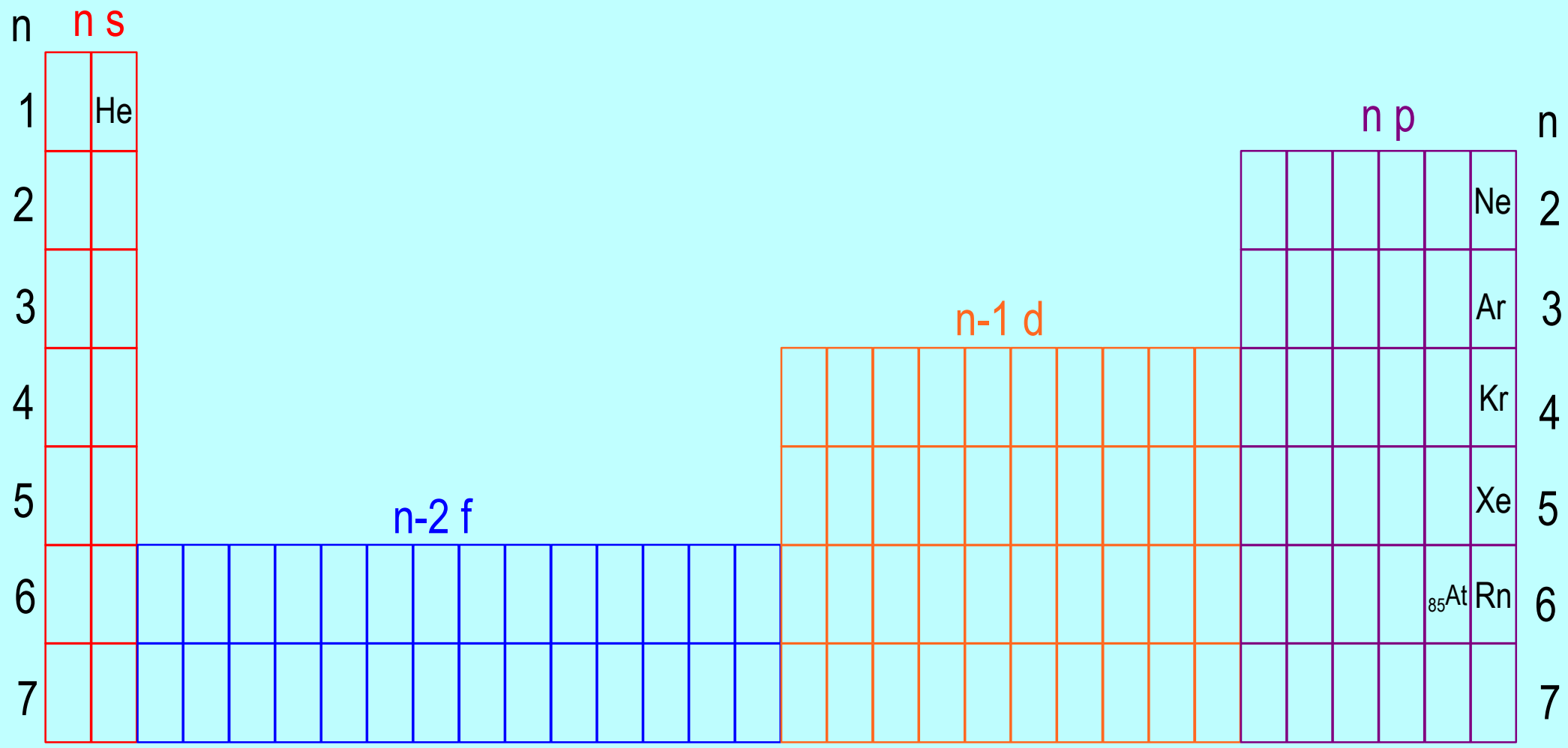
but if we want to show the principles of electron configuration this way is better:



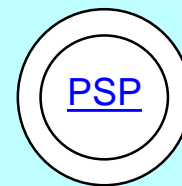








Describe a whole order of electron cloud:



K

As

Br

P

N

Electron configuration from noble gas:

Sb

Po

Ba

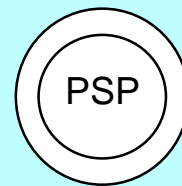
I

Pb

Tl

Fe

Ce



Co

Tb

Ni

Lu

Os

Th

Ir

U

Pt

Pu



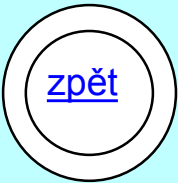
[zpět](#)

n	n s																					n																															
1		He																				Ne	2																														
2																							Ar	3																													
3																								Kr	4																												
4																									Xe	5																											
5																										Rn	6																										
6			Ce												Tb							Lu																															
7			Th	U	Pu																																																

n-2 f

n-1 d

n p



n	n s																		n p						n																						
1		He																					N				Ne	2																			
2																								P				Ar	3																		
3																				n-1 d																						As		Br		Kr	4
4	K																							Sb		I		Xe	5																		
5		n-2 f																											Tl	Pb		Po		Rn	6												
6		Ba																										7																			
7																																				7											