Electron Configurations

expressing the quantum numbers of the electrons in an atom by a shortcut method

The electron configuration method of expressing the quantum numbers of the electrons in an atom has the following advantages:

The electron configuration method of expressing the quantum numbers of the electrons in an atom has the following advantages:

It is much simpler than listing all the quantum numbers

The electron configuration method of expressing the quantum numbers of the electrons in an atom has the following advantages:

It is much simpler than listing all the quantum numbers.

It expresses the important quantities that are needed for chemistry and leaves out details that have little effect.

The electron configuration method of expressing the quantum numbers of the electrons in an atom has the following advantages:

It is much simpler than listing all the quantum numbers.

It expresses the important quantities that are needed for chemistry and leaves out details that have little effect.

It is clearer to see the relationship to the periodic chart of the elements and why the properties vary as they do.

The electron configuration method is short-hand for the quantum numbers, n, l, m_l and m_s.

For an electron that has an a principal quantum number n, the number n is written.

The electron configuration method is short-hand for the quantum numbers, n, l, m_l and m_s.

For an electron that has an a principal quantum number n, the number n is written.

For the quantum number l, the following is used:

l = 0 the letter “s”
l = 1 the letter “p”
l = 2 the letter “d”
l = 3 the letter “f”

It turns out that for the ground state, these are all the l values, i.e. letters, that are needed.

$n = n$ use number “n”

$l = 0$ the letter “s”
$l = 1$ the letter “p”
$l = 2$ the letter “d”
$l = 3$ the letter “f”

Example: For an electron for $n = 2$ and $l = 1$ the designation is:

2p

n = n use number "n"

l = 0 the letter "s"
l = 1 the letter "p"
l = 2 the letter "d"
l = 3 the letter "f"

Example: For an electron for n = 1 and l = 0 the designation is:

1s

n = n   use number “n”

l = 0   the letter “s”
l = 1   the letter “p”
l = 2   the letter “d”
l = 3   the letter “f”

Example: For an electron for n = 4 and l = 3 the designation is:

4f

n = n   use number “n”

l = 0   the letter “s”
l = 1   the letter “p”
l = 2   the letter “d”
l = 3   the letter “f”

To express all the electrons in the atom one designates the electrons in each energy level by placing a superscript on the letter. This number is the total number of electrons that have this particular number and letter.

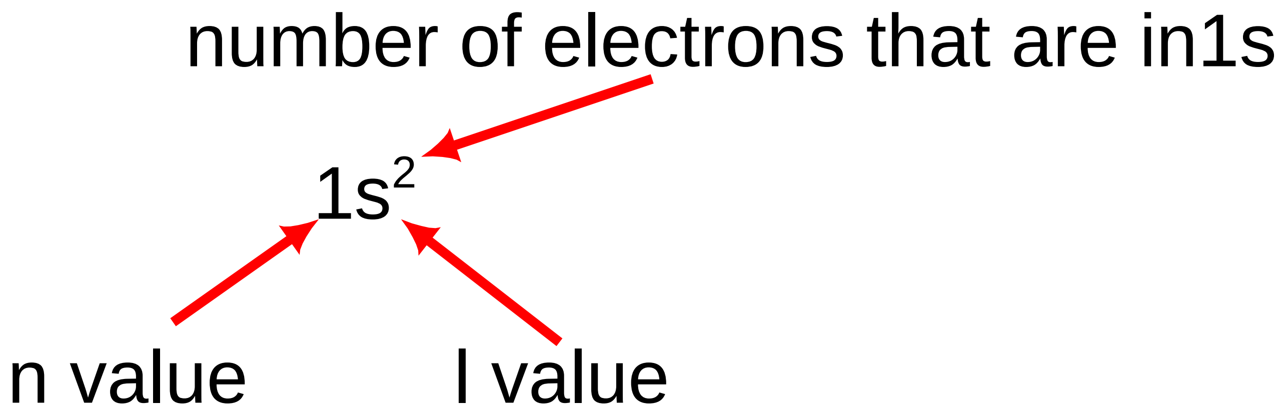
For example, He has 2 electrons that are 1s. So the total is given as:

$$1s^2$$

n = n use number “n”

l = 0 the letter “s”
l = 1 the letter “p”
l = 2 the letter “d”
l = 3 the letter “f”

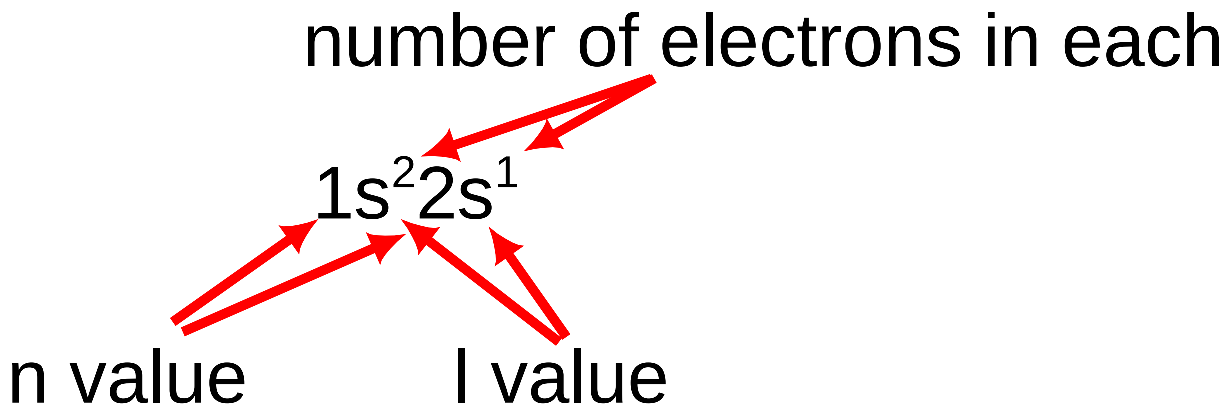
For example, He has 2 electrons that are 1s. So the total is given as:



n = n use number “n”

l = 0 the letter “s”
l = 1 the letter “p”
l = 2 the letter “d”
l = 3 the letter “f”

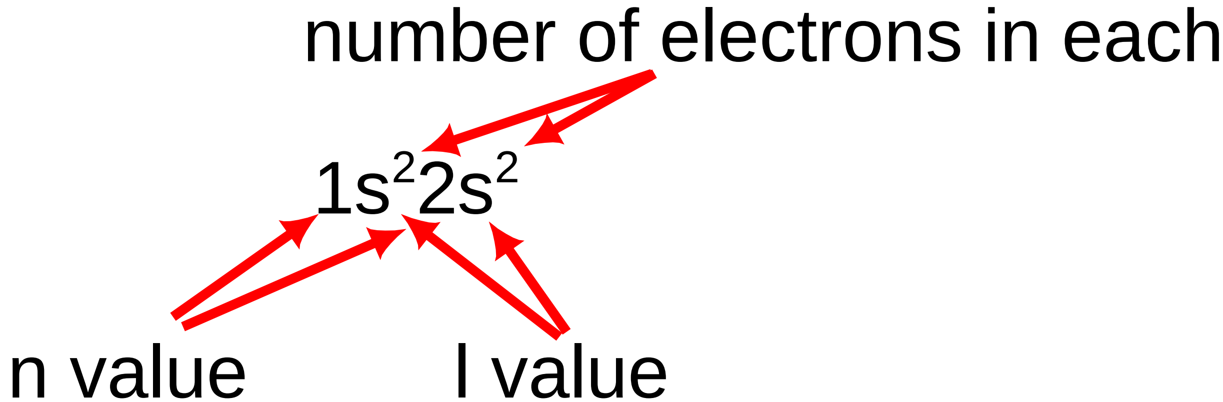
Li has 2 electrons that are 1s and 1 that is 2s.
So the total is given as:



n = n use number “n”

l = 0 the letter “s”
l = 1 the letter “p”
l = 2 the letter “d”
l = 3 the letter “f”

Be has 2 electrons that are 1s and 2 that are 2s.
So the total is given as:



n = n   use number “n”

l = 0   the letter “s”
l = 1   the letter “p”
l = 2   the letter “d”
l = 3   the letter “f”

Inspection of the selection rule yields the following conclusion. The total allowed number of electrons in:

l = 0 is 2
l = 1 is 6
l = 2 is 10
l = 3 is 14

$n = n$ use number "n"

$l = 0$ the letter "s"
$l = 1$ the letter "p"
$l = 2$ the letter "d"
$l = 3$ the letter "f"

Why?

$l = 0$ is 2 $m_l = 0$ $m_s = \pm 1/2 \rightarrow$ 2 combinations
$l = 1$ is 6
$l = 2$ is 10
$l = 3$ is 14

n = n   use number “n”

l = 0   the letter “s”
l = 1   the letter “p”
l = 2   the letter “d”
l = 3   the letter “f”

Why?

l = 0 is 2 $m_l = 0$ $m_s = \pm½$ → 2
l = 1 is 6 $m_l = -1, 0, +1$ $m_s = \pm½$ → 6
l = 2 is 10
l = 3 is 14

$n = n$ use number “n”

$l = 0$ the letter “s”
$l = 1$ the letter “p”
$l = 2$ the letter “d”
$l = 3$ the letter “f”

Why?

$l = 0$ is 2 $m_l = 0$ $m_s = \pm½$ → 2
$l = 1$ is 6 $m_l = -1, 0, +1$ $m_s = \pm½$ → 6
$l = 2$ is 10 $m_l = -2, -1, 0, +1, +2$ $m_s = \pm½$ → 10
$l = 3$ is 14

n = n   use number "n"

l = 0   the letter "s"
l = 1   the letter "p"
l = 2   the letter "d"
l = 3   the letter "f"

Why?

$l = 0$ is 2 $m_l = 0$ $m_s = \pm ½$ → 2
$l = 1$ is 6 $m_l = -1, 0, +1$ $m_s = \pm ½$ → 6
$l = 2$ is 10 $m_l = -2, -1, 0, +1, +2$ $m_s = \pm ½$ → 10
$l = 3$ is 14 $m_l = -3,-2,-1,0,+1,+2,+3$ $m_s = \pm ½$ → 14

n = n	use number “n”		
			Total allowed:
l = 0	the letter “s”	———	2
l = 1	the letter “p”	———	6
l = 2	the letter “d”	———	10
l = 3	the letter “f”	———	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

n = n	use number "n"		
			Total allowed:
l = 0	the letter "s"	———	2
l = 1	the letter "p"	———	6
l = 2	the letter "d"	———	10
l = 3	the letter "f"	———	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

Example: What is the electron configuration of Ar?

Answer: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$

n = n   use number “n”

		Total allowed:
l = 0	the letter “s”	2
l = 1	the letter “p”	6
l = 2	the letter “d”	10
l = 3	the letter “f”	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

Example: What is the electron configuration of Ar?

(total of electron = 18)

Answer: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$

n = n	use number “n”		
			Total allowed:
l = 0	the letter “s”	———	2
l = 1	the letter “p”	———	6
l = 2	the letter “d”	———	10
l = 3	the letter “f”	———	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

Example: What is the electron configuration of Fe?

Answer: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

n = n   use number "n"

		Total allowed:
l = 0	the letter "s" ———	2
l = 1	the letter "p" ———	6
l = 2	the letter "d" ———	10
l = 3	the letter "f" ———	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

Example: What is the electron configuration of Fe?

(total of electron = 26)

Answer: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

n = n	use number "n"	
		Total allowed:
l = 0	the letter "s"	2
l = 1	the letter "p"	6
l = 2	the letter "d"	10
l = 3	the letter "f"	14

Given this, one can construct the electron configuration of any atom by the aufbau principle if one knows the sequence of the energy levels.

Example: What is the electron configuration of Fe?

(total of electron = 26)

Answer: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

Wait a minute! - Shouldn't 3d come before 4s?

n = n   use number “n”

l = 0   the letter “s”
l = 1   the letter “p”
l = 2   the letter “d”
l = 3   the letter “f”

No, 3d is not a lower energy than 4s - this doesn’t break any of the previous rules. The energy levels are in the following sequence:

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

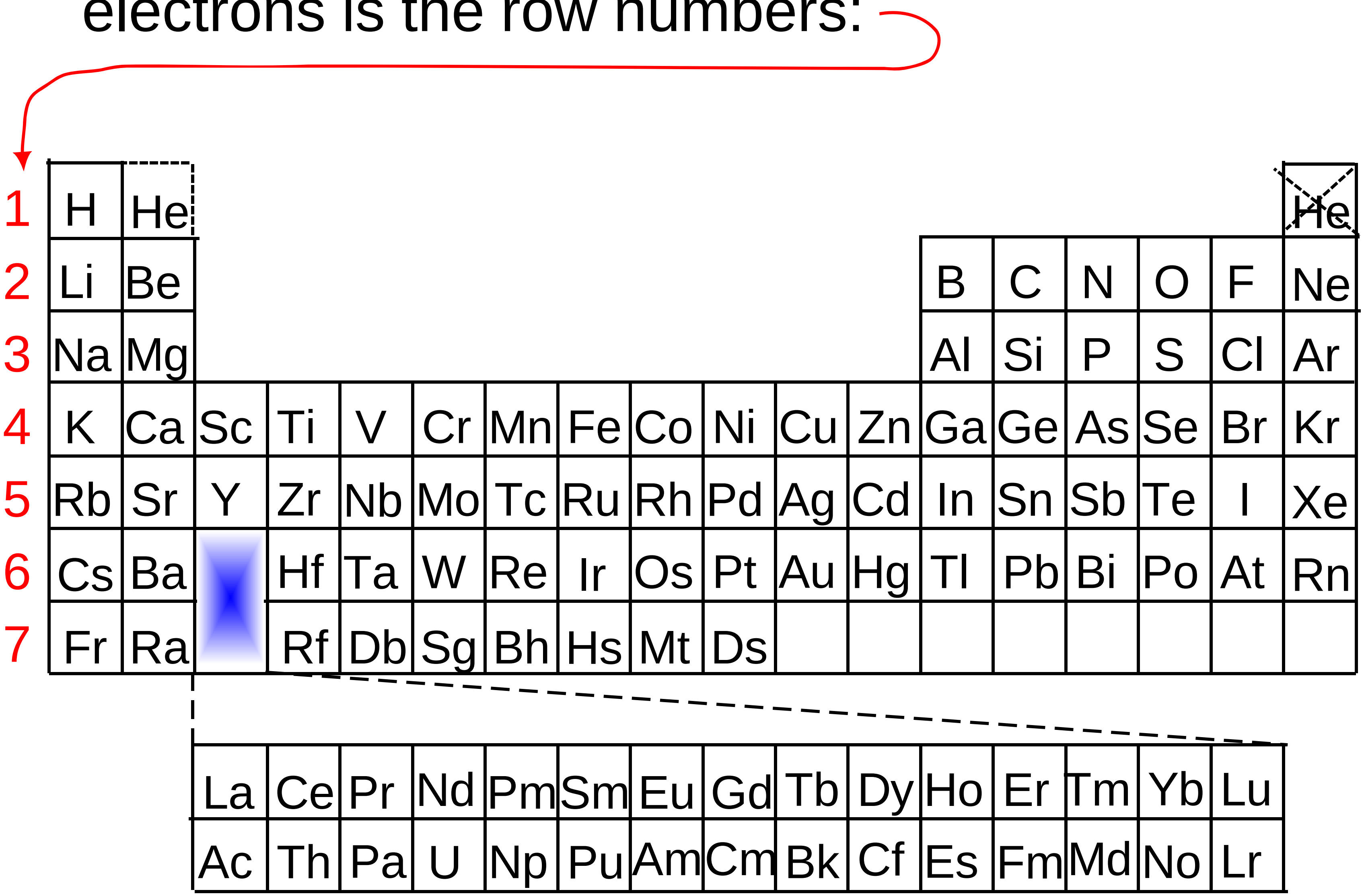
Either memorize this sequence or use the great cheat-sheet on the wall (officially called the periodic chart).

Here is how to use the periodic chart for determining the sequence:

1	H	He																He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba		Hf	Ta	W	Re	Ir	Os	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds								

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

The principal quantum number for the s and p electrons is the row numbers:

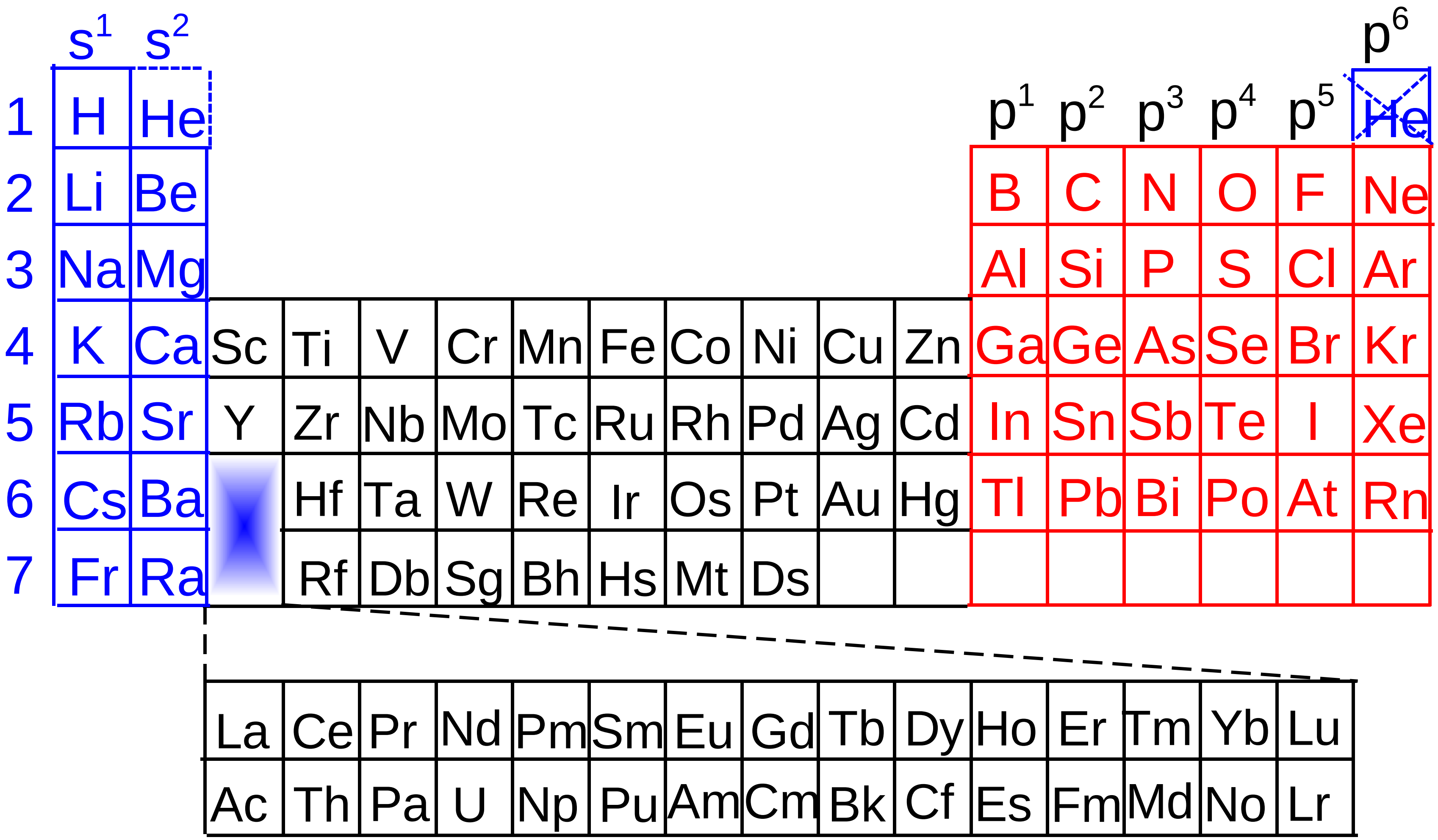


The s electron sequence is the first 2 columns:
(Note that He is s^2 - not on the other side.)

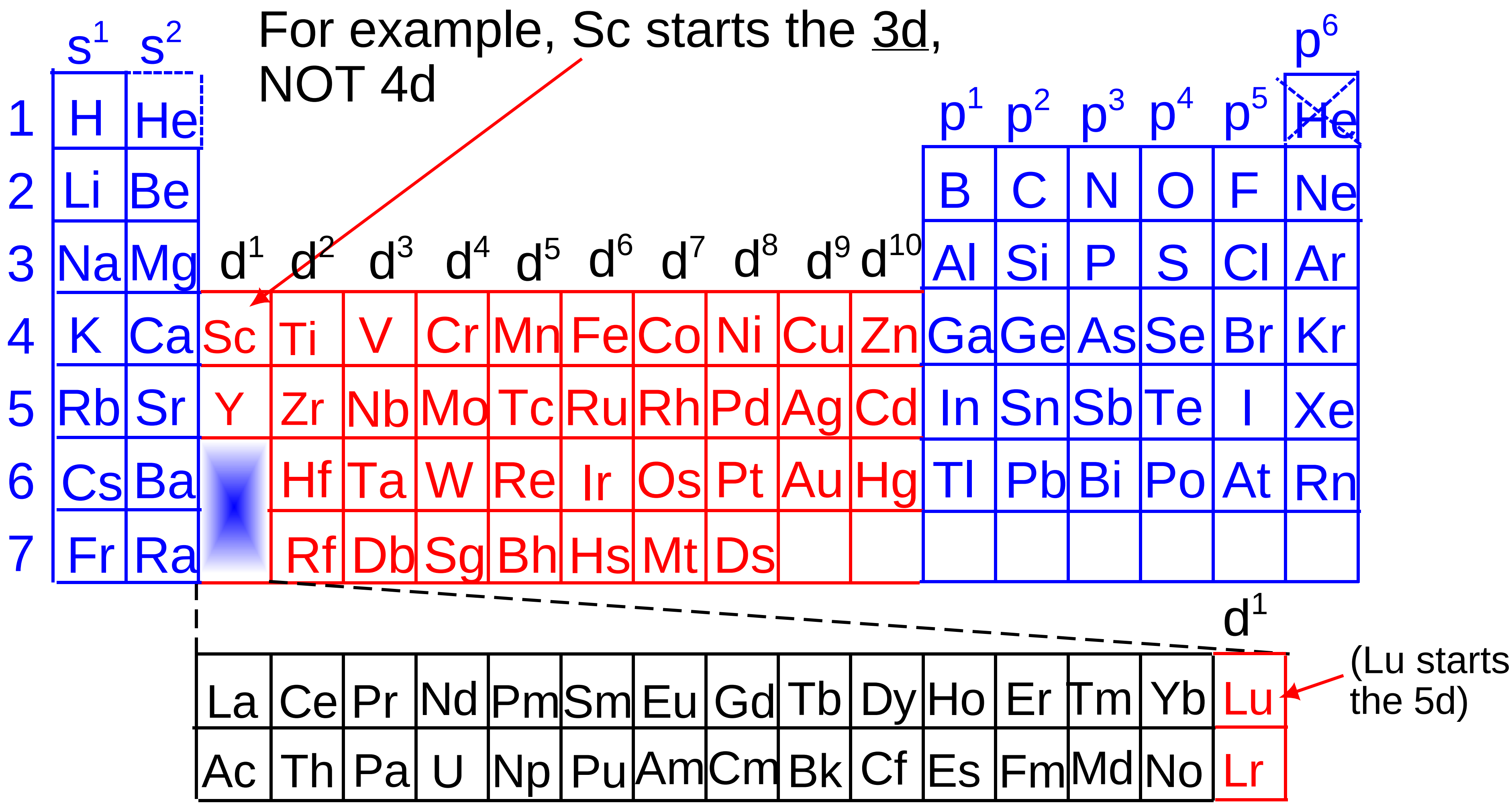
	s^1	s^2																
1	H	He																~~He~~
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba		Hf	Ta	W	Re	Ir	Os	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds								

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

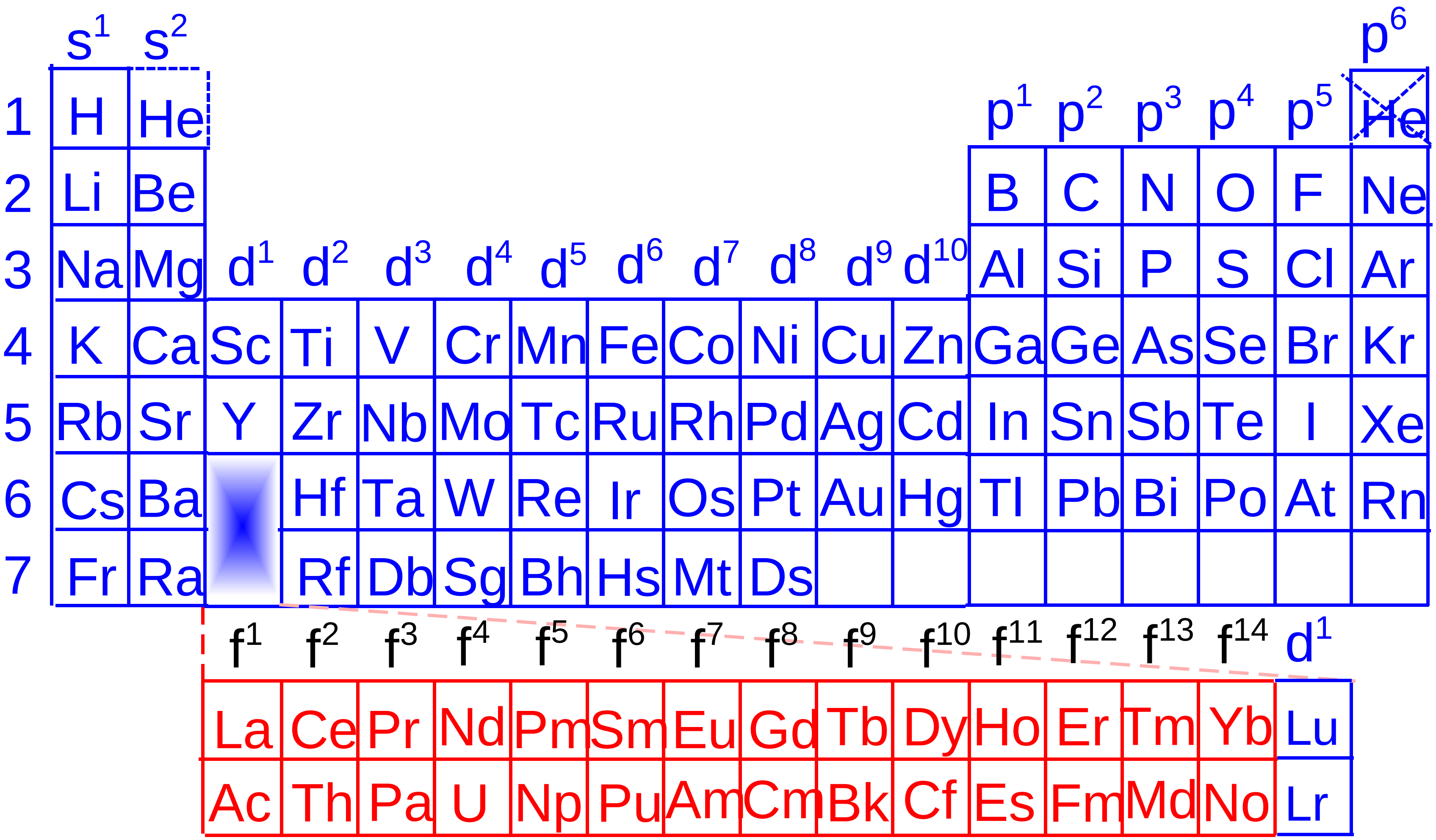
The p electron sequence is the last 6 columns:



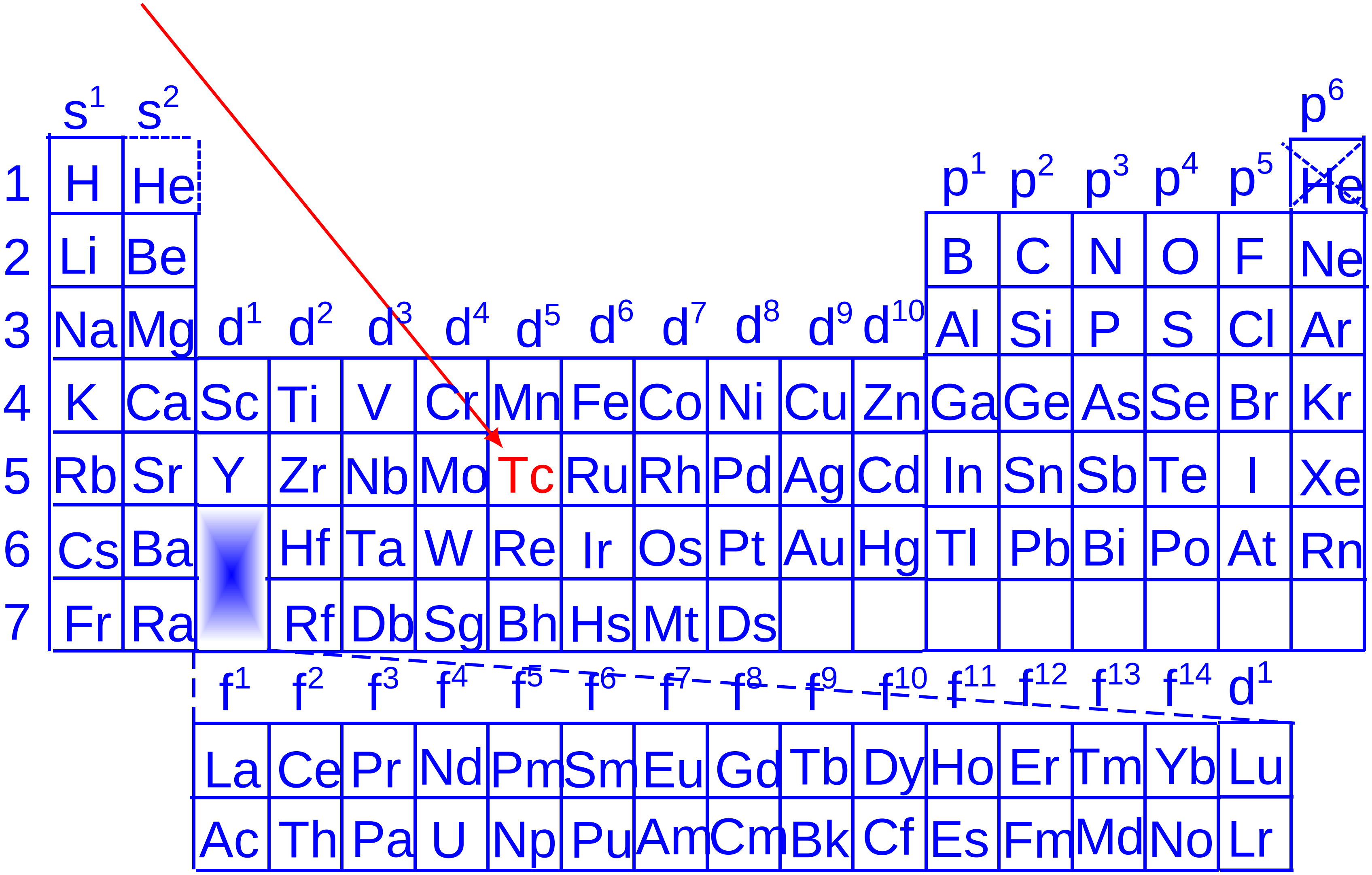
The d electron sequence is columns 3 through 10.
However, the n value is (row number) - 1 !



The f electron sequence is from La through Yb for the 4f and Ac through No for the 5f.



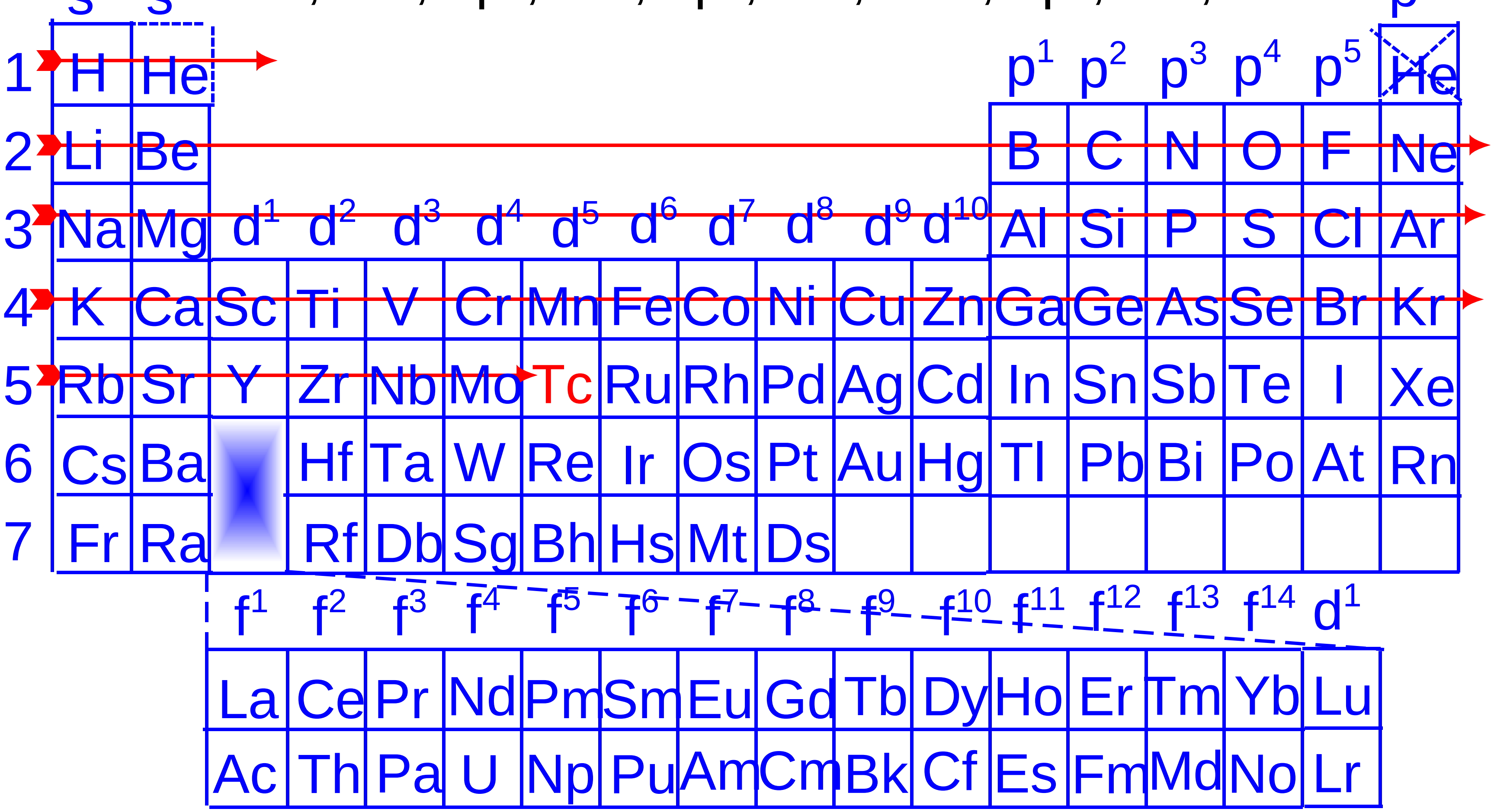
Example: What is the electron configuration of Tc?



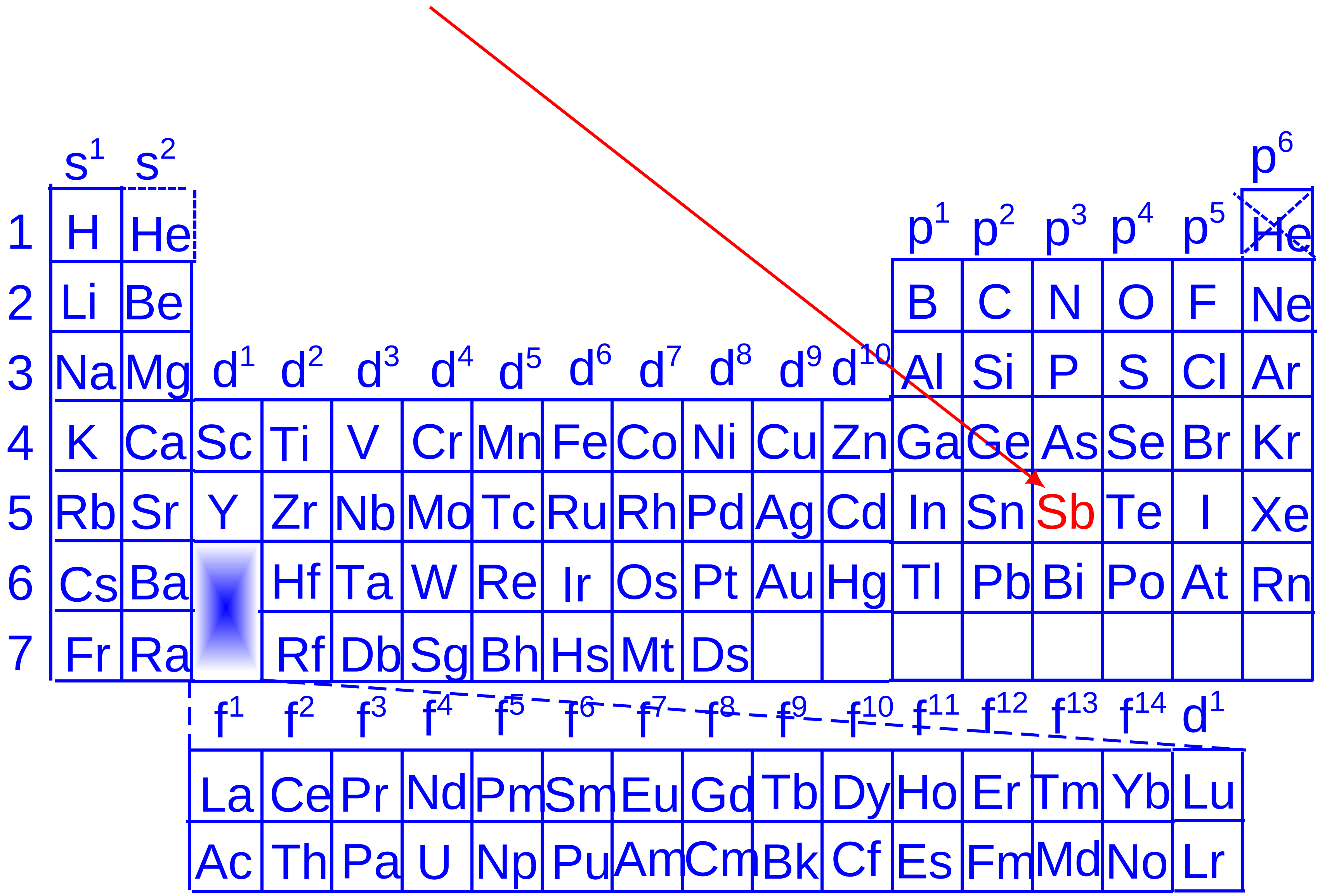
Example: What is the electron configuration of Tc?

Starting at H and counting the s's, p's etc.

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^5$



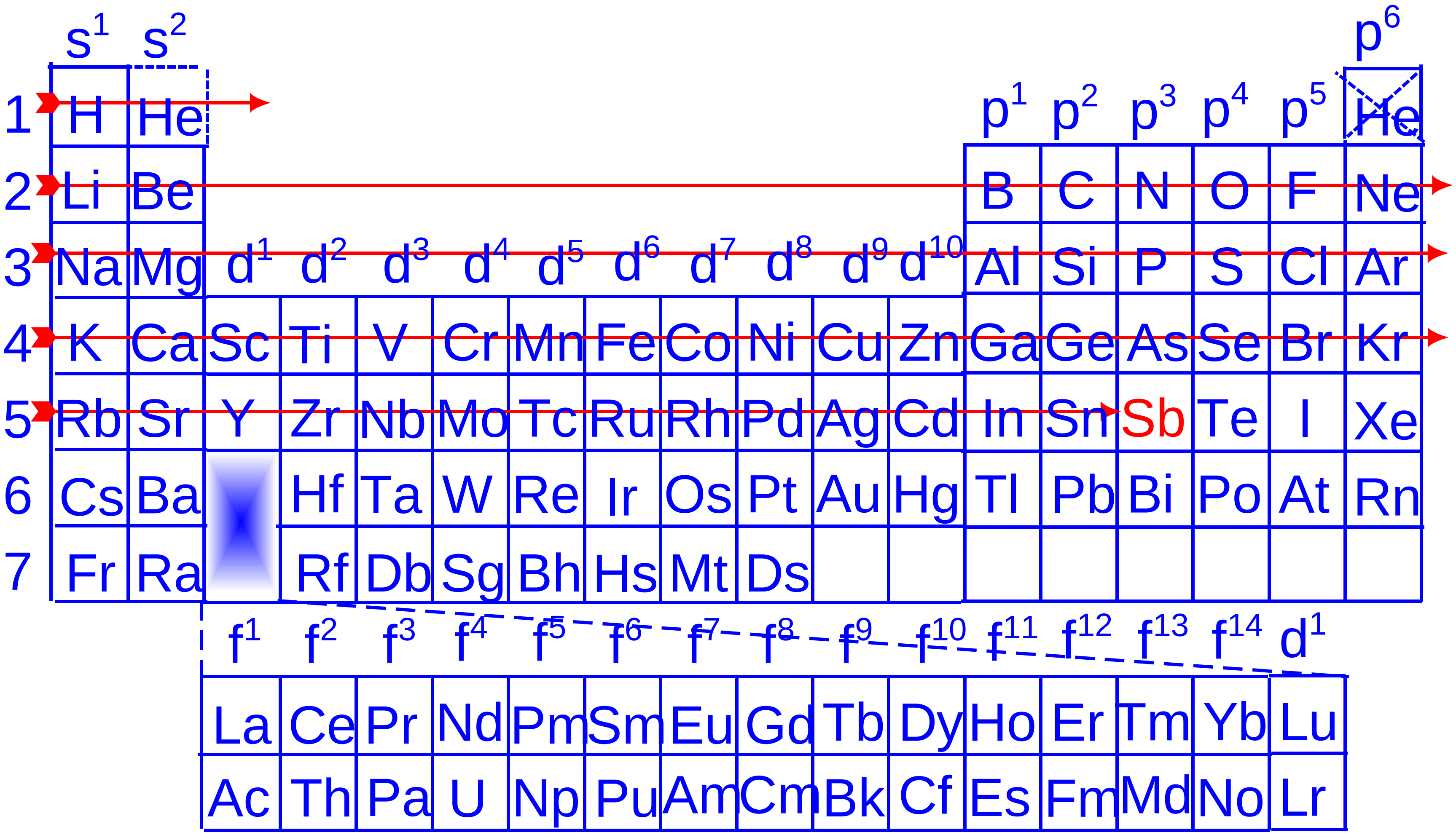
How about Sb?



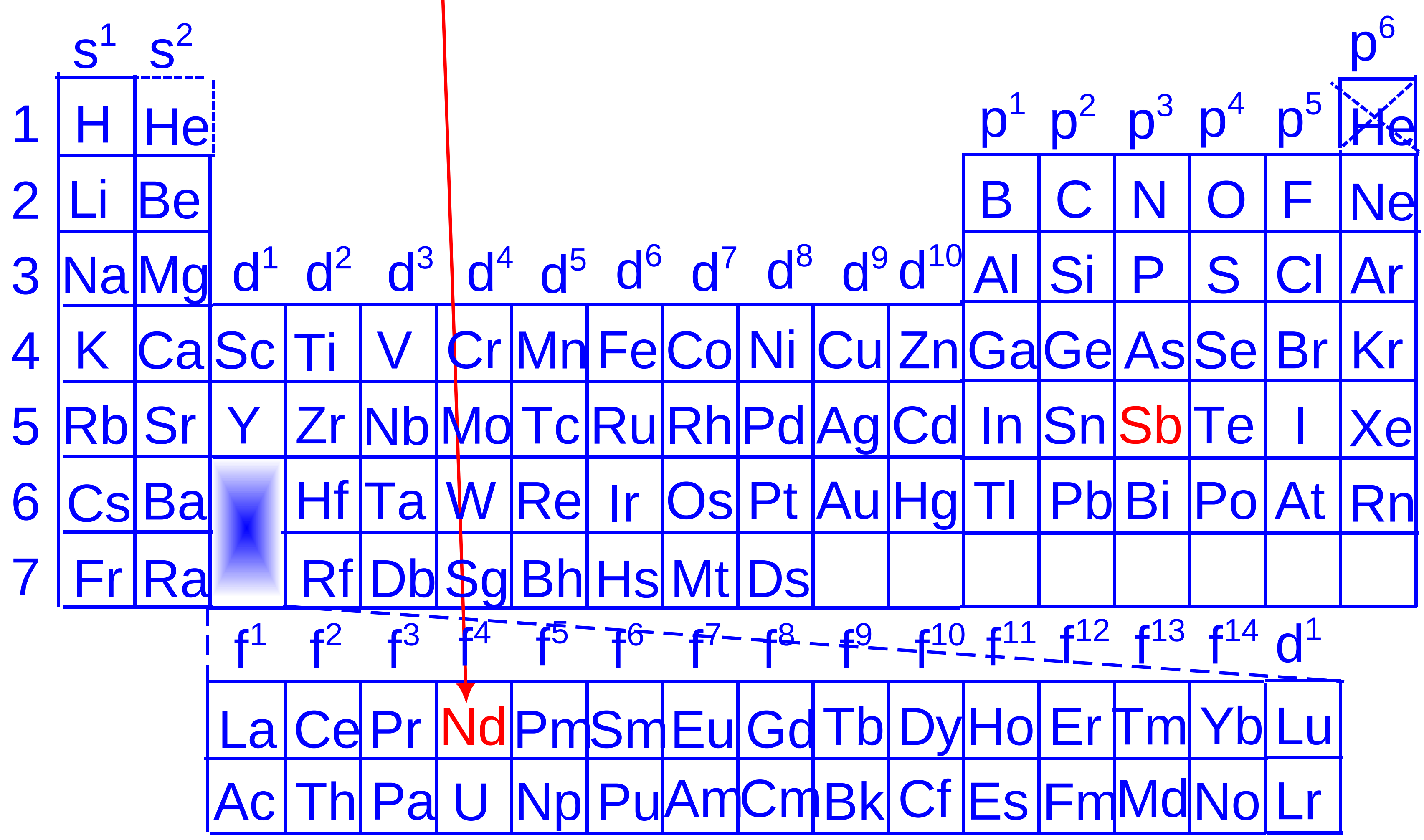
s1 s2
p6
1 H He
p1 p2 p3 p4 p5 He
2 Li Be B C N O F Ne
3 Na Mg d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 Al Si P S Cl Ar
4 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
5 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
6 Cs Ba Hf Ta W Re Ir Os Pt Au Hg Tl Pb Bi Po At Rn
7 Fr Ra Rf Db Sg Bh Hs Mt Ds
f1 f2 f3 f4 f5 f6 f7 f8 f9 f10 f11 f12 f13 f14 d1
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

How about Sb?

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^3$



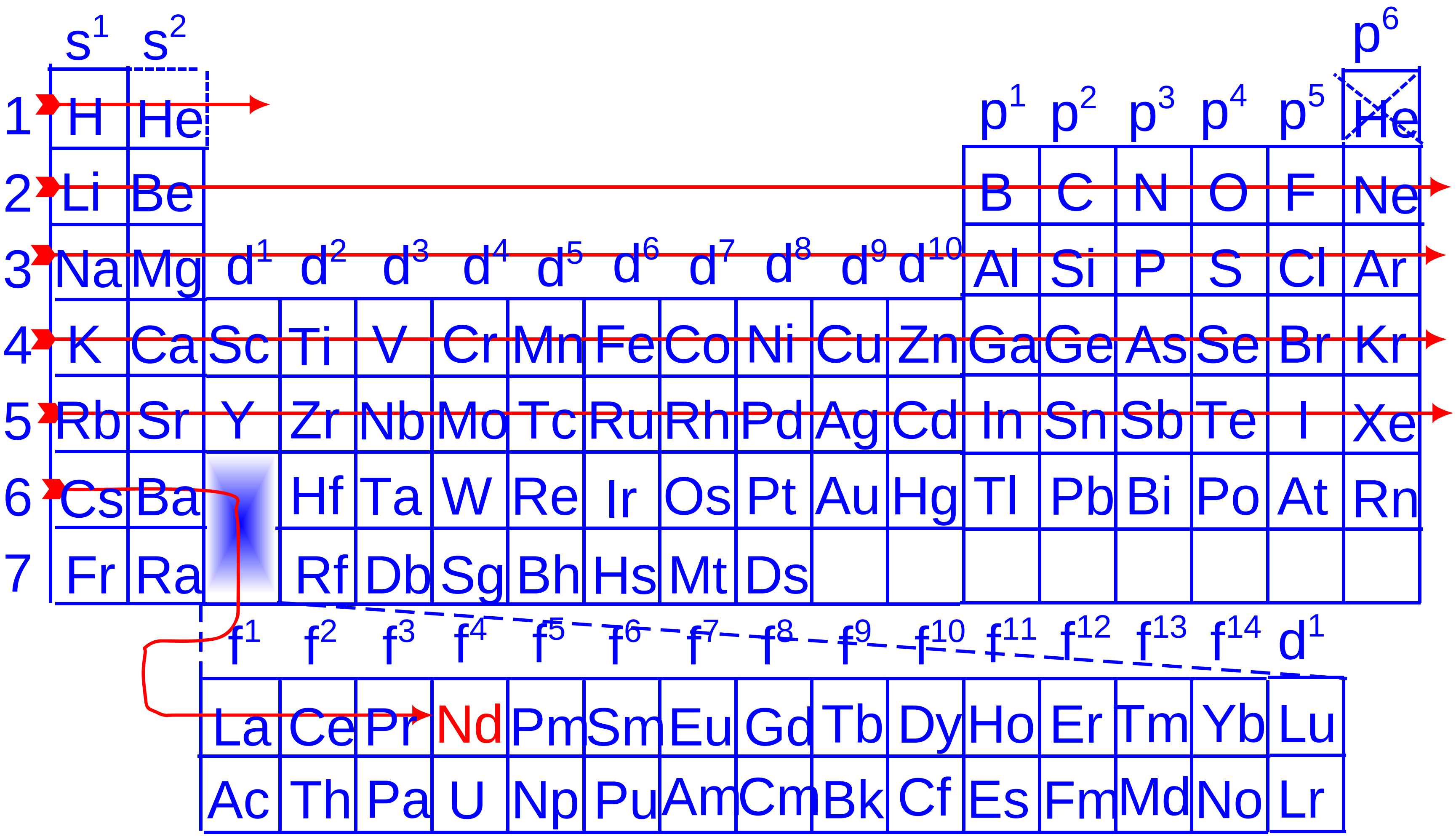
How about Nd?



s1 s2
p6
p1 p2 p3 p4 p5
1 H He He
2 Li Be B C N O F Ne
3 Na Mg d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 Al Si P S Cl Ar
4 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
5 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
6 Cs Ba Hf Ta W Re Ir Os Pt Au Hg Tl Pb Bi Po At Rn
7 Fr Ra Rf Db Sg Bh Hs Mt Ds
f1 f2 f3 f4 f5 f6 f7 f8 f9 f10 f11 f12 f13 f14 d1
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

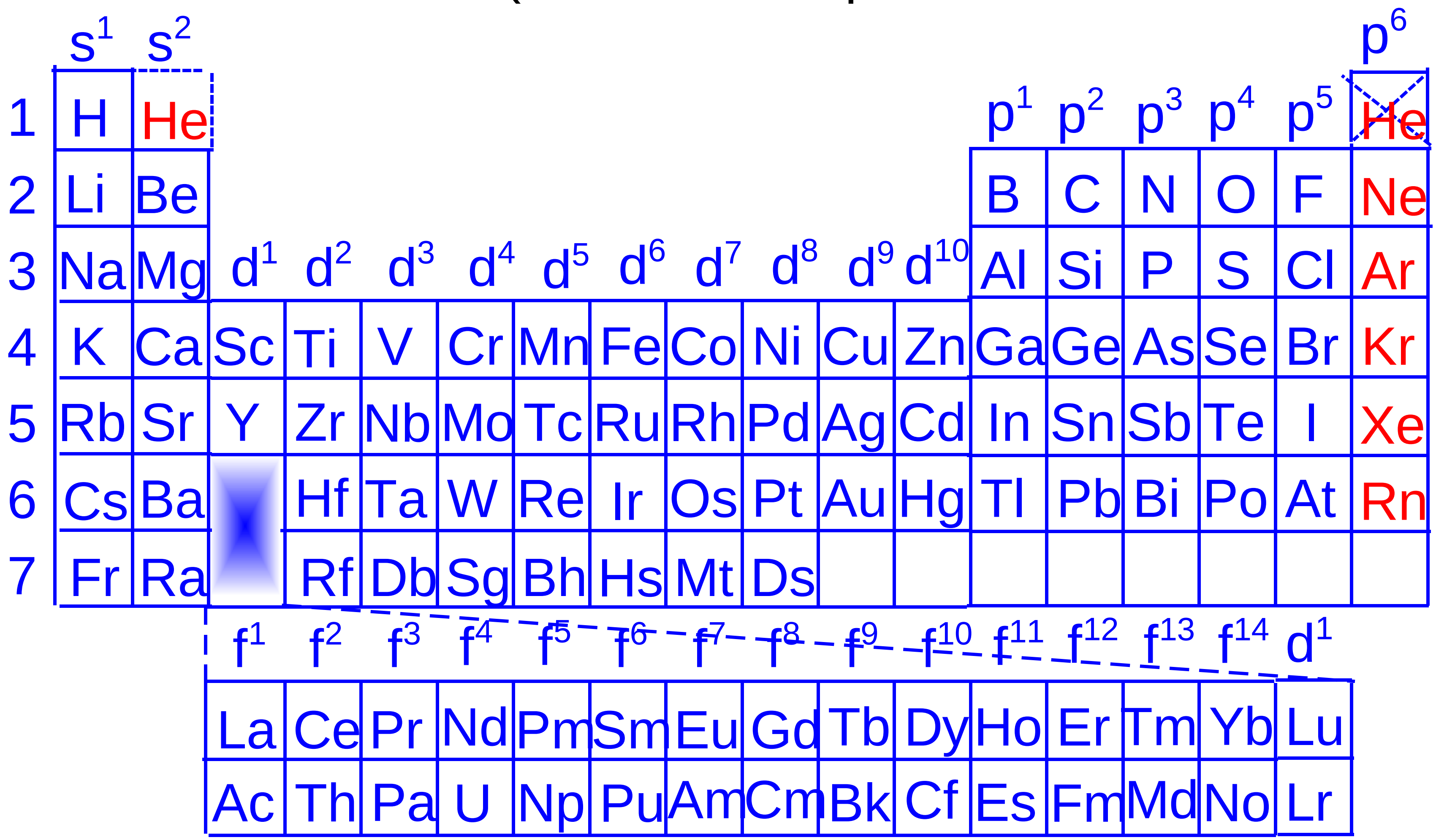
How about Nd?

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^6, 6s^2, 4f^4$



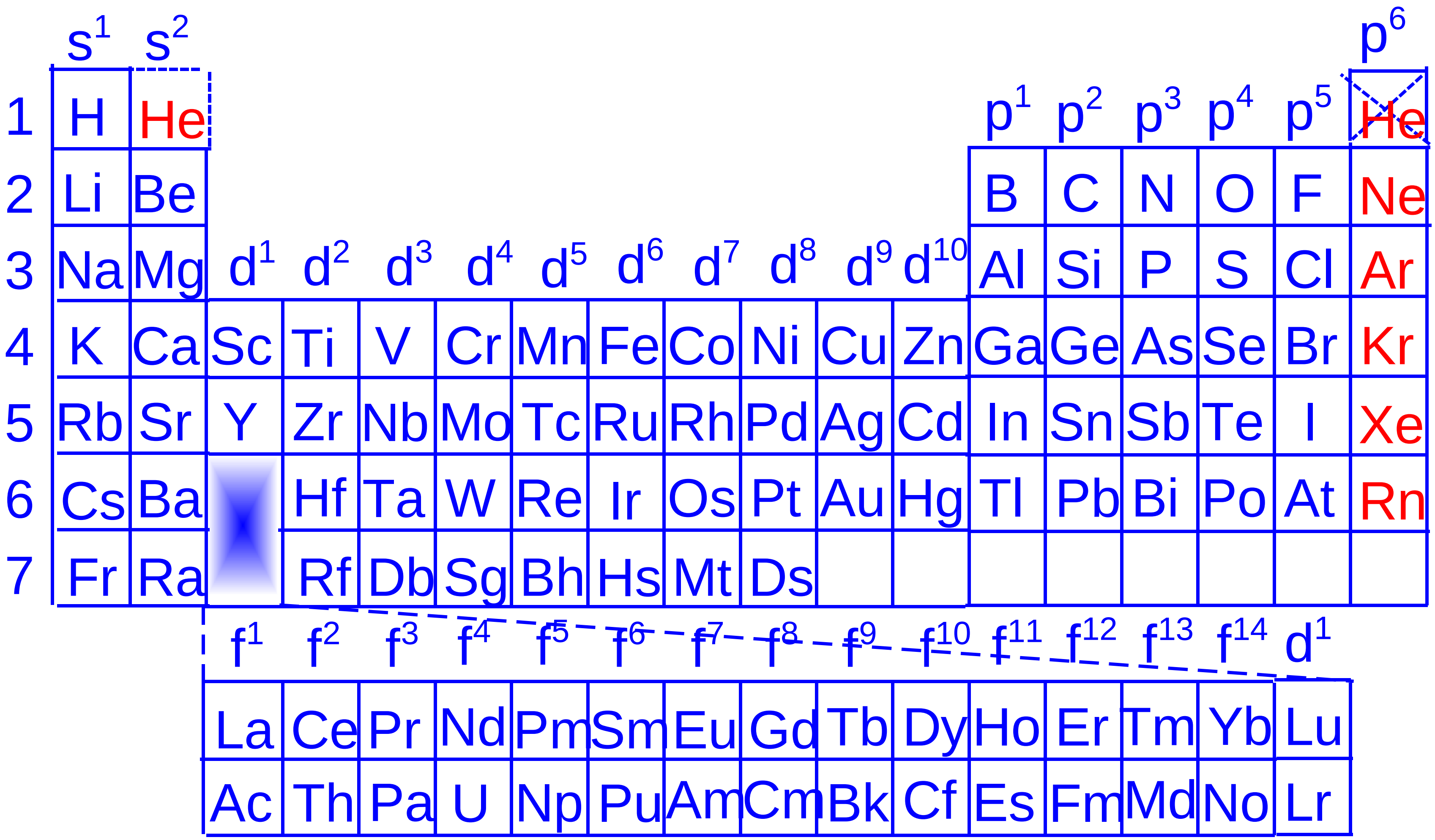
Core versus valence electrons:

The electron configuration ending with p^6 is extremely stable. These are the noble gasses and their electrons are called "core electrons". (row 1 has no p electrons, ∴He is noble)

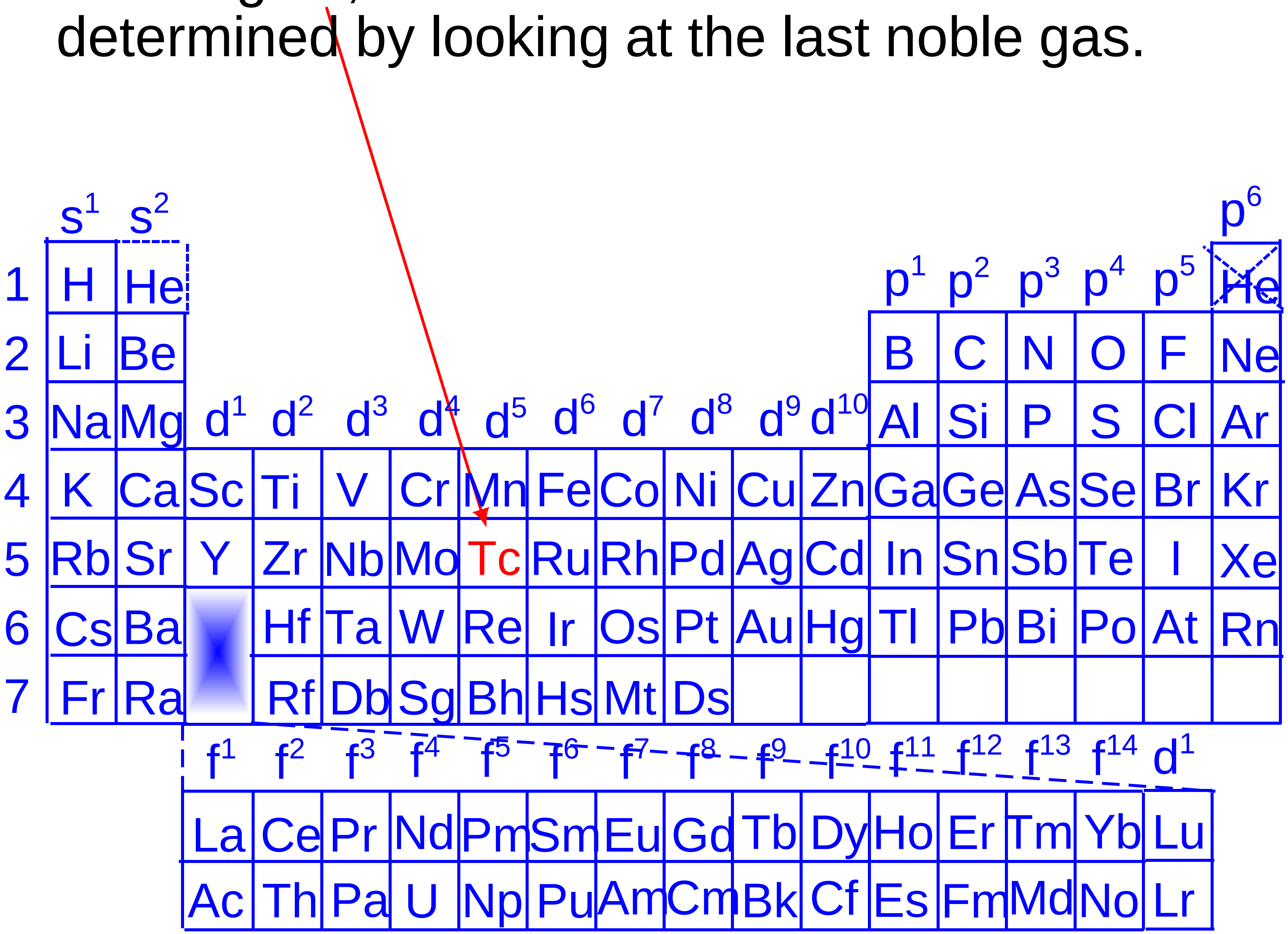


Core versus valence electrons:

The electron configuration ending with p^6 is extremely stable

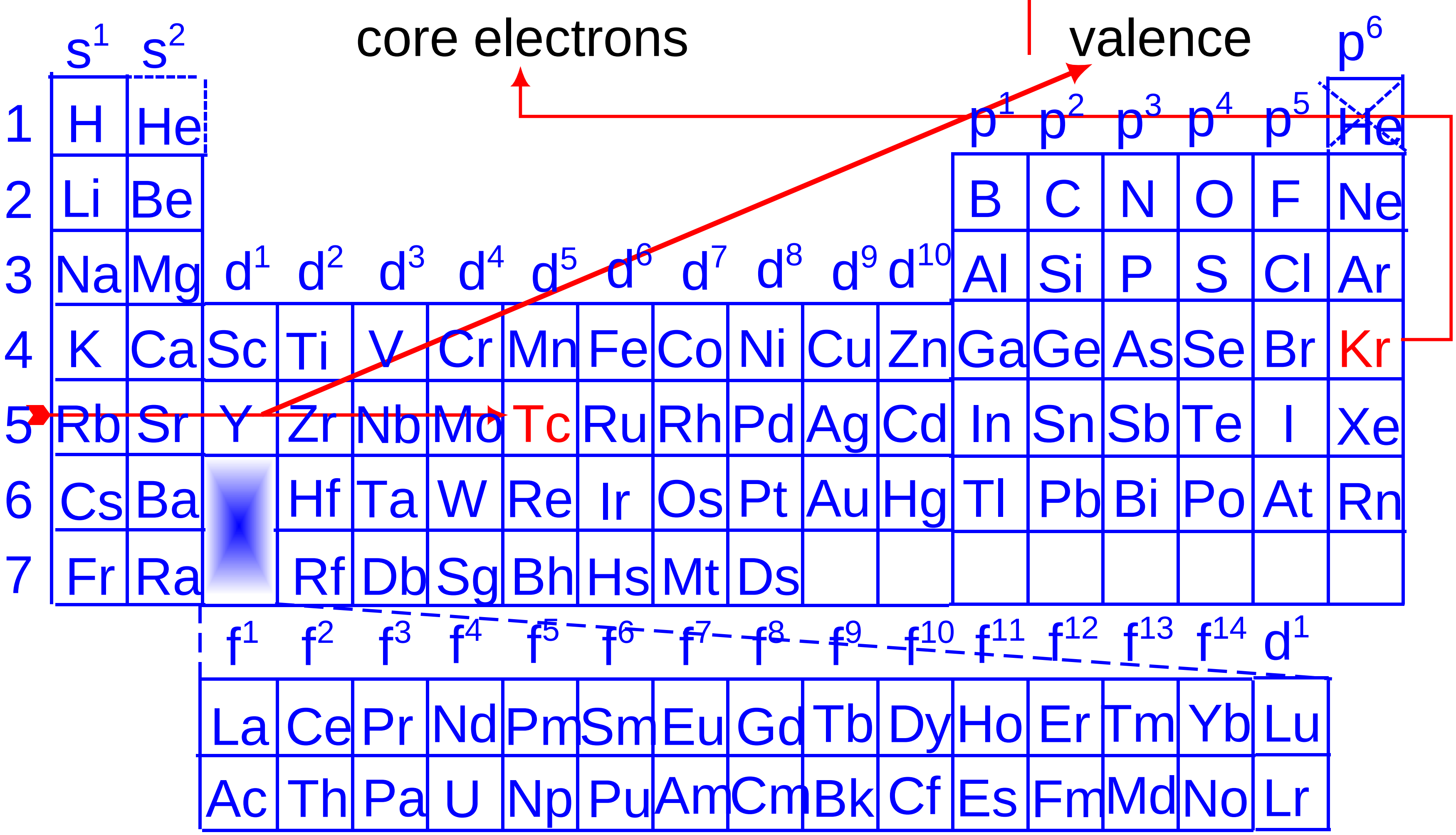


Redoing Tc, the core and valence electrons are determined by looking at the last noble gas.



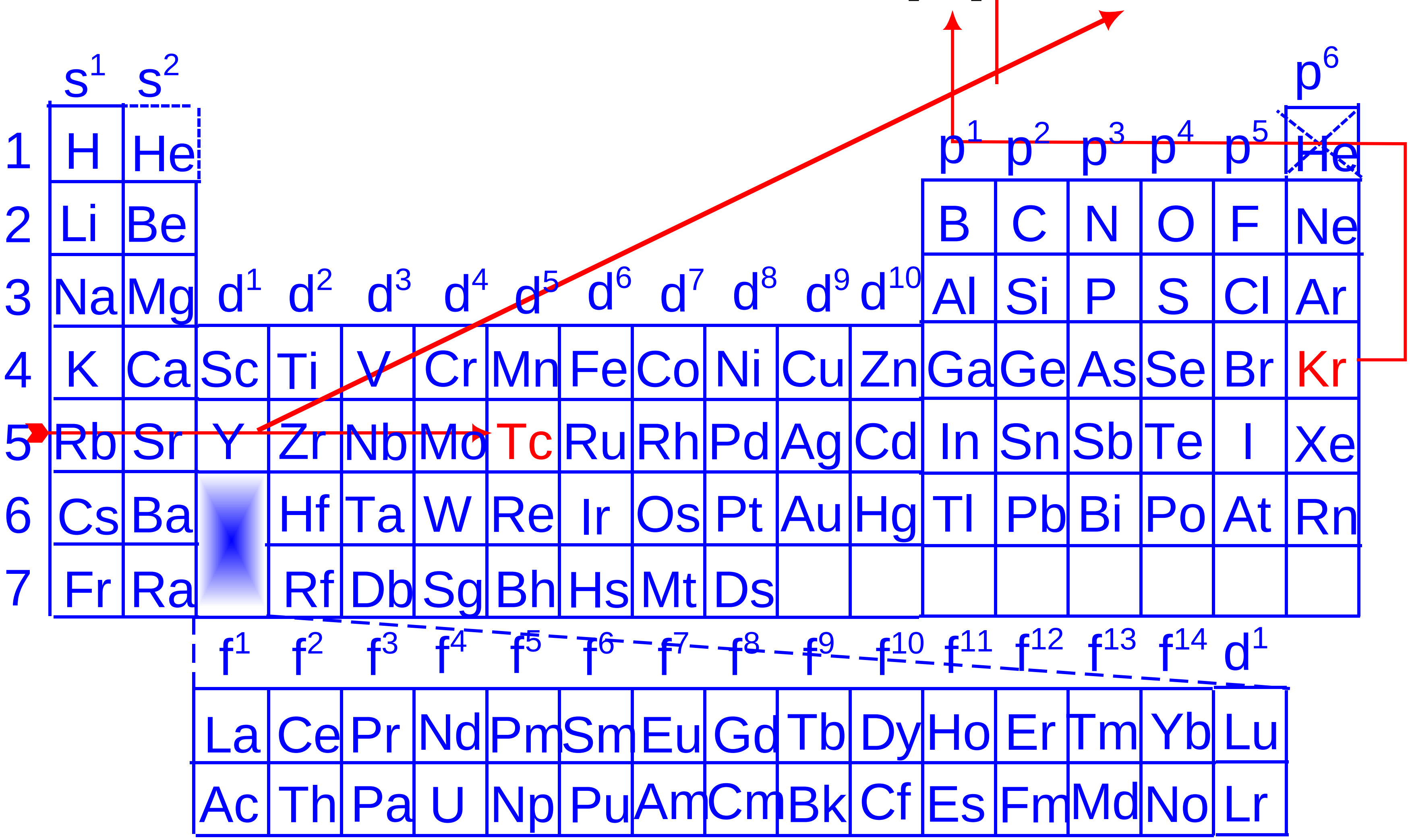
Redoing Tc, the core and valence electrons are determined by looking at the last noble gas.

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^5$

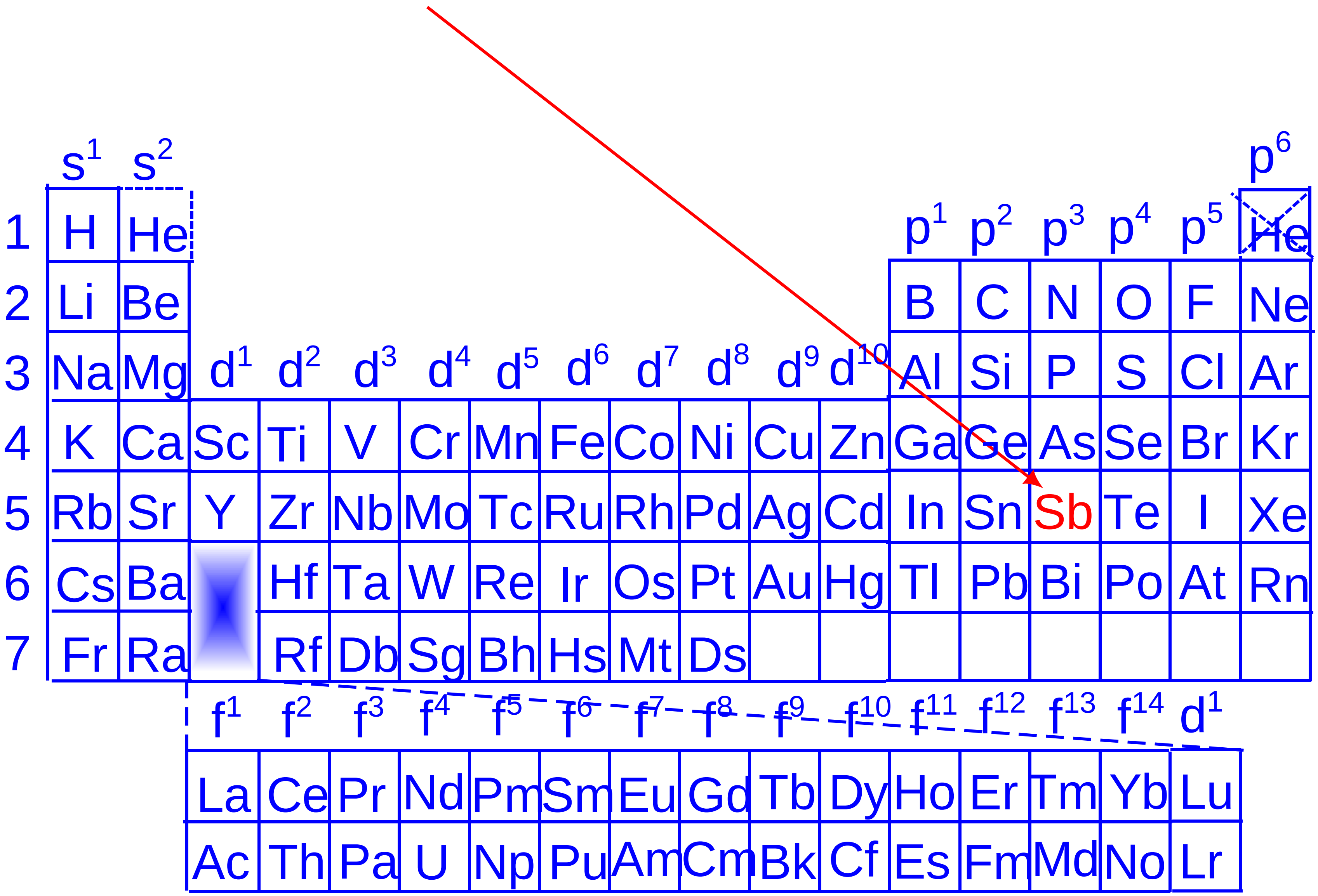


Redoing Tc, the core and valence electrons are determined by looking at the last noble gas.

This can be rewritten as: [Kr] $5s^2$, $4d^5$

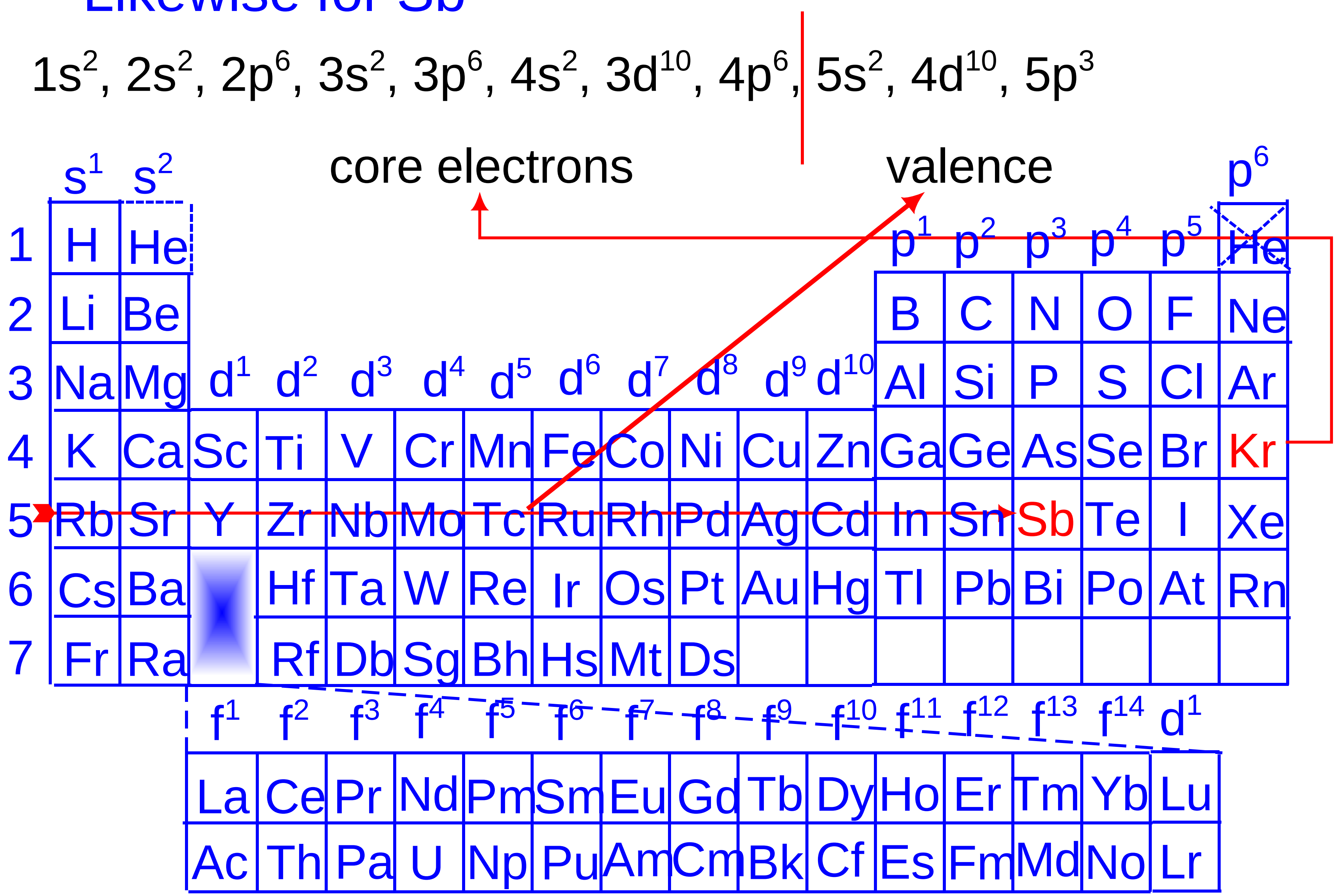


Likewise for Sb



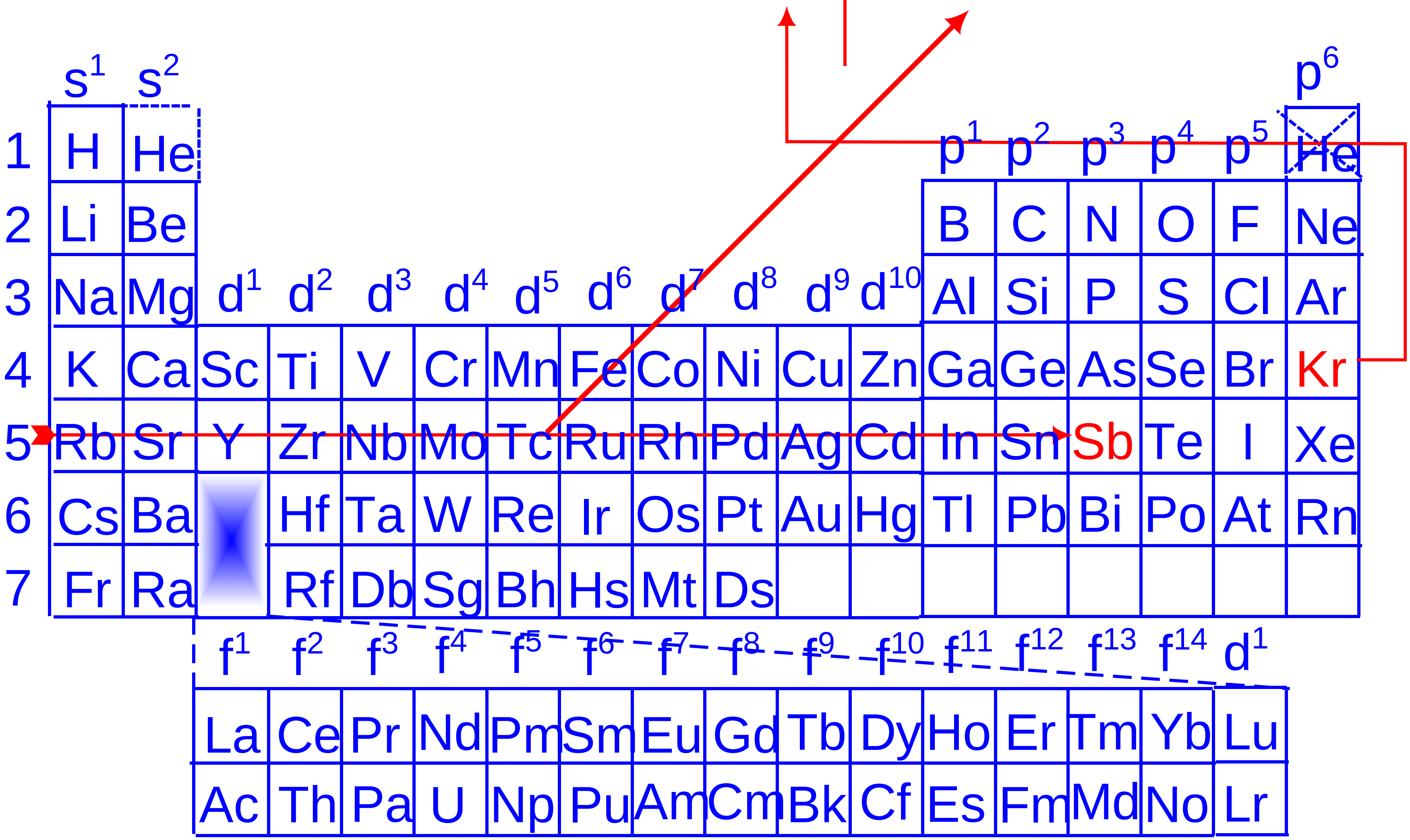
Likewise for Sb

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^3$



Likewise for Sb

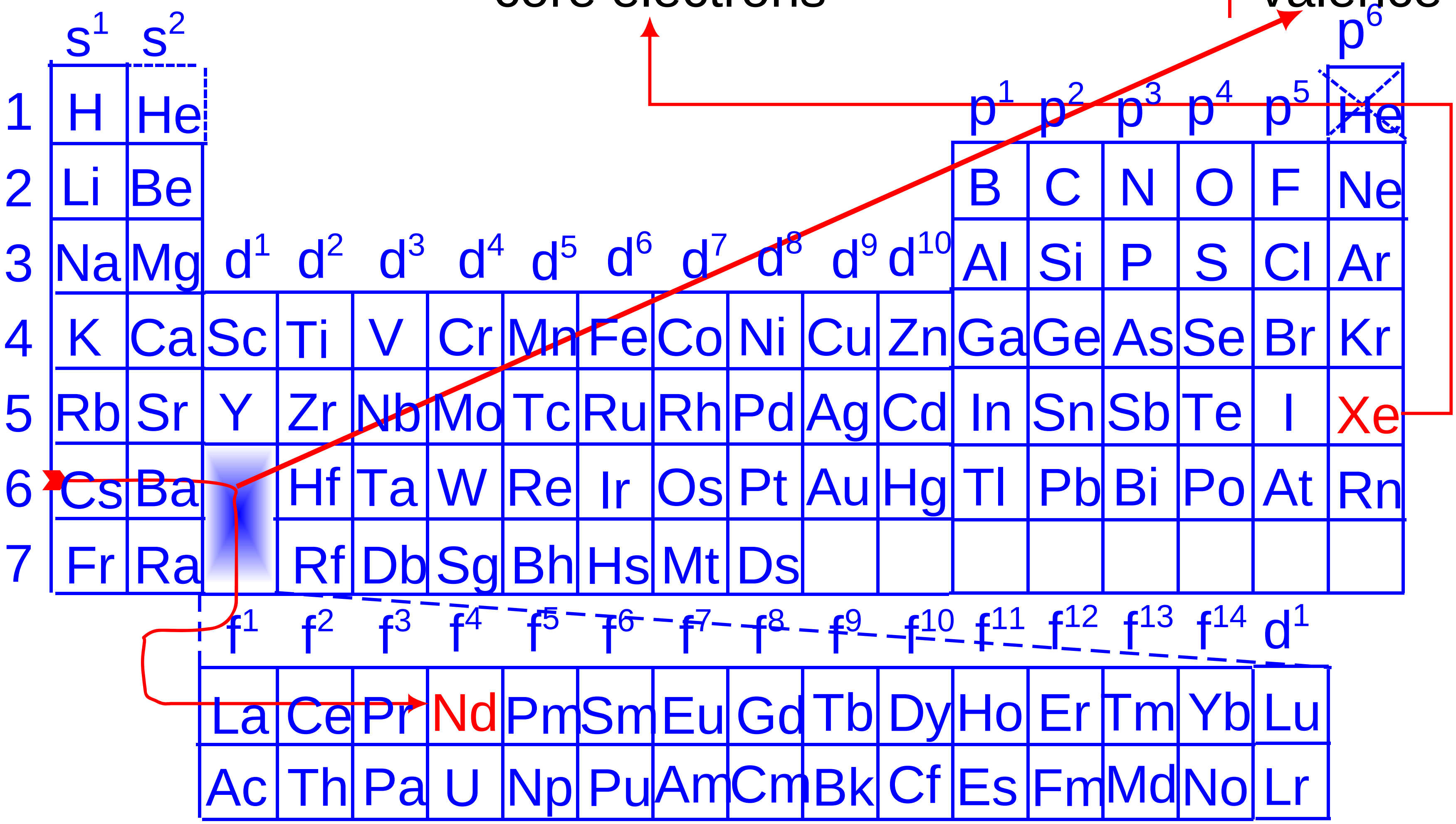
Thus: [Kr] $5s^2, 4d^{10}, 5p^3$



...and for Nd.

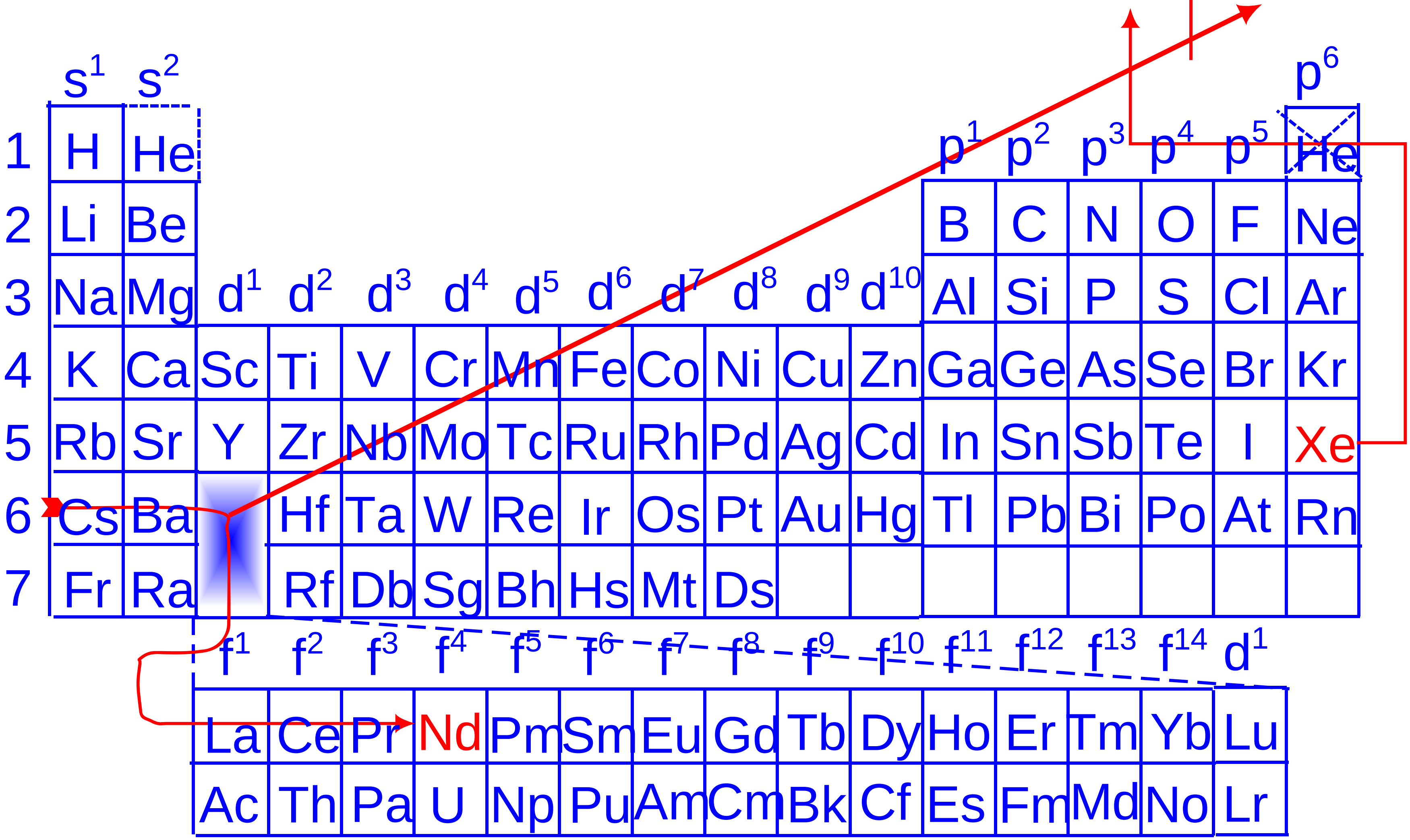
$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^6, \mid 6s^2, 4f^4$

core electrons valence



...and for Nd.

Thus yielding: [Xe] $6s^2$, $4f^4$



The End