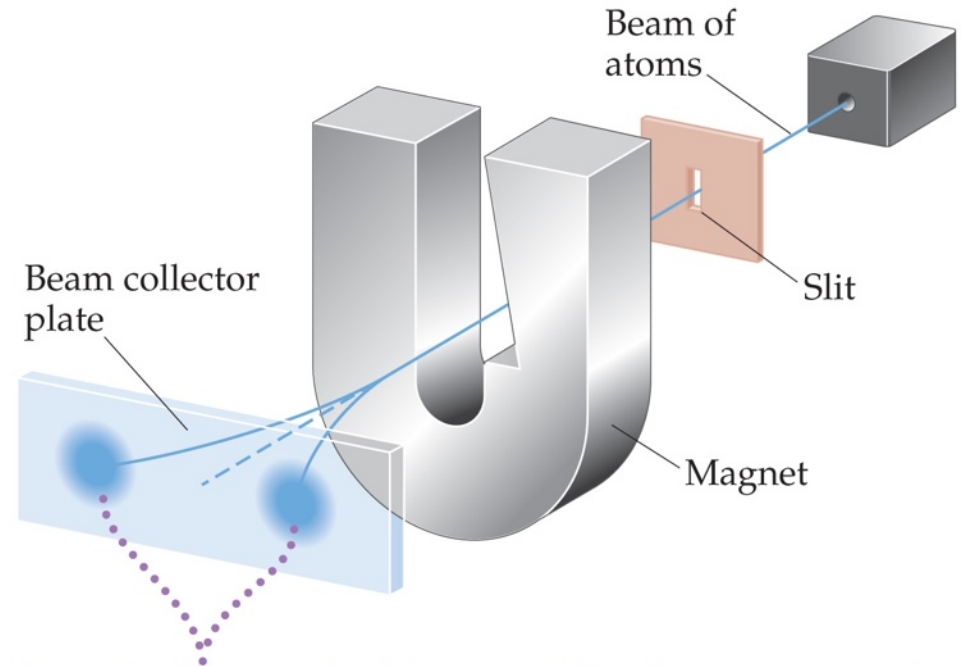


# Electron Configuration

The electron configuration of an atom tells us how the electrons are distributed among the various atomic orbitals.

# Spin Quantum Number, $m_s$

- In the 1920s, it was discovered that two electrons in the same orbital do not have exactly the same energy.
- The “spin” of an electron describes its magnetic field, which affects its energy.

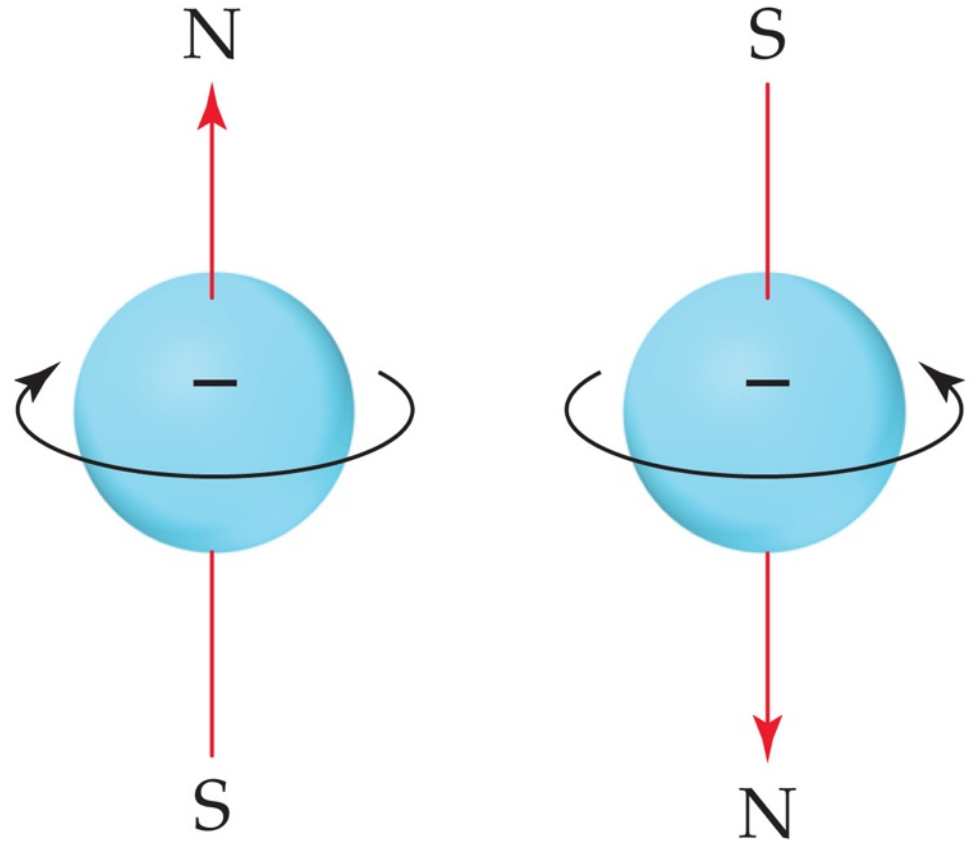


Atoms having unpaired electron with spin quantum number  $m_s = +1/2$  deflect in one direction; those having unpaired electron with  $m_s = -1/2$  deflect in opposite direction

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# Spin Quantum Number, $m_s$

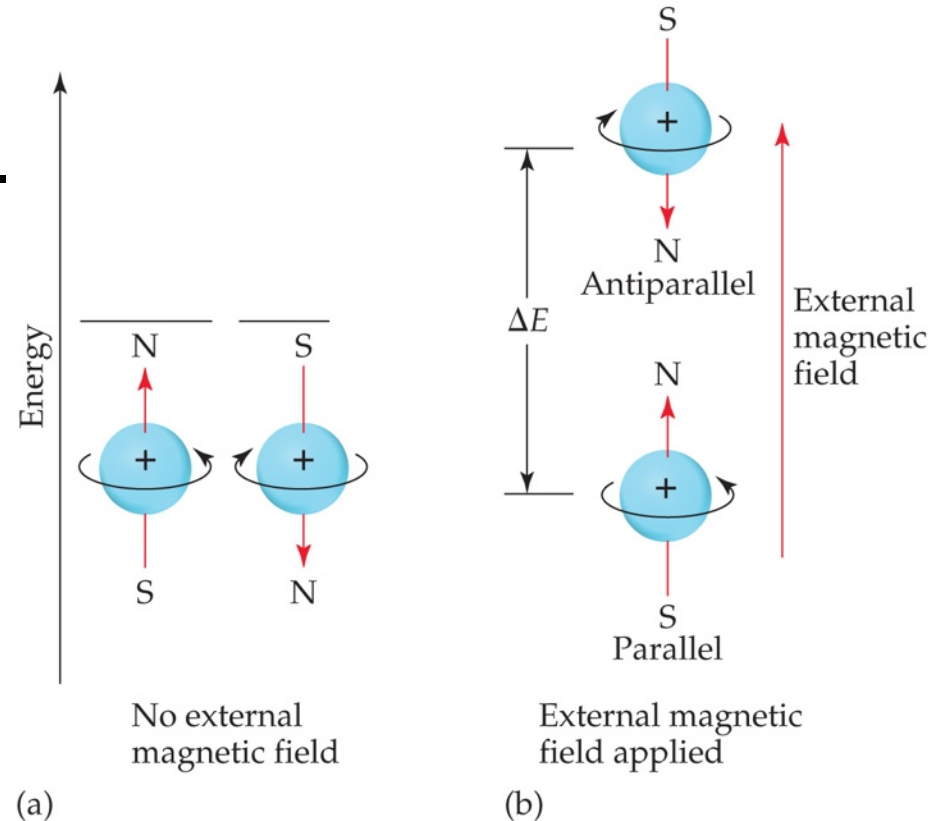
- This led to a fourth quantum number, the spin quantum number,  $m_s$ .
- The spin quantum number has only 2 allowed values:  $+1/2$  and  $-1/2$ .



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# Pauli Exclusion Principle

- No two electrons in the same atom can have exactly the same energy.
- Therefore, no two electrons in the same atom can have identical sets of quantum numbers.
- maximum of **two** electrons per orbital



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# Orbital Filling Rules

---

(1) electrons are added to orbitals beginning with the orbital of the lowest energy

(aufbau principle)

(2) maximum of two electrons per orbital

(Pauli exclusion principle)

# First Period

principal quantum number ( $n$ ) = 1

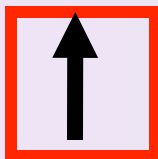
Hydrogen

$Z = 1$

$1s^1$

$1s$

H

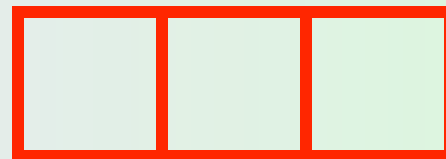


$2s$



$1s^2$

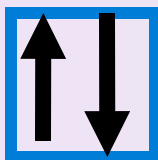
$2p$



Helium

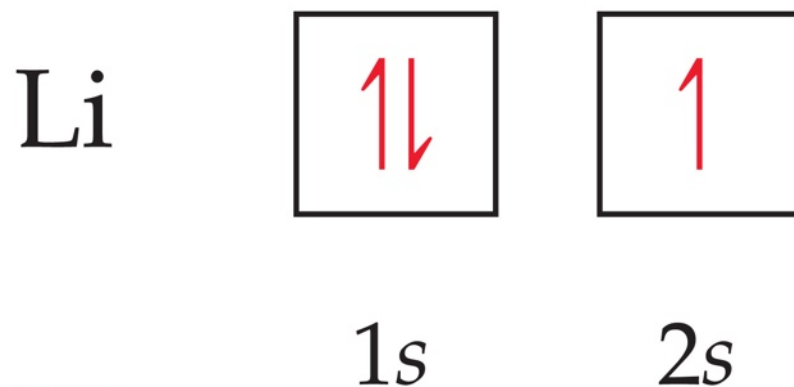
$Z = 2$

He



# Orbital Diagrams

- Each box in the diagram represents one orbital.
- Half-arrows represent the electrons.
- The direction of the arrow represents the relative spin of the electron.

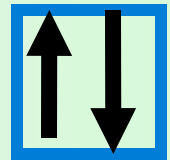


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# Diamagnetism and Paramagnetism

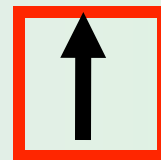
**Diamagnetic** substances are basically unaffected by a magnetic field.

all electron spins are paired He



**Paramagnetic** substances are attracted by a magnet.

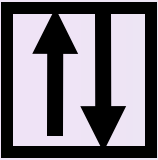
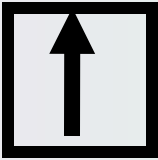
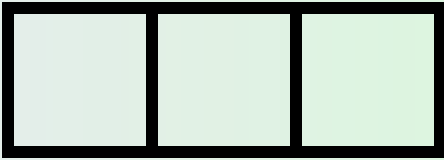
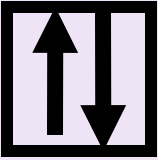
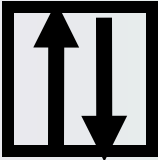
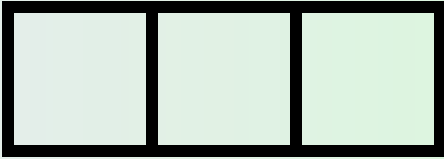
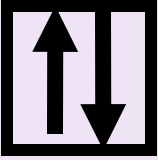
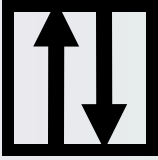
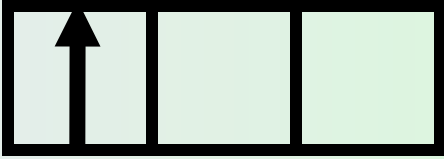
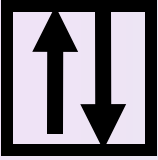
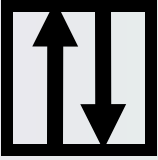
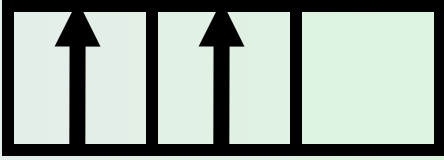
contain at least one electron with an unpaired spin H





# Second Period

principal quantum number ( $n$ ) = 2

	$Z$	$1s$	$2s$	$2p$
Li	3			
Be	4			
B	5			
C	6			



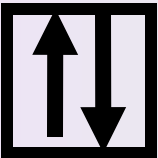
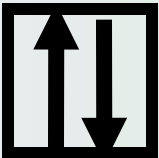
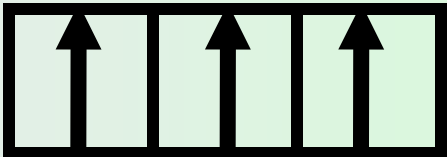
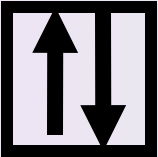
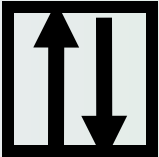
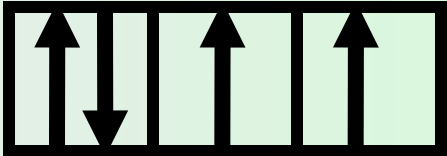
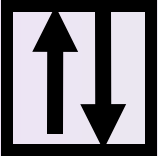
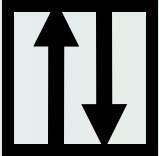
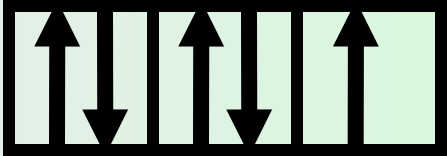
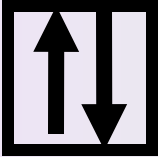
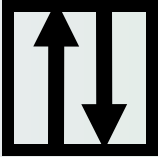
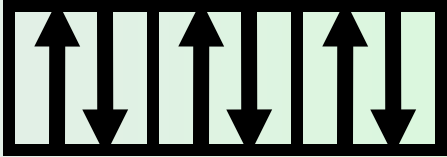
# Hund's Rule

---

(3) when two or more orbitals are of equal energy, each one is singly occupied before any are doubly occupied

the most stable arrangement of the electrons in the sub-shells is the one with the greatest number of parallel spins

## Second Period cont...

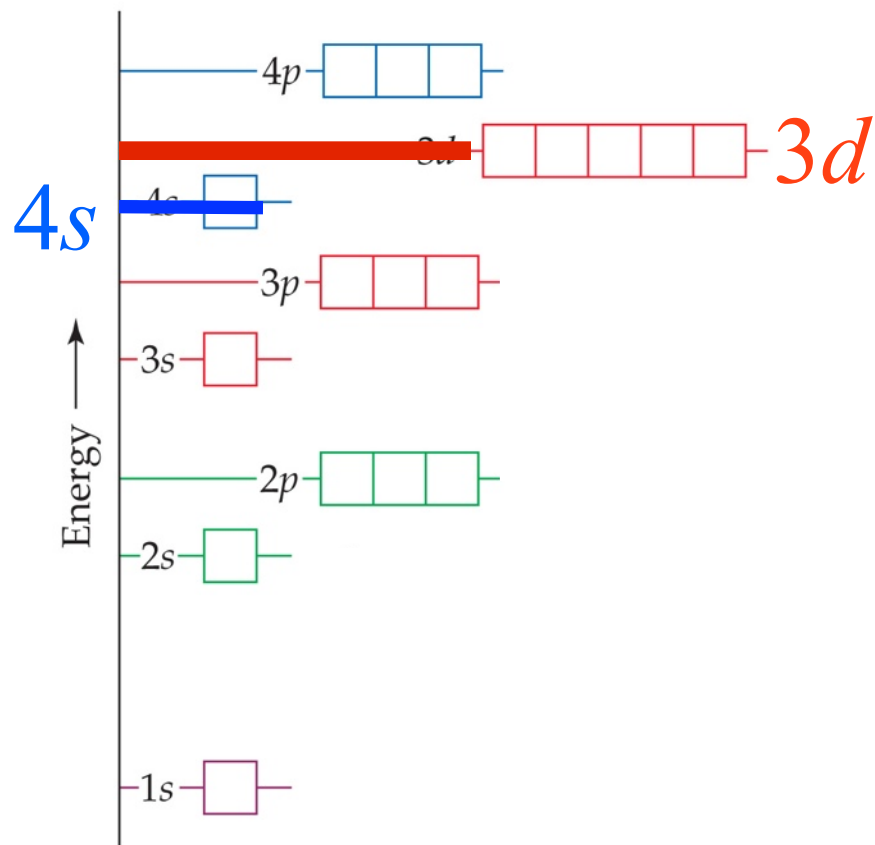
	$Z$	$1s$	$2s$	$2p$
N	7			
O	8			
F	9			
Ne	10			



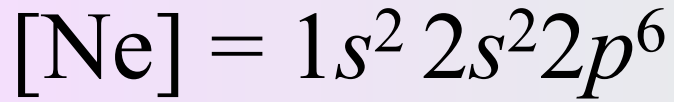
# **The Building-Up Principle**

The Aufbau principle

# Energies of Orbitals



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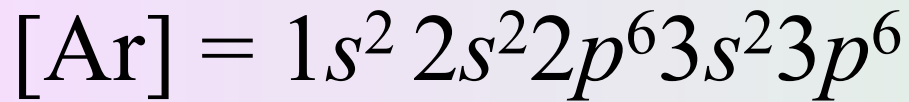


## Third Period

[Ne] core

Na	11	[Ne]	$3s^1$
Mg	12	[Ne]	$3s^2$
Al	13	[Ne]	$3s^2 3p^1$
Si	14	[Ne]	$3s^2 3p^2$
P	15	[Ne]	$3s^2 3p^3$
S	16	[Ne]	$3s^2 3p^4$
Cl	17	[Ne]	$3s^2 3p^5$
Ar	18	[Ne]	$3s^2 3p^6$





## Fourth Period

[Ar] core

K	19	[Ar]	$4s^1$
Ca	20	[Ar]	$4s^2$
Sc	21	[Ar]	$4s^2 3d^1$

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn  
first series of transition elements



# Transition Metals

---

have incompletely filled  $d$  subshells or readily give rise to cations that have incompletely filled  $d$  subshells



# First Transition Series

Sc	21	[Ar]	$4s^23d^1$
Ti	22	[Ar]	$4s^23d^2$
V	23	[Ar]	$4s^23d^3$
Cr	24	[Ar]	$4s^13d^5$
Mn	25	[Ar]	
Fe	26	[Ar]	
Co	27	[Ar]	
Ni	28	[Ar]	
Cu	29	[Ar]	
Zn	30	[Ar]	



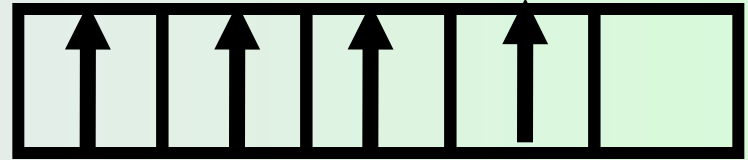
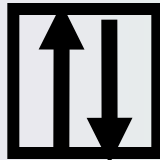
# Periodic Anomalies

$4s$

$3d$

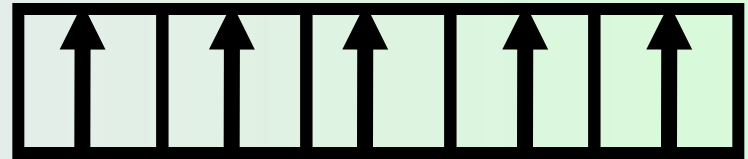
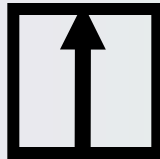
Cr expected

[Ar]



Cr actual

[Ar]



# First Transition Series

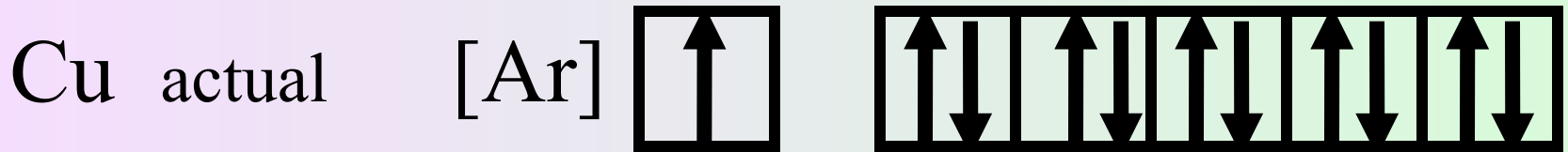
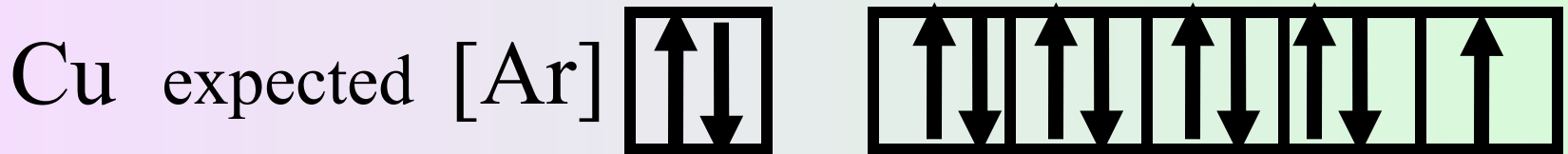
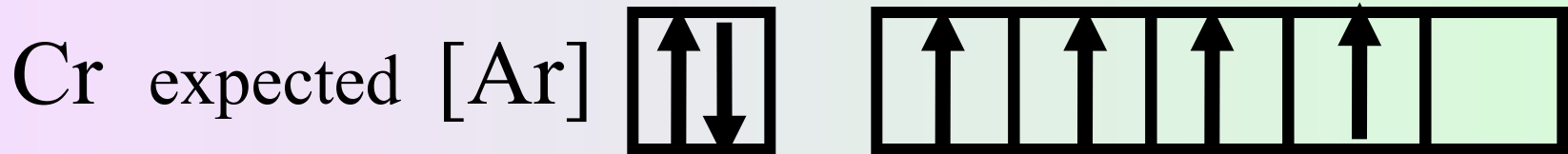
Sc	21	[Ar]	$4s^23d^1$
Ti	22	[Ar]	$4s^23d^2$
V	23	[Ar]	$4s^23d^3$
Cr	24	[Ar]	$4s^13d^5$
Mn	25	[Ar]	$4s^23d^5$
Fe	26	[Ar]	$4s^23d^6$
Co	27	[Ar]	$4s^23d^7$
Ni	28	[Ar]	$4s^23d^8$
Cu	29	[Ar]	$4s^13d^{10}$
Zn	30	[Ar]	$4s^23d^{10}$



# Periodic Anomalies

$4s$

$3d$



## Fifth Period

[Kr] core

contains second series of transition elements in which the  $4d$  orbitals are filled

$4d$  orbitals are filled in a manner similar, but not identical, to that of  $3d$  orbitals in first transition series

# Sixth Period

[Xe] core

6s fills before 4f

lanthanaide series: 14 elements  
corresponding to filling 4f orbitals

4f fills before 5d

# Seventh Period

[Rn] core

$7s$  fills before  $5f$

actinide series: 14 elements

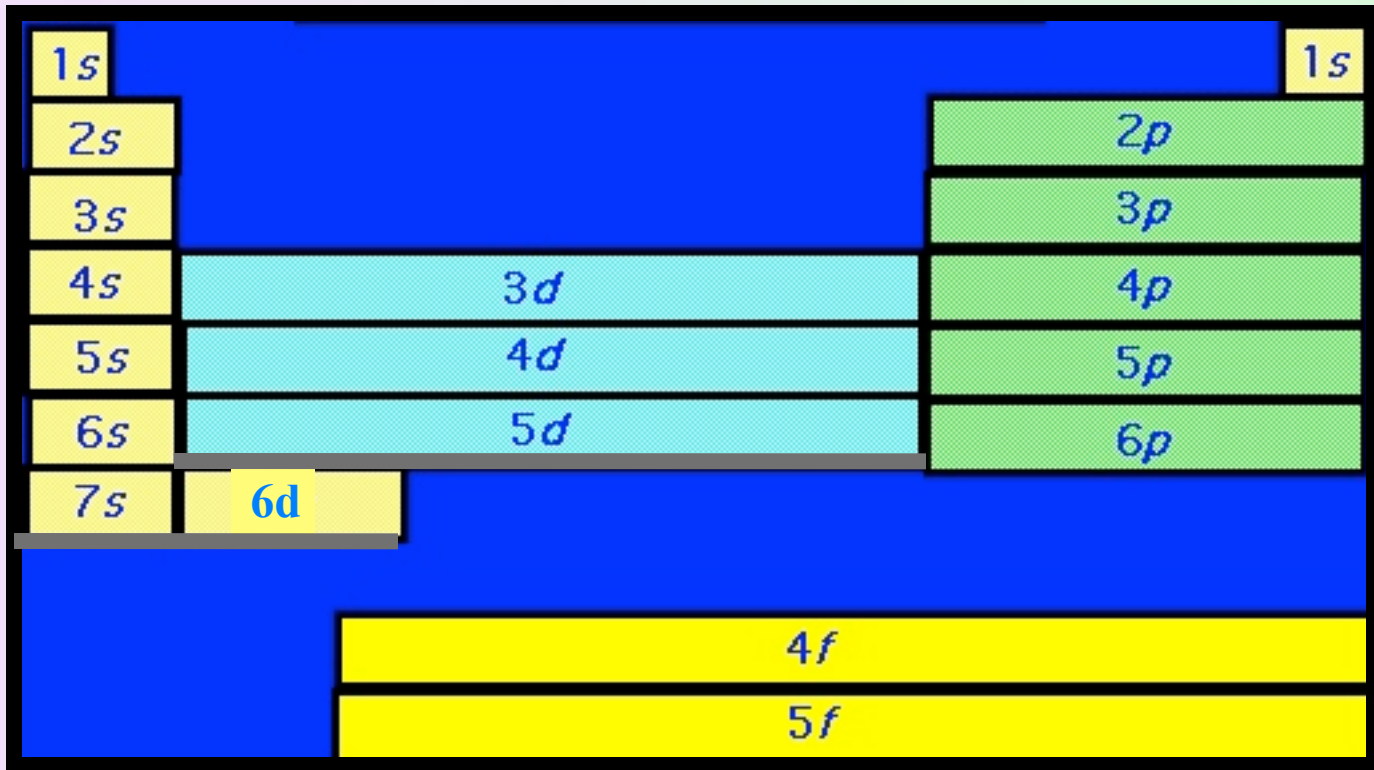
corresponding to filling  $5f$  orbitals

$5f$  fills before  $6d$









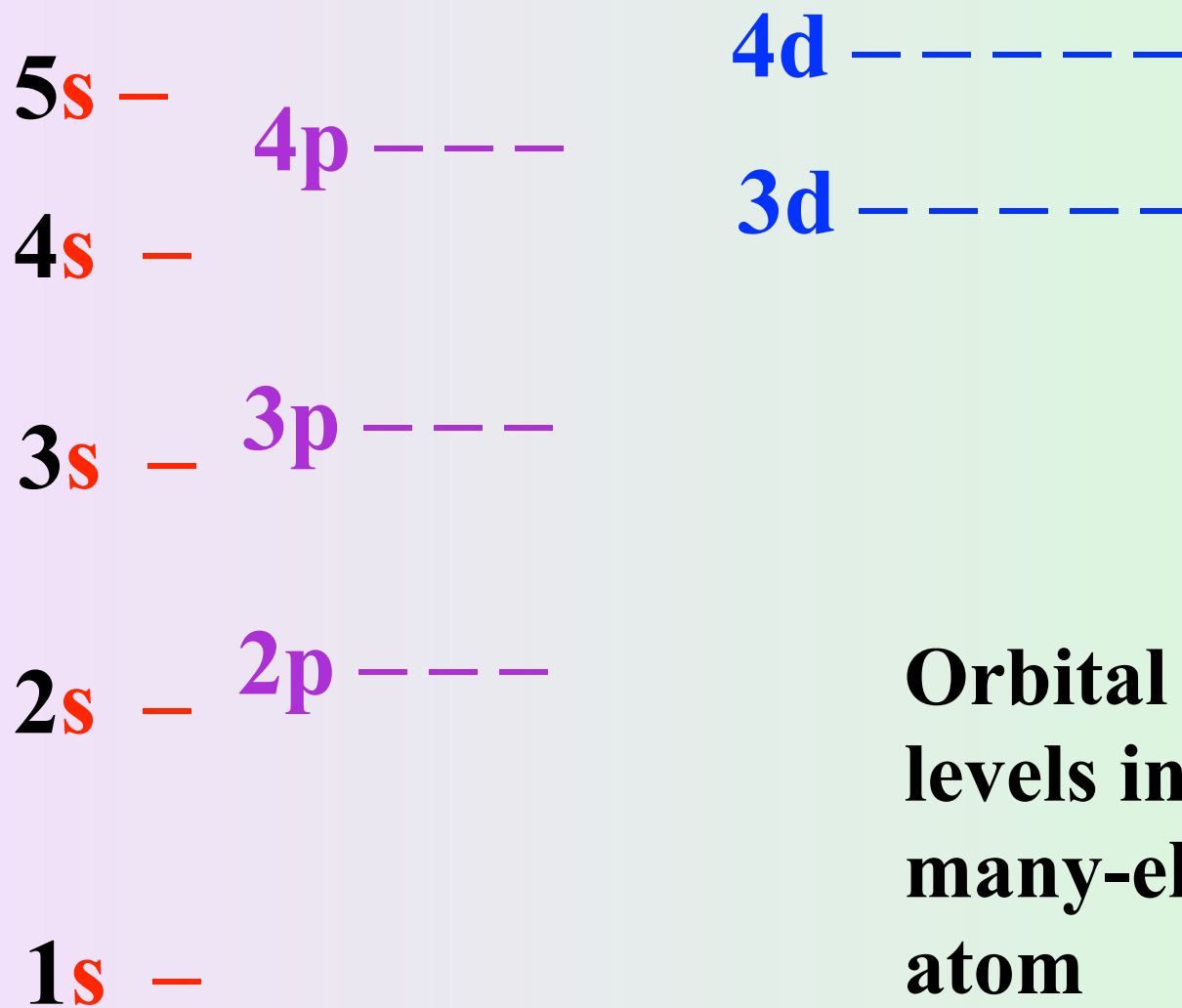
Subshell filling of elements in regions of the periodic table

K	19	[Ar] 4s <sup>1</sup>
Ca	20	[Ar] 4s <sup>2</sup>
Sc	21	[Ar] 4s <sup>2</sup> 3d <sup>1</sup>

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn

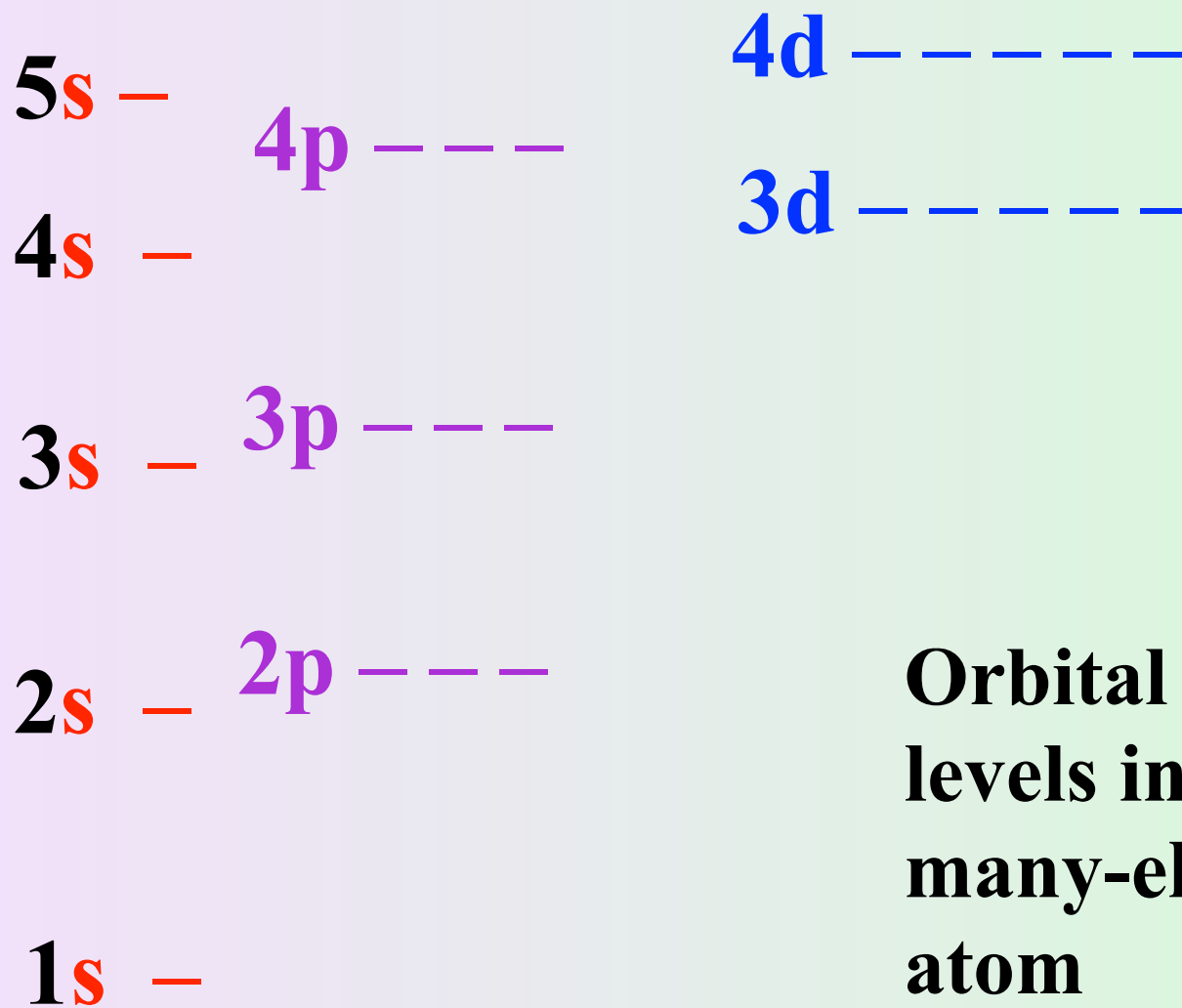
Zn	30	[Ar] 4s <sup>2</sup> 3d <sup>10</sup>
Ga	31	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>1</sup>
Ge	32	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>2</sup>
As	33	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>3</sup>
Se	34	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>4</sup>
Br	35	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>5</sup>
Kr	36	[Ar] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>6</sup>





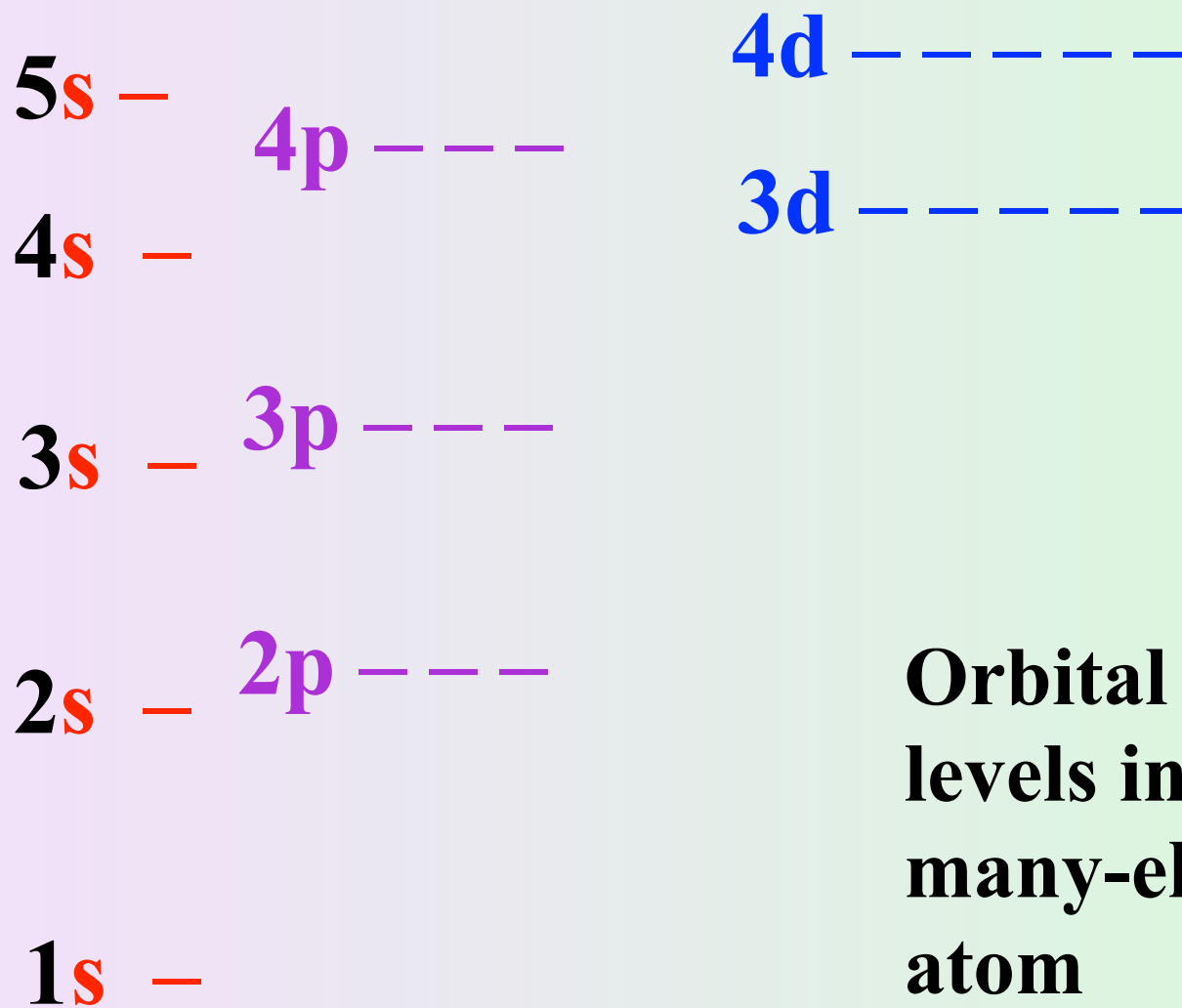
**Orbital energy  
levels in a  
many-electron  
atom**





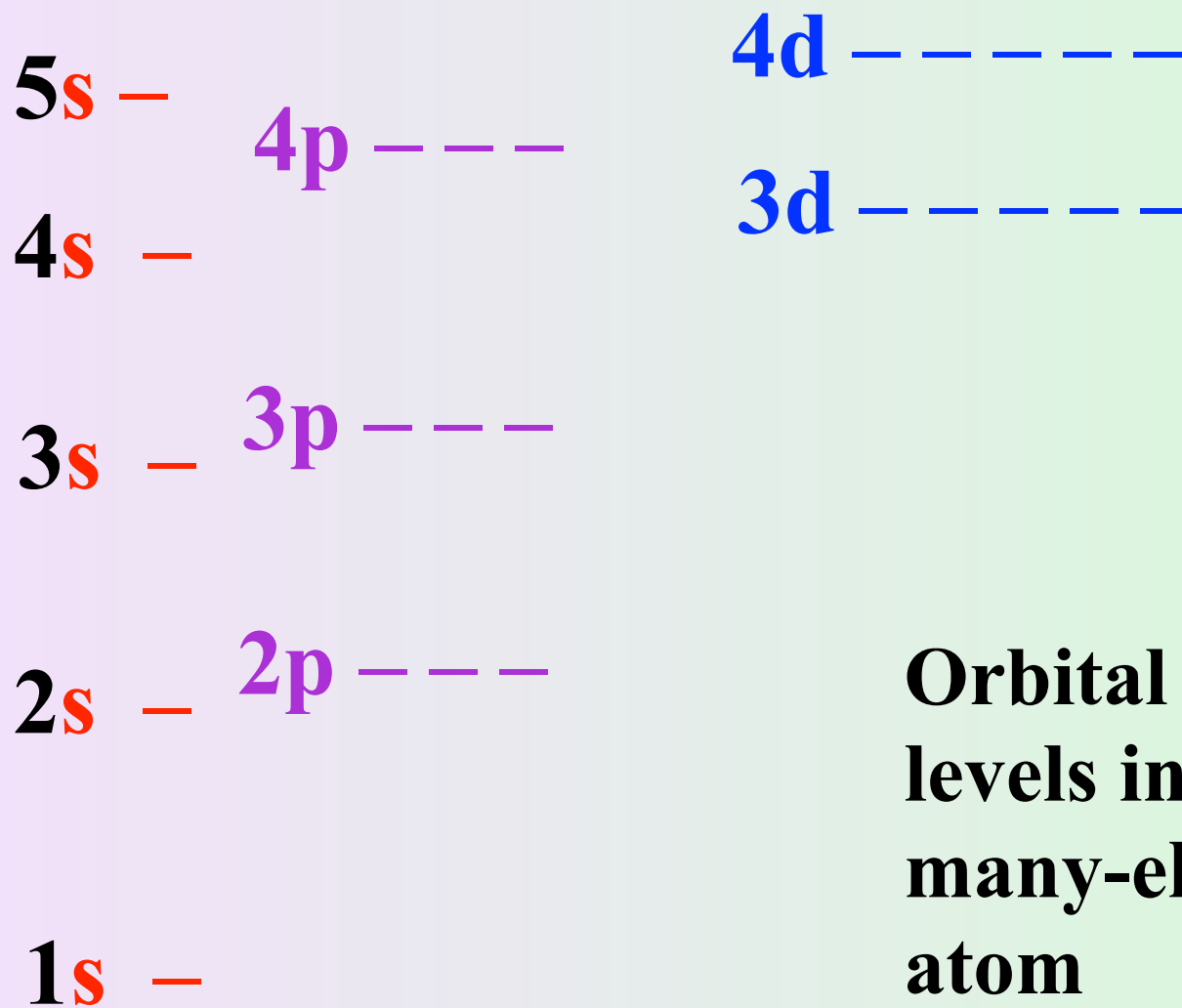
**Orbital energy  
levels in a  
many-electron  
atom**





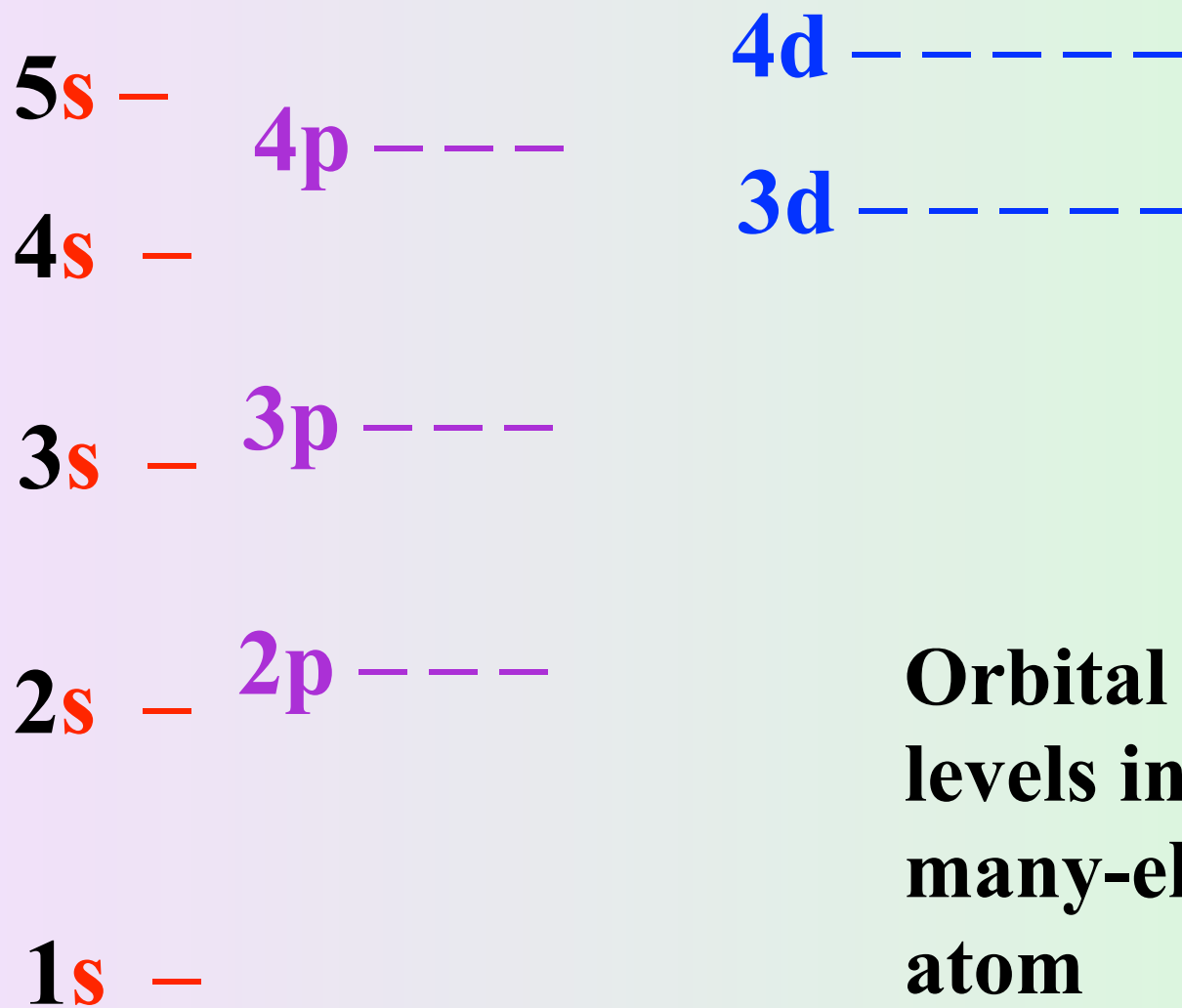
**Orbital energy  
levels in a  
many-electron  
atom**





**Orbital energy  
levels in a  
many-electron  
atom**

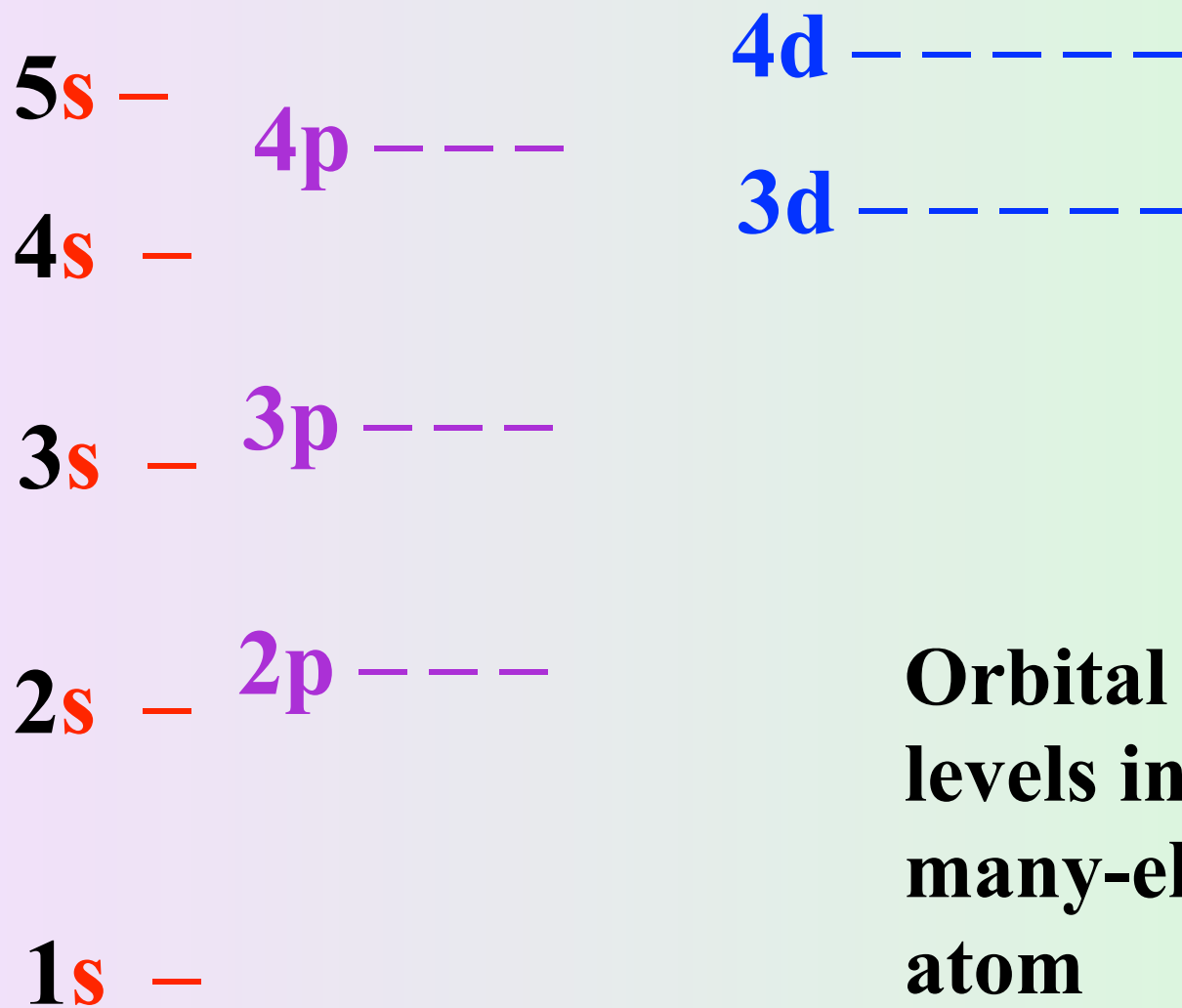




**Orbital energy  
levels in a  
many-electron  
atom**







**Orbital energy  
levels in a  
many-electron  
atom**





# Electron Configurations



- This term shows the distribution of all electrons in an atom.
- Each component consists of
  - A number denoting the energy level,

# Electron Configurations



- This term shows the distribution of all electrons in an atom
- Each component consists of
  - A number denoting the energy level,
  - A letter denoting the type of orbital,

# Electron Configurations



- This term shows the distribution of all electrons in an atom.
- Each component consists of
  - A number denoting the energy level,
  - A letter denoting the type of orbital,
  - A superscript denoting the number of electrons in those orbitals.