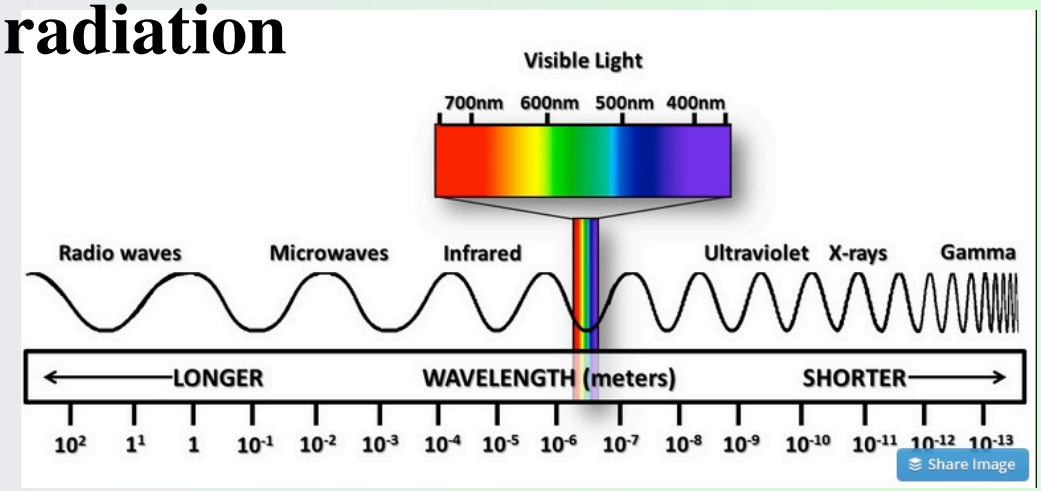
Quantum Theory

review

The Players

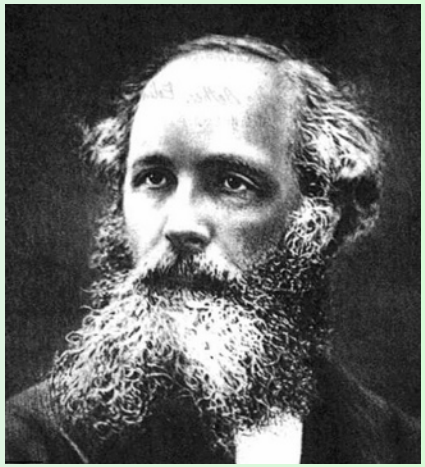
light is electromagnetic radiation

$$c = \nu \lambda$$



high frequency-short wavelength

low frequency-long wavelength



- **James Clerk Maxwell**

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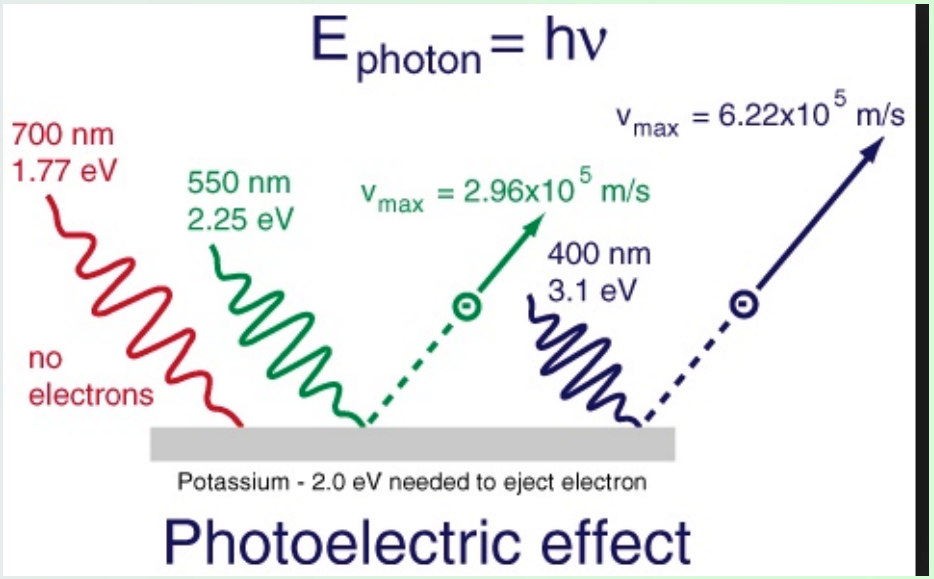
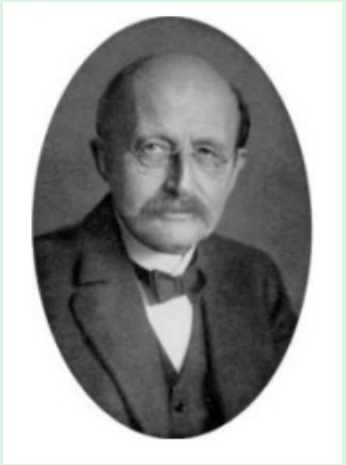
light is quantized



where $h = 6.626 \times 10^{-34}$ J s

$$\Delta E = h\nu$$

- **Albert Einstein**
- **Max Planck**



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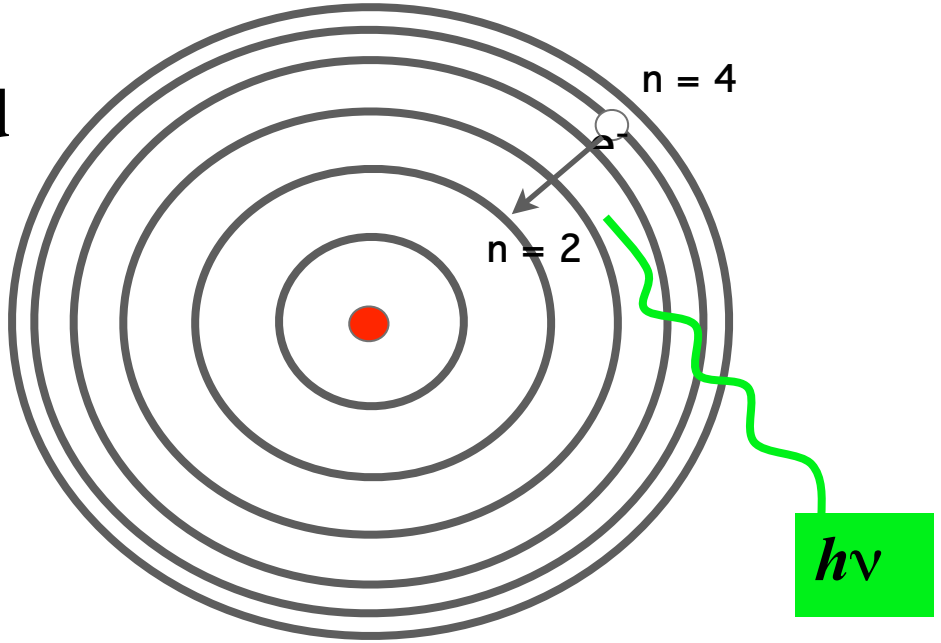
electron position is quantized

excited state of hydrogen



- **Neils Bohr**

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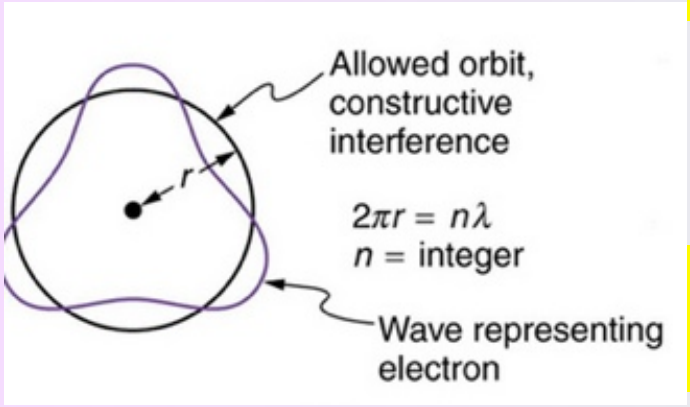
an answer as to why (?) electron position is quantized

$$\lambda = \frac{h}{mv}$$



$$\Delta x \, \Delta P = h/4\pi$$

- **Werner Heisenberg**
- **Louis Victor De Broglie**

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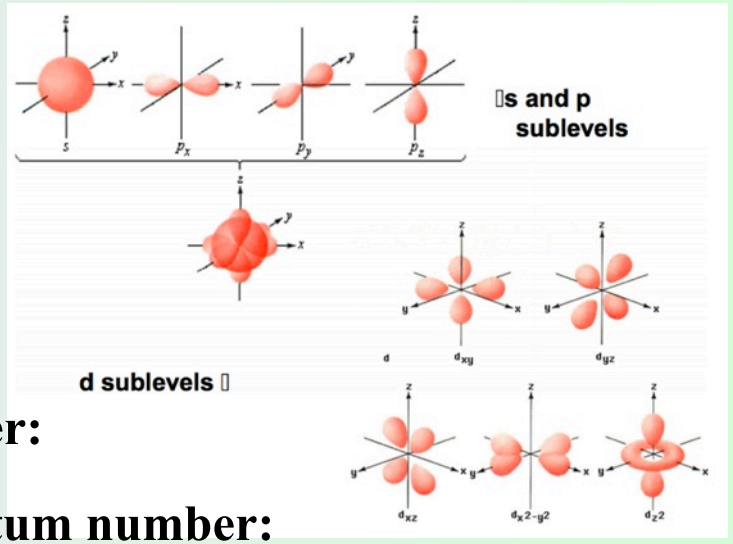
probability distributions of electron position



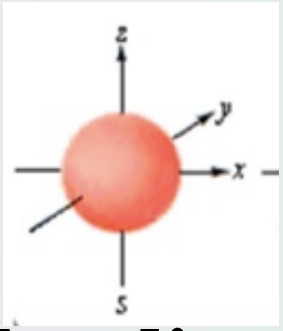
principal quantum number:

angular momentum quantum number:

magnetic quantum number:

n	l	m_l
(1,	0,	0)

1s



Erwin Schrodinger

Electron Configuration

review

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

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)

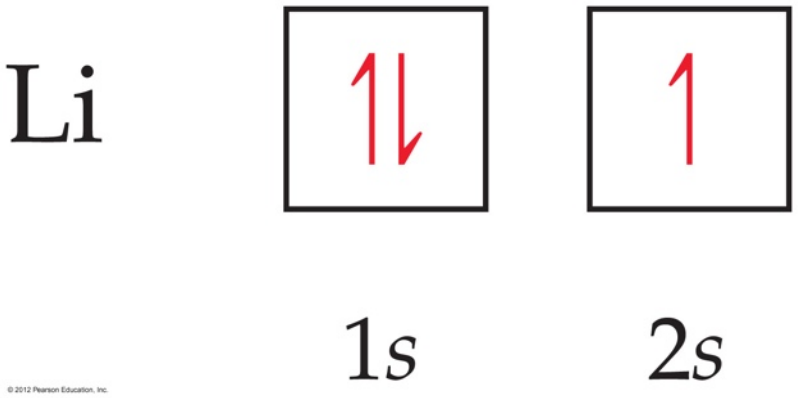
Hund's Rule

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

greatest number of parallel spins

Orbital Diagrams

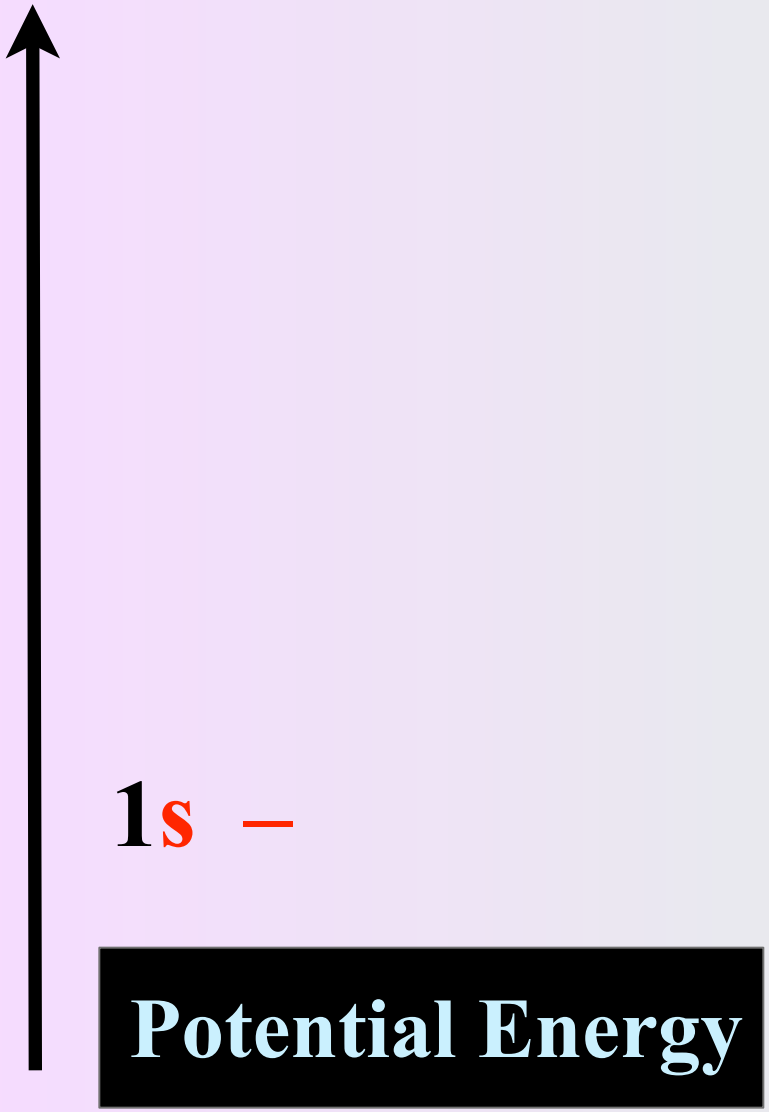
- Each box in the diagram represents one orbital.
- Half-arrows represent the electrons.
- The direction of the arrow represents the relative spin of the electron.



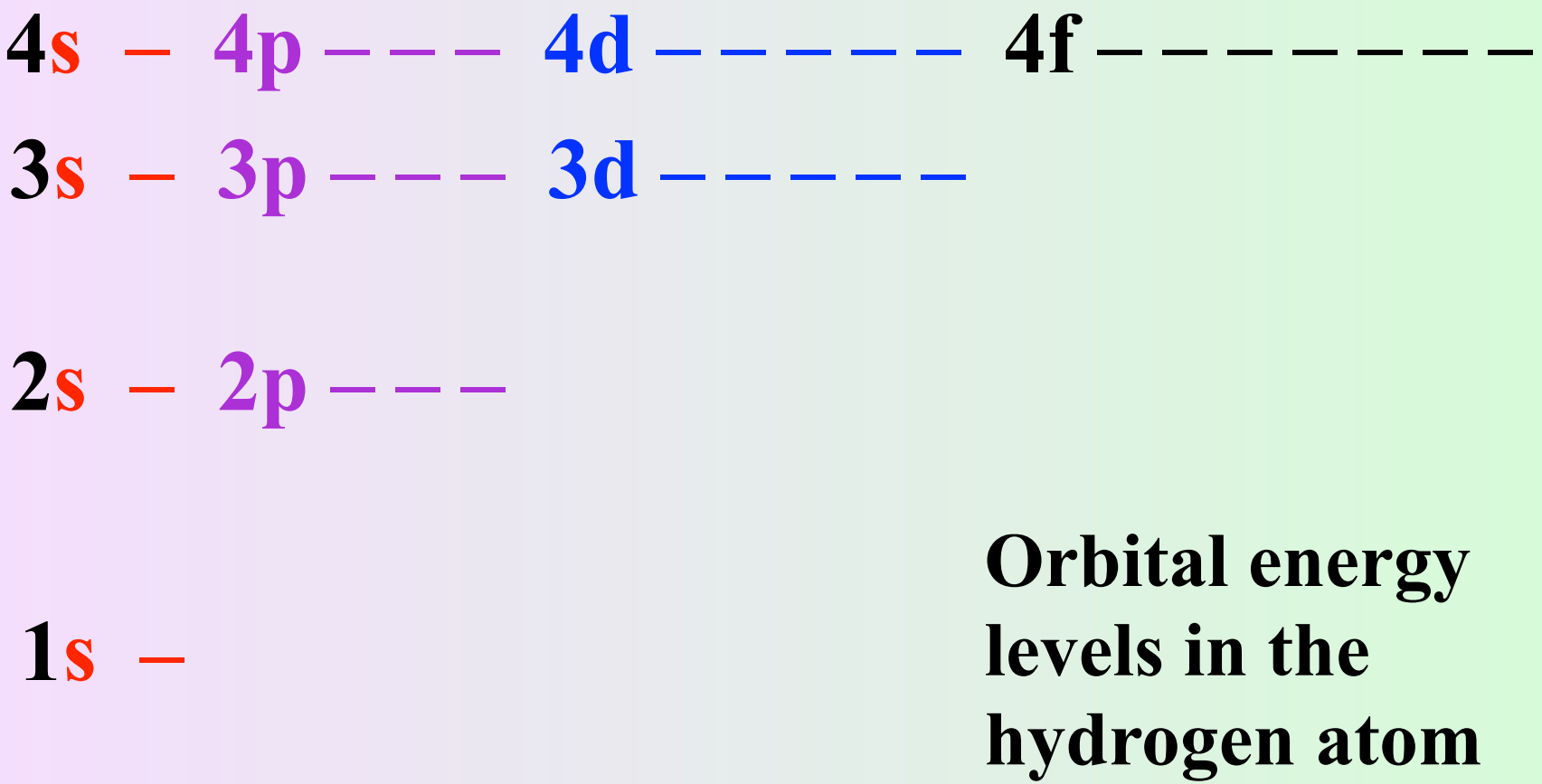
energies of hydrogen orbitals

for the hydrogen atom, all orbitals with the same principal quantum number have the same energy

i.e., they are "degenerate"



Orbital energy levels in the hydrogen atom

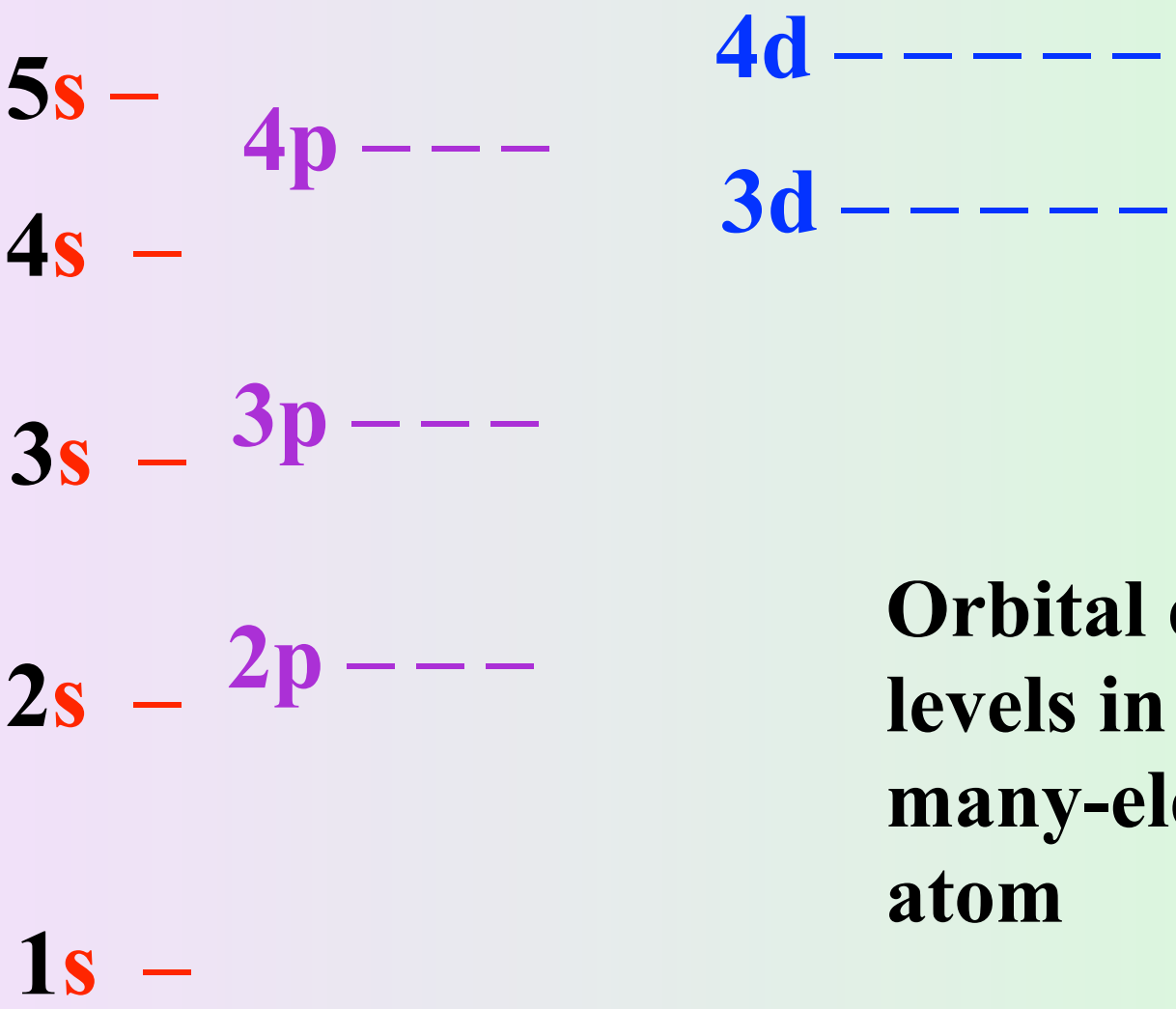


Orbital energy levels in the hydrogen atom

energies of multi-electron orbitals

for a many-electron atom, the energy depends on both the principal quantum number and the angular momentum quantum number

i.e., each subshell represents a different energy in a multi-electron system



Orbital energy levels in a many-electron atom

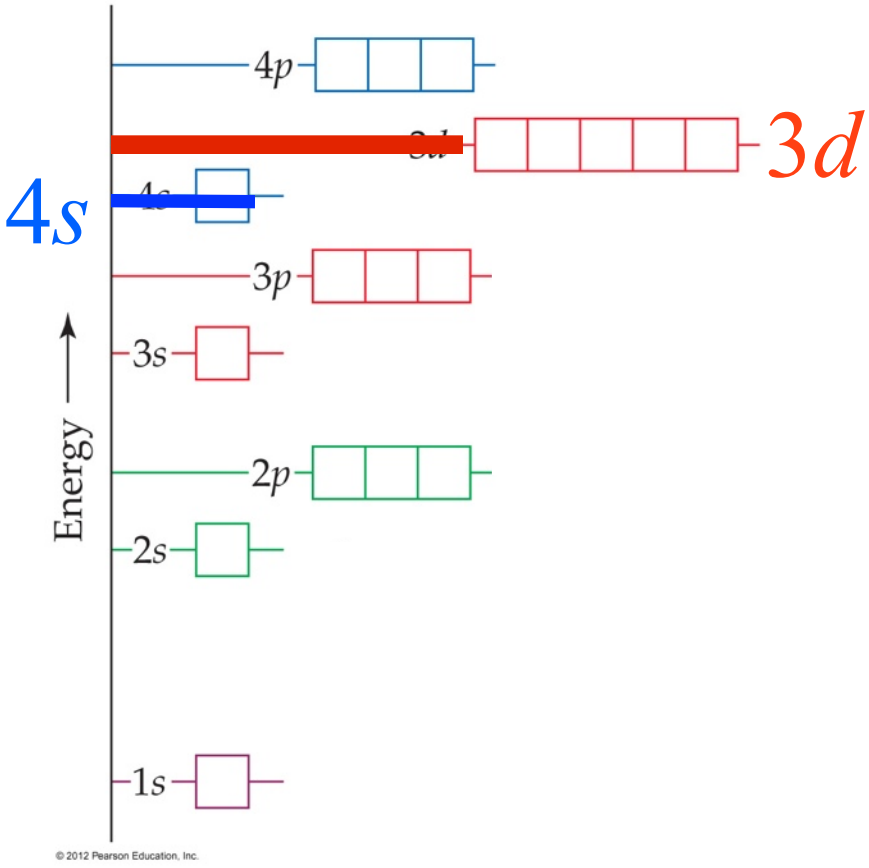
Shielding Effect

in a many-electron atom, electrons in the 1*s* orbital shield the electrons located in the 2*s* and 2*p* orbitals from the electrostatic attraction of the protons in the nucleus

core electrons block valence electrons attraction to the protons in the nucleus

2*s* orbital is said to be more "penetrating" and is less shielded than the 2*p*

Energies of Orbitals



$[Ar] = 1s^2\,2s^2 2p^6 3s^2 3p^6$

Fourth Period

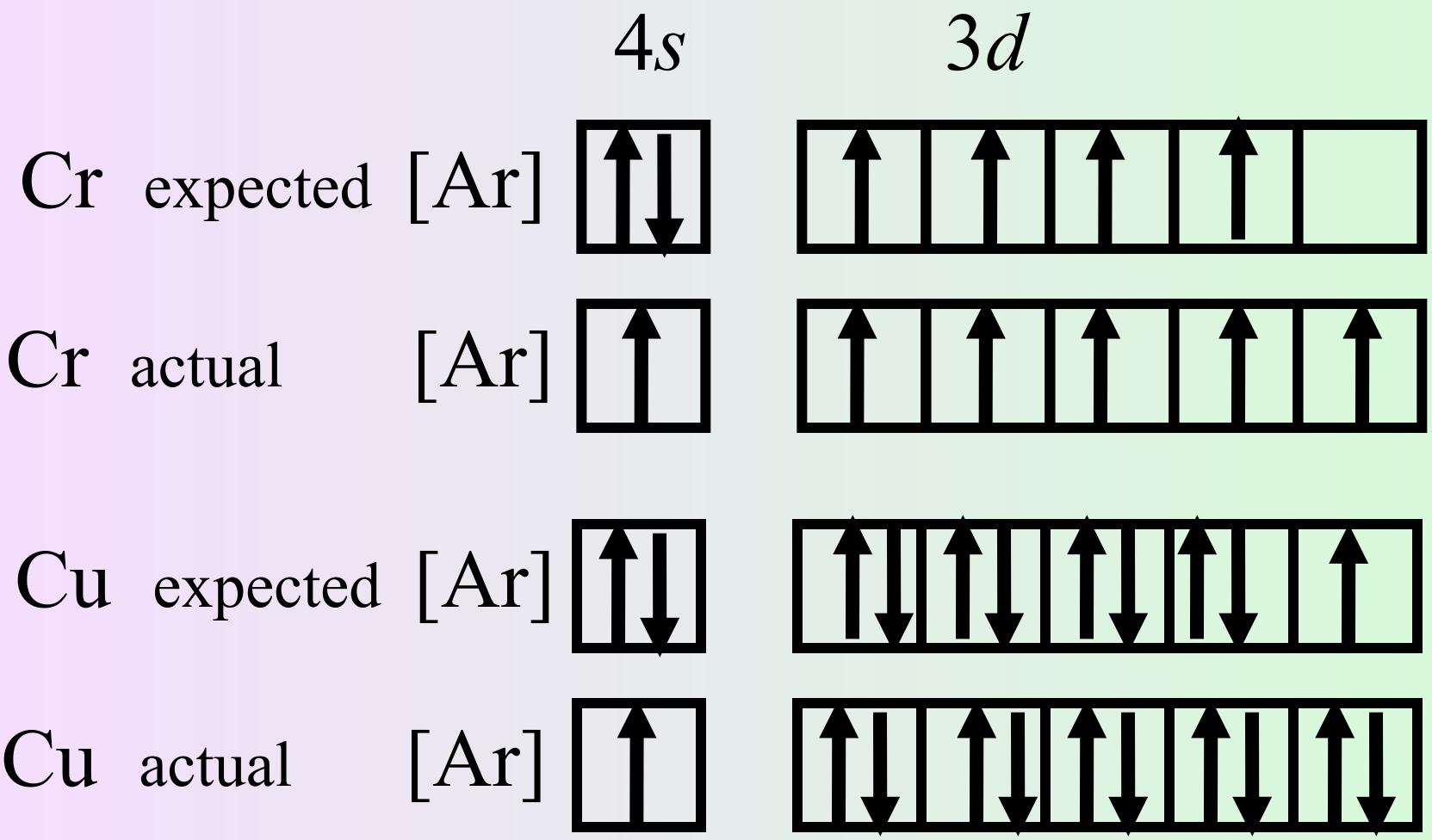
[Ar] core

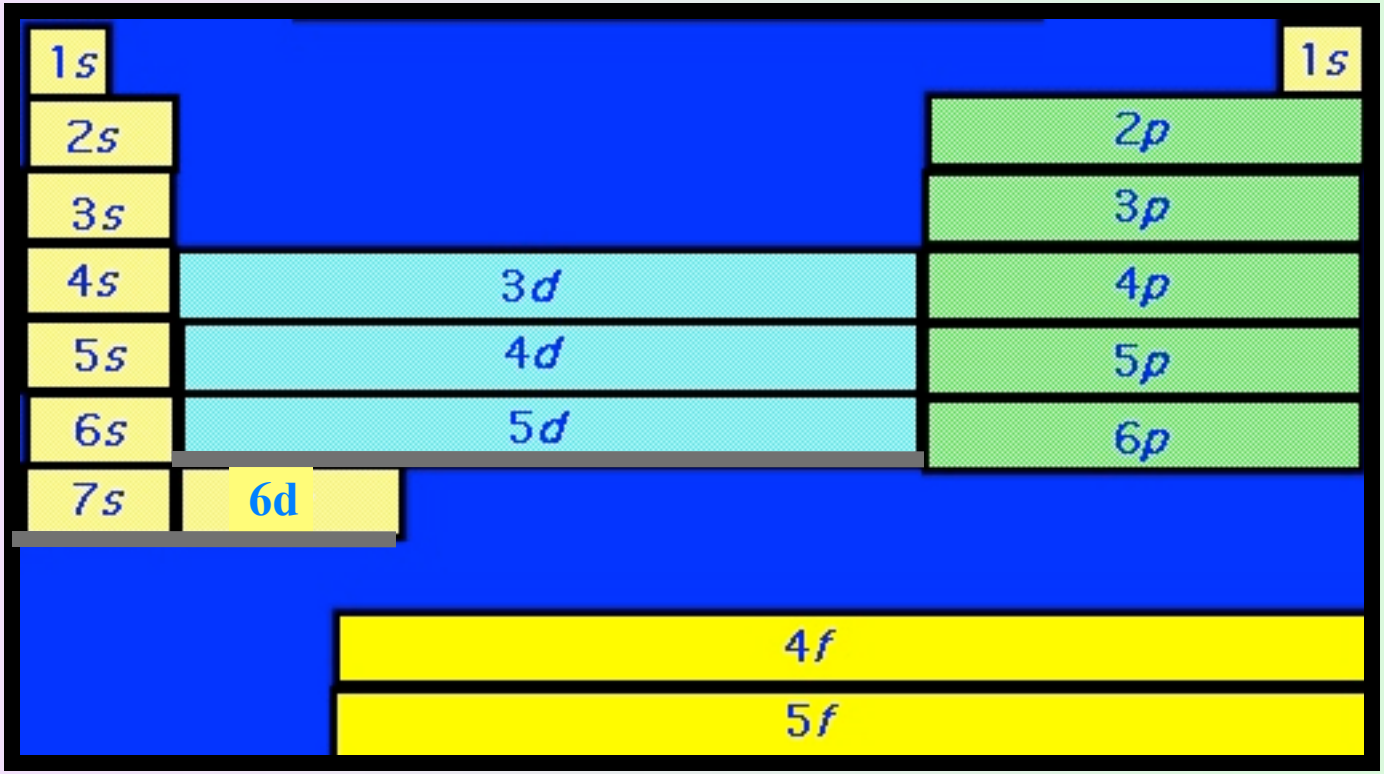
K	19	[Ar]	$4s^1$
Ca	20	[Ar]	$4s^2$
Sc	21	[Ar]	$4s^2 3d^1$

First Transition Series

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

Periodic Anomalies

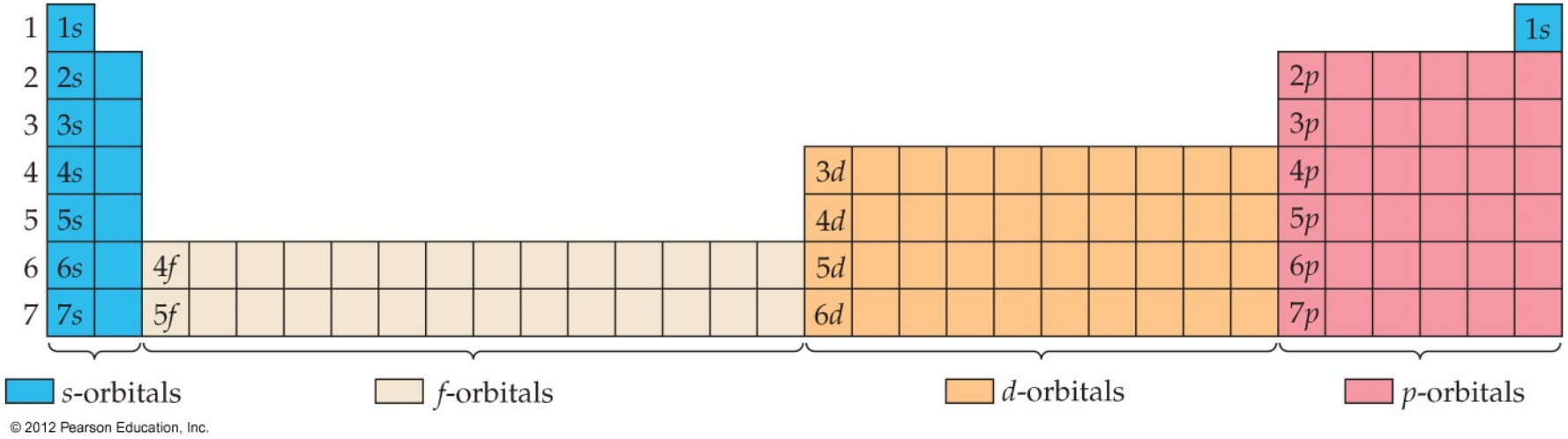




Subshell filling of elements in regions of the periodic table

Periodic Table

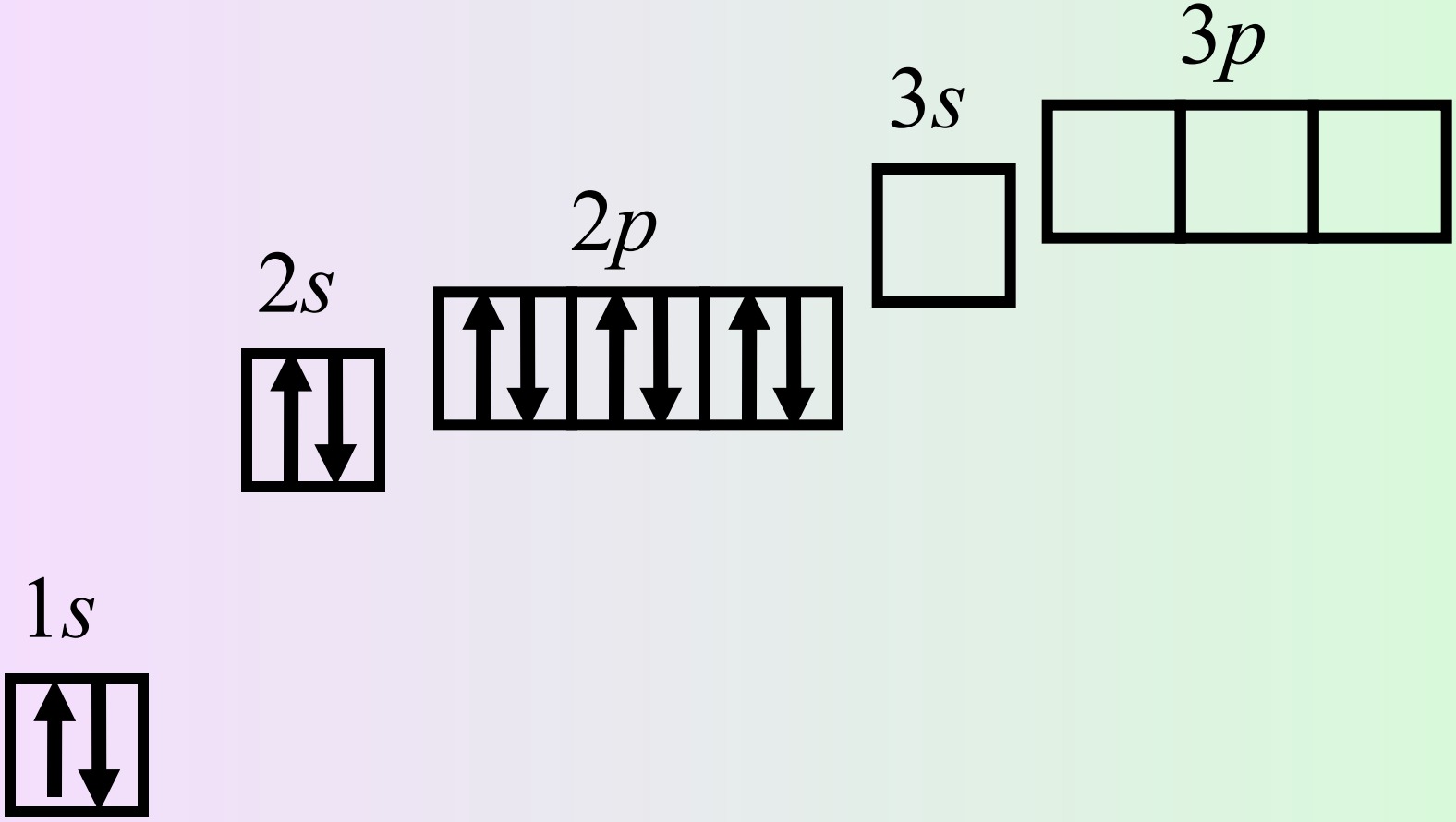
- We fill orbitals in increasing order of energy.
- Different blocks on the periodic table (shaded in different colors in this chart) correspond to different types of orbitals.



Electronic Structure of Atoms

Na 11 $1s^2\ 2s^2 2p^6\ 3s^1$

[Ne] $3s^1$



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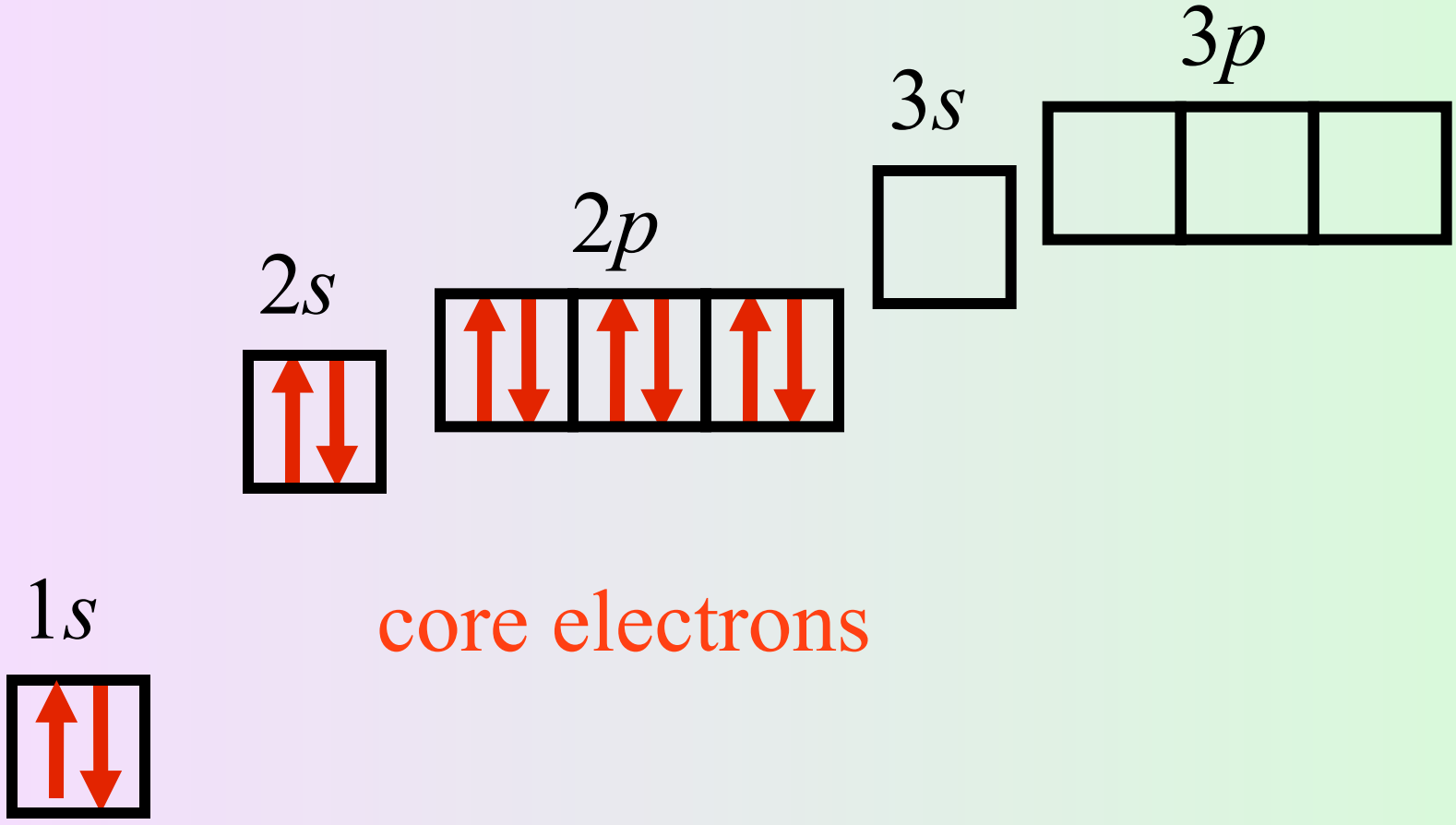

Na 11 $1s^2\ 2s^2 2p^6\ 3s^1$

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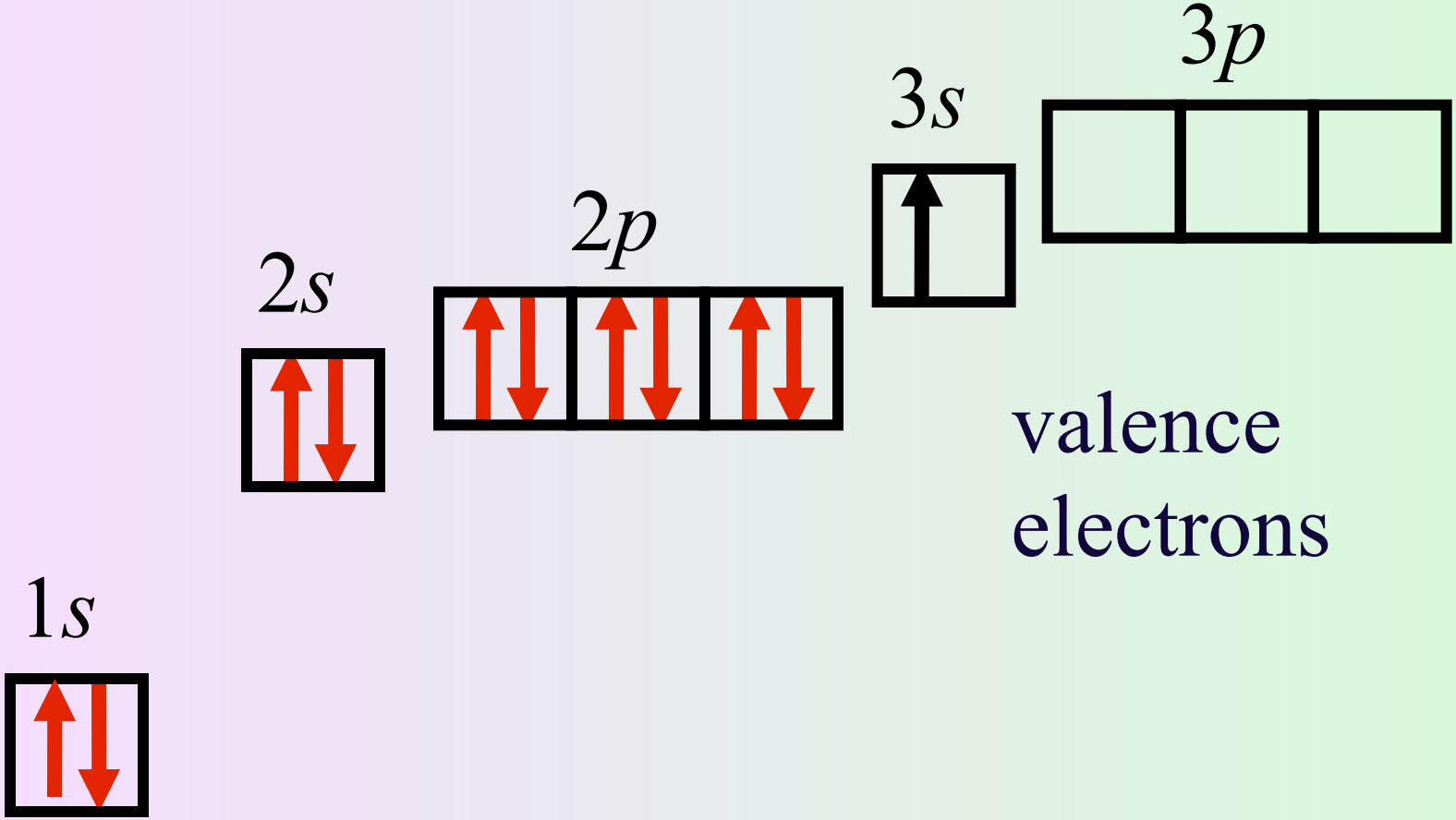
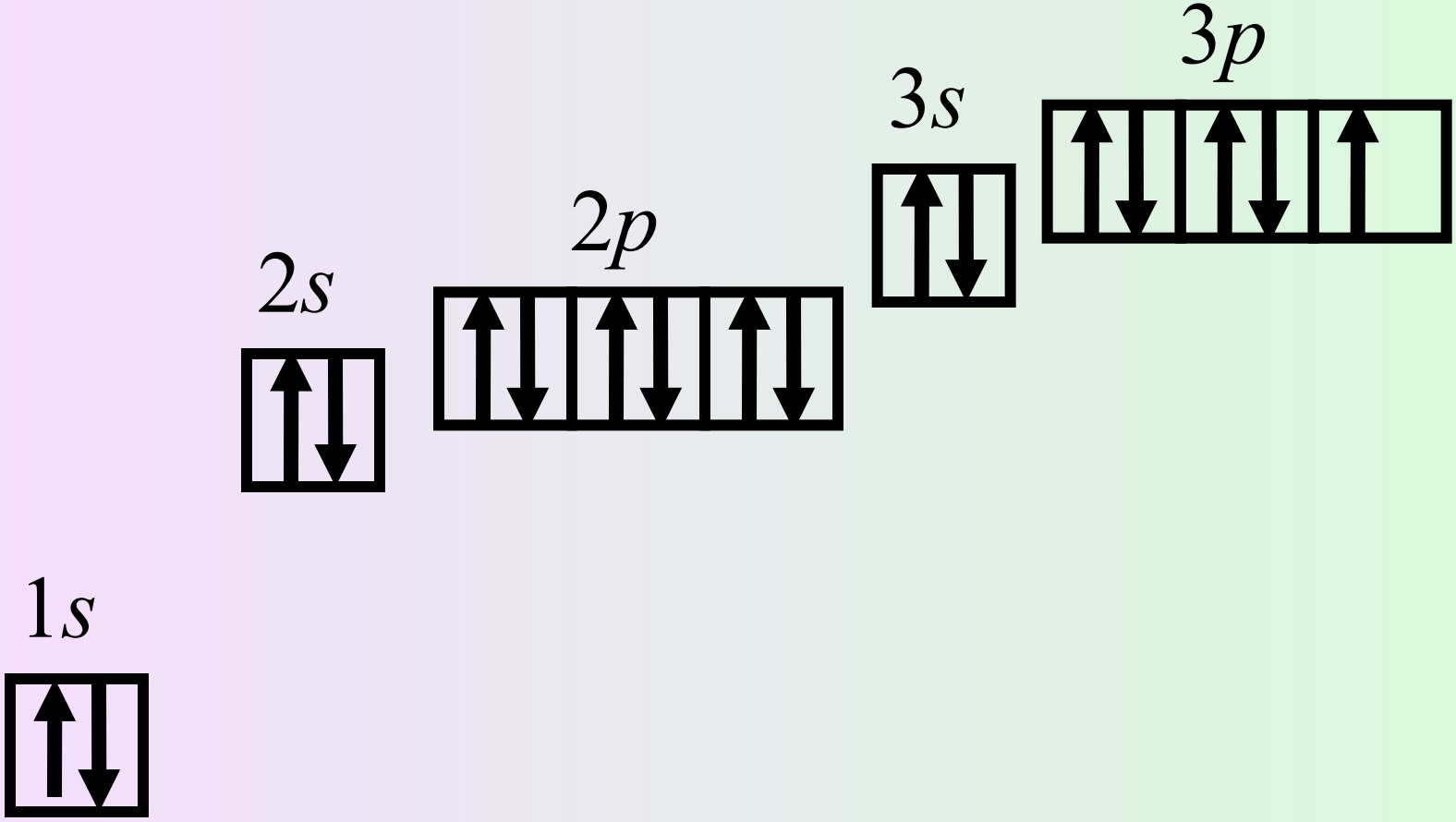


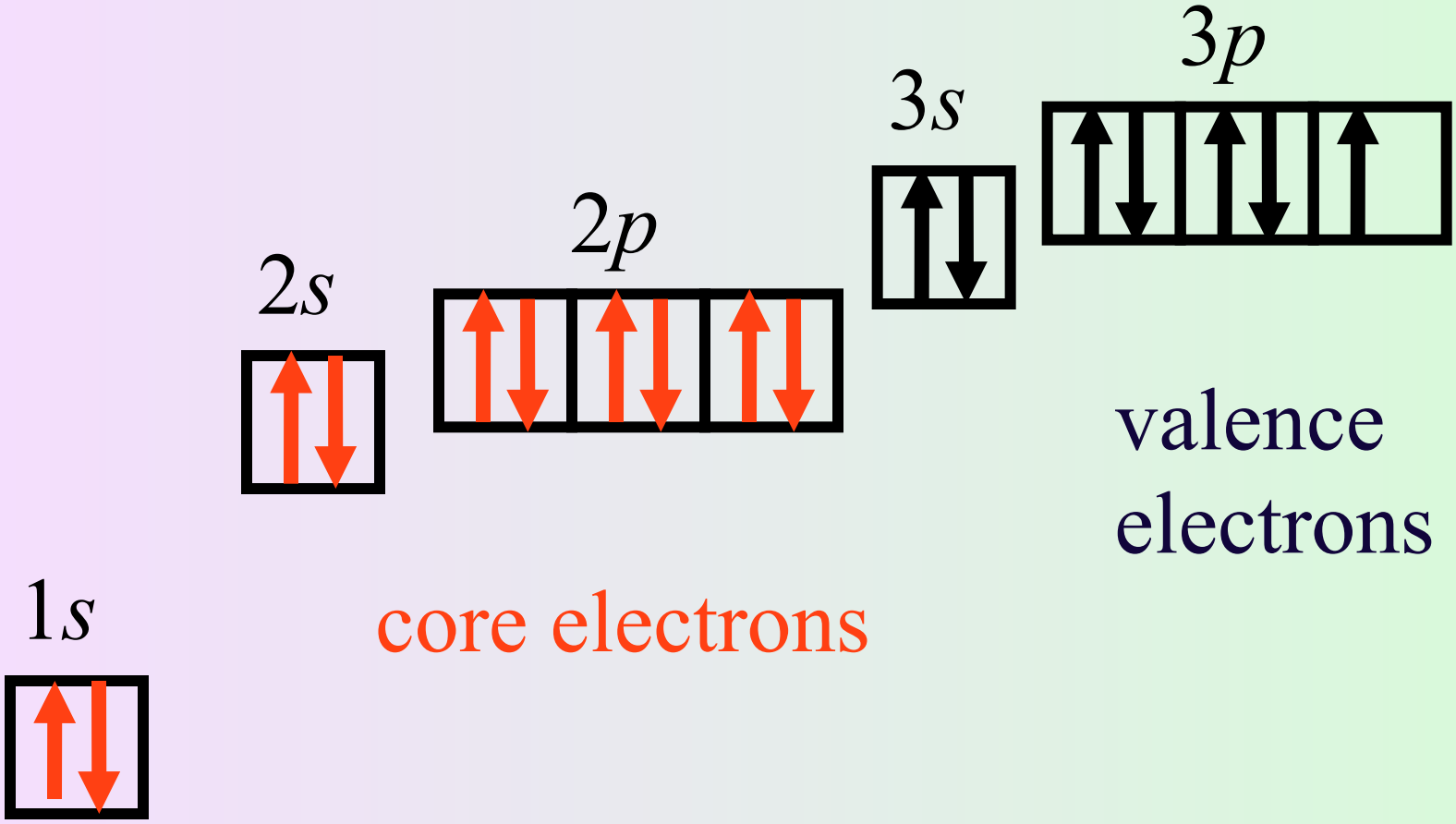
Cl 17 $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

[Ne] $3s^2 3p^5$



Cl 17 $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

[Ne] $3s^2 3p^5$



Valence Electrons

The outer electrons of an atom, which are those involved in chemical bonding, are often called the **valence electrons**.

Elements in the same group of the periodic table have analogous valence-electron figurations.

Lewis Dot Symbols

A Lewis dot symbol consists of the symbol of an element and one dot for each valence electron in an atom of the element.

1A	2A	3A	4A	5A	6A	7A	8A
H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn
Fr	Ra						