Lesson 8
Atomic Structure and Periodicity

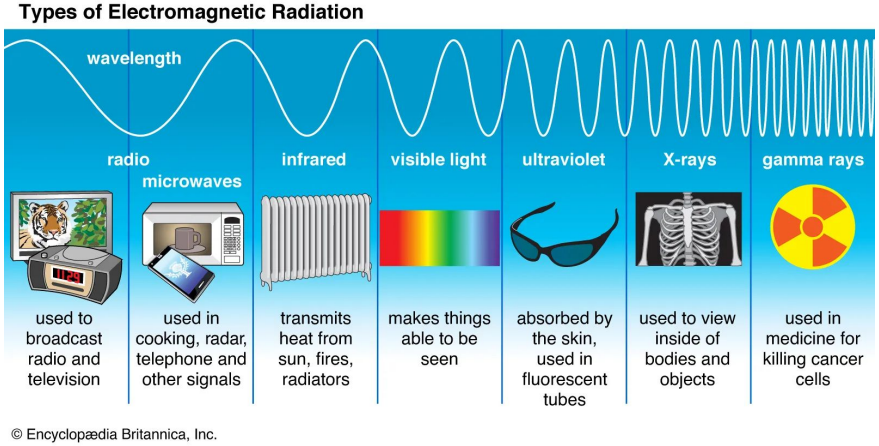
Electromagnetic radiation

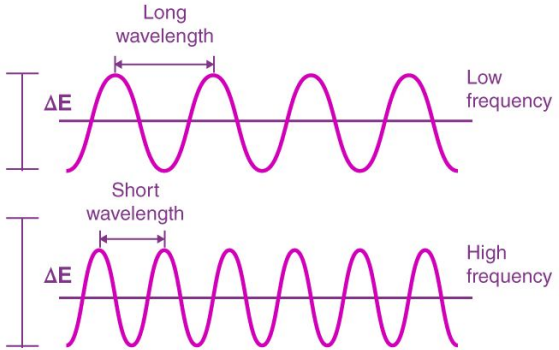
Energy travels through space by electromagnetic radiation

- Wavelength - the distance from one wave to another
- Frequency - the number of waves per second

$$c = v\lambda$$

- Speed of light: c = 3.0 x 10^8 m/s
- Wavelength = λ
- Frequency = *v*





Matter and energy

Matter and energy can be directly converted into each other

- Energy can only be gained or lost in whole number multiples of quantity *hv*

$$\Delta E = nhv$$

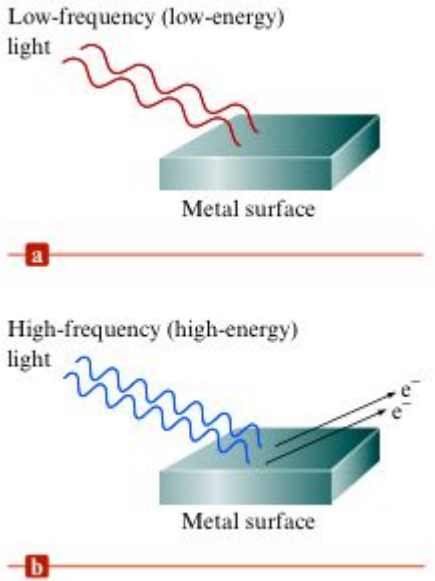
- Planck's constant (*h*) = 6.626×10^{-34} J•s
- *n* is an integer (1, 2, 3,...)

Each packet of energy is called a *quantum*

Matter and energy

Photoelectric effect - electrons are emitted from a metal surface when light is shined on it

- Electrons are only be emitted if the frequency of light was above a certain threshold, and it would increase as the frequency increased



All matter has a wavelength

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

m = mass (kg)

Quantum Numbers

Principal quantum number (n) - integer values size and energy of the orbital

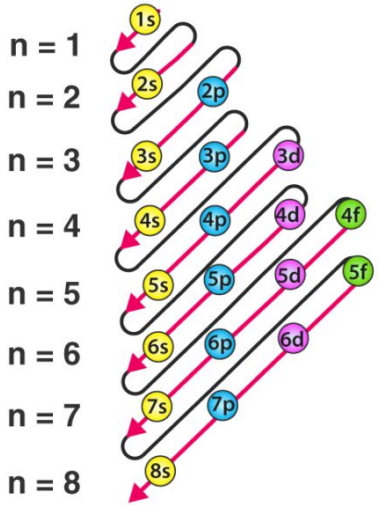
Angular momentum quantum number (l) - values from 0 to n - 1 describes the shape of the atomic orbital (also called the subshell)

Magnetic quantum number (m_l) - values from l to -l describes the orientation in space

Electron spin quantum number (m_s) - indicates the direction of the electron spin

TABLE 7.2 | Quantum Numbers for the First Four Levels of Orbitals in the Hydrogen Atom

n	ℓ	Sublevel Designation	m_ℓ	Number of Orbitals
1	0	1*s*	0	1
2	0	2*s*	0	1
	1	2*p*	−1, 0, +1	3
3	0	3*s*	0	1
	1	3*p*	−1, 0, 1	3
	2	3*d*	−2, −1, 0, 1, 2	5
4	0	4*s*	0	1
	1	4*p*	−1, 0, 1	3
	2	4*d*	−2, −1, 0, 1, 2	5
	3	4*f*	−3, −2, −1, 0, 1, 2, 3	7



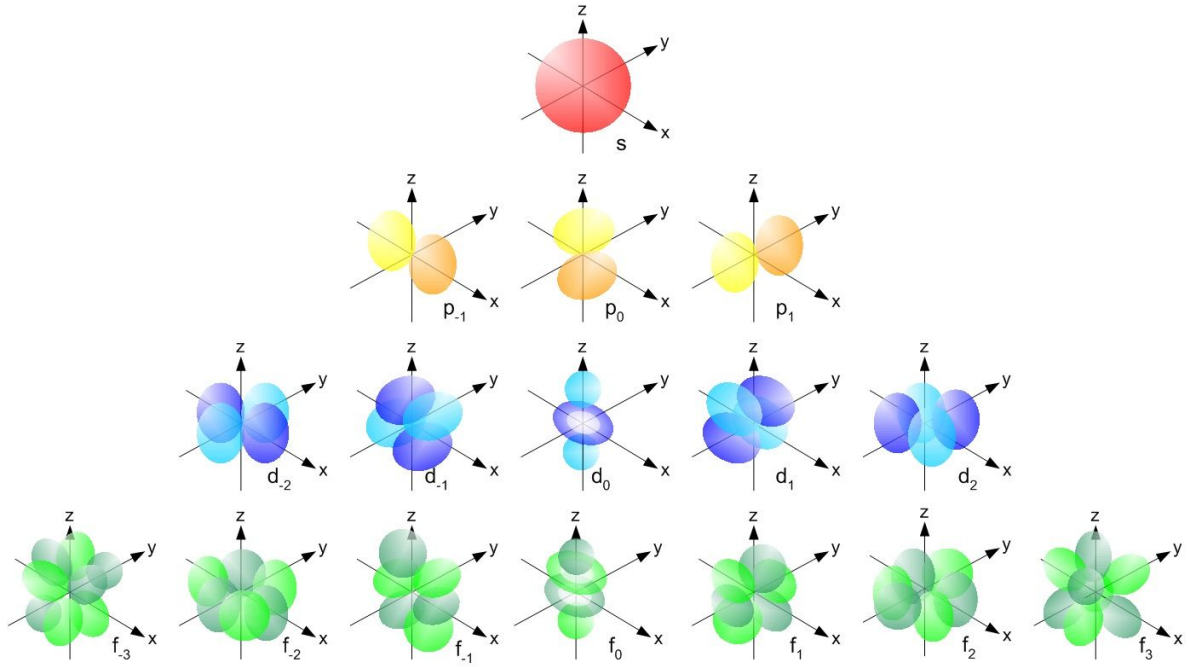
Orbital Shapes and Energies

s-orbitals: spherical

p-orbitals: dumbbell-shaped

d-orbitals: cloverleaf-shaped

f-orbitals: complex shapes

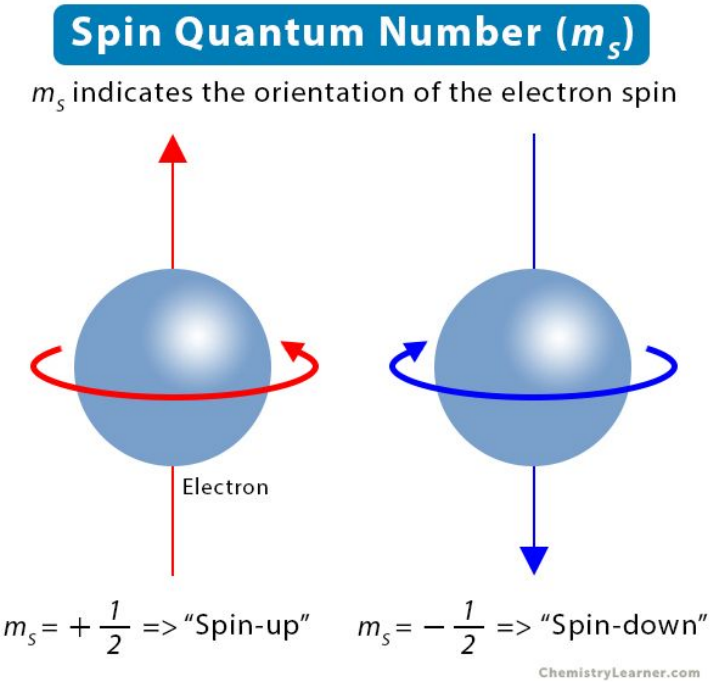


Electron Spin

Electron spin quantum number (m_s) - indicates the direction of the electron spin

- Either +½ or -½ (opposite directions)

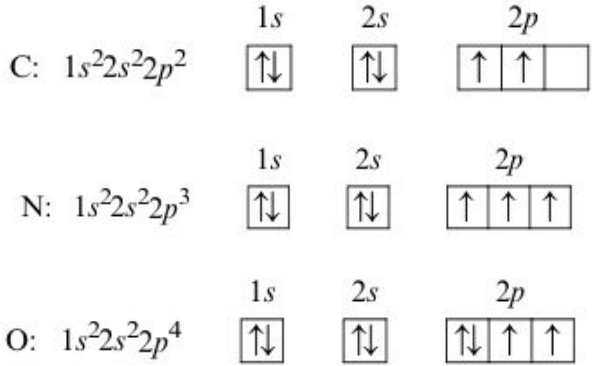
Pauli exclusion principle: no two electrons have have the same set of four quantum numbers (n, l, m_l, and m_s)

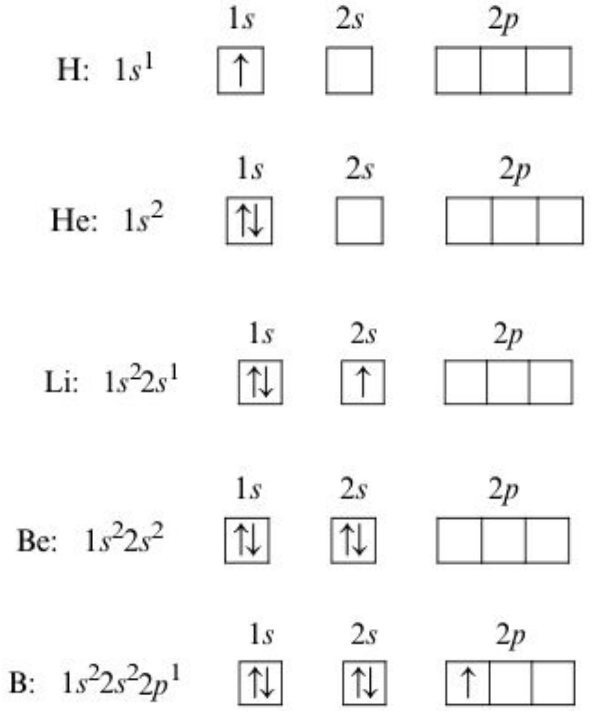


Electron Configuration

Aufbau Principle - electrons fill the subshells of the lowest energy available before filling subshells of higher energy

Hund's rule - every orbital in a sublevel must be singly occupied before it is double occupied

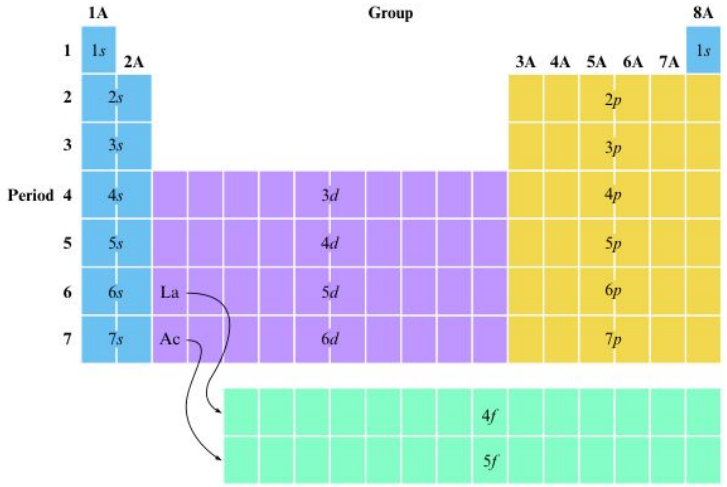




Electron Configuration

Tips:

- (n+1)s orbitals always fill before nd orbitals
  - Ex. 5s .. 4d..
- (n+2)s orbitals fill before nf orbitals
  - Ex. 7s.. 5f..



Exceptions:

Cu: [Ar] $4s^1 3d^{10}$ instead of [Ar] $4s^2 3d^9$

Cr: [Ar] $4s^1 3d^5$ instead of [Ar] $4s^2 3d^4$

Electron Configuration

Determine if the given set of quantum numbers is valid:

a. $n = 3, l = 2, m_l = 1, m_s = +½$

b. $n = 2, l = 2, m_l = -1, m_s = -½$

c. $n = 4, l = 3, m_l = 0, m_s = +1$

Electron Configuration

Write the electron configuration using arrows

a. Carbon

b. Oxygen

c. Sodium

Electron Configuration

Write the full electron configuration

a. Neon

b. Phosphorus

c. Iron

Electron Configuration

Write the electron configuration using noble gas configuration

a. Tellurium

b. Copper

c. Iridium