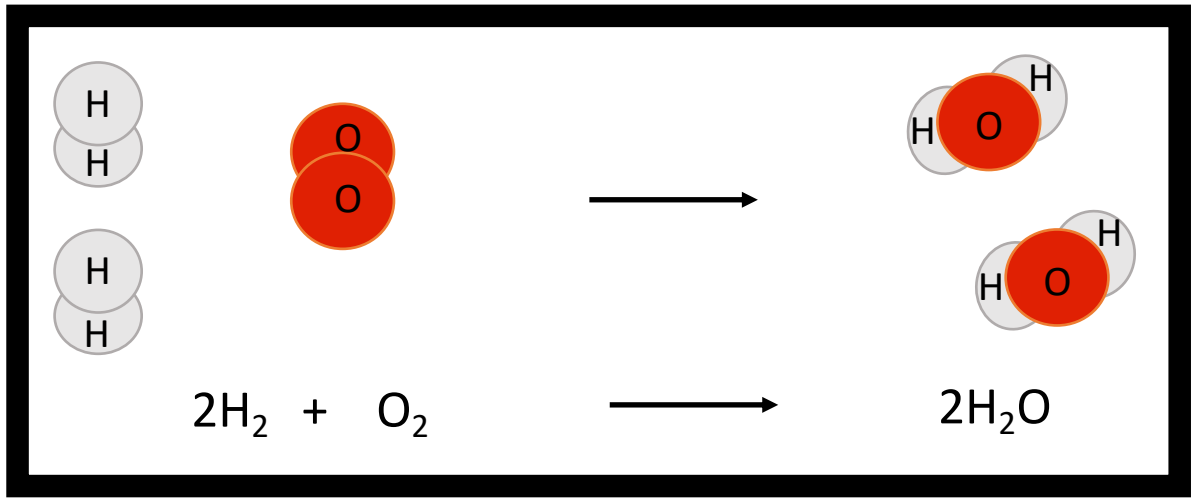
Stoichiometry

Stoichiometry

- Chemical equations
- The mole and molar mass
- Chemical formulas
- Mass relationships in equations
- Limiting reactant

Coefficient tells the number of molecules;
Subscripts tells the number of atoms of each element in a molecule.



Writing balanced reaction

1. Write the correct formula for each substance

$$H_2 + Cl_2 \longrightarrow HCl$$

2. Add coefficients so the number of atoms of each element are the same on both sides of the equation

$$H_2 + Cl_2 \longrightarrow 2\,HCl$$

Balancing a Chemical Reaction

1. Assume one molecule of the most complicated substance

$$C_5H_{12} + O_2 \longrightarrow CO_2 + H_2O$$

2. Adjust the coefficient of CO_2 to balance C

$$C_5H_{12} + O_2 \longrightarrow 5\ CO_2 + H_2O$$

3. Adjust the coefficient of H_2O to balance H

$$C_5H_{12} + O_2 \longrightarrow 5\ CO_2 + 6\ H_2O$$

4. Adjust the coefficient of O_2 to balance O

$$C_5H_{12} + 8\ O_2 \longrightarrow 5\ CO_2 + 6\ H_2O$$

Balancing a Chemical Reaction

- Sometimes fractional coefficients are obtained

$C_5H_{10} + O_2 \longrightarrow CO_2 + H_2O$

$C_5H_{10} + O_2 \longrightarrow 5\ CO_2 + H_2O$

$C_5H_{10} + O_2 \longrightarrow 5\ CO_2 + 5\ H_2O$

$C_5H_{10} + (15/2)\ O_2 \longrightarrow 5\ CO_2 + 5\ H_2O$

- Multiply all coefficients by the denominator

$2\ C_5H_{10} + 15\ O_2 \longrightarrow 10\ CO_2 + 10\ H_2O$

Combination and Decomposition Reaction

Two or more reactants combine to form a single product. Many elements react with one another in this fashion to form compound.

$$A + B \longrightarrow C$$

One single reactant break apart to form two or more substances. Many compound react this way once heated.

$$A \longrightarrow B + C$$

Combustion Reaction

It is the process of burning, the combination of an organic substance with oxygen to produce a flame.

- When an organic compound burns in oxygen, the carbon reacts with oxygen to form CO_2 , and the hydrogen forms water, H_2O.

Balance the following reaction

$$C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$$

Balance the following reaction

$$(C_2H_5)_2O + O_2 \longrightarrow CO_2 + H_2O$$

$$Fe_2 + O_2 \longrightarrow Fe_2O_3$$

$$SO_2 + O_2 + H_2O \longrightarrow H_2SO_4$$

$$Ba(OH)_2 + HClO_4 \longrightarrow Ba(ClO_4)_2 + H_2O$$

Formula Weight

Sum of the atomic weights for the atoms in its empirical formula.

Molecular Mass

It is the avarage mass as calculated by adding together the atomic weights of the atoms in the molecular formula.

Percent Composition

One can find the percentage of the mass of a compound that comes from each of the elements in the compound by using this equation:

The percentage by mass of carbon in ethane (C_2H_6) is…

$$\%C = \frac{(2)(12.01\ amu)}{(30.068\ amu)} \times 100 = 79.89\%$$

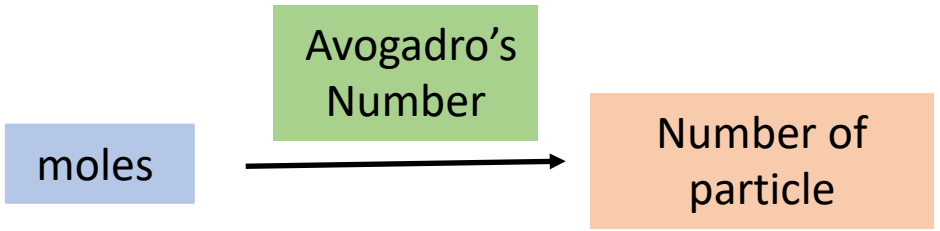
Mole

- One mole is the amount of substance that contains as many entities as the number of atoms in exactly 12 grams of the ^{12}C isotope of carbon.

- Avogadro's number is the experimentally determined number of atoms in 12 g of isotopically pure 12C, and is equal to 6.022×10^{23}
- One mole of anything contains 6.022×10^{23} entities

Molar Mass
The molar mass (M) of any atom, molecule or compound is the mass (in grams) of one mole of that substance. The molar mass in grams is numerically equal to the atomic mass or molecular mass expressed in u (or amu).

From moles to number of identies:



➢ How many moles of C_2H_6 are present in 3.00×10^{21} molecules of C_2H_6 ?

➢ How many Na atoms are present in 0.35 mol of Na?

Empirical Formula

Given: Mass % element → (Assume 100 gr of sample) → Gramm of each element → (Use molar mass) → Moles of each elements → (Calculate molar ratio) → Empirical Formula

ES 1: L analisi elementare di un compost di p.f.= 180.1 ha dato I seguenti risultati: C=40.00 %, H= 6,68%, O=53.32%. Si scriva la formula molecolare del composto.

2. Si calcoli il numero di grammi di zolfo che contengono un numero di atomi di S uguale al numero di atomi di Cu contentuti in 1,000 gr di Cu.

3. The compound para-aminobenzoic acid (you may have seen it listed as PABA on your bottle of sunscreen) is composed of carbon (61.31%), hydrogen (5.14%), nitrogen (10.21%), and oxygen (23.33%). Find the empirical formula of PABA.

4. What mass of SO_2 is produced from reaction of 3.8 g of FeS_2 and excess O_2 ?

5. What mass of SO_3 forms from the reaction of 4.1 g of SO_2 with an excess of O_2 ?

6. Un campione di 10 g di nichel viene mescolato con 20 g di zolfo e riscaldato. Calcolare il peso di NiS formato e dire quale elemento è in eccesso ed in quale quantità.

7. Dalla completa combustione di 0,424 gr di un composto organico contenente C, H ed O si ottengono 0.254 gr di H_2O e 0.621 gr di CO_2. Sapendo che la massa molecolare dl compost è 60 u determinare la formula molecolare del composto.

8.Il peso formula del sale ABrx vale 199.98 e quello dell’ ossidio di AOy vale 56.08. Noto che l’elemento A ha lo stesso numero di ossidazione nei due composti, se ne calcoli il peso atomico .

9. 13.736 grammi di una miscela costituita da FeS e FeS_2 vengono fatti reagire con un eccesso di ossigeno. Terminata la reazione si sono ottenuti 9.917 grammi di Fe_2O_3. Si determine la composizione della miscela.

Electronic Structure of atoms

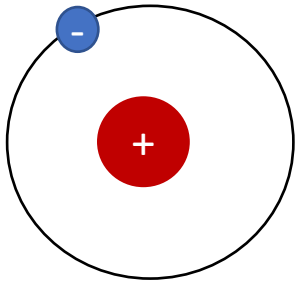
Rutherford and Bohr Theory

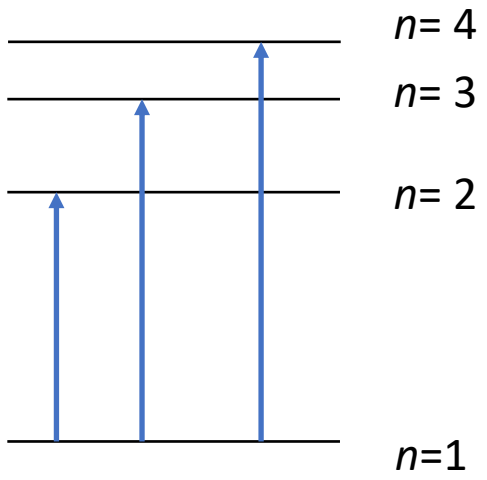
Rutherford assumed that electrons orbited the nucleus analogous to planets orbiting the sun; however, a charged particle moving in a circular path should lose energy

Niels Bohr noted the line spectra of certain elements and assumed that electrons were confined to specific energy states.

1.Only orbits of specific radii are permitted for electrons in an atom
2. An electron in a permitted orbit has a specific energy
3. Energy is only emitted or absorbed by an electron as it moves from one allowed energy state to another

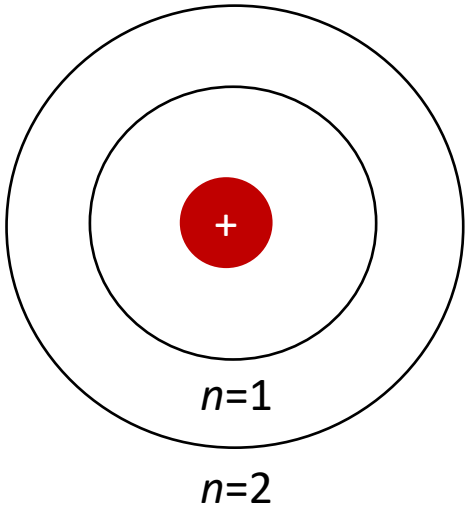
n is the principal quantum number





Bohr Model

n = Electrons in the Bohr model can only move between orbits by absorbing and emitting energy in quanta (E = h!).



n describes the energy level on which the orbital resides.
• The values of n are integers ≥ 1.

$e^- = 2\ n^2$

Angular Momentum Quantum Number (*l*)
This quantum number defines the shape of the orbital.
• Allowed l values are integers ranging from 0 to n − 1.
• Letter designations to communicate the different values of l and, therefore, the shapes and types of orbitals.

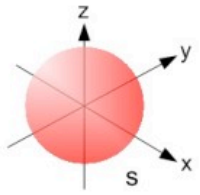
Magnetic Quantuum Number (*m*)
Describes the three-dimensional orientation of the orbital. Values are integers ranging from -l to l: −l ≤ ml ≤ l • Therefore, on any given energy level, there can be up to 1 s orbital, 3 p orbitals, 5 d orbitals, 7 f orbitals, etc. • Orbitals with the same value of n form a shell. • Different orbital types within a shell are subshells.

Energy of Orbitals

- For a one-electron hydrogen atom, orbitals with the same n have the same energy. That is, they are degenerate.
- As the number of electrons increases, though, so does the repulsion between them.
- Therefore, in many-electron atoms, orbitals on the same n are no longer degenerate.

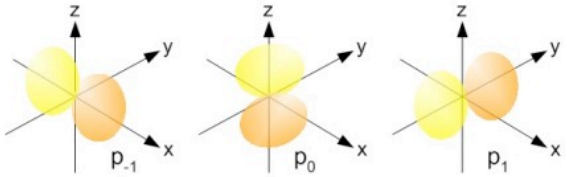
s orbitals

- Value of l = 0.
- Spherical in shape.
- Radius of sphere increases with increasing value of n



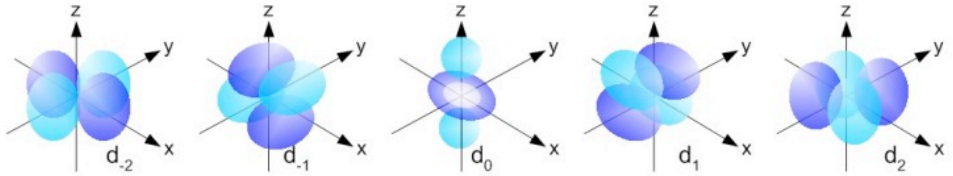
p orbitals

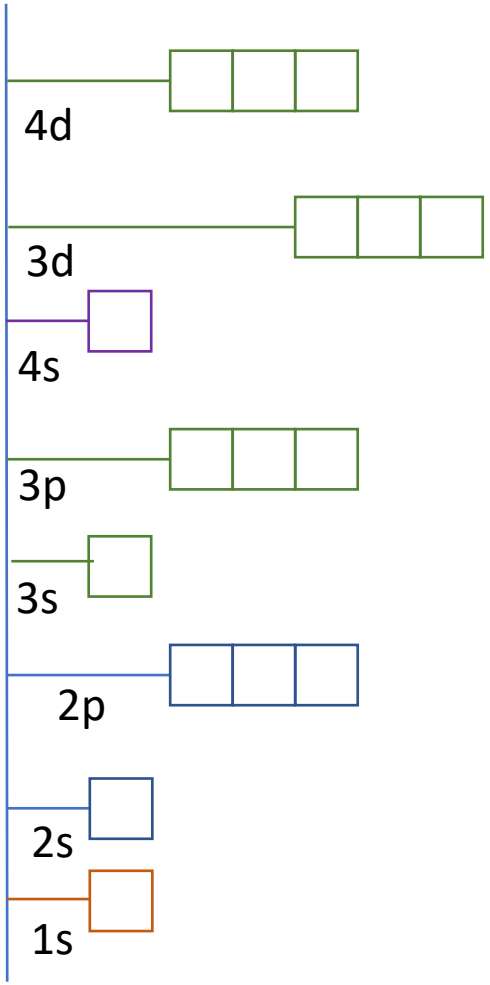
- Value of l = 1.
- Have two lobes with a node between them.
- The subscript denotes axis along which the orbital is aligned

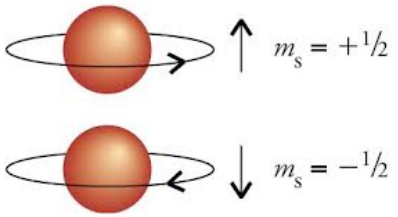


d orbitals

- Value of l is 2.
- Four of the five orbitals have 4 lobes; the other resembles a p orbital with a torus around the center.







Spin Quantum Number, m_s

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

Pauli Exclusion Principle

No two electrons in the same atom can have exactly the same energy. No two electrons in the same atom can have identical set of four quantum numbers n, l, ml, and ms .

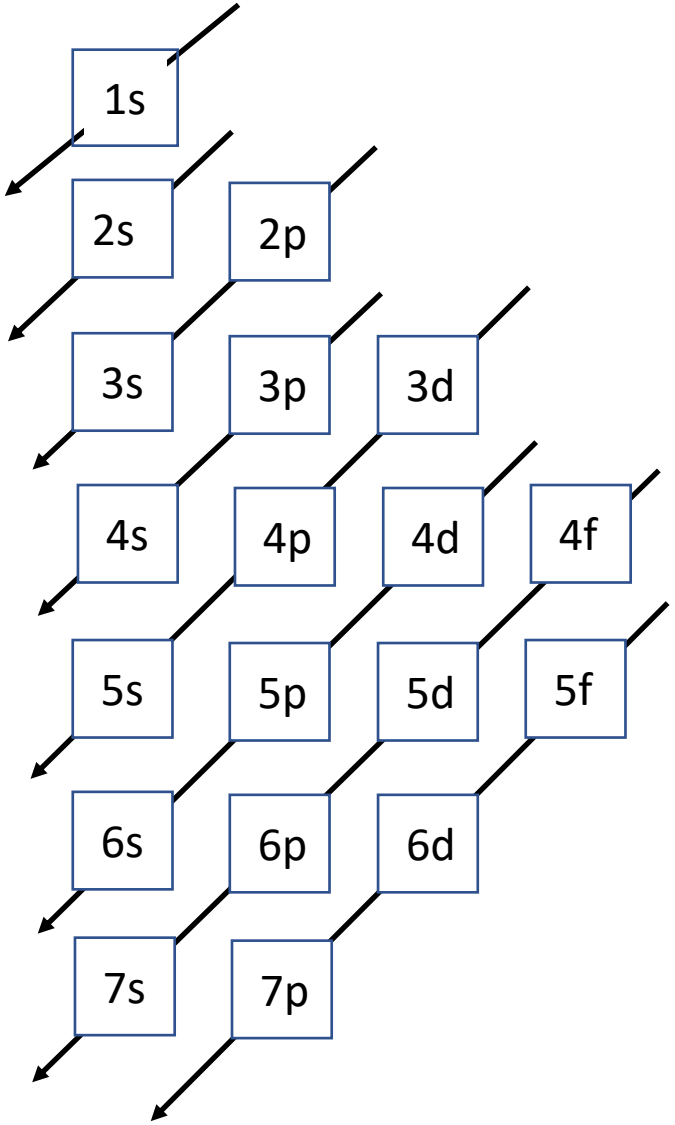
Hund Rule

For degenerate orbitals, the lowest energy is attained when the number of electrons with the same spin is maximized.

Aufbau Principle

Electrons are added to the lowest energy orbitals available.

Diagonal Rule



Write the electronic configuration of Ca (Z = 20)