

ORBITALS AND ELECTRONS

Quantum numbers descriptions:

Quantum number	Description	Possible values
Principal quantum number (n)	energy level	$n = 1, 2, 3, \dots$
Angular momentum quantum number (l)	orbital shape (s, p, d, f)	$l = 0, 1, \dots, n-1$
Magnetic quantum number (m_l)	orbital orientation (p _x , p _y , p _z)	$m_l = -l$ to $+l$
Spin quantum number (m_s)	describes spin of electron	$m_s = +\frac{1}{2}$ or $-\frac{1}{2}$

Each electron has a unique set of quantum numbers.

ELECTRONIC CONFIGURATION

Electron configuration: describes the location of all of the electrons in an element, e.g. Carbon = $1s^2 2s^2 2p^2$

Heisenberg Uncertainty Principle: the position and momentum of a particle cannot both be exactly known at the same time.

Pauli exclusion principle: no two electrons in an atom can have the same set of four quantum numbers (n, l, m, m_s) which means that each orbital with quantum numbers (n, l, m) can hold at most two electrons with opposite spins.

Hund's rule: when electrons added to orbitals of equal energy, a single electron enters each orbital before a second electron with opposite spin enters any orbital. The spins remain parallel if possible, e.g. Nitrogen:



Aufbau Principle: dictates the order in which orbitals fill. Some exceptions occur in the transition elements.



THE GAS PHASE

Units of Pressure:

$$1 \text{ atm} = 760 \text{ mmHg} = 760 \text{ torr} = 101.325 \text{ kPa} = 1.01325 \text{ bar}$$

IDEAL GAS POSTULATES

- molecules are very small compared to the distance b/w them
- molecules are continuously moving
- pressure of the gas = collisions of the molecules with container walls
- molecules do not experience intermolecular forces.
- $KE_{\text{avg}} = T$

$$\text{Ideal gas law: } PV = nRT$$

$$\text{Combined gas law: } \frac{PV}{T} = \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\text{Charles' law: } \frac{V_1}{T_1} = \frac{V_2}{T_2} \quad P = \text{constant}$$

$$\text{Boyle's law: } P_1V_1 = P_2V_2 \quad T = \text{constant}$$

$$\text{Avogadro's Law: } \frac{V_1}{n_1} = \frac{V_2}{n_2} \quad P = \text{constant}$$

STP = standard temperature (0°C or 273.15 K) and pressure (1 atm)

1 mol of ideal gas occupies $V = 22.4 \text{ L}$

standard conditions = 25°C and 1 atm

Dalton's law of partial pressure (mixture of the gases)

$$P = p_A + p_B + \dots + p_N$$

$$p_A = X_A \cdot P$$

$$X_A = \frac{n_A}{n_{\text{total}}} = \frac{N_A}{N_{\text{total}}}$$

GRAHAM'S LAW OF EFFUSION

$$\frac{v_A}{v_B} = \sqrt{\frac{M_B}{M_A}} \quad KE_A = \frac{1}{2} m_A v_A^2$$

$$KE_A = KE_B = T_A = T_B \text{ b/c } KE \propto T, \text{ but}$$

$$v_A \neq v_B \neq T_A = T_B$$

What leads to the gas "density"? High T & low P & lower molecular weight or small size of gas molecules

Real gases:

- have intermolecular attractions (non-elastic collisions) called Van der Waals forces.
- contain molecules that have volume (or measurable size)

$$\left(P_{\text{meas}} + a \frac{n^2}{V^2} \right) \cdot (V_{\text{meas}} - nb) = nRT$$

INTERMOLECULAR FORCES

DISPERSION FORCES:

Describe the attraction between the negatively charged electron cloud of one molecule and the positively charged nuclei of neighbouring molecules

DIPOLAR FORCES:

Describe the attraction between the negatively charged end of a polar molecule and the positively charged ends of neighbouring polar molecules

HYDROGEN BONDING:

Involves lone pairs of electrons on an electronegative atom of one molecule and a polar bond to hydrogen in another molecule, they are confined to molecules that contain O, N, and F atoms.

POLARIZABILITY:

The ease with which the electron clouds are distorted

MOLECULAR SOLID:

Molecules in molecular solids are held in place by the types of forces: dispersion forces, dipolar interactions, and/or hydrogen bonds.

METALLIC SOLID:

Atoms in metallic solids are held in place by delocalised bonding

NETWORK SOLID:

Contains an array of covalent bonds linking every atom to its neighbours

IONIC SOLID:

Contains cations and anions, attracted to one another by coulombic interactions

SOLUTIONS

molarity (M)	moles of solute/volume of solution, $M = n/V$
molarity (m)	moles of solute/kg of solvent
mole fraction (x)	moles of solute/total moles
mass percent	mass of solute x 100/total mass of solution
parts per million (ppm)	mass of solute x 10 ⁶ /total mass of solution

Raoult's Law (distillation)

$$P_A = X_A P_A^*$$

Where P_A = partial pressure of A in solution

X_A = mole fraction of A in the liquid

P_A^* = vapour pressure of pure A

Colligative properties (melting/boiling points etc)

Freezing point depression: salt on the sidewalk in winter lowers the freezing point of H_2O to prevent the water from freezing

$$\Delta T_f = K_f m$$

Boiling point elevation: salt in pasta water increases the boiling point of H_2O so that the water boils hotter (and your pasta cooks more quickly).

$$\Delta T_b = K_b m$$

Osmotic pressure: increase in pressure due to a solvent crossing a membrane into a more concentrated solution

$$\Pi V = nRT$$



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