

## 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 <sub>x</sub> , p <sub>y</sub> , p <sub>z</sub> )	$m_l = -l$ 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 ( $0^\circ\text{C}$  or  $273.15 \text{ K}$ ) and pressure (1 atm)

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

standard conditions =  $25^\circ\text{C}$  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 <sup>6</sup> /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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## **Table of Contents Mcat Chemistry Review Sheet**

1. Understanding the eBook Mcat Chemistry Review Sheet
  - The Rise of Digital Reading Mcat Chemistry Review Sheet
  - Advantages of eBooks Over Traditional Books
2. Identifying Mcat Chemistry Review Sheet
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Mcat Chemistry Review Sheet
  - User-Friendly Interface
4. Exploring eBook Recommendations from Mcat Chemistry Review Sheet
  - Personalized Recommendations
  - Mcat Chemistry Review Sheet User Reviews and Ratings
  - Mcat Chemistry Review Sheet and Bestseller Lists
5. Accessing Mcat Chemistry Review Sheet Free and Paid eBooks
  - Mcat Chemistry Review Sheet Public Domain eBooks
  - Mcat Chemistry Review Sheet eBook Subscription Services
  - Mcat Chemistry Review Sheet Budget-Friendly Options
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- Mcat Chemistry Review Sheet Enhanced eBook Features
- 7. Enhancing Your Reading Experience
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  - Highlighting and Note-Taking Mcat Chemistry Review Sheet
  - Interactive Elements Mcat Chemistry Review Sheet
- 8. Staying Engaged with Mcat Chemistry Review Sheet
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Mcat Chemistry Review Sheet
- 9. Balancing eBooks and Physical Books Mcat Chemistry Review Sheet
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Mcat Chemistry Review Sheet
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Mcat Chemistry Review Sheet
  - Setting Reading Goals Mcat Chemistry Review Sheet
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Mcat Chemistry Review Sheet
  - Fact-Checking eBook Content of Mcat Chemistry Review Sheet
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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