



FOSSEE summer FELLOWSHIP 2023 REPORT

On

Creating concept mapping using **Freeplane**

Submitted by

Rohini Rana

B.E Computer Engineering

St. John College of Engineering & Management

Mumbai University, Palghar

Under the guidance of

Prof. Kannan M. Moudgalya

Chemical Engineering Department

IIT Bombay

Mentor

Dr. Rani Parvathy

July 03, 2023

Acknowledgment

I would like to sincerely express my profound gratitude to all those individuals who played an instrumental role in ensuring the successful completion of my Internship at FOSSEE, IIT Bombay. It is with immense appreciation that I take this opportunity to acknowledge their invaluable support and guidance.

First and foremost, I would like to extend my heartfelt thanks to Miss Rani Parvathy for her exceptional mentorship throughout my internship. Her patience, expertise, and dedication have been instrumental in shaping my growth and development during this period. I am truly grateful for her unwavering guidance and support.

I am truly honored to have been selected as an intern at IIT Bombay, and I sincerely appreciate the trust and confidence that the institution has placed in me. I am committed to upholding the principles and values of IIT Bombay and had tried my best to build a positive impact during my time as an intern.

Table of contents

1. Introduction-----	1
2. Reflection on the internship -----	2
i. Merits of concept map	
ii. Purpose of concept map	
iii. Outcome of concept map	
3. Maps-----	4
a. Chemical kinetics	
b. Electrochemistry	
c. Discovery of atomic particle	
d. Structure of an atom	
e. Atomic orbital	
f. d-block elements	
g. f-block elements	
h. Units and measurements	
i. Oscillation	
j. Sets	
4. Conclusion -----	48

Chapter 1

Introduction

Freeplane is an open-source mind mapping and brainstorming software. It is a powerful tool used for visualizing and organizing information in a hierarchical and interconnected manner. With Freeplane, users can create, edit, and manage mind maps, which are graphical representations of ideas, concepts, and relationships.

The software offers a flexible and intuitive interface that allows users to create nodes, add text, and connect nodes to establish relationships between ideas. It provides various features to enhance productivity, such as the ability to insert images, icons, and attachments, as well as add hyperlinks and notes to nodes. Users can also customize the appearance of their mind maps with different colors, styles, and layouts.

Freeplane supports collaboration by enabling users to share and collaborate on mind maps with others. It also offers features like filtering, searching, and outlining to help users navigate and organize complex information effectively. Additionally, the software supports plugins and extensions, allowing users to extend its functionality and tailor it to their specific needs.

Freeplane is available for multiple platforms, including Windows, Mac, and Linux, and it is licensed under the GNU General Public License (GPL), which means it can be freely used, modified, and distributed by users. It has gained popularity among students, professionals, and individuals looking to improve their productivity, brainstorm ideas, and organize information visually.

Chapter 2

Reflection on the internship

2.i Merits of the concept map

- **Integrates Prior Knowledge:** Concept maps allow learners to connect new information with their existing knowledge. By linking new concepts to pre-existing concepts on the map, learners can actively integrate and expand their understanding, fostering a deeper level of comprehension.
- **Versatility and Adaptability:** Concept maps can be used in various educational and professional contexts. They can be applied across different subjects, disciplines, and levels of complexity. Concept maps can also be created using digital tools, making them easily shareable, editable, and adaptable to different learning environments.
- **Promotes Critical Thinking:** Creating concept maps requires learners to analyze information, identify key concepts, and determine the relationships between them. This promotes critical thinking skills, as learners must evaluate and synthesize information to construct a meaningful and coherent map.
- **Facilitates Knowledge Retention:** The visual nature of concept maps aids in memory retention. By organizing information spatially and associating ideas with images or symbols, concept maps create a memorable representation that enhances recall and retrieval of information.
- **Encourages Creativity and Flexibility:** Concept maps provide a flexible framework for organizing ideas, allowing learners to explore different possibilities and make connections that may not be immediately apparent. This encourages creativity, as learners can freely add, modify, or rearrange concepts and relationships as their understanding deepens.

2.ii Purpose of the concept map

By employing concept maps, individuals can organize vast amounts of information into a coherent and structured framework, enabling them to grasp complex concepts more readily. These visual representations act as cognitive blueprints, empowering learners to comprehend intricate subject matter by highlighting the relationships and connections between different ideas. Through concept maps, learners gain a comprehensive understanding of the big picture while appreciating the interdependence and significance of individual components.

Engaging with concept maps cultivates critical thinking skills as individuals analyze, evaluate, and synthesize information. By deciphering the relationships between concepts and examining their hierarchical nature, learners develop the ability to categorize, compare, and discern cause-and-effect relationships, fostering higher-order thinking abilities and promoting a deeper understanding of the subject matter.

2.iii Outcomes of the concept map

The utilization of concept maps yields a multitude of positive outcomes, resulting in amplified understanding, honed critical thinking skills, unleashed creativity, enhanced communication, strengthened problem-solving abilities, and improved memory recall. These transformative outcomes work synergistically to foster a comprehensive and holistic learning experience that transcends disciplinary boundaries and enriches knowledge acquisition across various domains.

Concept maps serve as catalysts for improved understanding, as they visually organize and connect concepts, facilitating a clearer grasp of complex information. By representing relationships and hierarchies between ideas, concept maps enable learners to perceive the underlying structure and interconnectedness of knowledge, leading to a more profound comprehension of the subject matter.

Chapter 3

Abstract:

During my summer internship at the Soul Project, I developed mind maps for six chapters from the Chemistry textbook (Part I) of class XII, two chapters from the Physics textbook (Part I) of class XI and one chapter from the MATHEMATICS textbook (Part I) of class XI. The mind maps provided comprehensive overviews of each chapter, highlighting key concepts, their interrelationships, and practical applications. The chapters covered topics such as "Chemical kinetics" Chemical kinetics explores the rates and factors influencing chemical reactions, investigating the mechanisms and pathways of reactant transformation. It focuses on understanding the control factors such as reactant concentration, temperature, pressure, catalysts, and inhibitors that determine the reaction rate. "Electrochemistry" This chapter shows the relation between electrical energy and chemical energy and its vivid applications. Then "Structure of atom" this map is divided into 3 parts which is Discovery of fundamental particles, Atomic orbitals and Structure of atom which contain different experiments by scientist. "D-block" this chapter explores transition metals, with their multiple oxidation states, complex compounds, and unique properties, are essential catalysts and versatile elements crucial to industries and materials science. "F-block" is contain the lanthanides and actinides, is a group of elements with unique properties resulting from the filling of f orbitals. With high atomic numbers, varied oxidation states, and applications in nuclear energy and rare earth production, they significantly impact fields like chemistry, physics, and material science.

Then from Physics "Units and Measurement" this chapter highlights the importance of measurements, covering concepts such as scalars, vectors, SI units, measurement errors, precision, unit conversions, and proper unit selection. "Oscillation" this chapter delves into oscillatory motion, exploring concepts like displacement, amplitude, frequency, resonance, damping, and the pendulum, aiming to develop a solid understanding of oscillatory phenomena and their practical applications. Lastly chapter from Maths "Sets" this chapter covers oscillatory motion, including displacement, amplitude, frequency, resonance, damping, and the pendulum, providing a comprehensive understanding of these concepts and their applications.

Included detailed .docx files for each chapter, accompanied by mind map images. These resources provide comprehensive explanations and visual representations

1. Chemical kinetics

Chemical kinetics is the branch of chemistry that deals with the study of the rates at which chemical reactions occur and the factors that influence those rates. It involves the investigation of the underlying mechanisms and pathways through which reactants are transformed into products.

Chemical reactions occur when reactant molecules collide with each other with sufficient energy and proper orientation. However, not all collisions result in a reaction. Chemical kinetics aims to understand the factors that control the rate of a reaction, including the concentration of reactants, temperature, pressure, catalysts, and the presence of inhibitors.

DESCRIPTION:

The key concepts and principles in chemical kinetics include:

- **Reaction rate:**

The rate of a chemical reaction refers to the change in concentration of a reactant or product per unit of time. It is typically expressed as the rate of disappearance of reactants or the rate of formation of products.

- **Rate law:**

The rate law describes the mathematical relationship between the reaction rate and the concentrations of the reactants. It is determined experimentally and provides insights into the reaction mechanism.

- **Reaction order:**

The reaction order for a particular reactant is the exponent to which its concentration is raised in the rate law equation. The sum of the exponents gives the overall reaction order.

- **Activation energy:**

Activation energy is the minimum amount of energy required for a reaction to occur. It represents the energy barrier that must be overcome for reactant molecules to convert into products.

- **Reaction mechanisms:**

Reaction mechanisms are the step-by-step processes that describe how reactant molecules rearrange and form products. They involve elementary reactions, which are individual molecular events that occur during a chemical reaction

- **Catalysis:**

Catalysts are substances that increase the rate of a chemical reaction without being consumed in the process. They lower the activation energy by providing an alternative reaction pathway.

- **Rate constant**

The constant which defines the relationship between the molar concentration of the reactants and the rate of the chemical reaction is known as the rate constant.

- **Molecularity**

Molecularity is the number of molecules that come together to react in an elementary (single-step) reaction and is equal to the sum of stoichiometric coefficients of reactants in the elementary reaction with effective collision (sufficient energy) and correct orientation.

- **Effective collision**

An effective collision is defined as one in which molecules collide with sufficient energy and proper orientation, so that a reaction occurs.

Glossary:

There are several important formulas used in chemical kinetics to describe the rate of a reaction, the rate constant, and the reaction order. Here are some commonly used formulas:

1. Rate of Reaction (rate law):

$$\text{Rate} = k[A]^m[B]^n$$

where:

- Rate is the rate of the reaction
- k is the rate constant
- $[A]$ and $[B]$ are the concentrations of the reactants A and B, respectively
- m and n are the reaction orders with respect to A and B, respectively

The reaction orders (m and n) determine how the concentration of each reactant affects the rate of the reaction.

2. Integrated Rate Law:

- For a zero-order reaction: $[A] = [A]_0 - kt$
- For a first-order reaction: $\ln[A] = -kt + \ln[A]_0$
- For a second-order reaction: $1/[A] = kt + 1/[A]_0$

where:

- $[A]$ is the concentration of reactant A at a given time
- $[A]_0$ is the initial concentration of reactant A
- k is the rate constant
- t is the time elapsed

3. Arrhenius Equation:

The Arrhenius equation relates the rate constant (k) of a reaction to temperature (T) and the activation energy (E_a):

$$k = A * e^{(-E_a/RT)}$$

where:

- k is the rate constant
- A is the pre-exponential factor or frequency factor
- E_a is the activation energy
- R is the gas constant (8.314 J/(mol·K))
- T is the temperature in Kelvin

- **Detailed link of the attachments :**

NCERT link for Chemical Kinetics:

<https://ncert.nic.in/ncerts/l/lech104.pdf>

Study material:

<https://www.britannica.com/science/chemical-kinetics>

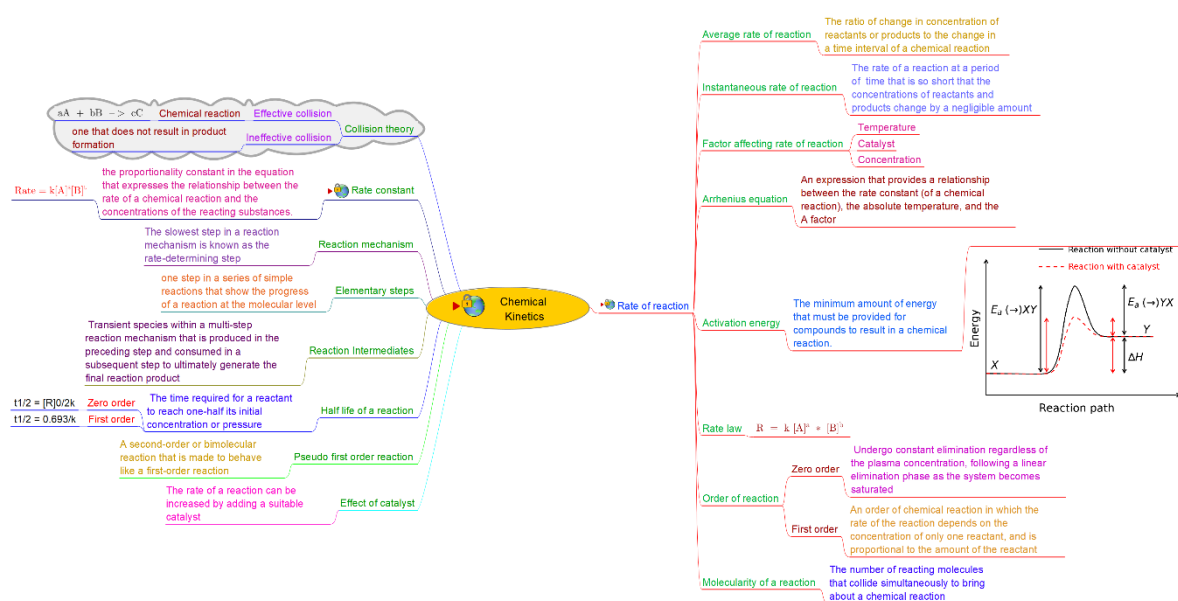
<https://ch301.cm.utexas.edu/help/ch302/kinetics.pdf>

PHET interactive simulation link:

<https://phet.colorado.edu/en/simulations/reactions-and-rates>

Activation energy image link:

https://en.wikipedia.org/wiki/Activation_energy



2. Electrochemistry

This chapter shows the relation between electrical energy and chemical energy. And explain the vivid process of creating electricity from chemical reaction and vice versa using cells like Daniel cell , galvanic cell and electrodes like standard electrode potential, hydrogen electrode. This topic chapter details a selection of areas including energy conversion and storage in particular fuel cells and Li ion batteries; electrosynthesis which covers both organic synthesis and the electrodeposition of homogeneous as well as nanostructured surfaces; corrosion; electroanalytical chemistry in the classic sense of analyte detection as well as probing mechanistic information regarding oxidation/reduction reactions of electroactive species at the nanoscale. Finally the applicability of electrochemistry to the biological sciences is briefly described.

Description:

- **Electrochemistry:**

Electrochemistry is the subdiscipline of Chemistry that deals with the study of the relationship between electrical energy and chemical changes.

- **Type of Cell:**

1. Electrochemical cell/Galvanic cell
2. Electrolytic cell

- **Electrochemical Cell:**

An electrochemical cell is a device that can generate electrical energy from the chemical reactions occurring in it, or use the electrical energy supplied to it to facilitate chemical reactions in it.

- **Electrolytic cell:**

An electrolytic cell is an electrochemical device that uses electrical energy to drive a non-spontaneous redox reaction.

- **Component of cells and Batteries:**

1. Anode

2. Cathode
3. Electrolyte

- **Anode**

An anode is the electrode in a polarized electrical device through which current flows in from an outside circuit.

- **Cathode:**

An anode is the electrode in a polarized electrical device through which current flows in from an outside circuit.

- **Electrolyte:**

An electrolyte is a medium containing ions that is electrically conducting through the movement of those ions, but not conducting electrons.

- **Corrosion:**

The decaying of metals on the grounds of the chemical reaction in the presence of the immediate environment

- **Batteries:**

A device that converts chemical energy contained within its active materials directly into electric energy by means of an electrochemical oxidation-reduction (redox) reaction. This type of reaction involves the transfer of electrons from one material to another via an electric circuit.

Glossary:

1. Standard Cell Potential

$$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}}$$

2. Nernst Equation

$$E_{\text{cell}} = E^0 - [RT/nF] \ln Q$$

3. Cell Potential Under Equilibrium:

Cell potential' E_{cell} ' becomes zero

4. Gibbs Energy and Cell Potential : $\Delta G = -nFE$

5. Conductivity of electrolytic solution: $C = 1/R$

6. Kohlrausch law: $\alpha = \Lambda / \tilde{E}m^\circ$

7. Faraday's First Law of Electrolysis: $w = ZQ$

8. Faraday's Second Law of Electrolysis: $W_2W_1 = E_2E_1$

● Details of the attachment download:

Salt Bridge image link: <https://www.flickr.com/photos/westcoaster/4134813027>

Galvanic cell image link :

https://commons.wikimedia.org/wiki/File:CNX_Chem_17_02_Galvanicel.png

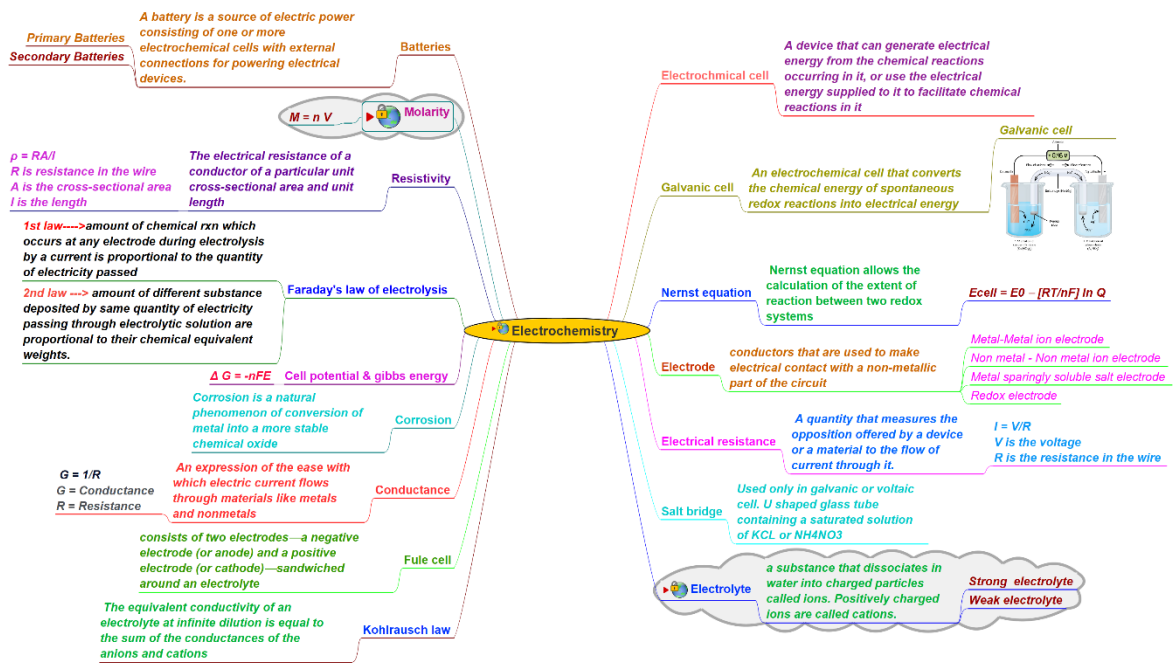
NCERT link of Electro Chemistry: Unit_3.pmd (ncert.nic.in)

PHET simulation link for concentration :

[Concentration - Solutions | Concentration | Saturation - PhET Interactive Simulations \(colorado.edu\)](#)

PHET simulation link for molarity :

[Molarity - Solutions | Moles | Volume - PhET Interactive Simulations \(colorado.edu\)](#)



3. Discovery of atomic particle (structure of atom1)

This chapter explains the developments that took place after the Rutherford experiment and many development occurred and played a major role in discovering the atomic behavior such as Planck quantum theory, photoelectric effect, dual behavior of matter, quantum mechanical model , Heisenberg's uncertainty principle.

Description:

- **Fundamental particles:**

Fundamental particles, also known as elementary particles, are the basic building blocks of matter. They are the smallest and indivisible entities that make up everything in the universe.

- **Electron:**

An electron is a negatively charged subatomic particle that together with protons and neutrons form an atom's nucleus

- **Proton:**

A positively charged elementary particle that is a fundamental constituent of all atomic nuclei

- **Neutron:**

A neutron is a neutral subatomic particle and is present in the nucleus of the atom. They are usually denoted by N and net charge associated with it is zero

Sr no.	Particles	Charge
1	Electron	Negative charge
2	Proton	Positive charge
3	Neutron	No charge/neutral

- **Isotopes:**

Isotopes can be defined as the variants of chemical elements that possess the same number of protons and electrons, but a different number of neutrons.

- **Isobar:**

The atoms which have the same mass number but different atomic numbers are called isobars.

- **Atomic number:**

The atomic number of an atom is equal to the number of protons in the nucleus of an atom or the number of electrons in an electrically neutral atom.

- **Mass number:**

The mass number (A), also called atomic mass number or nucleon number, is the total number of protons and neutrons (together known as nucleons) in an atomic nucleus.

- **Discover of electron:**

The electron was discovered in 1897 by J.J. Thomson through experiments on cathode rays. Thomson observed the deflection of cathode rays by electric and magnetic fields, concluding the presence of negatively charged particles, which he named electrons.

- J.J. Thomson's experiments with cathode ray tubes showed that all atoms contain tiny negatively charged subatomic particles or electrons.
- Thomson's plum pudding model of the atom had negatively-charged electrons embedded within a positively-charged "soup."
- Rutherford's gold foil experiment showed that the atom is mostly empty space with a tiny, dense, positively-charged nucleus.
- Based on these results, Rutherford proposed the nuclear model of the atom.

- **Discovery of proton:**

The proton was discovered in 1919 by Ernest Rutherford through experiments on alpha particle scattering. Rutherford observed that some

alpha particles were deflected at large angles, suggesting a concentrated positive charge at the centre of the atom. He concluded that this positive charge was carried by a new subatomic particle, which he named the proton.

- **Discovery of nucleus:**

The nucleus was discovered in 1911 by Ernest Rutherford through the gold foil experiment. Rutherford bombarded a thin gold foil with alpha particles and observed that some of them were deflected at large angles, indicating a dense, positively charged central region. This led to the conclusion that atoms have a small, dense nucleus at their centre.

Glossary:

- Atomic no of X = Mass no of X - No of neutrons
- mass number = protons + neutrons

Detailed links of the attachments:

NCERT link of the chapter Structure of atom:

<https://ncert.nic.in/textbook/pdf/kech102.pdf>

PHET interactive simulation for isotopes and atomic mass:

<https://phet.colorado.edu/en/simulations/isotopes-and-atomic-mass>

PHET interactive simulation to build a nucleus:

<https://phet.colorado.edu/en/simulations/build-a-nucleus>

Extra study links:

<https://www.britannica.com/science/Millikan-oil-drop-experiment>

link for the image for Thomson model:

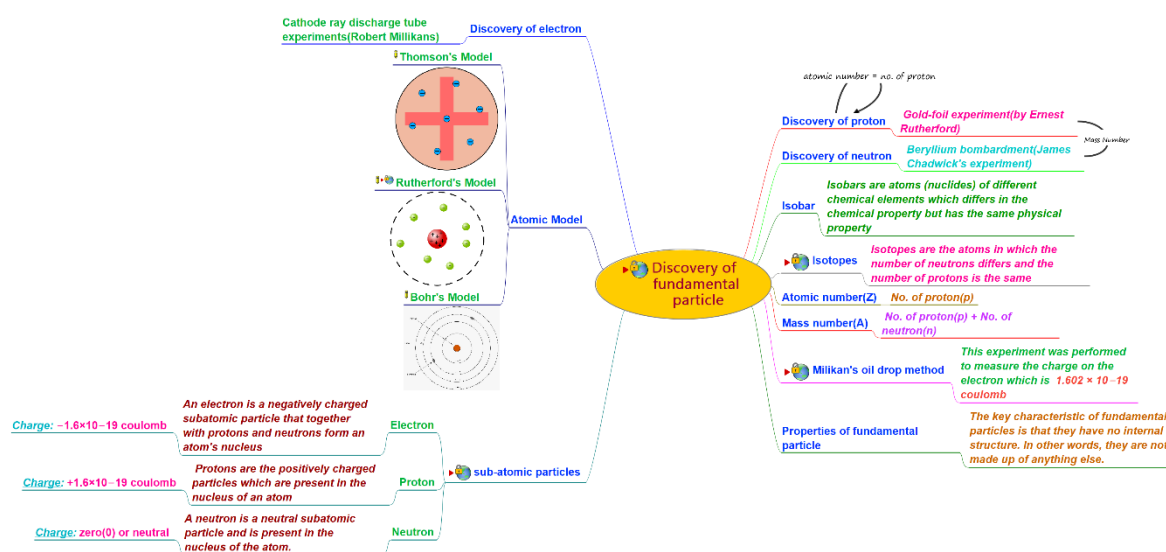
https://en.wikipedia.org/wiki/Plum_pudding_model

image link for the Rutherford model:

https://commons.wikimedia.org/wiki/File:Rutherford_atomic_planetary_model.svg

image link for the Bohr's mode:

https://commons.wikimedia.org/wiki/File:Bohr%27s_model.svg



4. Structure of atom(part2)

This chapter focuses on the discovery of the fundamental particles; like electron, proton and neutron along with the discovery of the charges on each particle. It emphasizes the importance of the most significant experiments such as cathode ray tube, gold foil experiment and beryllium bombardment experiment which were used to discover the electron, proton and neutron respectively. Along with the discovery of fundamental particles the charges on each particle were discovered. Millikan's oil drop method came up with the value of charge on the electron. Further it explains the atomic number, atomic mass number and concepts of isotopes and isobars etc.

Description:

- **Planck Quantum theory:**

Planck's quantum theory states that energy is emitted or absorbed in discrete packets called quanta. Each quantum's energy is directly proportional to the frequency of the radiation. The proportionality constant is known as Planck's constant (h). This theory was proposed to explain phenomena like black body radiation and the photoelectric effect.

- **Dual behavior of matter :**

The dual behavior of matter, as described by quantum mechanics, suggests that particles like electrons and photons can exhibit both particle-like and wave-like properties. This means that they can display characteristics of discrete particles, such as position and momentum, as well as exhibit wave-like properties, such as interference and diffraction. This duality is fundamental to understanding the behavior of microscopic particles and is supported by experimental evidence such as the double-slit experiment.

- **Electromagnetic spectrum:**

The electromagnetic spectrum is the range of frequencies (the spectrum) of electromagnetic radiation and their respective wavelengths and photon energies.

- **Heisenberg's Uncertainty Principle :**

The Heisenberg uncertainty principle states that there is a fundamental limit to the precision with which certain pairs of physical properties, such as position and momentum, can be known simultaneously. It implies that the more accurately we measure one property, the less accurately we can measure the other. This principle arises from the wave-like nature of particles and the inherent randomness in quantum mechanics. It fundamentally challenges our classical intuition about the determinacy of physical properties at the microscopic level.

- **Quantum mechanical model :**

The quantum mechanical model, also known as the wave function model or Schrödinger's model, describes the behavior of particles at the atomic and subatomic levels. It incorporates wave-particle duality and probabilistic nature, where particles are described by wave-like mathematical functions called wave functions. The model uses the Schrödinger equation to determine the wave function, which provides information about the particle's position, momentum, energy, and other physical properties. Unlike classical physics, the quantum mechanical model allows for the existence of discrete energy levels and quantized behavior, providing a more accurate understanding of the microscopic world.

Glossary:

- **Planck's Quantum Theory:**

$$E = hf$$

Where,

E = the energy of a photon

h = Planck's constant ($6.62607015 \times 10^{-34} \text{ J}\cdot\text{s}$)

f = the frequency of the photon

- **Photoelectric Effect:**

The Einstein equation: $E = hf = \phi + KE$

Where,

E = the energy of the incident photon

hf = the energy of the photon

ϕ = the work function (minimum energy required to remove an electron from a metal)

KE = the kinetic energy of the emitted electron

- **Dual Behavior of Matter:**

De Broglie's equation: $\lambda = h / p$

Where,

λ = the wavelength

h = Planck's constant

p = the momentum of the particle

- **Heisenberg's Uncertainty Principle:**

$$\Delta x * \Delta p \geq h/4\pi$$

Where,

Δx = represents the uncertainty in position

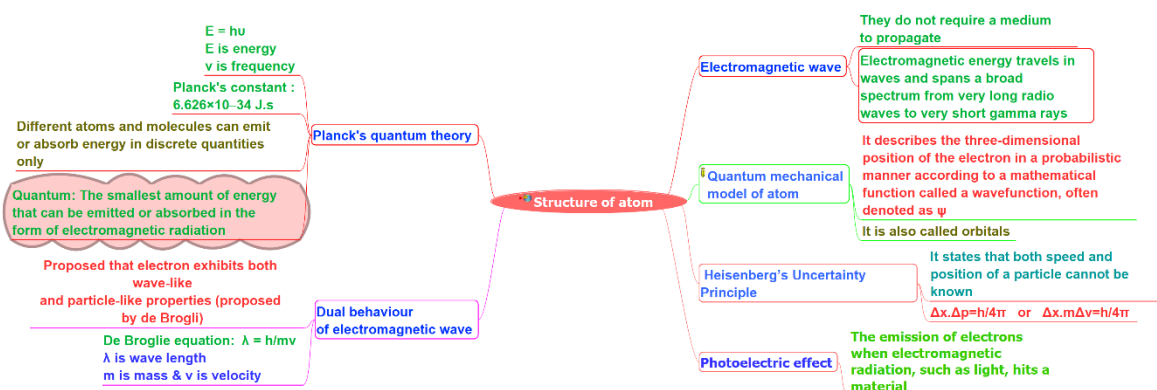
Δp = represents the uncertainty in momentum.

Detailed links of the attachment:

NCERT link: <https://ncert.nic.in/ncerts/l/kech102.pdf>

PHET interactive simulation link for Rutherford scattering:

<https://phet.colorado.edu/en/simulations/rutherford-scattering>



5. Atomic Orbital(structure of atom3)

This document explains the concept of atomic orbitals. Atomic orbitals are regions of space around an atomic nucleus where there is a high probability of finding an electron. They are the building blocks of an atom's electronic structure and describe the behavior and properties of electrons within an atom. There are different orbitals and the quantum numbers define the characteristics of each atomic orbital. Different orbitals also have different energy levels. Three principles are used for assigning electrons to an atomic orbital; they are Pauli's exclusion principle, Aufbau principle and Hund's rule of maximum multiplicity.

Description:

- **Atomic Orbital:**

Atomic orbitals are the 3-dimensional spaces around the nucleus where the probability of finding an electron is maximum.

Shell	K	L	M	N
Orbital	s	s, p	s,p,d	s,p,d,f
No of electrons	2	2, 6	2,6,10	2,6,10,14

- **Difference between orbit and orbital;**

Sr no.	Orbit	Orbital
1	Circular path around the nucleus in which an electron	Orbital is a quantum mechanical concept and refers to the one electron wave function ψ in an atom
2	It can be defined as the path that gets established in a circular motion by revolving the electron around the nucleus.	An orbital can be defined as the space or region where the electron is most likely to be found.

3	The shape of molecules cannot be explained by an orbits	The shapes of molecules can be found out as they are directional by nature.
4	A well-defined orbit goes against the Heisenberg principle	An ideal orbital agrees with the theory of Heisenberg's Principles.

- **Different types of atomic orbital:**

Shell no.	Shell	shape
1	S (sharp)	Spherical
2	P (principle)	dumb bell
3	D (diffuse)	Various
4	F (fundamental)	

- **Different types of Quantum Numbers:**

1	Principle Quantum Number(n)
2	Azimuthal Quantum Number(l)
3	Magnetic Orbital Quantum Number(ml)
4	Electron Spin Quantum Number(ms)

- **Principle quantum number:**

The principal quantum number, signified by n , is the main energy level occupied by the electron. Energy levels are fixed distances from the nucleus of a given atom.

- **Azimuthal quantum number:**

Azimuthal quantum number describes the shape of the orbital. It is denoted by ℓ . Values of ℓ are from zero to $n-1$. With the help of the value of the azimuthal quantum number, we can determine the total number of energy sublevels in a given energy level.

- **Magnetic quantum number:**

It specifies the orientation in space of an orbital of a given energy (n) and shape (ℓ). This number divides the subshell into individual orbitals which hold the electrons; there are $2\ell+1$ orbitals in each subshell.

- **Spin quantum number:**

The fourth quantum number which is introduced to describe the orientation of the electron spin (rotation) in space, is called the spin quantum number. It can be clockwise or anticlockwise. It is represented by 's' or 'ms'.

- **Orbitals in s-shell:** 1s and 2s

- **Orbitals in p-shell:** $2p_x$, $2p_y$ and $2p_z$

- **Orbitals in d-shell:** d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$ and d_{z^2}

- **Orbitals in f-shell:** $7f_y^3$, $7f_z^3$, $7f_x^3$, $7f_{y(z^2-x^2)}$, $7f_{z(x^2-y^2)}$, and $7f_{x(z^2-y^2)}$

Glossary:

- Firstly a shell is determined by principal quantum number. It surrounds the nucleus. These shells are also represented by letters like K, L, M and N shell.
- The Azimuthal quantum number ' ℓ ' can have values ranging from 0 to $n-1$ the number of subshells in a

Details of the attachment download:

s orbital image link:

https://commons.wikimedia.org/wiki/File:S-orbitals_2s_withNodes.jpg

p orbital image link:

https://commons.wikimedia.org/wiki/File:Px_py_pz_orbitals.png

d orbital image link: <https://www.flickr.com/photos/ncssm/9424523628>

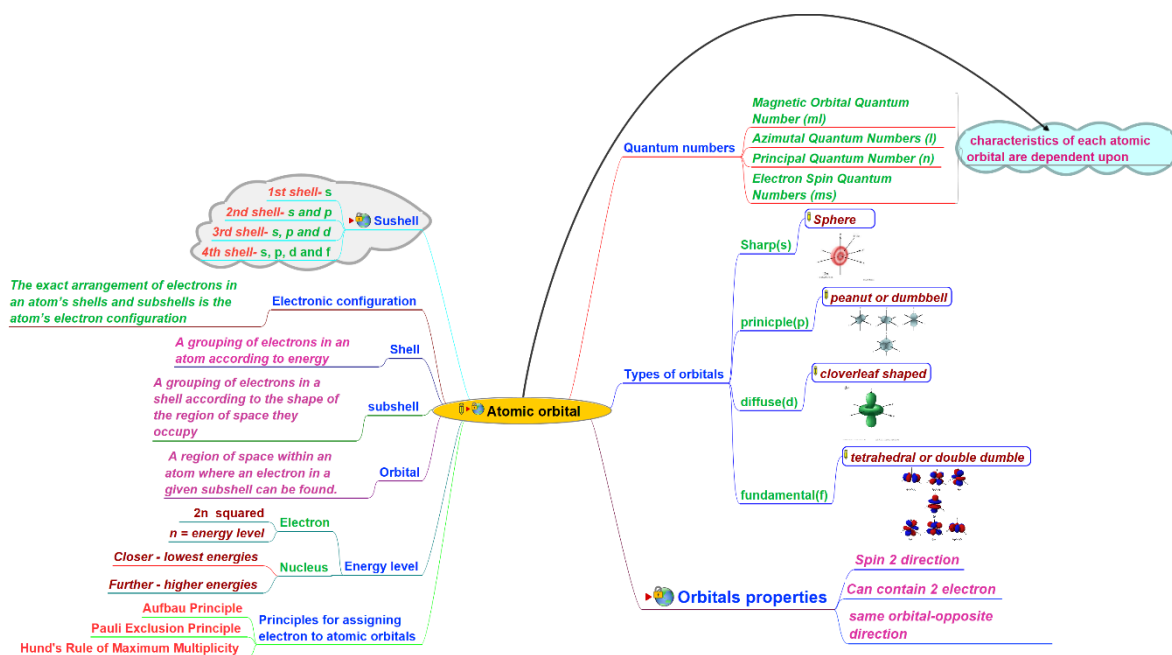
f orbital image link: https://commons.wikimedia.org/wiki/File:F_orbital.png

NCERT link of Atomic Orbital: <https://ncert.nic.in/ncerts/l/kech102.pdf>

Wikipedia link of Atomic Orbitals: https://en.wikipedia.org/wiki/Atomic_orbital

Extra Study links:

- [Atomic Orbital | Types, Energies, Diagram, Examples, Summary \(alevelchemistry.co.uk\)](https://alevelchemistry.co.uk)
- [Quantum Numbers, Atomic Orbitals, and Electron Configurations \(angelo.edu\)](https://angelo.edu)
- [Orbitals \(fsu.edu\)](https://fsu.edu)
- [\(29\) What is | Difference between Shell, Sub shell and Orbital | Structure of Atom Kya Hai | Chemistry - YouTube](https://www.youtube.com/watch?v=29W0q0q0q0q)
- [s Atomic Orbitals - Chemistry LibreTexts](https://www.libretexts.org)



6. d-block

The d-block, or transition metals, are a group of elements in the periodic table with electrons in their d orbitals. They exhibit multiple oxidation states and form complex compounds. These elements have high melting and boiling points, good conductivity, and are used in various fields including industry, catalysis, and materials science. They play crucial roles in the production of alloys like steel, act as catalysts in chemical reactions, and find applications in diverse industries. Their unique properties make them essential and versatile elements in the periodic table.

Description:

- **Atomic Orbital:**

Atomic orbitals are the 3-dimensional spaces around the nucleus where the probability of finding an electron is maximum.

Shell	K	L	M	N
Orbital	s	s, p	s,p,d	s,p,d,f
No of electrons	2	2, 6	2,6,10	2,6,10,14

- **Difference between orbit and orbital;**

Sr no.	Orbit	Orbital
1	Circular path around the nucleus in which an electron	Orbital is a quantum mechanical concept and refers to the one electron wave function ψ in an atom
2	It can be defined as the path that gets established in a circular motion by revolving the electron around the nucleus.	An orbital can be defined as the space or region where the electron is most likely to be found.
3	The shape of molecules	The shapes of molecules can be

	cannot be explained by an orbits	found out as they are directional by nature.
4	A well-defined orbit goes against the Heisenberg principle	An ideal orbital agrees with the theory of Heisenberg's Principles.

- **Different types of atomic orbital:**

Shell no.	Shell	shape
1	S (sharp)	Spherical
2	P (principle)	dumb bell
3	D (diffuse)	Various
4	F (fundamental)	

- **Different types of Quantum Numbers:**

1	Principle Quantum Number(n)
2	Azimuthal Quantum Number(l)
3	Magnetic Orbital Quantum Number(ml)
4	Electron Spin Quantum Number(ms)

- **Principle quantum number:**

The principal quantum number, signified by n , is the main energy level occupied by the electron. Energy levels are fixed distances from the nucleus of a given atom.

- **Azimuthal quantum number:**

Azimuthal quantum number describes the shape of the orbital. It is denoted by ℓ . Values of ℓ are from zero to $n-1$. With the help of the value of the azimuthal quantum number, we can determine the total number of energy sublevels in a given energy level.

- **Magnetic quantum number:**

It specifies the orientation in space of an orbital of a given energy (n) and shape (ℓ). This number divides the subshell into individual orbitals which hold the electrons; there are $2\ell+1$ orbitals in each subshell.

- **Spin quantum number:**

The fourth quantum number which is introduced to describe the orientation of the electron spin (rotation) in space, is called the spin quantum number. It can be clockwise or anticlockwise. It is represented by 's' or 'ms'.

- **Orbitals in s-shell:** 1s and 2s

- **Orbitals in p-shell:** $2p_x$, $2p_y$ and $2p_z$

- **Orbitals in d-shell:** d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$ and d_{z^2}

- **Orbitals in f-shell:** $7f_y^3$, $7f_z^3$, $7f_x^3$, $7f_{y(z^2-x^2)}$, $7f_{z(x^2-y^2)}$, and $7f_{x(y^2-z^2)}$

Glossary:

- Firstly a shell is determined by principal quantum number. It surrounds the nucleus. These shells are also represented by letters like K, L, M and N shell.
- The Azimuthal quantum number ' ℓ ' can have values ranging from 0 to $n-1$ the number of subshells in a

Details of the attachment download:

s orbital image link:

https://commons.wikimedia.org/wiki/File:S-orbitals_2s_withNodes.jpg

p orbital image link:

https://commons.wikimedia.org/wiki/File:Px_py_pz_orbitals.png

d orbital image link: <https://www.flickr.com/photos/ncssm/9424523628>

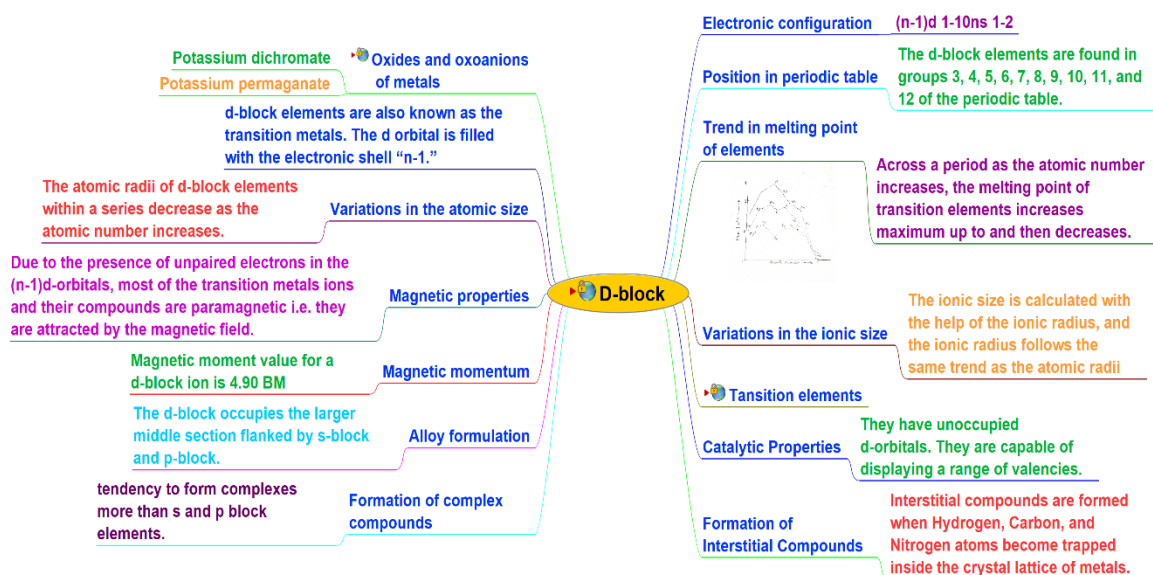
f orbital image link: https://commons.wikimedia.org/wiki/File:F_orbital.png

NCERT link of Atomic Orbital: <https://ncert.nic.in/ncerts/l/kech102.pdf>

Wikipedia link of Atomic Orbitals: https://en.wikipedia.org/wiki/Atomic_orbital

Extra Study links:

- [Atomic Orbital | Types, Energies, Diagram, Examples, Summary \(alevelchemistry.co.uk\)](http://alevelchemistry.co.uk)
- [Quantum Numbers, Atomic Orbitals, and Electron Configurations \(angelo.edu\)](http://angelo.edu)
- [Orbitals \(fsu.edu\)](http://fsu.edu)
- [\(29\) What is | Difference between Shell, Sub shell and Orbital | Structure of Atom Kya Hai | Chemistry - YouTube](https://www.youtube.com/watch?v=29W0K0K0K0K)
- [s Atomic Orbitals - Chemistry LibreTexts](https://www.libretexts.org/Bookshelves/Chemistry/Book%3A_Atomic_Structure_and_Chemical_Bonding/Chapter_1%3A_Atomic_Structure/Section_1.3%3A_Atomic_Orbitals)



7. f-block

The f-block, also known as the inner transition metals, is a group of elements in the periodic table that consists of the lanthanides and actinides. These elements occupy the two rows located below the main body of the periodic table. The f-block elements have electrons filling their f orbitals, which leads to their unique properties such as high atomic numbers, radioactive nature, and varied oxidation states. They are known for their applications in nuclear energy, medical imaging, and the production of rare earth metals, which are vital for various technologies. The f-block elements have a significant impact on fields such as chemistry, physics, and material science due to their intriguing electronic configurations and diverse chemical behaviors.

Description:

- **Atomic Orbital:**

Atomic orbitals are the 3-dimensional spaces around the nucleus where the probability of finding an electron is maximum.

Shell	K	L	M	N
Orbital	s	s, p	s,p,d	s,p,d,f
No of electrons	2	2, 6	2,6,10	2,6,10,14

- **Difference between orbit and orbital;**

Sr no.	Orbit	Orbital
1	Circular path around the nucleus in which an electron	Orbital is a quantum mechanical concept and refers to the one electron wave function ψ in an atom
2	It can be defined as the path that gets established in a circular motion by revolving the electron around the nucleus.	An orbital can be defined as the space or region where the electron is most likely to be found.

3	The shape of molecules cannot be explained by an orbits	The shapes of molecules can be found out as they are directional by nature.
4	A well-defined orbit goes against the Heisenberg principle	An ideal orbital agrees with the theory of Heisenberg's Principles.

- **Different types of atomic orbital:**

Shell no.	Shell	shape
1	S (sharp)	Spherical
2	P (principle)	dumb bell
3	D (diffuse)	Various
4	F (fundamental)	

- **Different types of Quantum Numbers:**

1	Principle Quantum Number(n)
2	Azimuthal Quantum Number(l)
3	Magnetic Orbital Quantum Number(ml)
4	Electron Spin Quantum Number(ms)

- **Principle quantum number:**

The principal quantum number, signified by n , is the main energy level occupied by the electron. Energy levels are fixed distances from the nucleus of a given atom.

- **Azimuthal quantum number:**

Azimuthal quantum number describes the shape of the orbital. It is denoted by ℓ . Values of ℓ are from zero to $n-1$. With the help of the value of the azimuthal quantum number, we can determine the total number of energy sublevels in a given energy level.

- **Magnetic quantum number:**

It specifies the orientation in space of an orbital of a given energy (n) and shape (ℓ). This number divides the subshell into individual orbitals which hold the electrons; there are $2\ell+1$ orbitals in each subshell.

- **Spin quantum number:**

The fourth quantum number which is introduced to describe the orientation of the electron spin (rotation) in space, is called the spin quantum number. It can be clockwise or anticlockwise. It is represented by 's' or 'ms'.

- **Orbitals in s-shell:** 1s and 2s

- **Orbitals in p-shell:** $2p_x$, $2p_y$ and $2p_z$

- **Orbitals in d-shell:** d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$ and d_{z^2}

- **Orbitals in f-shell:** $7f_y^3$, $7f_z^3$, $7f_x^3$, $7f_{y(z^2-x^2)}$, $7f_{z(x^2-y^2)}$, and $7f_{x(y^2-z^2)}$

Glossary:

- Firstly a shell is determined by principal quantum number. It surrounds the nucleus. These shells are also represented by letters like K, L, M and N shell.
- The Azimuthal quantum number ' ℓ ' can have values ranging from 0 to $n - 1$ the number of subshells

Details of the attachment download:

s orbital image link:

https://commons.wikimedia.org/wiki/File:S-orbitals_2s_withNodes.jpg

p orbital image link:

https://commons.wikimedia.org/wiki/File:Px_py_pz_orbitals.png

d orbital image link: <https://www.flickr.com/photos/ncssm/9424523628>

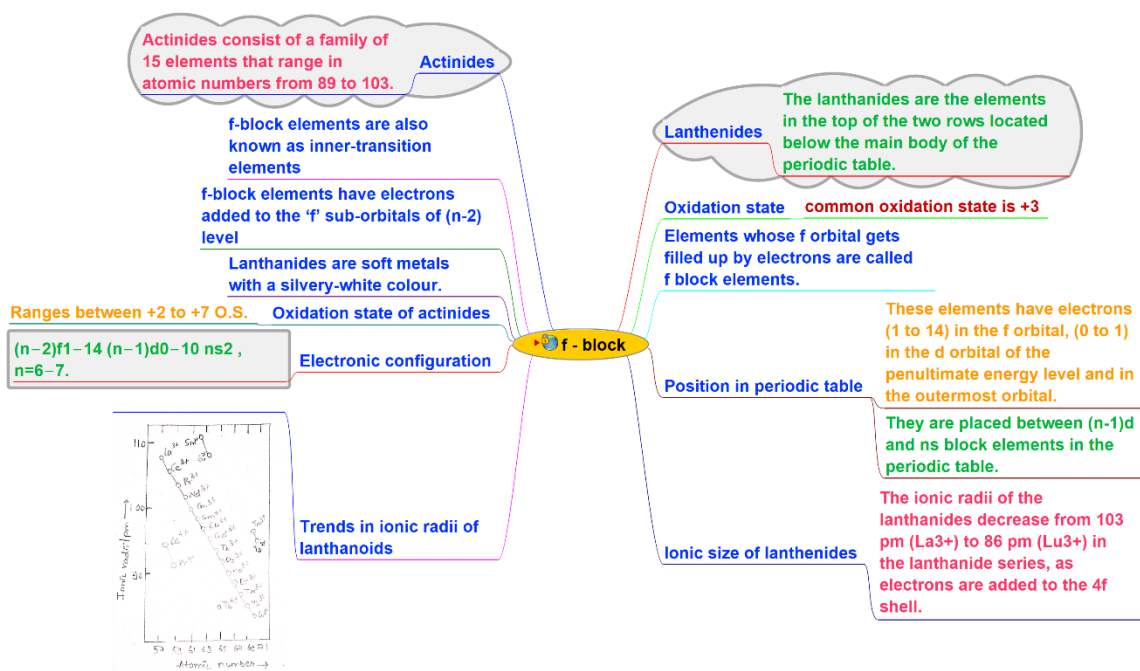
f orbital image link: https://commons.wikimedia.org/wiki/File:F_orbital.png

NCERT link of Atomic Orbital: <https://ncert.nic.in/ncerts/l/kech102.pdf>

Wikipedia link of Atomic Orbitals: https://en.wikipedia.org/wiki/Atomic_orbital

Extra Study links:

- [Atomic Orbital | Types, Energies, Diagram, Examples, Summary \(alevelchemistry.co.uk\)](http://alevelchemistry.co.uk)
- [Quantum Numbers, Atomic Orbitals, and Electron Configurations \(angelo.edu\)](http://angelo.edu)
- [Orbitals \(fsu.edu\)](http://fsu.edu)
- [\(29\) What is | Difference between Shell, Sub shell and Orbital | Structure of Atom Kya Hai | Chemistry - YouTube](#)
- [Atomic Orbitals - Chemistry LibreTexts](#)



8. Units and Measurement

This chapter introduces the **importance of measurements** in various fields. It explains the distinction between scalars and vectors and highlights the International System of Units (SI) as the standard for measurement. It also covers base units and derived units, providing examples for different physical quantities. It also discusses measurement errors and uncertainties, emphasizing the significance of precision. Lastly, the chapter touches upon unit conversions and the proper selection of units for problem-solving.

Description:

- **Unit:**

A unit is a standard quantity used to express a particular physical or abstract property. For example, meters and kilograms are units of measurement for length and mass, respectively.

- **Measurement:**

Measurement is a comparison of an unknown quantity with a known fixed quantity of the same kind. The value obtained on measuring a quantity is called its measurement.

- **Systems of Units:**

Earlier three different units systems were used in different countries. These were CGS, FPS and MKS systems. Now-a-days internationally SI system of units is followed. In SI unit system, seven quantities are taken as the base quantities.

1. CGS System. Centimetre, Gram and Second are used to express length, mass and time respectively.
2. FPS System. Foot, pound and second are used to express length, mass and time respectively.
3. MKS System. Length is expressed in metre, mass is expressed in kilogram and time is expressed in second. Metre, kilogram and second are used to express length, mass and time respectively.

- **Measurement of length:**

Length is measured the distance between two points or place, it can be measured in metre (m), centimetre and kilometre.

- **Parallax Method:**

The parallax method is an astronomical technique that measures the apparent shift in the position of a celestial object when observed from different vantage points. By calculating the parallax angle, astronomers can determine the distance to nearby stars or objects.

- **Dimensions:**

The dimensions of a physical quantity are the powers to which the fundamental units of mass, length and time must be raised to represent the given physical quantity.

- **Fundamental units:**

Fundamental units are those that are independent of other variables, such as length, mass, time, temperature, current, luminous intensity, and substance quantity

- **Derived unit:**

Derived units are those that may be stated in terms of basic units and are also dependent on others.

- **Physical Quantities:**

A physical quantity can be expressed as a value, which is the algebraic multiplication of a numerical value and a unit. Examples of physical quantities are mass, amount of substance, length, time, temperature, electric current, light intensity, force, velocity, density, and many others.

Glossary:

Following are the seven fundamental quantities:

1. Length (metre)
2. Mass (kilogram)
3. Time (second)
4. Electric current (ampere)
5. Thermodynamic temperature (kelvin)
6. Amount of substance (mole)
7. Luminous intensity (candela)

- **Errors in measurement :**

Any measurement made with any measuring instrument gives a certain degree of uncertainty. This uncertainty is referred to as an error.

- **Absolute Error (Δx):**

It represents the difference between the measured value and the true value.

$$\Delta x = |\text{Measured Value} - \text{True Value}|$$

- **Relative Error (ϵ):**

It expresses the absolute error as a fraction or percentage of the true value.

$$\epsilon = (\Delta x / \text{True Value}) \times 100\%$$

- **Percentage Error:**

It is the relative error expressed as a percentage.

$$\text{Percentage Error} = \text{Relative Error} \times 100\%$$

- **Mean Absolute Error (MAE):**

It calculates the average absolute error of a set of measurements.

$$\text{MAE} = (1 / n) \sum |\text{Measured Value} - \text{True Value}|$$

- **Standard Deviation (σ):**

It measures the spread of the measurements around the mean value.

$$\sigma = \sqrt{[(1 / (n-1)) \sum (\text{Measured Value} - \text{Mean Value})^2]}$$

Detailed attachments link:

NCERT link for unit and measurement:

<https://ncert.nic.in/ncerts/l/keph102.pdf>

Interactive simulation of unit

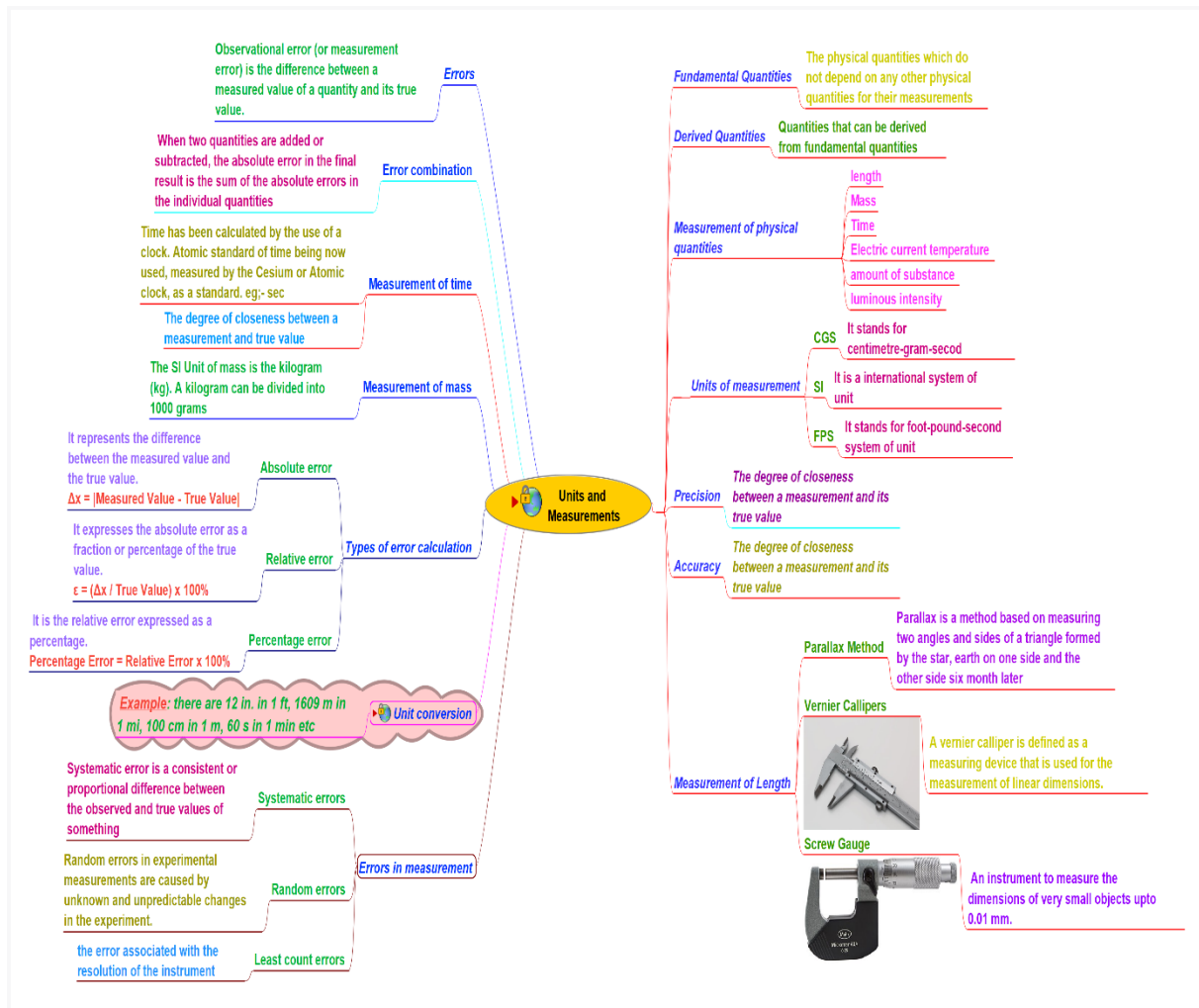
conversions: <https://www.edumedia-sciences.com/en/media/617-units-of-measurement?auth=cbfdaa3b2098a2d637978b00849858a3-7926>

screw gauge image link:

<https://www.edumedia-sciences.com/en/media/617-units-of-measurement?auth=cbfdaa3b2098a2d637978b00849858a3-7926>

vernier caliper image link:

<https://www.wallpaperflare.com/vernier-caliper-physics-measure-measurement-object-studio-shot-wallpaper-aecuc>



9. Oscillation

The chapter explores the mathematical representation of oscillatory motion, emphasizing the concepts of displacement, amplitude, frequency, and period. It also delves into important topics such as resonance, damping, resonance and the pendulum. This chapter shed light on the working of simple harmonic motion and explore it in depth along with its velocity, acceleration and energy. Through examples and illustrations, the chapter aims to develop a solid foundation in understanding oscillatory phenomena and their applications in various fields.

Description:

- **Oscillation:**

The process of repeating variations of any quantity or measure about its equilibrium value in time

- **Damped oscillation:**

Damped oscillations are classified according to the difference in energy between the restoring force applied and the restraining force acting.

- **Periodic motion:**

A motion that repeats itself after equal intervals of time is known as periodic motion. Examples of periodic motion: a tuning fork or motion of a pendulum

- **Oscillatory motion:**

The to and fro motion of an object from its mean position. The ideal condition is that the object can be in oscillatory motion forever in the absence of friction but in the real world, this is not possible and the object has to settle into equilibrium.

- **Simple harmonic motion:**

Simple harmonic motion, in physics, repetitive movement back and forth through an equilibrium, or central, position, so that the maximum displacement on one side of this position is equal to the maximum displacement on the other side. The time interval of each complete vibration is the same.

- **Uniform circular motion:**

Uniform circular motion is a specific type of motion in which an object travels in a circle with a constant speed. For example, any point on a propeller spinning at a constant rate is executing uniform circular motion.

- **Velocity in SHM:**

The velocity is the time derivative of the position, which is the slope at a point on the graph of position versus time.

- **Acceleration in SHM:**

The rate of change of velocity of a particle is called acceleration. Let the displacement of the particle be $x = A \sin \omega t$ and the velocity of the particle is v . Then acceleration. As $x = A \sin \omega t$.

- **Energy in SHM:**

A motion in which the restoring force is directly proportional to the displacement of the body from its mean position. Basically, it is the sum of its potential energy and kinetic energy.

- **Simple pendulum:**

A simple pendulum has a heavy point mass (known as bob) suspended from a rigid support by a massless and inextensible string.

- **Resonance:**

It is relatively large selective response of an object or a system that vibrates in step or phase, with an externally applied oscillatory force.

Glossary:

1. Simple Harmonic Motion (SHM):

- o Equation of motion: $x = A \cos(\omega t + \phi)$
- o Angular frequency: $\omega = 2\pi f = \sqrt{k/m}$
- o Time period: $T = 1/f = 2\pi/\omega$
- o Angular velocity: $\omega = 2\pi/T$

- o Maximum velocity: $v_{\max} = A\omega$
- o Maximum acceleration: $a_{\max} = A\omega^2$

2. Oscillations of a Spring:

- o Hooke's Law: $F = -kx$
- o Time period of a mass-spring system: $T = 2\pi\sqrt{m/k}$
- o Angular frequency of a mass-spring system: $\omega = \sqrt{k/m}$

3. Simple Pendulum:

- o Time period of a simple pendulum: $T = 2\pi\sqrt{L/g}$
- o Angular frequency of a simple pendulum: $\omega = \sqrt{g/L}$

4. Damped Oscillations:

- o Displacement in damped oscillations: $x(t) = Ae^{-(bt/2m)}\cos(\omega'dt + \phi)$
- o Damping constant: $b = 2m\gamma$
- o Angular frequency in damped oscillations: $\omega' = \sqrt{(\omega_0^2 - (\gamma/2m)^2)}$
- o Time constant: $\tau = 1/\gamma$

5. Forced Oscillations and Resonance:

- o Resonance condition: $\omega = \omega_0$
- o Amplitude of forced oscillations: $A = (F_0/m) / \sqrt{((\omega_0^2 - \omega^2)^2 + (\gamma\omega)^2)}$
- o Quality factor: $Q = \omega_0/\gamma$

Detailed links of attachments:

NCERT link: <https://ncert.nic.in/textbook/pdf/keph206.pdf>

Extra study material:

https://scholar.harvard.edu/files/david-morin/files/waves_oscillations.pdf

PHET interactive simulation for pendulum lab:

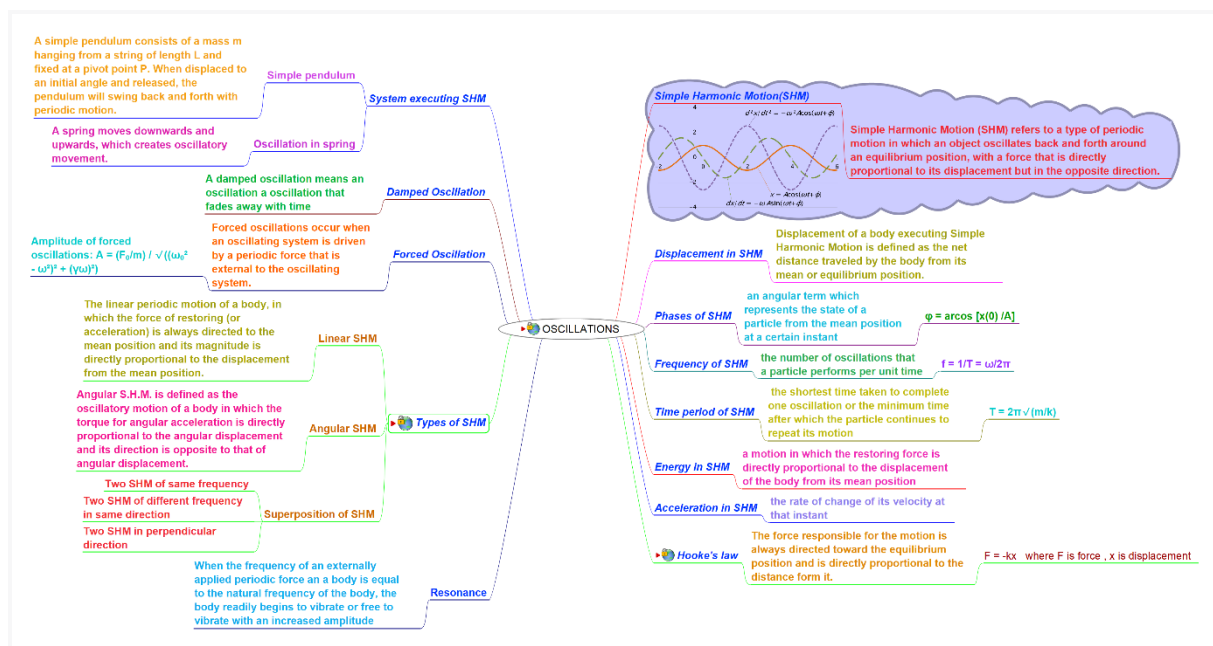
<https://phet.colorado.edu/en/simulations/pendulum-lab>

PHET interactive simulation for Hooke's law:

<https://phet.colorado.edu/en/simulations/hookes-law>

Image link of simple harmonic motion:

https://commons.wikimedia.org/wiki/File:Simple_harmonic_motion_and_its_velocity_and_acceleration.png



10. Sets

In mathematics, a set is a collection of distinct elements or objects. It is an abstract concept used to classify and organize objects based on common properties or characteristics. The elements of a set can be anything, such as numbers, letters, or even other sets.

Sets are typically denoted by listing their elements within curly braces. For example, $\{1,2,3\}$ is a set that contains the number 1,2 and 3. The elements of a set are unordered, which means the order in which they are listed does not matter. Additionally, sets do not contain duplicate elements, so each element appears only once in a given set.

Description:

- **Set:**

A set is well defined as the collection of data that does not carry from person to person.

There are different types of sets which are as follows:

1. Empty Sets:

The empty set is the unique set having no elements; its size or cardinality is zero.

2. Singleton Sets:

A singleton, also known as a unit set or one-point set, is a set with exactly one element.

3. Finite Sets:

A finite set is a set that has a finite number of elements that means a set which one could in principle count and finish counting.

4. Infinite Sets:

An infinite set is a set that is not a finite set. These sets may be countable or uncountable.

5. Equal Sets:

Two sets A and B can be equal only if each element of set A is also the element of the set B. Also if two sets are the subsets of each other, they are said to be equal. Can be represented as $A = B$.

6. Subsets:

Set A is a subset of a set B if all elements of A are also elements of B; B is then a superset of A.

7. Power Sets:

The power set of a set S is the set of all subsets of S, including the empty set and S itself.

8. Universal Sets:

The set containing all objects or elements and of which all other sets are subsets.

9. Disjoint Sets:

A pair of sets which does not have any common element are called disjoint sets.

There are various operation performed on the sets which are as follows:

1. Union of sets:

A set containing all elements that are in A or in B (possibly both)

2. Intersection of sets:

The intersection of two sets A and B, is the set containing all elements of A that also belong to B or equivalently, all elements of B that also belong to A.

3. Difference of sets:

The difference of a set, say A from universal set U is equal to empty set. When a superset is subtracted from a subset, then result is an empty set

4. Complement of set:

A is the set of all members of the universal set U which are not the elements of A.

Glossary:

Sets Theory Formulas of Difference of Sets

- $A - A = \emptyset$
- $B - A = B \cap A'$
- $B - A = B - (A \cap B)$
- $n(A \cup B) = n(A - B) + n(B - A) + n(A \cap B)$
- $n(A - B) = n(A \cup B) - n(B)$
- $n(A - B) = n(A) - n(A \cap B)$
- $(A - B) = A$ if $A \cap B = \emptyset$
- $(A - B) \cap C = (A \cap C) - (B \cap C)$
- $A \Delta B = (A - B) \cup (B - A)$
- $n(A') = n(U) - n(A)$

Sets Theory Formulas of Complement Sets

- Law of Double complementation: $(A')' = A$
- Laws of Empty set and Universal Set: $\emptyset' = U$ and $U' = \emptyset$
- Complement Law : $A \cup A' = U$, $A \cap A' = \emptyset$ and $A' = U - A$
- De Morgan's Laws: $(A \cup B)' = A' \cap B'$ and $(A \cap B)' = A' \cup B'$

Details of the attachment download:

NCERT link for Sets chapter:

[FINAL Ch_1 02.01.06 \(ncert.nic.in\)](https://ncert.nic.in/FINAL_Ch_1_02.01.06(ncert.nic.in))

Link for Wikipedia:

[https://en.wikipedia.org/wiki/Set_\(mathematics\)](https://en.wikipedia.org/wiki/Set_(mathematics))

link for image of intersection:

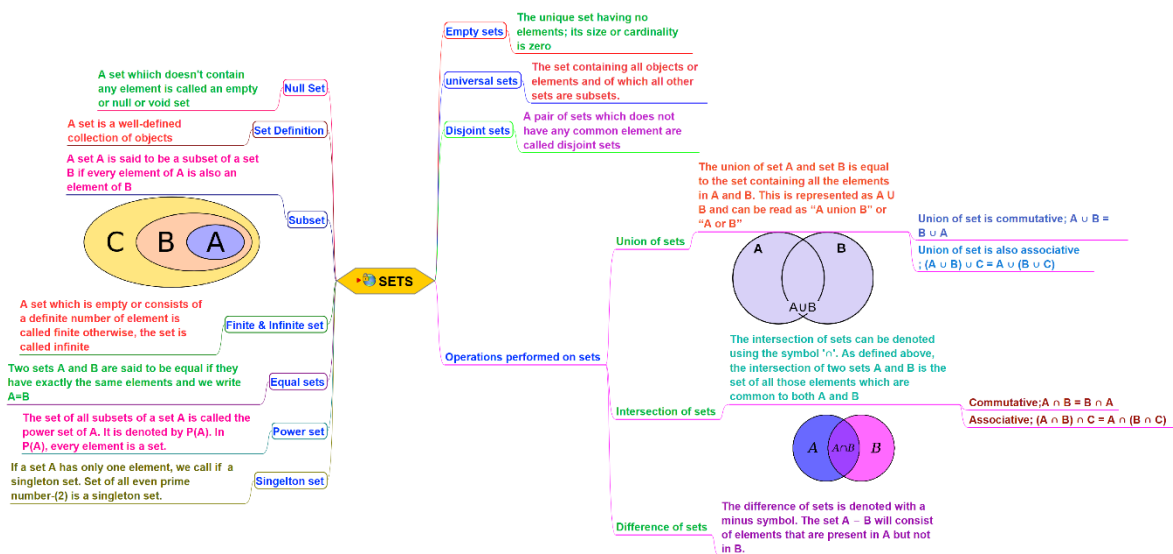
https://en.wikipedia.org/wiki/Set_theory

link for image of union:

https://commons.wikimedia.org/wiki/File:Venn_diagram_for_A_union_B.svg

link for image of subset:

https://commons.wikimedia.org/wiki/File:Subset_with_expansion.svg



Chapter 4

Conclusion

This internship has been a transformative journey that has empowered me with invaluable insights, skills, and experiences that will resonate throughout my personal and professional life. The opportunities to apply theoretical knowledge in a practical setting, to contribute to meaningful projects, and to work alongside exceptional individuals have been truly life-changing.

I extend my heartfelt appreciation to everyone involved in making this internship a remarkable and influential chapter of my academic and professional trajectory. Your unwavering support, belief in my abilities, and the wealth of opportunities and knowledge I have gained through this internship at FOSSEE Team, IIT Bombay, will forever hold a special place in my heart.