A STUDY ON FUNDAMENTAL CONCEPTS OF CHEMISTRY

A dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Education

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CERTIFICATE

This is to certify that Mrs. Abhilasha Malhotra has completed M.Ed. dissertation entitled "A study on fundamental concepts of chemistry" under my guidance and supervision. As far as I know her work is a first hand and original work.

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Contents

LIST OF GRAPHS

LIST OF FIGURES AND DIAGRAMS

6 MFA 1 Structure Of Atom 7 MFA 2 Models of Atom 8 MFA 3 Laws Of Chemical Combination 9 MFA 4 Mole Concept 10 MFA 5 Flame Test 11 MFA 6 Periodic Table 12 Optionaire for students 13 Interview questions for teacher 14 Links of video/audio used in study 15 Concept Maps 16 Information about flame test 17 Periodic Table November 2016 Version 18 Periodic Table December 2018 Version 19 Std Deviation - Fundamental Concepts 20 High Medium Low performers of Experimental and Control Group based on Marks obtained 21 Student Wise performance of Experimental Pre-test and Post Test 22 Comparison of experimental group Pre Test and Post Test 23 Cumulative statistical Measures of Pre-test for Experimental and control Group 24 Concept map constructed by students	

Chapter 1

Introduction

A study on fundamental concepts of chemistry

1.0 Introduction

Education has always been **i**mportant but perhaps never more so in man's history than today. In a science-based world, education and research are crucial to the entire developmental process of a country, its welfare, progress and security. It is characteristic of a world permeated by science that in some essential ways the future shape of things is unpredictable. Education helps the society and its constituents to upgrade and upscale living conditions, which in turn enhances the satisfaction quotient of a human being, as a better living index is a sign which ensures prosperous living. (Michalos, 2007) Society creates a great impact on the learning behavior of students. Education is the most powerful tool for social change. Mission of education is to promote student achievement and prepare them for global competitiveness by fostering educational excellence and ensuring equal access. Education also acts as an integrative force in society, imparting values that foster social cohesion and national identity. Society bank upon teacher's capability to provide students with problematic practical situations obligating the student to confront previous understandings, in order to solve problems through interactive and thought-provoking methods (Cornelius-White & Harbaugh, 2010)

Teacher is a pioneer for his pupils' who are budding future of nation and bears moral responsibility of the nourishment of youth in accordance with their dynamic needs of this emerging era of globalization in which learning occurs at any place at any time according to the pace and need of learners. It is an academic paradigm shift from teaching to learning. Surely it is a great challenging demand on the part of a teacher to bring incessant and creative changes in his teaching strategies for involving students and for keeping pace with the rapidly changing learning strategies of 21st century

Modern education emphasizes ~~on~~ learner centered approach and joyful learning which is advocated by educationists and many education commissions. According to them, children need to keep active throughout the teaching and learning process and encourage self-learning and independent learning. Through learner cantered approach student enjoy their learning as this encourages their participation. The present education scenario claims that learning is not an isolated activity; it is connected with child's idea and the surrounding environment. It points out that, the ideas, views, thoughts, and experiences which are existing in a learner's mind are the main source for learning. Learning takes place in the minds of learner in the form of internalization of ideas, views and thoughts. To make it much more meaningful teacher has to create situation to engage the learners in meaning making experience.

The present education practice also emphasizes the importance of technology usage in education. It is observed that the learner, the teacher and the learning experience are influenced by computer and information and communication technology. The 21st century society expects children learning through technology mediation. At present, technology is not only used for transfer of knowledge but also used for discussion, debate and collaborative activity. Hence, blend of technology into constructivism engage students actively in learning and teaching process.

Education has enabled India marching towards a knowledge base economy. By leveraging its strengths in human capital and ICT services, India can become a major global knowledge-based economy," said Bindu N. Lohani, ADB Vice-President for Knowledge Management and Sustainable Development. Enabling Platform like Skype, Microsoft Team and Zoom etc., enhances and increases the speed of learning exponentially as it provides opportunity to learners to get associated with like mined people and communities of similar interest at the comfort of location of their own choice.

Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity, particularly in relation to the environment. Science helps in connecting knowledge across disciplinary boundaries to provide a broader framework for insightful construction of knowledge. Science is a dynamic, expanding body of knowledge, covering ever -new domains of experience. In a progressive forward -looking society, science can play a truly liberating role in helping people escape from the vicious cycle of poverty, ignorance and superstition. The advances in science and technology have transformed traditional field of work such as agriculture and industry, led to the emergence of the wholly new fields of work. People today are faced with an increasingly fast-changing world where the most important skills are flexibility innovation and creativity. These different imperatives must be kept in mind in shaping science education. (NCF2005) To meet these challenges, lifelong learners must be prepared instead of temporary learners. It necessitates a pedagogical shift from transmitting a body of expected knowledge that is largely memorized to one that is largely process oriented. If this pedagogical shift could not be possible, the same concept taught within different subjects will have separate meanings (atom in physics versus atom in chemistry). Hence there is a strong need to search more potential ways of instruction and curriculum presentation to achieve the pre-determined instructional objectives, and for the enhancement of meaningful learning because in today's competitive world it holds the key to success forever.

Scientists have always been the backbone of society through their concreted efforts for solving visible societal problems and developing new technologies for betterment of society, such as easing poverty and disease, traveling faster, and making our lives more convenient the environment was considered a source of natural resources which should be exploited to fuel societal development. Chemistry is viewed as a scientific tool which could harness natural resources to enhance our lives in these ways. Chemistry has played a significant role in the eradication of deadly diseases like polio, leprosy, malaria, jaundice by developing life-saving pharmaceuticals and presently also helping in finding solution to corona pandemic

We live in a world where changes, transition, development and construction are bound to happen and is inevitable part of our daily life. To reinvigorate the education system of this volatile world acceptance of changes is mandatory. All are vitally affected by science and recent years have witnessed significant reforms in science education. All need to be familiar with applications and implications of principles of science to be able to live effectively in a technological world and to build and run an equitable and high-quality education system.

1.2 Nature of Chemistry

Chemistry is defined as the science of atoms and molecules as it deals with the composition, structure and properties of matter which can be best described and understood in terms of these basic constituents of matter. Chemistry is the scientific discipline involved with elements and compounds composed of atoms, molecules and ions; their composition, structure, properties, behaviour and the changes they undergo during a reaction with other substances. Chemistry is the science not only about one hundred elements but also of the infinite variety of molecules and related species that may be built from them. Chemistry is often referred to as the central science because it joins together physics and mathematics, biology and medicine, and the earth and environmental sciences. Knowledge of the nature of chemicals and chemical processes therefore provides insights into a variety of physical and biological phenomena. Knowing something about chemistry is worthwhile because it provides an excellent basis for understanding the physical universe we live in. For better or for worse, everything is chemical.

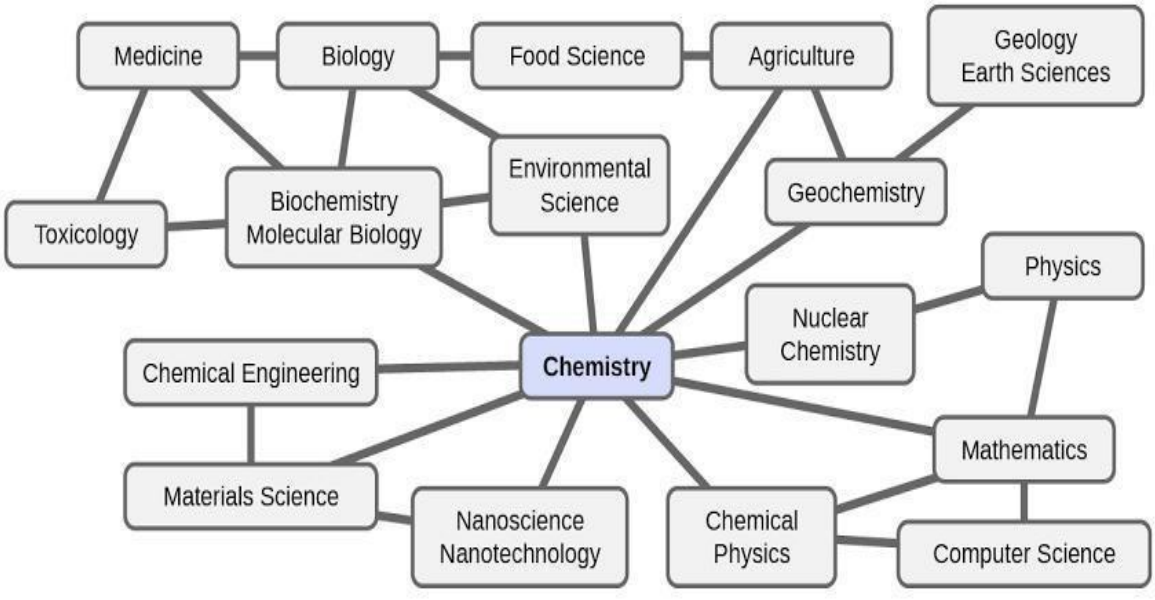


Figure -1 Concept Map Showing Relation of Chemistry with other branches of Science
Source:https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_Chemistry_%28OpenSTAX%29/01%3A_Essential_Ideas/1.1%3A_Chemistry_in_Context

1.3 Purpose of studying chemistry

Secondary education forms a basis for professional courses or higher (degree) education. Secondary Education is an integral part of school education and it orientates students to the world of work and helps them in making educational or vocational choices. Secondary level of education occupies a very vital place in our education ladder, as it provides link between middle and higher secondary education. Majority of the students completing secondary educations either go for

higher education including professional courses or enter the society to make a living. (Shankar, C 2014)

Chemistry is the study of matter and energy and the interaction between them. There are many reasons to study chemistry, even if you aren't pursuing a career in science. Chemistry is everywhere in the world around you! It's in the food you eat, clothes you wear, water you drink, medicines, air, cleaners. Chemistry is an incredibly fascinating field of study, because it is so fundamental to our world, chemistry plays a role in everyone's lives and touches almost every aspect of our existence in some way. Chemical technologies enrich our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world. (Helmenstine 2018)

Advances in chemistry have helped us develop effective pain relief, design more robust materials for fillings, and find better ways to repair and replace teeth. All branches of science derive from chemistry, it is now a prerequisite for many courses at university. Thus, it is quite obvious that Chemistry is involved in every walk of the life.

To add impetus to innovations required for recent walks of life, chemistry must evolve from education. Following figure explains how chemistry links all aspects of life.

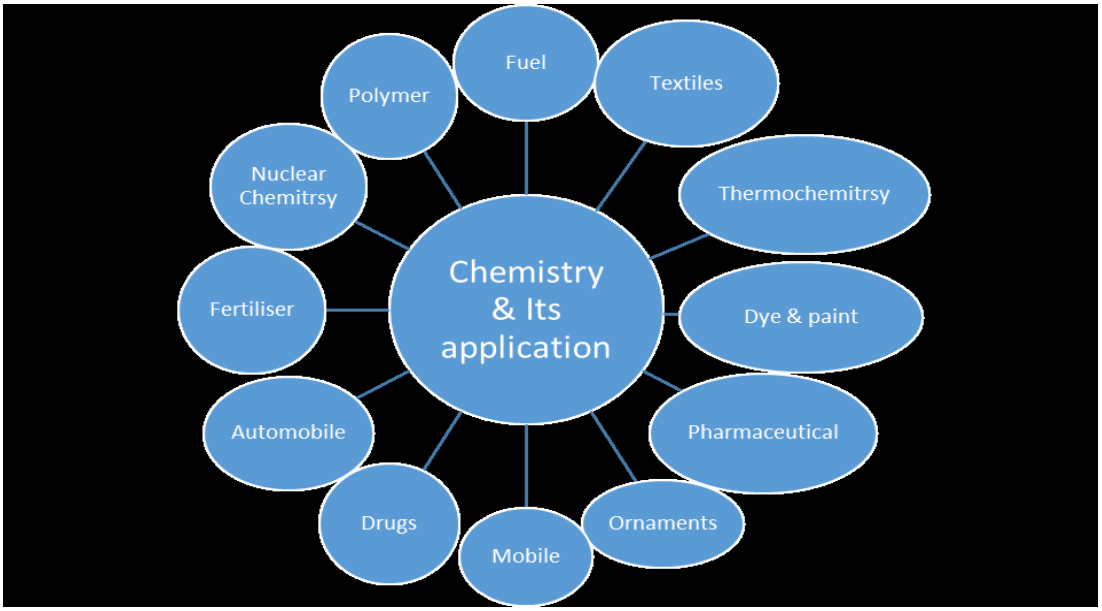


Figure -2 Chemistry and its application

Chemistry as a subject has a significant importance in students daily lives and the society in general. Everything on the earth is made of chemicals. Chemistry helps students understand how items around them are made e.g. cooking gas. In our daily life, we fall sick and consequently need drugs which are made by scientists through chemistry. This helps to know what drugs to take by showing their contents and their impacts on our bodies. (Lebowski, J. J, 1991). In our daily lives, we wear clothes that are made of fabrics such as nylon which is learned in chemistry. It also boosts the industry sector through extraction of valuable metallic such as copper, zinc, and magnesium

and helps in understanding the chemical reactions of such metals. (Leader, 2019) . Chemistry as a subject creates interest and awareness among students on social issues like global warming, power etc solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world. (Helmenstine A. , 2019)

1.4 Objectives of teaching chemistry at higher secondary level

The following are the Main Objectives of teaching chemistry at higher secondary level (Source Anand Krishnan K 2017) : -

1 To acquire real scientific Knowledge.

2 To develop in the students the capacity to solve problems

3 To develop interest of pupil in learning chemistry.

4 To make them realize the impact of chemistry on society.

5 To develop economic efficiency.

6 To develop in students the thrust for knowledge and higher education.

7 To develop practical skills

8 To develop interest of sense of appreciations.

Primary	Knowledge	Interest, Attitude, appreciation	Observation, Manipulative
Secondary	Knowledge Comprehension, Meta cognitive, Application	Interest, Appreciation, Habit Formation	Observation, Drawing, experimental skill
Higher Secondary	Knowledge Comprehension, Meta cognitive, Application, Analysis, Synthesis, Evaluation	Interest, Appreciation, Habit Formation, Attitude	Observation, Drawing, Problem solving

Table 1.0 Objectives of Chemistry curriculum Primary, Secondary and Higher Secondary (Source Anand Krishnan K 2017)

1.5 Key fundamental concepts of chemistry in Grade Nine

Concepts are mental representations, abstract objects or abilities that make up the fundamental building blocks of thoughts and beliefs. They play an important role in all aspects of cognition. Fundamentals in any field really means the base on which the whole structure of knowledge for that field is built upon. The Fundamentals of Chemistry may include an **introduction** to the matter, (pure substances, mixtures), atoms and molecules, element and compounds, ions, electrons,

protons, neutrons, atomic mass, molecular mass, formula unit mass, laws of chemical combination, mole concept, structure of atom, models of atom, electrons distribution in different orbits, valency atomic number, mass number, isotopes ,isobars, periodic table, flame test, symbols of elements, formulae of simple compounds and many more.

1.6 Importance of enhancing fundamental concepts.

Chemistry has a crucial role in finding sustainable solutions to challenges like energy crisis, environmental protection, health care, food and water safety. Green chemistry is another project which strives to work at molecular level to achieve better environment. Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances and discovery and application of new chemical technologies leading to the prevention / reduction of hazardous chemicals which deteriorate the environment and to conserve materials and energy (EPA, March). Therefore, it is essential for secondary student to gain deep knowledge about chemistry so that they can acquire some interest in not only learning but for ensuring that knowledge of chemistry can also help them land in a rewarding career in the industry and in educational institution. Pupils count on the experience and dedication of teachers to plan and implement farsighted strategies and enable students to overcome certain common hindrances in understanding the key fundamentals of chemistry.

1.7 General and conceptual hindrances in enhancing fundamental concepts

Few factors which inhibit cognition and hampers curiosity and conceptual understanding are mentioned below:

1.7.1 Difficulties in comprehending.

It is also found that the abstract nature of chemistry poses two major difficulties.

- The first is invisible nature of fundamental particles on which the whole science depends.
- The second is the complexity of even the simplest phenomenon.

For above reasons students are expected to memorize without understanding, take it as a burden and ultimately lose interest. It is observed at times that these abstract concepts if not presented in chronological order or from simple to complex becomes comprehendible.

1.7.2 Difficulty in visualization in teaching/learning of chemistry

Visualization puts abstract concepts of chemistry in vivid and visible manner to students. Nature of chemistry is microscopic and many of its processes are invisible to students. Since long visual metaphors are tried to render chemical structures and process less complex. Though these metaphors are helpful in early stages of learning but eventually they interfere with a rich understanding of basic chemical concepts. Recent pedagogical researches suggest that computer-generated three-dimensional animations can provide richer understanding. Many methods like class summary, flash cards etc can be used for conceptual clarity but till date lecture method is

more prevalent. Merry Cole in her work on spatial reasoning explains those students with more spatial clarity comprehend better. Teachers who could present content with more visuals found easier time in class and interactions with students was cohesive also indicated about positive correlation between mental rotation ability and understanding the particulate nature of matter.

1.7.3 Difficulties in effective demonstration

Difficulties unless presented properly, many students cannot benefit from chemistry demonstrations. These demonstrations can be, in fact, pedagogically harmful. Even if presented properly at times like in chemistry laboratory example experiment is going on where smell of ammonia is to be detected but suddenly slight wind blew and few students could not assimilate the smell of ammonia or due to any medical reason could not distinguish the smell of ammonia in such case they mug up pungent smell of ammonia. Sometimes few students may be absent on the day of practical and inflexible schedules of school doesn't give them any other chance. Same is the case with fast reactions if student misses the observation then has to cram the words given in chemistry laboratory manual. Contemporary pedagogies try to sort out such problems.

1.7.4 Behavioural problems related with chemistry learning

One of the most important principles in the psychology of learning is that students should construct their own knowledge in mind (Hollenbeck, 2009). The teacher becomes a mediator to assist this process, allows students to discover and implement their ideas independently, processes the data so that it is understandable for them. Learners have difficulty in understanding most of the concepts in chemistry and have incorrect notions that hinder consistent train (Garnet, 1992; Hesse, 1992; Pardo & Solez – Patolez, 1995; Renstorm, 1990; Staver, 1995). This fact leads to the problem of developing students' interest in chemistry as a school subject. The application of the constructivist approach is a method that can be beneficial in overcoming this case. Constructivist approaches in teaching and learning of science are applied to enable students to make meaningful connections between significant new knowledge and transient (Hollenbeck, 2009). Thus it can be expected that it will increase the attractiveness of teaching as the subject chemistry and the study content.

1.7 Steps to enhance fundamental concepts of chemistry curriculum at school level

Following are the key steps to enhance the fundamentals concepts of chemistry: -

- Be designed to meet the needs of most pupils who will never become chemists (or even scientists), seeking to educate through chemistry as well as in chemistry.
- Be strongly 'applications-led' in its construction, the applications being related to the lifestyle of the pupils and being used to define the curriculum: fundamentally, the content is determined not by the logic of chemistry but by the needs of pupils.
- Reflect attempts to answer questions like: what are the questions that chemistry asks? How does chemistry obtain its answers? How does this chemistry relate to life?

- Not be too ‘content-laden’, so that there is adequate time to pursue misconceptions, to aim at deep understanding of ideas rather than content coverage, and to develop the appreciation of chemistry as a major influence on lifestyle and social progress; avoid using analogies or models (or multiple models) in a way which causes information overload.
- Not introduce sub-micro and symbolic ideas too soon or too rapidly; avoid developing topics with high information demand before the underpinning ideas are adequately established to overload and confusion.
- Be set in language which is accessible to the pupils, avoiding the use of unnecessary jargon and offering careful clarification of words where the normal contextual meaning can cause confusion.
- Be couched in terms of aims which seek to develop conceptual understanding rather than recall of information, being aware of likely alternative conceptions and misconceptions.
- Offer experiences of graded problem-solving situations starting from the more algorithmic and moving on to the more open-ended.
- Involve laboratory work with very clear aims: these should emphasise the role of lab work in making chemistry real as well as developing (or challenging) ideas rather than a focus on practical hands-on skills; lab work should offer opportunities for genuine problem solving.
- Require assessment which is integrated into the curriculum and reflects curriculum purpose, is formative as well as summative and aims to give credit for understanding rather than recall, for thinking rather than memorisation.
- CONCEPT MAPS Concept maps require the learner to concentrate on a small number of key concepts. Concept maps encourage the learner to become consciously aware of the relationships between concepts and to apply effort to establish the relationships between both new and old concepts. They are regarded as a metacognitive tool which when used effectively can help the learner to "learn how to learn"(Novak, 1990b; Novak & Gowin, 1984)

1.9 Emphasis on enhancing chemistry curriculum

Recognizing the importance of chemistry, some efforts have been made to improve the curriculum of chemistry in India after independence. The agencies that have helped in the curriculum improvement program are as under

Chemstudy. – Chemical educational material study, This is an experiment based chemistry course. Each succeeding step has discovery based on laboratory work. In chemical study practical work proceeds theory and employs inductive approach. The following are the recommendations of chemical study

- Experiment must permit student to make his own discovery of the principle which unify chemistry and make it easier to understand.
- Its emphasis is on the making of careful observation and quantitative measurements under control experimental conditions.
- Stress is on the preparation of tables for recording data which help in making deduction.

- Involves challenging, discussions and questions, which help in the application of principles observed in the experiments to new situations.

UNESCO planning 1964 – The following are the recommendations given by UNESCO planning commission 1964

- Learning of chemistry be made compulsory.
- More emphasis to be put on practical application on chemistry.

Indian Education commission (1964-66) – Few recommendations of Indian Education commission (1964-66) are as follows :-

- Chemistry should be taught as a separate subject in Middle classes.
- Chemistry should be made as an elective subject at a senior secondary stage and be offered only to those students who are interested in taking it up as an elective subject.

National Policy of Education (1986)– As per NPE chemistry is to be taught as a part of the integrated science course up to class X and as a separate subject in Class XI and XII

The chemistry curriculum at school level should:

Meet needs of all learners: Meet the needs of most school pupils (who will never become chemists or even scientists), and most students who will undertake chemistry degrees but never become bench chemists. Thus, the curriculum must seek to educate through chemistry as well as in chemistry.

Relate to life: At school level, be strongly 'applications-led' in construction, while university courses should relate tightly to applications

Reveal chemistry's role in society: Reflect attempts to answer questions like: what are the questions that chemistry asks? How does chemistry obtain its answers? How does this chemistry relate to life?

Have a low content base: Not be too 'content-laden', so that there is adequate time to pursue misconceptions, to aim at deep understanding of ideas rather than content coverage, and to develop the appreciation of chemistry as a major influence on lifestyle and social progress.

Be within information processing capacity: Not introduce sub-micro and symbolic ideas too soon or too rapidly; avoid developing topics with high information demand before the underpinning ideas are adequately established to avoid overload and confusion

Take account of language and communication: Be set in language which is accessible (especially at school level) and offer learners opportunities to express chemical ideas verbally and in writing (especially at university).

Aim at conceptual understanding: Be couched in terms of aims which seek to develop conceptual understanding rather than recall of information, being aware of likely alternative conceptions and misconceptions.

Offer genuine problem-solving experience: Offer experiences of more open-ended problems (along with algorithmic exercises), with emphasis on the use of groupwork to solve 'real-life' problems in chemistry

Use laboratory work appropriately: Involve laboratory work with very clear aims: these should emphasise the role of laboratory work in making chemistry real as well as developing (or challenging) ideas rather than any focus on practical hands-on skills; laboratory work should offer opportunities for genuine problem solving.

Involve appropriate assessment: Involve assessment which is integrated into the curriculum and reflects curriculum purpose, is formative as well as summative and aims to give credit for understanding rather than recall, for thinking rather than memorization.

1.10 Theories and Pedagogy of teaching chemistry.

The art of teaching is continuously evolving and advancing, making chemistry teachers re-evaluate their methods of instruction every year. According to Ngozi Mbajiorgu and Norman Reid the aim is to develop a chemistry curriculum which will meet the needs of learners and societal demands. The aim is to develop a curriculum which is a sound reflection of the nature and methods of chemistry as a discipline, with its important place in a modern society. (Kristen KB, Malinda WG, 2017). Few sciences based pedagogical methods and technologies best used currently to teach chemistry in schools are discussed below:

Problem Based Learning (PBL): This is one of the easiest teaching methods to implement due to minimal preparation time. It is important for problem-based questions to be relevant to real life so that students can identify with the problem, making it become personal. Case studies, vignettes, and open-ended task completion problems are the most common used. Problem-Based Learning can be incorporated into the POGIL method during the application phase to test the new knowledge learned. Example -project on use of man –made materials in food industry or project on colours used in food industry.

Process Oriented Guided Inquiry Learning (POGIL): The Process-Oriented Guided Inquiry Learning (POGIL) method is the newest and most challenging methodology to implement of the six methods. Student success with this method in general chemistry classes is well documented. (Walker L, Warfa A-RM,2017).

POGIL's three phase learning cycle:

Exploration phase - During the exploration phase, students analyze models to collect as much information as possible, looking for patterns and relationships.

Concept invention to formation phase - In the concept phase, students conceptualize the observed patterns and relationship and pathway is revealed.

Application phase - Application phase is the last phase of the learning cycle and it is during this time that students apply concepts learned to new situations.

Examples – balancing chemical equations , mole calculations , estimation of products etc

Project Based Learning (PjBL): Project Based Learning (PjBL) is a very popular and effective method to teach chemistry. In the past, PjBL, was given as home assignment. Many students lack adequate support at home to complete these types of assignments, resulting in an overall negative impact on the students. Chemistry teachers, implementing project-based learning inside of the classroom, can design projects to specifically meet the learning needs of students in their classroom. It is an invaluable component that may be incorporated into pedagogies of 21st century. Project-Based Learning (PjBL) is a method of teaching that facilitates learning through student engaged projects centered on concepts to be learned. During the process of working on a project; students are creating, questioning, and revising knowledge, while developing their skills in critical thinking, collaboration, communication, reasoning and synthesis.

Examples – enthalpy change in system , slow reactions entropy changes etc.

Peer Lead Team Learning (PLTL): Under the PLTL model, undergraduate students who have done well in the class previously are recruited and trained as workshop leaders or peer leaders who guide the efforts of a group of six to eight students. These peer-led groups meet weekly (separate from the lecture and the instructor) to work together on problems that are carefully structured to help the students build conceptual understanding and problem-solving skills. This pedagogy facilitates passive students, who are not too much interactive, to learn through listening the discussions of other students.

Examples – Chiral structures in organic chemistry, IUPAC nomenclature

Peer-Led Team Learning offers several educational opportunities:

- Solving problems in workshop allows students to assess their own understanding of key course concepts
- The supportive, small-group format encourages questions and discussions that lead to conceptual understanding
- Students learn through explaining concepts to other students
- Many students are more willing to discuss their questions with other students than with a professor
- Students learn to work in teams and to communicate effectively
- Peer leaders learn teaching and group management skills and gain self-confidence

Peer Lead Guided Inquiry (PLGI); This is another form combining peer-led team learning with a guided inquiry approach, together is called peer-led guided inquiry (PLGI).

Peer Instruction: A structured teaching practice that requires students to examine their own and their classmates' reactions to and analysis of the content, is a simple yet effective way to engage students. Rather than simply lecturing and having a discussion, the instructor periodically asks students to consider a carefully designed "concept" question, related to known areas of common confusion or misunderstanding. Students take a few minutes to

formulate their answers to these questions and then work in small groups to arrive at consensus. This group discussion often results in students explaining the concepts and providing clarifications to their teammates who may have answered it incorrectly at first (hence the name of the practice, Peer Instruction). Full class discussion, guided by the instructor, takes place as a final step providing further clarification and explanation as needed. There are many teaching methods in which either student can be centered, or teacher can be centered. It can be direct instructions or personalized learning, or can be low tech or high tech. It can be kinesthetic learning or game-based learning. To integrate learning strategies into situation based pedagogical methods, technological platform is essential to support teachers' fraternity.

1.11 Innovations in pedagogy through technological integration

Incorporating online blogging, discussion boards, or constructing wiki pages allows students to build online literacy skills, which is a critical asset in today's workforce. Aligning with the application of appropriate technology servers are the core foundation for teaching all millennials learners. Several activities support students learning for reflections, critiquing and concept mapping. YouTube, computer simulations, extra marks learning app. Khan academy etc are used usually after explaining the concepts and video tutorials which help them to conceptualize their learning better.

Turntin or kahoot are used for checking lab reports, proving feedback and assessment help. Such platforms can be used to encourage students to develop explicit variety of skills through visualization.

1.11.1 ChemViz (visualization in chemistry): This project is a curriculum materials development project wherein computational approach to chemistry is used. The unique aspect of this approach is the use of a high-performance computing environment. It is used to obtain images and animations of atoms, molecules and chemical process. The investigators of this approach proposed a pedagogical approach that starts with a computational experiment on an abstract concept and then proceeds to present a model and then access to a high-performance computing environment (eg., a cray supercomputer) Also computational approach in contrast to theory and experimentation allows students to explore how the laws of chemistry behave. Technology certainly makes learning more concrete and more visual. Here for a student to obtain images of a model a set of programs are used. First student uses interface program, Boogie, to set the parameters and then create an input file. Boogie would ask user some more specific details which is then sent to Cray supercomputer. The Cray supercomputer uses DISCO, a research- level chemistry program to do calculations based on the input file from Boogie. The resulting output files are automatically returned to students' personal computers and to view image, the student uses NCSA Collage which creates three dimensions although at times it makes the concepts so simple and their imagination power or virtual thinking and critical analysis does not develop very well. While selecting experiences for specific objective to be achieved a teacher must be aware of epistemology of chemistry and integrate accordingly.

1.11.2 Virtual labs: It is one of the most effective ways for chemistry teachers to engage their students with active learning. Virtual labs enable students simulate what it is like to exhibit in a chemistry job in a STEM field. This is an excellent way for students to realize their own potential by getting to think like they are working in a field. Students become actively engaged when they can see concepts being studied, applied to real life.

Going from teacher-centered learning to student-centered learning can be a little nerve racking initially, for both the teacher and the student. Student-centered learning gives students the ability to actively learn and engage with their peers without depending on the teacher for answers.

1.11.3 Chemistry laboratory in a digital environment: Microscale chemistry practical can reduce students' cognitive load, free up more time for discussion, and have added benefits in terms of safety and sustainability. A simple Google search of chemistry video games puts students in a virtual world of molecules, molar masses, and complex equations. In India, ministry of Electronics and Information technology have funded Olabs. Internationally also International Union of Pure and Applied Chemistry (IUPAC) and many more organization are working on digital chemistry.

Below is a list of freely available online chemistry lab resources, including general chemistry and organic chemistry simulations. (ACS, 2019)

- Virtual lab Simulator.
- Virtlab.
- Virtual Chemistry Experiments
- Dartmouth ChemLab
- Virtual Chemistry Lab
- Chemistry Experiments Simulations.
- ACD/ChemSketch Freeware.
- Web-Based High School Chemistry Simulations.
- Hi! Hydrogen
- Virtual Chemistry Book The Interactive Library
- General Chemistry Jeopardy Games
- Y Science Laboratories

Resources listed above are helpful not only in gaining information but for practicing any where any times. The following chemistry laboratory simulations and educational learning exercises are available for a fee.

Commercial products

Following is the list of Commercial Products in the market: -

- Online Chem labs.
- Late Nite Labs

- ChemLab
- TeqSmart Learning Objects.
- Chemistry Lab Page
- Chemistry moves from the lab and the classroom to the computer, as working in a virtual chemistry laboratory and viewing simulations provide additional ways of learning chemistry.
- PhET Interactive Simulations.
- ChemCollective.
- Chemistry Solutions: Featured Simulations.
- MERLOT Simulations Collection
- CK-12 Chemistry Simulations.
- Molecular Workbench
- Virtual Chemistry Experiments.
- General Chemistry Interactive Simulations.
- Electrolyte Solutions Simulations.
- Simulations for chemistry.
- Virtual Laboratory: Ideal gas Law

1.12 Teaching-learning strategies for development of fundamental concepts

1.12.1 Spatial ability: Spatial information, such as shape, size, structure, and motion, is particularly important in the natural sciences, and certain branches of science are devoted to studying spatial properties. For example, anatomy is the study of the structure of living things, geology is the science of the structure of the earth, and stereochemistry is the study of the structure of compounds. Understanding spatial information is particularly challenging when the relevant structures are not directly observable, for example, because they occur at a scale of space that is not visible (e.g., molecules) or are internal to some three-dimensional (3-D) structure that we typically only see from the outside (e.g., internal anatomy). In these cases, spatial information is represented most directly through spatial representations such as diagrams, concrete and virtual models, and animations; it is also represented using nonspatial representations such as text, symbols, and formulae.

1.12.2 Concept Map : Paradigm shift of teachers centred to learner centred has changed the focus of education approach. NCF 2005 has emphasized on constructionist approach- Concept mapping is one among them. It was first developed by Joseph O' Novac in 1972. Concept maps are graphical tool which organises and represent knowledge in hierarchical manner. This method can be effectively used in teaching science which consist of myriads of abstract concepts and their complex relations. It reduces the extra time required to set up in the class room introduction. It also compares the student achievement and retention. A **concept** map or **conceptual diagram** is a **diagram** that depicts suggested relationships between **concepts**.

1.12.3 Constructivism: Social constructivism views learning as the active construction of knowledge. This occurs as learners use their present conceptual frameworks to make sense of their experiences of the physical world and the words and images they hear and see. Learners constructs knowledge through active engagement with physical and social environment. Constructivism is a theory of learning which describes how learners build on existing or prior knowledge to incorporate new knowledge, based on their learning experiences. The theory is based on the principle that knowledge is not "discovered", but constructed in the mind of the learner. Bodner was among the first chemistry educators to consider chemistry education through a constructivist lens, basing his thoughts on the work of Herron, Piaget and von Glaserfield (Bodner, 1986, 2006, Bodner and Klobuchar, 2001).

1.12.4 Collaborative Learning Collaborative learning "is an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together" (Goodsell et al., 1992). Cooperative learning, a form of collaborative learning, is an instructional technique in which students work in groups to achieve a common goal, towards which each of them contribute (Galali, https://www.academia.edu)

1.12.5 Minimizing misconceptions: Chemistry concepts must be studied in a logical order because concepts are inter-related. Not having concept clarity can lead to confusion which makes the subject not comprehendible and difficult to remember. Due to this we know many students only muck up just before the exams and then forget easily. Many students struggle with and are unsuccessful in learning chemistry at all grade levels (Nakhleh, 1992). One possible reason is that students fail to understand fundamental concepts and are unable to build an understanding of more advanced concepts (Gabel, Samuel, & Hunn, 1987). Another possible reason is that understanding chemistry requires the use of multiple levels of description. According to Johnstone's chemistry is understood at three levels (1) Macroscopic – Dealing with phenomena at a sensory, tangible or visible level. (2) Sub Microscopic – Explanation or models at a particulate (Atomic, molecular) level which are abstract and unobservable (3) Symbolic – Formulas and equations used to represent phenomena. Johnstone's believed that chemistry students were not adequately exposed to the sub microscopic particulate models that are crucial to a scientific understanding of much of chemistry. (Johnstone's 1991)

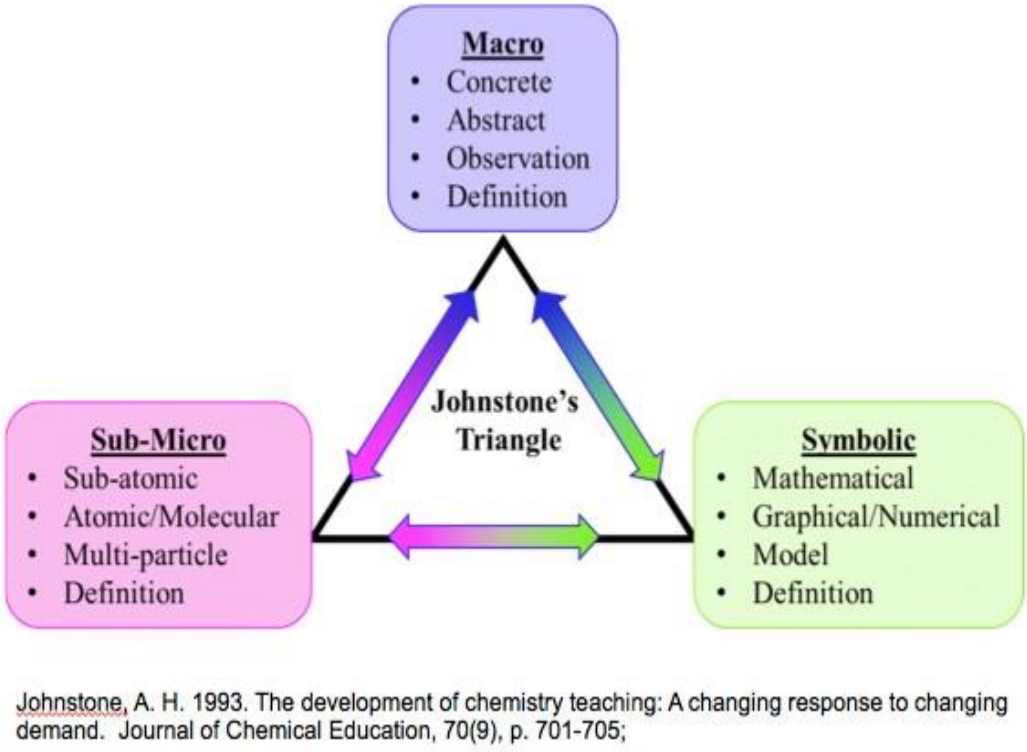


Figure -3 Johnstone's Triangle

1.13 Importance of developing educational software: A rich variety of educational software is and will be developed and made available for students and teachers at all levels. All such software will be available in all major Indian languages and will be accessible to a wide range of users including CWSN and differently-abled students, and will include:

A. Software to assist learners with disabilities (e.g. Text-to-speech software in all major Indian languages for blind/partially sighted students).

B. Intelligent Tutoring Systems to promote numeracy and foundational literacy and spatial ability In all major Indian languages.

C. Educational software in the form of serious games, simulations, and applications using augmented and virtual reality.

D. Software to create personalised learning trajectories for each learner based on curriculum, with content (readings, videos, interactive worksheets, etc.) Arranged in learning ladders.

E. Adaptive assessment tools that provide formative feedback to help learners take remedial steps, such as self-study or learning collaboratively with fellow students. Software to help teachers create adaptive assessments, formative as well as summative, evaluate the assessments, and provide appropriate feedback to learners. Such assessments will minimise the importance of rote memory,

and will instead focus on 21st century skills including critical and creative thinking, communication, and collaboration. Data generated by such tools, that reflects the performance of individual learners and overall institutional performance will be appropriately recorded in the NRED for subsequent analysis and research

Video viewing equipment: For maximal use of content in the open educational repository, institutions will be supported with inexpensive and portable video viewing equipment (e.g. Solar powered video playback and projection devices). Teachers will be encouraged to integrate such videos into teaching-learning processes, along with their own teaching, where ever they add value.

Advanced online courses: Educational institutions will be encouraged to offer course credits to students who complete specified courses (especially advanced electives) online, e.g. Via SWAYAM or other such platforms developed in the future. This will include courses on topics such as IT Enabled Services (ITES) and other such areas of vocational education and adult education that can benefit from online courses.

Support for appropriate information and communication technology usage: Most educational institutions have difficulty maintaining and using their hardware and software. This problem can be addressed through the creation of a large number of prestigious 'IT Ambassador' Fellowships for students who have completed their senior secondary courses. They can support school complexes with managing their IT infrastructure in a version of rural service that is similar to military service in some countries. Computer hardware and maintenance, as well as training in software installation and maintenance (especially for open-source software) must be taught to these students. As far as possible, local people must be given these Fellowships. This will also help promote entrepreneurship among these Fellows at a later date.

1.14 FORMATIVE ASSESSMENT

Classroom-based "formative assessment" has also taken on an increasingly important role in education policy in recent years. Formative assessment refers to the frequent, interactive assessment of student progress to identify learning needs and shape teaching (OECD, 2005).

1.15 Micro Formative assessments

Micro-Assessment: a narrowly focused short assessment that provides support for decision-making and planning. It is an evaluation of one or maximum two concepts. It may contain 5 to 10 questions maximum. The main purpose of micro-assessment is to check MLL. Another purpose of a micro-assessment is to quickly and easily find out enough to make a decision, set a direction or objective, or to perform preliminary or high-level planning. Even though copying & cramming are hindrances to understanding of fundamental concept, but if new assessment techniques are innovated we can assess real understanding. The verb "assess" comes from Latin roots meaning "to sit with." But the term has long since lost that association as most teachers now relate it directly with grading (Munson, 2009). The aim of developing this tool is to make evaluation and testing easy and SMART .

Following problems can be arrested at the beginning of scholastic and non-scholastic problems

- Sudden drop in achievement
- Probable cause of low academic achievement
- Continuous feedback to students teachers school management and parents
- Not effective pedagogy used can be diagnosed
- Low prior knowledge/concepts can be diagnosed
- Being specific and small in nature can categorically assess the content knowledge
- MLL not achieved could be easily identified
- Not motivated in academics can be specifically identified as such tests are comprising of essential fundamentals required at that level
- Immediate and specific feedback provides room for diagnosis and remediation.

Following are the advantages of Micro Formative assessments

- Continuous evaluation helps in bringing awareness of the achievement to the child, teachers and parents from time to time.
- Such assessments provide instant feedback
- As assessments are small they are less time consuming
- As assessments are small objective in nature they can be quickly attempted, and teacher can recapitulate the concepts
- Assessments are formative in nature and not judgemental
- Such practice would be baseline for teacher to change, adapt modify or completely abolish the current pedagogy used
- Stress free learning

1.16 Rationale

In order bring a paradigm change from being a developing country to a developed nation India needs to revamp and improve radically its system of education and specially in the field of science as Science is the backbone for any innovative developments which benefits masses and brings cluster of developmental ecosystem. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry. We are living in volatile, uncertain, complex and ambiguous (VUCA) world and to remain relevant in the continuously changing expectations of the society from the fraternity of science and technology it is vital that education should remain meaningful and enjoyable. India has made tremendous progress over the last few years, but we still need an education system which is constantly reviewed for its efficacy to ensure that changes if required are done in a manner that we should be able to progress at a much higher rate to ensure we bridge the gap in science and technology vis-a vis other competing nations. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry.

The education commission report (1964-66) has dealt with science education in depth, dealing with the quality of science education.. The main purpose of teaching chemistry is to make students of chemistry understand the basic concept of chemistry which includes organic , inorganic and physical chemistry needed for the further study of modern science and technology and to understand its application. Education commission also advocates that one of the factors that impede progress in pedagogy up gradation is the failure to develop proper educational research on teaching methods..

There should be a general atmosphere of reform. Experimental efforts should be encouraged and new methods of teaching diffused among all schools and teachers. The diffusion of new methods is necessary". A change in the model of teaching is required, so that the child makes meaningful connections between his/her prior concepts with new knowledge. For achieving this in the class room the teacher and the student need to actively engage in making meaningful connections. The research in chemistry education is focusing now more on the process of understanding and improving of chemistry learning. For some students' chemistry consist of a large number of apparently unrelated, irrelevant and useless materials that they have to memorized rather than understood. In chemistry, our senses cannot help us form concepts of elements and compounds, atoms or molecules, electrons or protons- one operates in a very different intellectual area. These concepts are not tangible in the way most of other concepts are. Therefore, many students feel that they do not have to understand chemistry, but rather memorize the different concepts. Thus, they concentrate on exam marks rather than on the development of the concept.

Also, English medium students are learning chemistry through a language which is not their mother tongue. Especially, at primary and secondary level when chemistry taught through a foreign language problem enabling the child to correctly comprehend the basic laws and concepts of chemistry is real one. Even if student understands the concepts he may find difficult in expressing his thought in his own words and to write in exams he may learn by cramming the concepts. This habit is developed in primary and secondary school education. By the time they came to the 9^{th} standard they have a fractional understanding of the basic concepts of chemistry. Their habit of rote memorization hinder the understanding of concepts of chemistry

Investigator has selected this topic for study to understand the difficulties encountered by students in achieving level of understanding and their ability to grasp knowledge. The investigator would study the gaps between actual and expected scenario, another objective is to study reaction of students and teachers towards the treatment.

1.17Objectives of the study were:

- To study the fundamental concepts of the chemistry
- Study the opinion of chemistry Teachers on fundamental concepts.
- To study reaction of students towards the treatment
- Difficulties encountered by students in achieving the level of understanding

1.18 Operational definition of terms

Concept mapping or concept Diagramming: For the proposed study a concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts.

Fundamental concepts: For the proposed study Fundamental concepts in the study means the base on which the whole structure of knowledge for that field is built upon.

Micro formative assessment (MFA): For the proposed study MFA means very small/ micro assessment which include very less content ie one or two concepts. For the present study it was two sets of 10 questions each.

Misconception: For the proposed study a view or opinion that is incorrect because based on faulty thinking or understanding.

Multiple mode of Presentation: For the proposed study Multiple modes of presentation refers to the various methods/strategies used for teaching of six selected concepts.

Spatial ability: For the proposed study Spatial ability or Visio-spatial ability is the capacity to understand, reason and remember the spatial relations among objects or space.

Treatment: For the proposed study Treatment means the efforts taken during the teaching of six selected concepts by investigator on experimental group.

1.19 Delimitations of the study:

The present Study would be delimited to few fundamental concepts chosen of grade 9 Chemistry text book

The present study would be delimited to English medium schools of New Delhi affiliated to Central Board of Secondary Education

1.20 Hypothesis of the study

There will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of teaching (including MFA) and control group with traditional methods.

1.21 Scope of the Study

Through this study investigator tries to understand the understanding of the student in the concepts of chemistry, which the students are learning in the 9^{th} standards. By knowing this one can understand which are the factors which help in understanding the concept and which factors hinders in development of the concept. This can help in deciding what sort of condition the teacher should provide the student so that they can develop conceptual understanding and are motivated intrinsically.

Chapter 2

Review of Related Literature

REVIEW OF RELATED LITERATURE

2.0 Introduction

Review of the related literature provides an opportunity to the investigator to get acquainted with the research work in the related field which is already done and what are the gaps/ untested hypothesis which provides opportunity for further study the subject and research on issues which are significant to the related topic. A scrutiny of the literature would help the researcher to appraise himself to the importance of the problem and how it was studied earlier and also allows the researcher to enlighten with the content. It also helps the researcher to examine and decide the scope of the problem and formulate focus questions, objectives and hypotheses. The examination of the literature would bolster the knowledge of the researcher in the fields of methodology used earlier and that would become a guiding beacon for selecting appropriate design and statistical measures and provides a framework for research and act as guiding path to signify the statement of problem. Adhikary, (2018)

Reviews found were on the following dimensions-

1 Fundamental concepts
2 Teaching-learning in chemistry
3 Misconceptions
4 Spatial ability
5 Concept development procedures/constructivist
6 Practical work
7 Computer assisted instructions
8 Assessment
9 Concept mapping
10 Collaborative learning
11 Techniques of learning
12 Achievement

2.1 Reviews related to fundamental concepts

John, Treesa Jomol (2012) Development of programmed instructional material on structure of atom in chemistry at secondary level and study of its effectiveness at different levels of intelligence. The major objectives of the study are:(i)To develop a Programmed Instructional

Material on Structure of Atom in Chemistry for IX class students. (ii) To find out the level of intelligence of the IX class students under study. (iii) To study the effect of Programmed Instructional Material on the performance of IX class students as compared to Traditional Method of Teaching. The sample consisted of 322 students studying in Class IX. Data analysis techniques included Researcher concluded teaching through Programmed Instructional Material (PIM) is more effective as compared to teaching the same topic through the Traditional Method of Teaching (TMT) that being male or female does not make any significant impact on the pupils' performance on the criterion test (post test).

2.2 Teaching-learning in chemistry

Adhikary, 2018. Development of some improvised and sustainable Teaching- Learning Modules in Chemistry and to study their pedagogical effectiveness The objectives of this study are: To design and develop some improvised and sustainable teaching learning modules in Chemistry for post-secondary/higher secondary (i.e. +2 level) students of Indian schools. To implement the proposed/designed pedagogical tools for the teaching chemistry courses of twelfth standard students. To compare the effectiveness of instructional programmes based on sustainable teaching-learning modules and traditional instructional program, how for teaching of concerned chemistry courses of twelfth standard students.To get feedback from higher secondary chemistry teachers in order to judge the effectiveness of the proposed/designed pedagogical tools/teaching learning modules/instructional programmes for teaching of concerned chemistry content. The sample consisted of 98 students of standard twelfth having chemistry as a major subject. The study was Quasi-Experimental Design.

2.3 Review related to the area of misconception

2.3.1 Doran (1972) The objective of study was of eight possible misconceptions. Test items used to obtain information about misconceptions were of alternate response, pictorial type was presented via motion picture film. These included continuous substances of matter, no space between particles, static particles, and a change in the size or the number of particles in explaining natural phenomena Implications of the study suggested that this study can aid curriculum developers in designing instructional materials and activities that begin 'where the student is 'and also for assessing what students might not have attained and why not findings were that misconcepts were prevalent among at least half of the students

2.3.2 Priydarshini E. And Patel R C , Pedagogical approach to refute misconception in science (IUCTE 2019). Misconception are the hindrance to construction of knowledge and comprehending any scientific phenomenon. Perception of students and exact ideas of scientist differ a lot which can be explained in terms of students' misconception,naïve theories alternate conceptions and alternate framework (Blauser 1987). Construction of concepts is not just from ignorance to knowledge but basically one set of knowledge replaces other. Over and above teaching the role of the teacher is to refute misconceptions. Teachers roles and practices are described as under, Learning doctors – Who identify misconception individually or as a group and Use of refutational text – Refutational text are the statements with utmost clarity which corrects the misconception, Use of cartoon concepts, Use of computer assisted instruction.

2.3.3 Griffiths and Preston (1992) With semi-structured interviews, investigated 12th-grade Canadian students' understanding of the concepts of atom and molecule. Thirty students of differing academic achievement and backgrounds in science were selected by a stratified random sampling. The subgroups of 10 students each were labelled as academic-science, academic-nonscience, and non-academic-nonscience. Among 52 misconceptions identified, at least one-third of the sample shared 19 misconceptions, while at least one half of the sample shared 6 of these. The six misconceptions were the following: Molecules are much larger than they are.Molecules within a phase may vary considerably in size.Molecules within a phase may have different shapes. Molecules in the solid phase are the heaviest.Molecules in the gaseous phase are the lightest. All atoms are alive. Moreover, 30-70% of the academic science group held some other misconceptions.These were the following: (1) Water molecules are composed of two or more solid spheres. (2) Pressure may affect the shape of a molecule. (3) Heat causes molecules to expand. (4) The size of an atom is determined primarily by the number of protons. (5) Collisions may results in a change of atomic size. They noticed that some of the misconceptions identified were parallel to the history of chemistry.

2.3.4 Haidar and Abraham (1991) compared applied and theoretical knowledge that 11th- and 12th-grade chemistry students had. The selected concepts, based on the particulate theory, included dissolution, diffusion, effusion, and states of matter. A two-form instrument called the "Physical Changes Concepts Test" was constructed. Problems in the application form were presented in everyday-life situations while those in the theoretical form were presented in chemistry terms such as molecules. The results revealed that more than 40% of the 183 high school students studied held misconceptions about the concepts. The study found that students used the particulate theory more often on the theoretical form than on the application form. In other words, students used macroscopic terms when they were asked in everyday language,and used microscopic terms when they were asked in chemistry terms. Consequently, patterns and distributions of misconceptions were different when both forms were considered.

2.4 Studies conducted on Spatial ability

2.4.1 Taehee Noh (1995) conducted a study on "The instructional influence of pictorial presentation of matter at the molecular level on student's conceptions and problems solving ability."Purpose of the study was to study the influence of pictorial presentation on concept formation and problem solving activity GALT(Group assessment of logical thinking),CCT(chemistry conception test),CPST(chemistry problem solving test) were the tools used . It was suggested that the correct concepts were framed with the pictorial material at the molecular level. However, the use of pictorial materials had no facilitating effect on problem-solving ability and some algorithm problems. Analysis of the results also indicated that logical reasoning ability as measured by GALT was significantly correlated with the student's conception, pictorial problem solving ability, algorithm problem solving ability and chemistry achievement test score.

2.4.2 Shamin Padalkar and Hegarty (2014) Developing Representational Competence in Chemistry the investigators noted spatial ability concept is not practiced in schools. According to Hegarty it was a flaw of education at school level that not only poses a problem for less able students for achievement in science but also more spatially abled students remain unrecognised.Objectives of the study were on teachers perception of Democritus view, Aristotle view and modern chemists view.Tools used were pro-test and post -test and questionnaire.Treatment had two experiments,first experiment required students to match models to their pre-test drawing and experienced the benefits of models ,as a result they adopted the strategy for using models to perform the task.To test the effectiveness of instruction in matching model versus feedback these factors were separated in the second experiment.Students who went through similar intervention to that of experiment one experiment one, were more accurate on post-test than control group who receive only verbal feedback and this effect was still evident when they perform diagram translation problems without models and after a seven-day delay (Stull and Hegarty, 2014). Findings were only feedback without opportunity to experience the benefits of model or developing model strategy did not give results as expected. Evidence for the effectiveness use of models in chemistry instructions which students first to generate solutions and diagrams to problem in then use the model to generate feedback on their solutions

2.4.3 Prakash, B. (1990)studied the effectiveness of concrete materials to enhance learning in physical sciences .Major findings were the use of concrete materials such as Charts ,models analogies , more lucid examples and other manipulable materials based on concrete thoughts and sequencing of instructions in a three stages cycle were found to help the concrete level operators in understanding the formal level concepts more effectively. The three stages of learning cycle were introduction, concept formation and concept application

2.4.4 Merryn, L. (2017) Spatial reasoning and understanding the particulate nature of matter: A middle school perspective. This dissertation employed a mixed-methods approach to examine the relationship between spatial reasoning ability and understanding of chemistry content for both middle school students and their science teachers. Investigator studied the quantitative relationship between mental rotation, a type of spatial reasoning ability, and understanding a fundamental concept in chemistry, the particulate nature of matter. The data showed a significant, positive correlation between scores on the Purdue Spatial Visualization Test of Rotations (PSVT; Bodner& Guay, 1997) and the Particulate Nature of Matter Assessment (parnoma; Yezierski, 2003) for middle school students prior to and after chemistry instruction. A significant difference in spatial ability among students choosing different answer choices on parnoma questions was also found. The second paper examined the ways in which students of different spatial abilities talked about matter and chemicals differently. Effect of spatial ability on acquisition of understanding chemistry as investigated Students with higher spatial ability tended to provide more of an explanation, though not necessarily in an articulate matter. In contrast, lower spatial ability students tended to use any keywords that seemed relevant but provided little or no explanation. The third paper examined the relationship between mental reasoning and understanding chemistry for middle school science teachers. Like their students, a significant, positive correlation between scores on the PSVT and the parnoma was observed. Teachers who used consistent reasoning in providing definitions and examples for matter and chemistry tended to have higher spatial abilities than those teachers who used inconsistent reasoning on the same questions. According to researcher this is the first study to explore the relationship between spatial reasoning and understanding of chemistry concepts at the middle school level. Though researcher are unable to infer cause and effect relationship from correlational data, these results illustrate a need to further investigate this relationship as well as identify the relationship between different spatial abilities (not just mental rotation) and other chemistry concepts

2.5 Review related to the conceptual developmental model

2.5.1 Aziz ,T.(1990)studied the comparative information -processing model of teaching in developing certain concepts in chemistry .Objectives were as follows :1.To develop teaching program in specific content in chemistry to teach inductively through concept attainment and inductive thinking models. 2 .Compare the teaching program based on information processing models with traditional teaching program in chemistry with regard to concept attainment model .It was found that Chemistry could not be effectively taught through model approach Model approach of teaching was better than the traditional approach of teaching. Concept attainment model and inductive thinking model were effective for the teaching science concepts .Information processing model were found superior approach for Teaching concept-based chemistry.

2.6 Studies related to practical work in chemistry

2.6.1 Mathewos Anza ,Mesfin Bibiso , Abedelfeta Mohammad , BerhanuKuma Assessment of Factors Influencing Practical Work in Chemistry: A Case of Secondary Schools in Wolaita Zone, Ethiopia The objective of this study was to explore factors that influence practical work in chemistry for secondary schools in Wolaita Zone, Ethiopia. The study has identified teachers‟, learners‟ and school principals‟ perceptions to indicate the key factors that seem to inhibit the effective use of practical work in chemistry. The sample for the study comprised 56 chemistry teachers, 75 secondary school students, and 5 school principals. Data were collected using structured questionnaires, focus group discussion and interview. The collected data were analyzed using simple quantitative and qualitative analysis. The study adopts descriptive survey design. Major findings were The findings are indicating a lot of concern has been shown about the inadequacy of chemistry laboratory in Wolaita Zone, Ethiopia.The lack of equipment funding, lack of understanding of the aims of the changes in the science curriculum, the shortage of time and lack of resources for practical work, the lack of mentorships for inexperienced teachers in order to build confidence in practical work and the inadequate opportunities for training and professional development. Most secondary schools have no science laboratories and the few that have them are ill-equipped and poorly maintained by co-ordinators.

2.7 Studies conducted on ICT

2.7.1 Anand Krishnan K (2017) investigated on "Development of multimedia courseware for teaching chemistry at higher secondary level ." Study was done to find out the effectiveness of multimedia courseware in teaching chemistry Traditional teaching is rigid ,time bound and outmoded , for attaining mastery of the subject and increasing motivation and also pace of learning the device was planned .Purpose of the study was to devise teaching tasks in the form of multimedia courseware objectives of the study were: 1. To find out the effectiveness of the Multimedia Courseware for teaching chemistry at higher secondary level. 2. To find out the attitude of the students toward Multimedia Courseware for teaching chemistry at higher secondary level. Finding and conclusions of the study clearly demonstrated the effectiveness of multimedia courseware for teaching chemistry at higher secondary level. The study clearly demonstrates the effectiveness of multimedia courseware for teaching chemistry at higher secondary level As the multimedia courseware gave ample opportunity for learner motivation and was appropriate for all categories of learners

2.7.2 Atef Yousef Makeed, Alkhutaba (2012) studied "The attitude of chemistry teachers towards using the computer in teaching eleventh grade." Some of the objectives of study was to 1.

To analyze the attitudes of chemistry teachers toward the use of computers. 2. To investigate the use of computer by Chemistry teachers in teaching and learning. 3. To examine the obstacles faced by teachers of Chemistry in the use of computers in teaching. This study employed both qualitative and quantitative designs to investigate the attitudes of chemistry teachers about the use of computers in education. Data was collected from 435 teachers from Jordanian public and private schools in Jordan in the academic year 2010-2011 in the area of Amman. The major findings of interview are there are some obstacles, which prevent chemistry teachers from using computers in the teaching process and findings suggested that research should be designed to investigate what kind of software is effective for developing positive attitudes of chemistry attitudes towards using computers in teaching of chemistry. The problems related to the compatibility of educational software with the curriculum were found and need of addressing local issues. There is urgent need for in depth surveys so that on the basis of generalizations policy makers could provide infrastructure and equipment's to improve teaching of chemistry via computers.

2.7.3 Parasurama (2017) conducted a study An Impact of Technology Based Constructivist Teaching on Academic Achievement of IX Standard Students of Bengaluru City. The study aims at comparing effectiveness of Constructivist Teaching and Technology Based Constructivist Teaching on academic achievement of students. Some of the main objectives of the study were To develop Constructivist Teaching (CT) and Technology Based Constructivist Teaching (TBCT) package for selected units of IX standard Social Science subject and To find out the impact of CT and TBCT on the academic achievement of students. To find out whether any difference exists between the group taught by CT and TBCT with respect to academic achievement. To find out whether any difference exists in the academic achievement of students of government and private school with respect CT and TBCT. To find out whether there would be any difference between boys and girls with respect to their academic achievement, due to the impact of CT and TBCT. To find out whether there would be any difference between High IQ and Low IQ students with respect to their academic achievement, due to the impact of CT and TBCT. To find out whether there would be any correlation between IQ and academic achievement of students. To find out the main effect and interaction effect of IQ and Gender on the academic achievement of students. The study used purposive sampling technique. The sample comprised of 156 students studying in IX standard of two schools (Government and Private School) of Bengaluru city affiliated to state board. Among them, 80 students were from government school and remaining 76 students from private school. The data collected from both the schools were analyzed using normality test, descriptive and inferential statistics. The study found that the students of both CT and TBCT group were performed better in their post-test compare to pre-test in government as well as private school. This means, the treatment CT and TBCT has influenced on the students' academic achievement. 256 Further comparison of academic achievement of students in CT and TBCT groups revealed that students of TBCT group performed for better in their post-test mean scores of academic achievements when compare to CT group. It indicates that, students were focused more in knowledge construction in the TBCT group with the help of technology component (integration

of technology) along with the 5 E's Instructional model, Jigsaw, constructivist assessment, scaffolding and ZPD.

2.8 Studies conducted on assessment

2.8.1 Elaina Edman Stephen G. Gilbreth Sheila Wynn Implementation of Formative Assessment in The Classroom The mission of this project was to identify the formative assessment literacy levels and the degree of classroom implementation of these strategies in districts and the resulting implications for leadership. The purpose of the project was to determine the use and implementation of formative assessments in classrooms in southwest Missouri. The literature substantiated the importance of formative assessment however; the lack of a widespread formalized program inhibits effective leadership practices in its implementation. The analysis of the survey responses revealed a gap in teacher knowledge of formative assessment and its use in classrooms. Major findings are as follows: 1.The project team found that professional development for formative assessment across the state is necessary. There must be a sense of urgency among leaders and teachers to implement a formative assessment initiative. The knowing-doing gap cannot be ignored; it must be addressed. Teachers know that it is a crucial piece to learning, but implementing it is sometimes difficult.

2.9 Studies conducted on concept mapping

2.9.1 Nicoll,G.,Francisco, J. And Nakhleh, M. (2001) studied on "An investigation of the value of using concepts maps in general chemistry". Concept maps were used for treatment group for entire course. Students were trained in constructing concept maps. Concept maps given as homework assignments and quizzes were evaluated and students received feedback and control group did not use concept maps at all. Data collected revealed a significant difference between two sections. Findings were that the treatment group could solve more complex problems than the control group.

2.9.2 Anamika (2011) An experiment on concept mapping cognitive skill and concept attainment of the 9th Grade Chemistry Students. Study was conducted to see the impact of concept mapping as a teaching learning strategy on cognitive skills and concept attainment of IX grade chemistry students. Objective of study were, (1) To study the effect of concept mapping on cognitive skills of IX Grade Chemistry students, (2) To measure the effect of concept mapping on concept attainment of IX Grade chemistry student, (3) To develop concept mapping as a teaching learning strategy for IX Grade chemistry student, (4) To implement concept mapping as a strategy in the selected content of IX grade chemistry. Hypothesis of the study : (1) There is no significant effect on concept mapping on cognitive skills of students belonging to Grade IX chemistry (2) There is

no significant effect of concept mapping on concept attainment on students belonging to Grade IX Chemistry. Process skill test of chemistry (PSTC) was the tool constructed and standardized by the investigator for which questionnaire was used. Finally, 65 items were selected through the process of item analysis. 40 items were kept in part -1 to measure the effect of concept mapping based on cognitive skills and the rest 25 items were put in part -2 to measure the effect of concept mapping on concept attainment. The spilt half reliability of test was found 0.79 (half test) and 0.88 (full test) while the reliability by KR-21 formula was found 0.70. Null Hypothesis 1 was rejected at both levels of significance and it was concluded that there is a significant effect of concept mapping on cognitive skills of Class IX chemistry student. It also proved that concept mapping has positive effects on 6 basic cognitive skills of science students.

2.9.3 Ahmed ShukriShawli (2018) conducted a case study on "Concept mapping as an assessment of cognitive load and mental effort in complex problem solving in chemistry". This research is an exploratory, descriptive study of students' cognitive load and mental effort related to complex problem solving in high school chemistry. The crux of this research is that from a cognitive point of view, the complexity associated with problem solving in chemistry can be understood from the context of cognitive load theory (CLT). The main objective of this descriptive research using five high school student case studies is to understand the cognitive load phenomena students encounter while learning subject matter that requires complex problem solving, specifically chemical equilibrium. This study employed a mixed methods multiple case study design, in which each participating student (n = 5) is conceptualized as a case. Each student case self-reported their mental effort on eight chemical equilibrium problems. The mean for each students' mental effort and problem solving was reported. Each student completed an equilibrium concept map which was scored. The concept map scores were reported. The analysis compared mental effort score, quiz score and concept map score. There was an inverse relationship between mental effort and concept map score. The more complex the concept map (higher score) the less mental effort students report using to solve the problems. There was a positive relationship between mental effort score and quiz score; and a negative relationship between concept map score and quiz score. Major findings state 1.That these correlations indicate that the variables are related to cognitive load. 2. Methodologically, concept mapping is a valid assessment of cognitive load and mental effort. 3. Further larger studies are needed to substantiate these findings and explain how concept mapping can be used as a representation of cognitive load and student learning.

2.10 Review related to collaborative learning

William James Loyd (2006) Collaborative learning communities: Influences on teacher and student learning. The purpose of this study is to investigate the development of teacher learning teams and their influence on student achievement, teacher learning, and uses of classroom

formative assessments to guide and inform instruction. Few research questions were 1.What are the benefits of participating in collaborative learning communities for teachers and for students? 2. How much staff development is there within the learning community and what is its quality? 3. What is the quality of product and problem sharing? 4. As a result of participating in a learning community, is instructional quality improving? 5. Do teachers feel more efficacious in their practice as a result of participating in a learning community? 6. What is the impact on student achievement when teachers participate in collaborative learning communities? Following were the major findings 1. Teachers Become More Certain About Their Practice 2. Craft Knowledge, Learning, and Reflection are Enhanced 3. Teachers Become More Assessment-Literate 4. CASL as a Form of Professional Staff Development. However, The quantitative analysis of assessment results in this study showed no statistically significant differences in performance on running record subtests between students in the treatment and control conditions. It was recognized prior to beginning the study, that if significant results were found, it would be impossible to relate them directly to the treatment condition. It was hoped, however, that such evidence would help to inspire a subsequent round of research where the work would be wholly quantitative in its focus.

2.11 Review related to techniques of learning

2.11.1 Thirunavukkarasu, E (2008) conducted an experimental study on "Effectiveness of select study techniques on improving the academic achievement of the students of class ix in science and mathematics "This study focuses on four types of study techniques, which are: i. The R-4 Cycle Technique, ii. The Percentage-Drill Technique, iii. The Cognitive Ladder Technique and iv. The Intra-Curricular Study Technique. Objectives of the study were: 1. To select study techniques of learners based on interactions with the students of Class IX. 2. To assess the effectiveness of the select study techniques in improving academic achievement of the students of Class IX in Science and Mathematics In this study, the sample for the study, namely the students of Class IX, studying in sixteen Kendriya Vidyalayas situated in Tamil Nadu and Kerala were divided into two groups: the experimental and the control.

2.11.2 Anilkumar, K P(2003) . Data collected was analysed by Descriptive statistical analysis, Differential statistical analysis and Analysis of variance. Major findings were Effective learning, retention, recall, and success in examinations depend up on the techniques of study the students employ throughout their student life. Wastage in education can be eliminated if each student knows the study techniques suitable for his/her subjects of study, Craft Knowledge, Learning, and Reflection are Enhanced, Teachers Become More Assessment-Literate

2.12 Review related to achievement

Shankar, C (2014)A study on achievement in chemistry in relation to certain selected variables. Objectives of the study are :To find out the level of achievement in chemistry of higher secondary students. To find out the level of educational aspiration of higher secondary students. To find out the level of emotional intelligence of higher secondary students. To find out the level of mental health of higher secondary students. To find out the level of scientific aptitude of higher secondary students. Simple random sampling technique was adopted for school selection. Then stratified sampling technique was adopted for sample selection. 40 higher secondary schools from four taluk (Tiruchengode, Rasipuram, 35 Velur and Namakkal) which consisted 15 educational Community Developmental blocks were considered for the study. Findings of the study were: Levels of Achievement in Chemistry Among the total 800 subjects, 087 (10.87 percent) students are high achievers in chemistry, 380 (47.51 percent) students are average achievers in chemistry, and 333 (41.62 percent) students are low achievers in chemistry.Levels of Educational Aspiration Among the total 800 subjects,178 (22.25 percent) have high educational aspiration, 524 (31.75 percent) have average educational aspiration, and 98 (12.25 percent) have low educational aspiration. Levels of Emotional Intelligence Among the total 800 subjects, 18(2.25 percent) have high emotional intelligence, 736 (86.65 percent) have average emotional intelligence, and 46 (5.75 percent) have low emotional intelligence . For the entire sample, achievement in chemistry and emotional intelligence do not found to be significantly correlated. So it indicates that emotional intelligence do not influence the achievement in chemistry. 4Out of 19 predictors, only three variables have significant effect on achievement in chemistry at 0.01 level and these three variables educational aspiration, mothers' education and community have positive influence and significantly contribute to the achievement in Chemistry of higher secondary school students in Namakkal 235 District. The other variables emotional intelligence, mental health, scientific aptitude, gender medium of school,type of school management, type of school, location of school, type of family, religion,fathers' education,fathers' occupation,mothers' occupation,parental monthly income,sibling and attendance do not significantly contribute to the achievement in Chemistry of higher secondary school students.

2.13 IMPLICATION OF REVIEW OF LITERATURE FOR THE PRESENT STUDY

Research is an iterative process but still enjoys a significant place in all the fields of knowledge. Research strengthens and revitalizes the field in which the research was carried out.The review revealed that every researcher conducted study with different perspectives and approach. A total of 23 studies were reviewed by investigator. From the above review, it was found that many studies are conducted in India as well as abroad in the different area of chemistry. Major area in which investigator was interested are difficulties encountered by students during understanding of

fundamental concepts, concept mapping, students misconceptions, practical work in chemistry, spatial ability, assessment techniques, constructivism approach etc.

Many of the studies reviewed were experimental but few like of Griffiths and Preston, Atef Yousef, Alkhutaba, Parasurama, Shankar C were survey studies. Griffiths and Preston conducted study with semi-structured interview Griffiths and Preston (1992) investigated 12th-grade Canadian students' understanding of the concepts of atom and molecule, Haidar and Abraham (1991) compared applied and theoretical knowledge that 11th- and 12th-grade chemistry students had. Few researchers like Doran(1972) conducted the study in the area of misconceptions and curriculum development. He investigated on elementary school student's misconception of chemistry concepts related to particulate nature of matter. Priydarshini.,E , Patel R C, studied on pedagogical approach to refute misconception in science (IUCTE 92).Merryn L conducted a mixed-method design of study while William James Loyd conducted a qualitative study on elementary school students and teachers related to collaborative learning. Review includes a study on constructivist approach on social science by Parasurama. He conducted a study on an Impact of Technology Based Constructivist Teaching on Academic Achievement of IX Standard Students of Bengaluru City. The study aims at comparing effectiveness of Constructivist Teaching and Technology Based Constructivist Teaching on academic achievement of students. Some of the main objectives of the study were To develop Constructivist Teaching (CT) and Technology Based Constructivist Teaching (TBCT) package for selected units of IX standard Social Science subject

Investigator found few studies on concept mapping done by Nicoll G Francisco, J.andNakhleh M, Anamika, Ahmed Shukri Shawli.. Ahmed Shukri Shawli conducted an exploratory, descriptive study of students' cognitive load and mental effort related to complex problem solving in high school chemistry. Nicoll G Francisco, J.andNakhleh M (2001) studied the value of using concepts maps in general chemistry. Anamika (2011) studied an experiment on concept mapping, cognitive skill and concept attainment of the 9th Grade Chemistry Students. Few studies like of John, Treesa, Anand Krishnan were on programmed instructional material .Anand Krishnan K (2017) investigated on development of multimedia courseware for teaching chemistry at higher secondary level. Atef Y M, alkhutaba (2012) studied the attitude of chemistry teachers towards using the computer in teaching eleventh grade. Prakash, B. (1990) studied the effectiveness of concrete materials to enhance learning in physical sciences.

Review also include a project study on formative assessment done by Elaina Edman Stephen G. Gilbreth Sheila Wynn on Implementation of Formative Assessment in The Classroom. The mission of this project was to identify the formative assessment literacy levels and the degree of classroom implementation of these strategies in districts and the resulting implications for leadership. The purpose of the project was to determine the use and implementation of formative assessments in classrooms in southwest Missouri.

Reviews related to spatial ability revealed following Teehee Noh (1995) conducted a study on the instructional influence of pictorial presentation of matter at the molecular level on student's conceptions and problems solving ability. Shamin Padalkar and Hegarty (2014) worked on developing representational competence in chemistry. The investigators noted spatial ability concept is not practiced in schools. Spatial reasoning has been linked to success in learning STEM subjects. Few studies examine middle school students' or in-service middle school teachers' understanding of chemistry concepts or its relation to spatial reasoning ability.

The investigator has chosen this study as none of the above reviewed studies have focussed on attainment of fundamental concepts in relation to technology integration and micro-assessments in traditional teaching. This experimental study endeavours to assess the fundamental concepts of chemistry of grade 9 students.

Chapter 3

Research Design and Methodology

RESEARCH DESIGN AND METHODOLGY

3.0 Introduction

This chapter describes the design used in conducting the study. Detailed descriptions of the population, sample, research methodology, sampling technique is discussed. Design is considered as the heart of the research study. It is the blue print of the research. Research design is a systematic plan of research work which is essential for every research study. Design regarding what, where, when, how much, by what means, concerning a research study constitute a research design.It is a conceptual framework within which research is conducted.The design includes an outline of what the researcher will do from writing the hypotheses and its operational implications to the final analysis of data. This chapter also describes the objective, purpose, hypotheses, significance and types of research, scope, variables, tools, delimitations and operational definition of the terms involved in the stated problem.

3.1 Research Design

Design is the blue print of the procedures that enable the researcher to test hypothesis by reaching valid conclusions about relationship between independent and dependent variables.Mixed-method and a quasi-experimental design was implemented for this study.The design used consisted of non-equivalent groups with pretest and a posttest because of the need to use intact classes to measure group differences. The design of the study is presented as below:

O_1 X O_2

Where O_1 = Pre-test (experimental group)

O_2= Post-test (experimental group)

X stands for exposure of a group to an experiment (treatment variable)

O_2 X O_3

Where O_2 = Post-test (experimental group)

O_3 = Post-test (control group)

The study examined the effectiveness of treatment to understand the fundamental concepts of chemistry in ninth standard of CBSE school in New Delhi. Treatment studied the effect of multiple mode of technology integration, concept maps on achievement, effect of micro assessments on achievement.Each of the concept was presented holistically with the central theme of making concepts clear,easy,and interesting.

Mixed methodology or mixed designs in research in education : This type of research is more towards seeing the compatibility of the quantitative research with the qualitative research. The research reviews of this kind is also of recent origin. This type of study helps in getting a reasonably good comprehensive knowledge of the phenomena

3.2 Population of Study :

Education in Delhi is provided/governed,/regulated by the Department of Education (DoE), Govt of NCT, Delhi. For the above purpose, entire Delhi is categorised into 'Districts' and further sub-categorised into 'Zones' of education.

In Zone 18, District West-B, New Delhi there are three types of Schools. Government (Run by DoE), Government Aided (Governed by DoE) and Private Unaided (Regulated by DoE).

Approximately 10,600 students studying in Class IX in the all the Schools of 'Zone 18' constitute the population of Study. The details of total number of Schools and Students studying in Class IX covered under each type of School are mentioned below:

S.No.	Type of School	Total No. of Schools *	Approx. total No. of Students #
1	Government School	42	4200
2	Government Aided School	05	500
3	Private Unaided School	59	5900
	Total	**106**	**10600**

(Source : * Information available on official website of Department of Education, Delhi.

#Assuming on an average 100 students study in each type of School)

3.3 Sampling Technique and Sample

Randomized purposive cluster sampling with explicit purpose of enhancing understanding of fundamental concepts in chemistry.The basic concept of purposive sampling technique is, to select the representative sample from the big population. The samples are selected on the basis of some questions like; who can represent the characteristics of population, and who can give the required information, etc…. Logic, common-sense and availability of required experimental condition are required here. Schools are having their tight academic schedule throughout the year, so very few schools are permitting for research work.

As the present study was experimental one, the investigator had decided to select two schools from the population.The investigator selected randomly purposive sampling technique in the selection of school. Two schools of New Delhi were purposefully selected for the present study.The sample for the present study consisted of 89 students studying in Class IX which were randomly selected.The sample constituted of two sections, one section was control group and other section was experimental group of two different schools Both the private schools selected were co-educational English medium schools and were situated in densely populated area of District West B Zone of New Delhi, the sample ensured a fair representation of students from all the sections of the society.

Final setting of the sample was done after the treatment as either few students were absent or were involved in some other work.

3.4 Objectives of the study were:

1. To study the fundamental concepts of the chemistry
2. Study the opinion of chemistry Teachers on fundamental concepts.
3. To study reaction of students towards the treatment
4. Difficulties encountered by students in achieving the level of understanding

3.5 Delimitations of the study:

1. The present Study would be delimited to few fundamental concepts chosen of grade 9 Chemistry text book of NCERT
2. The present study would be delimited to English medium school of New Delhi affiliated to Central Board of Secondary Education

3.6 Variables Involved :The present study involves two kinds of variables as given below:

Dependent variable

The dependent variable in this study was the students performance scores on the academic achievement test (both pre test and post test) designed to measure different kinds of capabilities purported to have been developed by administering the treatment and before the treatment to the learners under treatment conditions.As the academic achievement test is intended to measure various categories in the cognitive domain of educational objectives like knowledge,comprehension, application, analysis synthesis and evaluation,the scores on the academic achievement test is the result of all these cognitive processes.

Independent Variables

The study involved treatment Groups (Experimental group Vs Control group) dependent variables The dependent variable is achievement in chemistry and the independent variables are capacity to develop concept maps,strategy and learning together.cooperatively.

3.7Tools and Techniques used

It is generally accepted that chemistry is inherently a difficult subject to learn. A major problem arises because the basic concepts of chemistry can only be interpreted in submicrolevel and representational notations of unseen conceptual models. It is difficult for students to link chemistry at this sub-microlevel with their everyday lives and thus fail to see the underlying relevance of much of the chemistry they are taught. Therefore investigator worked on to develop sound pedagogical tools for linking teaching chemistry contents with everyday life. (Johnstone's 1991)

Tools and techniques used for the study are described below

Academic achievement tests : This test was constructed by investigator for six concepts taken in the study. The test comprised of 40 marks having 40 MCQ for pre-test and similar test of 40 marks having 40 MCQ for post-test.

Multiple modes of presentation: Videos and information from different resources are shown in class or send through whatsapp groups.

Concept maps: Concept map was used as a tool, that enriches students' understanding of a new concept, by building relationships between abstract ideas and concepts which deepens understanding and comprehension. Students were shown many concept maps for each topic selected and then given practice for concept diagramming.

Brief information on the selected topics

Micro Formative Assessment- This test was constructed by the investigator for six concepts taken in the study. The test comprised of 20 questions with weightage of 20 marks having basic and simple test items in the form of MCQ..

Problem solving: This tool was used for concepts of mole concept and laws of chemical combination thereby helping students in better understanding and application of concepts.

Opinionnaire for students: This tool was used for taking opinions of the students to analyse content and methodology.

Interview schedule for teachers: This tool was used to understand the concept clarity, difficulties encountered in teaching of abstract concepts, concept mapping and problem solving and to analyse content and methodology.

3.8 Plan and procedure of the study

Investigator selected some fundamental concepts of chemistry from chemistry textbook standard 9. Structure of Atom, Models of atom, Laws of chemical combination,Concept of Mole, Periodic table and Flame test. All are the backbone of the basic understanding of chemistry. In depth and conceptual Knowledge of these subjects is absolute essential and basic for students to acquire to gain confidence in the subject. Periodic table and flame test were two concepts out of the CBSE syllabus but investigator confined to just introductory level.Treatment studies the effect of multiple mode of teaching through technology integration, concept maps on achievement ,effect of micro assessments on achievement. Teaching of chemistry with multiple modes of presentation of contents also helps in enhancing their spatial ability which in turn enriches their learning holistically. Each of the concept was presented holistically with the central theme of making concepts clear, easy, and interesting.

To make the process of understanding and grasping student friendly, investigator developed 5 E lesson plan. Concept diagrams were shown for each concept and students were also taught how to make concept diagram so that learning can be imbibed and this process made the subject interesting and interactive. Investigator administered two micro formative assessment for each concept ,each ten marks during the lesson. This technique gave a detailed orientation of the concept. This technique

also facilitated investigator to know whether MLL are achieved or not. Investigator also strive to make learning process interactive through constructive approach.Concept diagramming were taught to students by providing with inputs of concepts and bullet points information's and students were then made to connect the dots through their own understanding of the subject, which will enable students to keep the knowledge imbibed and learnings will not get faded away with time.

The study took place in three stages as mentioned below

3.8.1 Stage 1-Planning and preparatory phase

Permission from school authorities–Permission from the authorities of two schools were taken to conduct the treatment. One school is experimental school where treatment is given and another school is control group where same concepts were taught by traditional method are used.

The Investigator selected Mixed method and quasi-experimental Method for conducting the present study. The Pre-test Post-test Non- equivalent group design (Best &Kahn, 2007) is selected as Experimental design for the study. One Experimental and One Control group each from two schools of New Delhi district are selected randomly for the study.

3.8.2 Stage 2 –Execution of treatment

The execution of the experiment in both the schools took around 20 days. Investigator sought the permission from the heads of institutions for conducting the study and explained the present study was on the chemistry syllabus of Class IX. After getting permission from Principal and other authorities first teachers and then students were oriented about the treatment. The entire administration work took about two days to complete for each school. Before the start of the testing and teaching programmes, the investigator collected the list of names and class roll numbers of students in each section and kept a separate record of this list. Study is a mixed-method design so analysis was done qualitatively and quantitatively. Academic achievement test (pre test and post test) and Micro formative Assessment were analysed quantitatively and opinionniare of students and questionnaire for teachers qualitatively. This was done for experimental group but for control group only academic achievement test (pre test and post test) were conducted.

Tests for quantitative analysis

Administration of the Test

Academic achievement test-Pre-test and Post-test (Appendix-E) The Academic achievement tests were designed to ascertain the effectiveness of the treatment by measuring the learner's performance on clearly defined educational tasks. Through the Academic achievement test the terminal behaviour of the learner reached after the completion of the unit of an instructional programme is assessed for ascertaining the extent to which the set objectives have been realized. Academic achievement tests were prepared by the investigator for the present study.The test is applicable for the students studying in Class IX under CBSE Syllabus. Both pre-test and post-test were equivalent tests.

Administration of Pre-test

Administration of Pre-test: On the first day, the academic achievement pre-test developed by the investigator was administered as pre-test on one section of each school-experimental and control. Though there was no specified time limit for this test, it took a period of forty minutes duration to complete the test.This includes the time taken for giving instructions and distributing test booklets and collecting them back.The students were directed to follow the given instructions.

Administration of Post-test

Administration of Post-test: On completion of treatment of all six fundamental concepts through technology integrated, contructivist approach and using MFA to experimental group and Traditional Method for control group. Almost equivalent test was administered as post-test to both the groups.The students were asked to respond to each item by putting a tick mark on the correct answer. It has been noticed that the students of both the groups took lesser time to complete the test as compared to the time taken by them to complete the test when it was administered as pre-test.

Description of Micro formative assessments taken during the study is given in appendix3

Qualitative analysis

Opinionnaiare of students On the last day, the students of experimental group who were taught through the multiple mode of technology integration were given an opinionnaire to give their opinions towards the treatment. The opinionnaire consisted ten statements with necessary instructions for the students.The students were requested to put tick mark on any one of the answers which they feel apt about the programme. The students took approximately 10 minutes to complete the opinionnaire

Questionnaire of teachers

In order to judge the effectiveness of the treatment and proposed pedagogical tools, an interview of teachers was conducted. Questionnaire for interview was presented to expert for validation. Few basic questions were discussed during the interview in order to judge the opinions of chemistry teachers regarding implementation and effectiveness of the treatment and also the experiences of teachers.

3.8.3 Stage 3 Collection of Data

Data collected from academic achievement test (pre test and post test), opinionniare of students and interview of teachers were collected, analysed and interpreted. Papers distributed for the MCQ tests were collected, checked and all marks were entered in spreadsheet and spreadsheet for all data was prepared.

3.9 Data Analysis:

Data was analysed by first entering the data then followed by ordering the data in excel sheet.Data was analysed and interpreted using many statistical measures like mean, median, mode, skewness, kurtosis, standard deviation t-test and correlation of product moment(r). Details of these are described in detail in next chapter and summarized data in appendices also.

Chapter 4

Analysis and Interpretation of Data

Analysis and Interpretation of Data

4.0 Introduction

In this study the investigator focused on understanding of fundamental concepts with multiple modes of presentation as experimental variable with central idea that enhanced environment brings enhanced learning. In the study investigator checked the effectiveness of teaching with reference to traditional approach for the selected six concepts in chemistry of ninth grade chemistry curricula of NCERT textbook of CBSE schools. The achievement data in post-test of experimental and control group after the treatment, the analyses and the interpretations of the obtained data is presented here after. The interpretation is given after the analyses of the data on the basis of the objectives of the study.

Investigator began the process of looking at the findings from the data collected from experiment by reviewing objectives to lead the thought process and analysis. The objectives of the study were

1. To study the fundamental concepts of the chemistry
2. Study the opinion of chemistry Teachers on fundamental concepts.
3. To study reaction of students towards the treatment
4. Difficulties encountered by students in achieving the level of understanding

4.1 Statistical measures used

The data collected using the academic achievement test scores for pre-test and post-test was used for calculating means of pre-test and means of post-test. Other statistical measures like Median, Mode, Standard Deviation, variance, Skewness, Kurtosis along with mean were calculated for both pre-test and post-test. T-test, chi-square and correlation of product moment were also calculated. Along with above mentioned statistical measures profiling of each student was done for pre-test, six Micro Formative Assessment (MFA) for six selected concepts of the study and Post-test.

4.2 Hypothesis of the study

There will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of presentation (including MFA) and control group with traditional methods.

4.3 Analysis of Data Pertaining to Hypothesis of the study

Data was analysed and interpreted both quantitatively and qualitatively. Pre-test and post-test of both experimental group and control group were analysed quantitatively whereas concept maps, opinionnaire of students and interview of teachers were analysed qualitatively. To test

hypothesis, the data were tabulated coded and put in order. The analysis of the study is given in the following sections.

4.4 QUANTITATIVE ANALYSIS

Data analysis was done quantitatively for the following

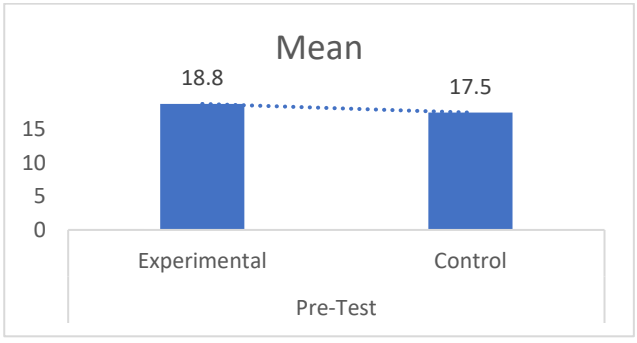
1. Pre-test and Post-test (Academic Achievement Test)
2. Micro Formative Assessment (MFA)

Statistical measures like Mean, Median, Mode, Standard Deviation, Variance, Skewness, Kurtosis were calculated for both pre-test and post-test for both Academic Achievement Test and Micro Formative Assessment (MFA). T-test, F-Test, Chi-square and correlation of product moment were calculated only for academic achievement tests (pre-tests and post-tests).

Data Analysis for Pre-test and Post-test (Academic Achievement Test)

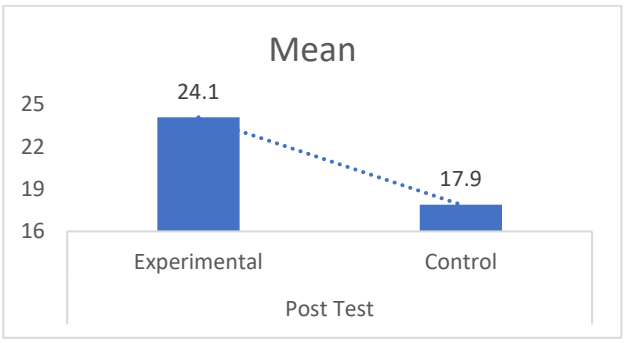
4.4.1 Data Analysis for means

Pre-test was conducted before the treatment and it was administered on both experimental and control group. Means of pre-test result revealed that experimental group and control group were equivalent groups. It appears that there is no significant difference in the basic understanding level of both the groups as the mean of the pre-test score of both are almost similar (Graph 4.1)



Graph 4.1

However, after the treatment was given to experimental group and control group was taught in traditional method a post-test was administered to both groups. Analysing data for means of post-test of both groups revealed a significant difference between results

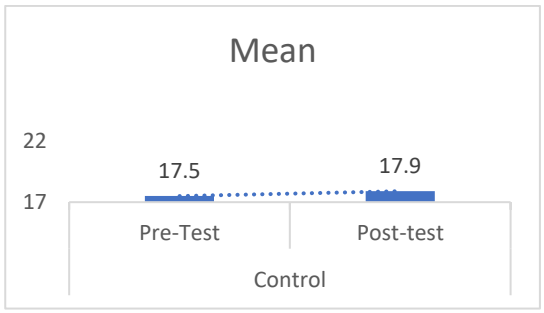


Graph 4.2

Table 4.1 Means of Pre-test for experimental and control group

	Pre-Test		Post-Test	
	Experimental	Control	Experimental	Control
Mean	18.8	17.5	24.1	17.9

Mean difference of pre-test and post-test for Experimental group is approximately 5.3 marks. The significant difference in the Pre and Post Test is the result of the treatment provided to the Experimental group by the investigator, whereas controlled group has shown only a mean improvement of 0.4 marks.(Graph 4.3)



Graph 4.3

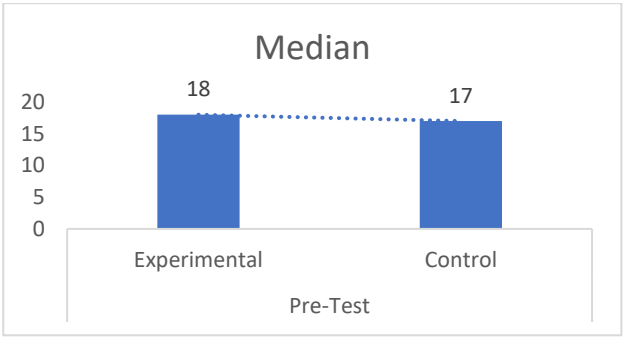
4.4.2 Data Analysis for Median

Data analysis for Median for pre-test for both experimental group and control group indicated not much significant difference was observed.

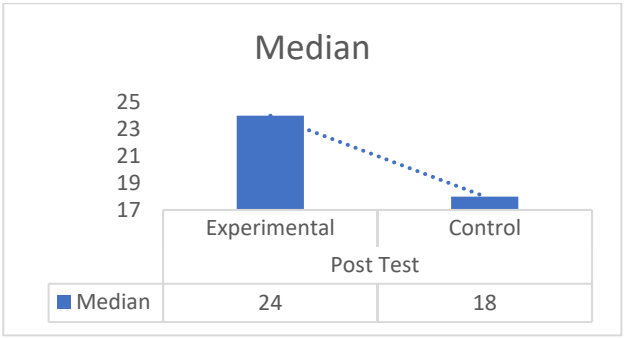
When we compared post-test between experimental and control groups it was observed that there was a significant difference. Table 4.4 depicts data for the median after treatment in experimental group and traditional teaching in control group.

Table 4.2 Median of Pre-test and Post-Test for experimental and control group

	Pre-Test		Post-Test	
	Experimental	Control	Experimental	Control
Median	18.0	17.0	**24.0**	**18.0**



Graph 4.4



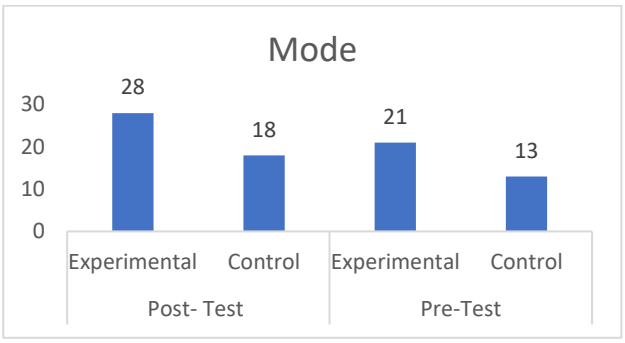
Graph 4.5

4.4.3 Data Analysis for Mode

Mode for pre-test and post-test exhibited that modes of experimental group were higher than control group. Mode changed from 21 to 28 in post-test. The statistical result (Mode) of both groups are summarized below in table (Refer -Table 4.3 and Graph 4.6)

Table 4.3 Mode of pre-test and Post Test for experimental and control group

	Post- Test		**Pre-Test**	
	Experimental	**Control**	**Experimental**	**Control**
Mode	**28.0**	**18.0**	**21.0**	**13.0**



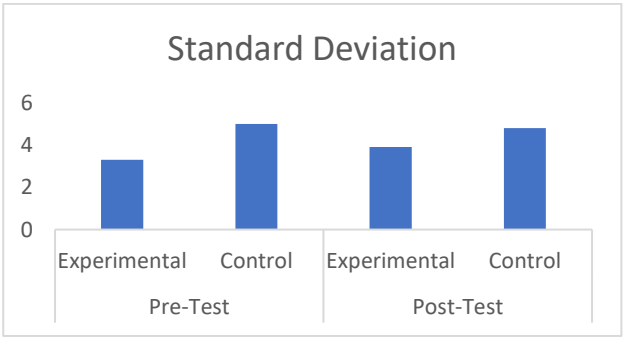
Graph 4.6

4.4.4 Data Analysis for Standard Deviation

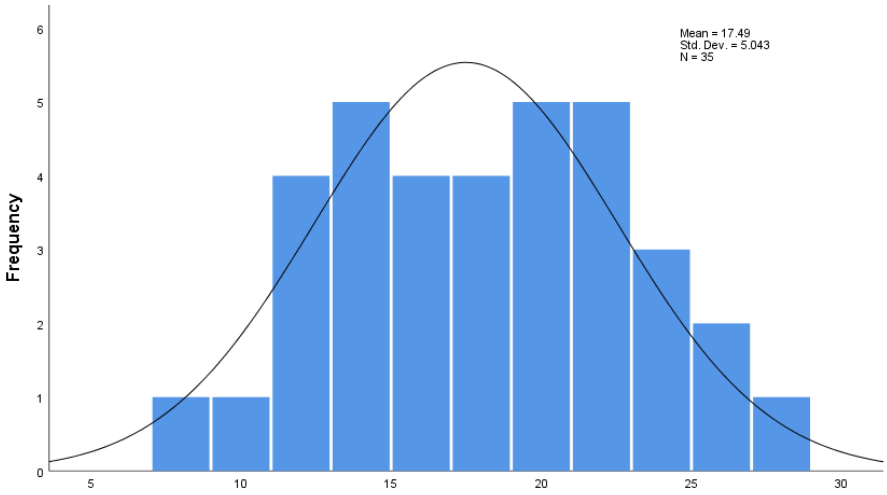
Standard deviation is a number used to tell how measurements for a group are spread out from the average (mean), or expected value. A low standard deviation means that most of the numbers are close to the average. A high standard deviation means that the numbers are more spread out.

Table 4.4 Standard Deviation of Pre-test and Post-Test for experimental and control group

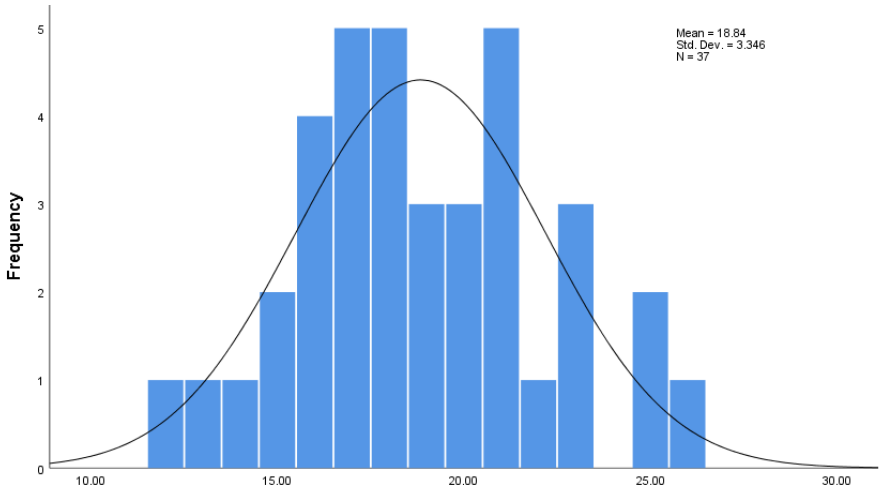
	Pre-Test		Post-Test	
	Experimental	Control	Experimental	Control
Standard Deviation	3.3	5.0	3.9	4.8



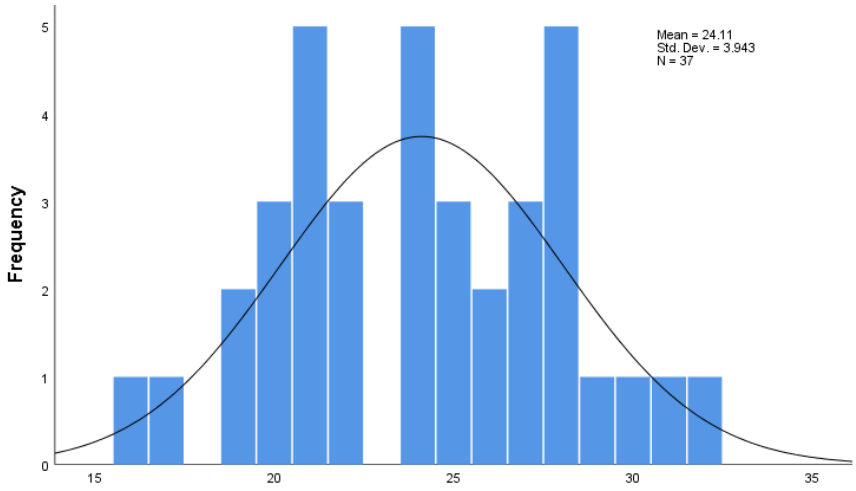
Graph 4.7



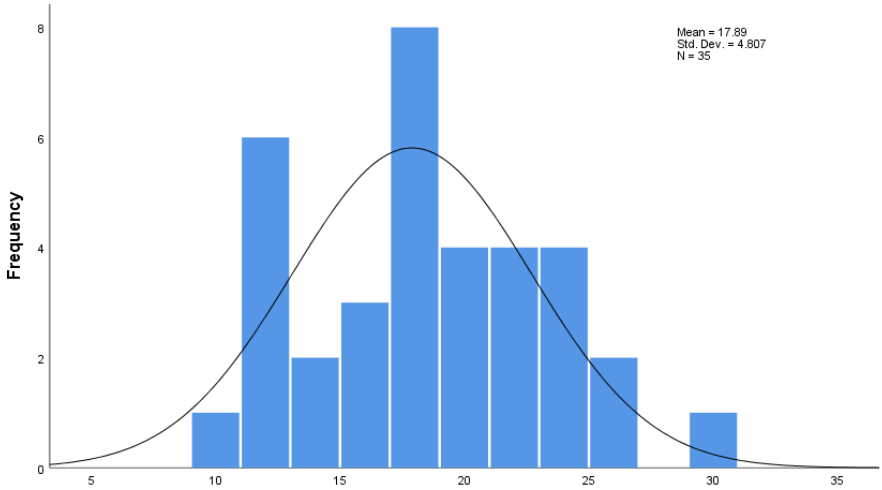
Graph 4.8 Standard Deviation Control Group Pre-Test



Graph 4.9 Standard Deviation Experimental Group Pre-Test



Graph 4.10 Standard Deviation Experimental Group Post-



Graph 4.11 Standard Deviation control Group Post-Test

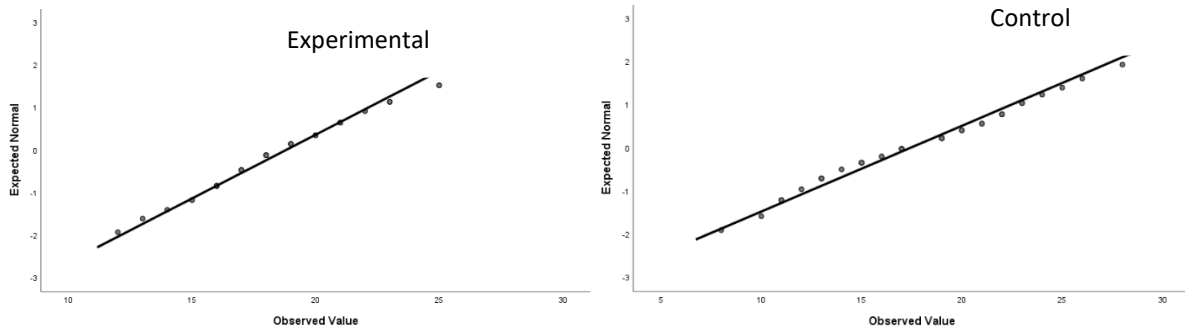
4.4.5 Data Analysis for skewness

The Pre-Test and Post-Test data for both the Experimental and Control group are symmetrical with slightly positive skewness. The skewness for Pre-Test and Post - Test are between 0.0 to 0.2. Size of Right-Hand Tail of Experimental group Pre - Test and Control group Post – Test is slightly larger than Left Hand tail.

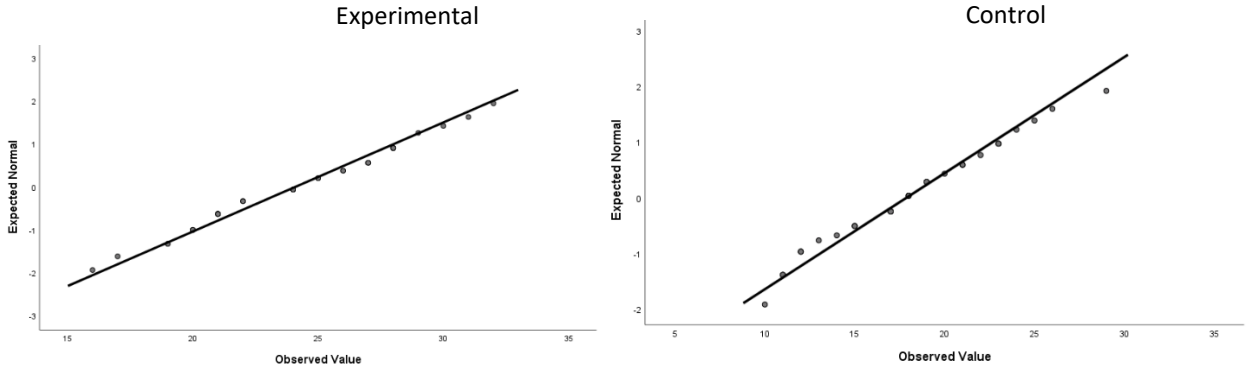
Table 4.5 Skewness of Pre-test for experimental and control group

Metrices	Pre-Test		Post-Test	
	Experimental	Control	Experimental	Control
Skewness	0.2	0.1	0.0	0.2

The slight skewness shows that the distribution is spread little unevenly. The sample skewness may not disturb the results or analysis for the skewness observed is small (Graph 4.12 & Graph 4.13)



Graph 4.12 Normal Q-Q plot of Pre-Test of Experimental and Control group



Graph 4.13 Normal Q-Q plot of Post-Test of Experimental and Control group

4.4.6 Data Analysis for kurtosis

The Kurtosis of Pre-Test data of Experimental and Control group is less than 0, which indicates it is light tailed dataset. Pre-Test data of Control group has much data in its tails as compare to Experimental group.

The Kurtosis of Post-Test data of Experimental and Control group is also less than 0, which indicates it is also light tailed dataset. Post-Test data of Experimental and Control group has similar data in its respective tails.

Table 4.6 Kurtosis of Pre-test for experimental and control group

Metrices	Pre-Test		Post-Test	
	Experimental	Control	Experimental	Control
Kurtosis	-0.3	-0.8	-0.7	-0.6

Kurtosis is appearing in negative forms for experimental as well as control groups indicating that the distribution is rather flat in its disposition. This also does not disturb the analysis or results of the experiment. The deviations from normal may not be significant.

4.4.7 Data Analysis for t-test

A paired-samples t-test was conducted to compare Post – Test marks of Experimental and Control group. There was a significant effect. The difference in the marks for Experimental (M=24.11, SD=3.9) and no caffeine (M= 17.89, SD=4.8) conditions; t (66) =5.99, p =0.00. These results suggest that investigator focused on multiple modes of teaching with central idea to enhance environment of learning has significantly improved the result of Experimental group as comparison to the control group.

Graph 4.14 t-Test Post-Test Experimental & Control Group

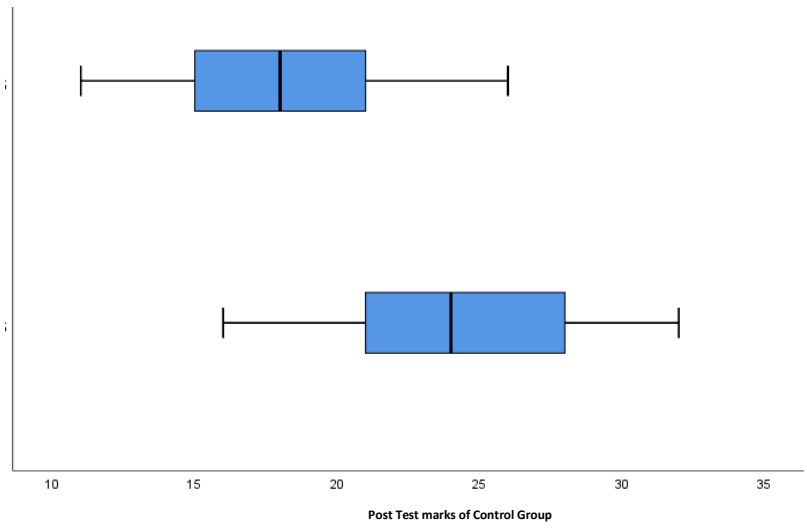


Table 4.7 showing variance statistics of the experimental data

t-Test: Two-Sample Assuming Unequal Variances			
	Experimental Post Test	Control Post Test	Remarks
Mean	24.10810811	17.88571429	
Variance	15.54354354	23.10420168	
Observations	37	35	
Hypothesized Mean Difference	0		
Df	66		
t Stat	5.986903087		Greater than t critical one tail (Null hypothesis rejected)
P(T<=t) one-tail	4.8798E-08		Less than .05 (Null Hypothesis rejected)
t Critical one-tail	1.668270514		
P(T<=t) two-tail	9.75961E-08		
t Critical two-tail	1.996564419		

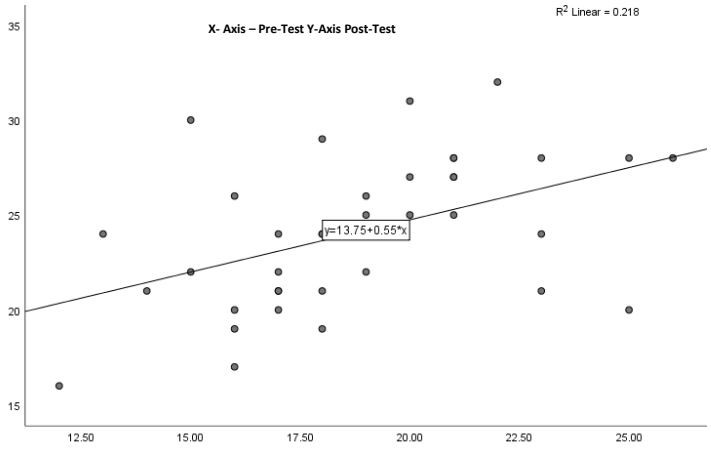
4.4.8 Data Analysis for Pearson Correlation

A Pearson product-moment correlation coefficient was computed to assess the relationship between the Pre – Test and Post – Test of the Experimental group.

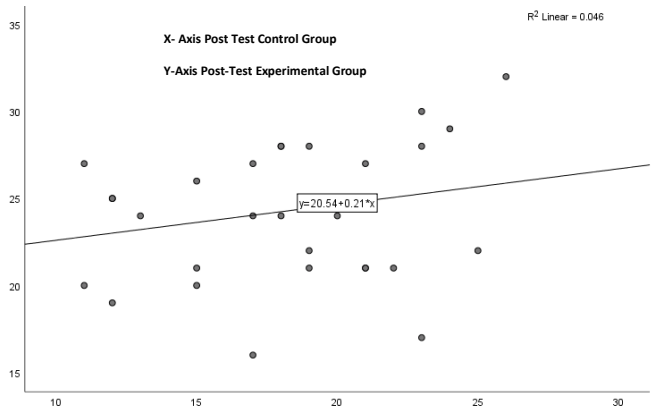
There was a positive correlation between the Pre – Test and Post – Test of the Experimental group, ($r = 0.467$, $n = 37$, $p = 0.002$). A scatterplot above summarizes the result. Overall, there was a strong, positive correlation between the Pre – Test and Post – Test of the Experimental group. Increases in Pre-Test marks were correlated with increases in Post -Test marks.

A Pearson product-moment correlation coefficient was computed to assess the relationship between the Post – Test of the Control group and Post – Test of the Experimental group.

There was a positive correlation between the Pre – Test and Post – Test of the Experimental group, ($r = 0.214$, $n = 30$, $p = 0.256$). A scatterplot above summarizes the result. Overall, there was a positive correlation between the Post – Test of the Control group and Post – Test of the Experimental group.



Graph 4.15 Pearson product-moment correlation coefficient Experimental Group Pre-Test & Post-



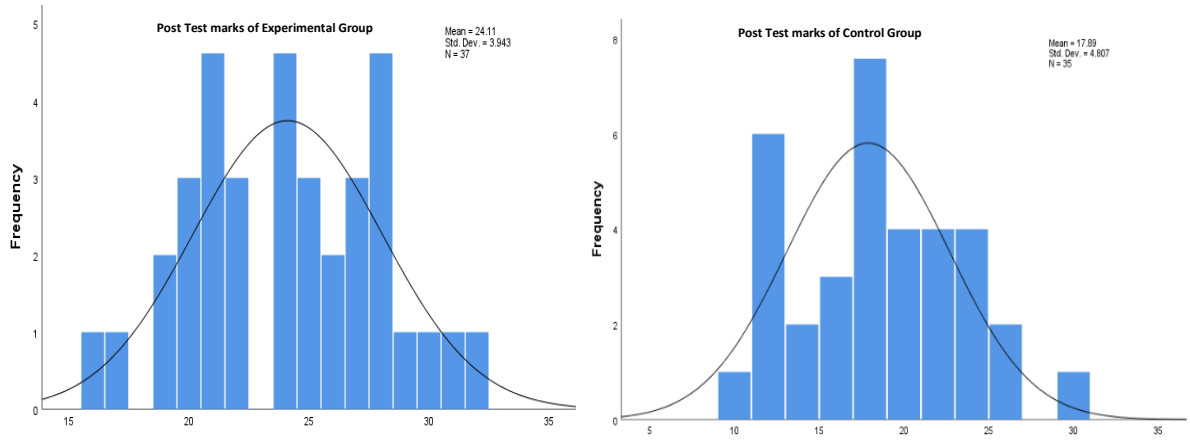
Graph 4.16 Pearson product-moment correlation coefficient control & Experimental Group Post- Test

Table 4.8 Pearson product moment correlation Experimental and Control Group

Pearson Correlation –Experimental	*Experimental Group*		
	Pre-Test	*Post-Test*	
Pre-Test Control Group	1		Positive Relation
Post Test Control Group	0.466736467	1	
	Post Test		
Pearson Correlation -Post Test	*Experimental*	*Control*	
Post Test Experimental Group	1		Positive Relation
Post Test Control Group	0.214209871	1	

4.4.9 Data Analysis for F-test

F test which is part of ANOVA was calculated in study. The null hypothesis here is that the group means are all equal. A big F, with a small p-value, means that the null hypothesis is discredited, and investigator would assert that the means are significantly different. Analyzing the data in detail for experimental group showed that p is small and F value is big. Table given below directs to inferring that ratio of variance reflects significant change in class performance dispersion.



Graph 4.17 f-Test Post-Test Experimental & Control Group

There was an insignificant effect of Post – Test marks of Experimental and Control group at the p>.05 level for the three conditions [F(36, 34) = 0.67, p = 0.12]. Variance of Post – Test marks of Experimental and Control group are statistically similar.

Table 4.9 showing the sample variances

F-Test Two-Sample for Variances			
	Post Test		
	Experimental	Control	Remarks
Mean	24.10810811	17.88571429	
Variance	15.54354354	23.10420168	
Observations	37.00000000	35.00000000	
Df	36.00000000	34.00000000	Description
F	0.67275830		
P(F<=f) one-tail	0.12194679		Greater than .05, Null Hypothesis is not rejected
F Critical one-tail	0.57046473		

4.4.10 Data Analysis for Chi-square

A chi-square-test was conducted with following hypothesis:

1. Post-Test marks of Experimental group is equal to Mean of Post Test of Control group.
   $\chi 2(1) = 0.00, p=0.00$

2. Post-Test marks of Control group is equal to Mean of Post Test of Experimental group.
   $\chi 2(1) = 0.00, p=0.01$

3. Mean of Post-Test marks of Control group is equal to Mean of Post Test of Experimental group.
   $\chi 2(1) = 0.00, p=0.05$

H0: Post-test Experimental = MEAN Post-test Control	P-Value (Post Test)	CHI SQUARE VALUE
	0.000000	0.00

H0: Post-test Control = MEAN Post-test Experimental	P-Value	CHI SQUARE VALUE
	0.01	0.00

Table 4.10 Chi Square Post Test Experimental & Control

Chi Square			
	Hypothesis	Actual Value	Expected
Post Test Experimental	Mean Experimental = Mean Control	24.11	17.89
Post Test Control	Mean Control = Mean Experimental	17.89	24.11
	P-Value	0.05	
	CHI SQUARE VALUE	0.00	

The chi square result shows that the experimental group is better than the control group. The significance of difference between means is found to be significant at 0.05 level. It implies that the treatment provided in the experiment was effective.

This result shows that observed and expected frequencies in the experimental group shows Significant differences and this difference observed is true and it is shown by obtaining the Chi square value being significant at 0.05 level of confidence. It shows that the experimental group achievement result is not due to chance factors but a true representation of the Achievement as a difference for progress.

4.4.11 Data Analysis for Micro Formative Assessment (MFA)

Data analysis on MFA was for all the selected six concepts taught in experimental group. Academic achievement test was an objective type test where 40 MCQ were given and so was MFA but it was micro in nature. MFA was conducted for each of the 6 concepts. Each MFA consisted of 20 MCQ which were further divided into two parts. First 10 questions were given between the treatment given for the concept and last 10 MCQ were given after the treatment.

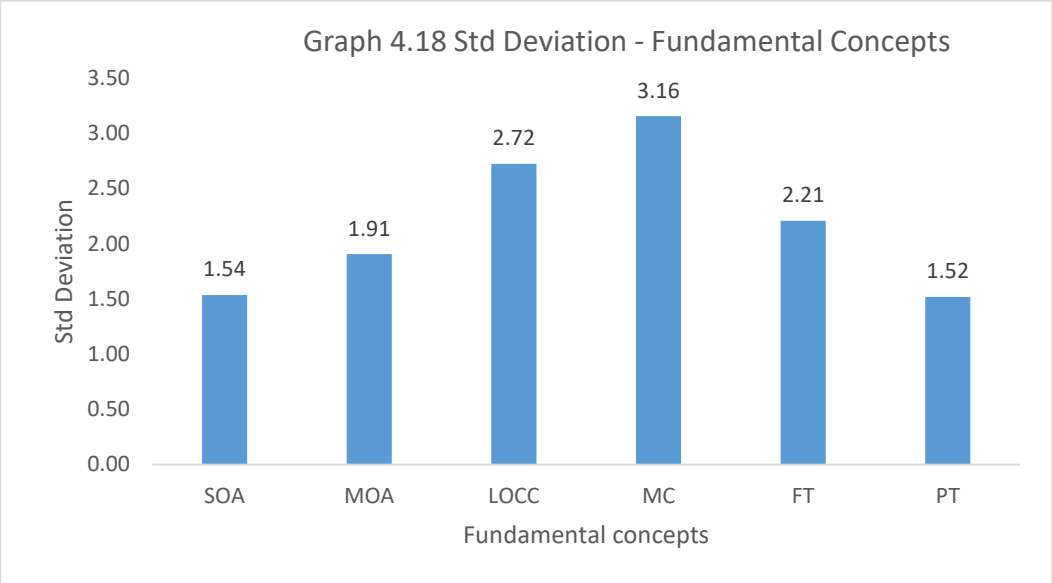
Table 4.11 All Micro formative assessment on content taught in Experimental group

	SOA	MOA	LOCC	MC	FT	PT
Median	15.0	14.0	14.0	16.0	14.0	14.0
Mean	14.8	14.2	13.6	15.4	13.8	14.0
Mode	15.0	14.0	17.0	19.0	12.0	14.0
Kurt	4.6	-0.4	-0.7	-0.5	-1.3	2.1
Skewness	-1.4	0.2	-0.3	-0.6	0.1	1.1
Std. Deviation	1.5	1.9	2.7	3.2	2.2	1.5

SOA- structure of atom
MOA- models of atom
LOCC- laws of chemical combination
MC –mole concept
FT- flame test
PT- periodic table

During the analysis it was found that students have developed concepts clarity to good extent but connectivity between concepts was limited. Students were already aware of structure of atom, models of atom, laws of chemical combination, and mole concept but flame test and periodic table were new concepts for them. Analyzing and inferring the data given in the table exhibited that all concepts fairly understood but mole concept was most comprehended by all.

The standard deviation of each of the test in a graphical representation given below shows that the spread is even for each test.



4.4.12 Qualitative analysis of concept maps

Concepts maps was a new concept. Students found this method quite interesting for understanding as well as for reflection of their understanding. Students constructed concept maps for all six-concept taught. Initially all concepts were introduced in way to arouse inquisitiveness. Concepts were introduced in such a way so that students could connect with their previous understanding. A scaffolding was built in way so that new concept could be easily understood. After introduction few concept maps were shown on smart board and concept was revived again. Along with concept how concepts were related was discussed and how concept maps are constructed was also simultaneously discussed to give the wholesome learning. This not only helped in recognizing MLL of that class but also misconceptions they had. All this enhanced wholesome learning for each and every child. Concepts maps were drawn on black board with the help of student's responses and made connections and branches for each concept. Then at the end each child was encouraged to draw concept maps on all six selected topics of the study. Few photos of selected concept maps constructed by students are shown in appendix 15

4.4.13 Qualitative analysis of opinionnaire of students

An opinionnaire is a set of statements where the group under study is asked to endorse or reject some questions or statements to generalize the view of that group . once the opinionnaire was given to students and they responded a table was formed (Appendix 12). Electronic media was often used by many but sometimes they do discuss assignments with peers Work load according to students was more than expected There was mixed responses on many questions like for question 4,8,10 but for question 1,2,3,5 views were similar.

4.4.14 Qualitative analysis of interview of teachers

NCERT is enough for standard 9. NCERT is more of activities based. Concept are explained through activities. Use of reference books is just for variety of questions Teaching of mole concept liking more as more of mental ability and teaching of models of atoms like less as models are more of theoretical where children less engaged so less concentration. Yes, she you think that concepts of chemistry are clearly defined in the textbook. According to both teacher's language used in the textbook of chemistry for explaining chemistry concepts are easy n simple to understand. Yes in many case they encourage group discussion in class, group discussion in the class is encouraged to broaden our way of thinking and to get more creative concepts and easy approach for topics. Students are motivated to come forward and explain the concept which they have understood the best to support peer learning because sometimes peers can make concept more easily and well explained. Difficulties faced in teaching of the atomic structure are common 3 D structure and live demonstration are easier to understand, and many small concepts are the concepts where students gets confused. They integrate or use ICT in teaching of chemistry for showing flow chart, videos lessons and other demonstrations. They were bilingual at times. They often discussed different concepts with peers for getting ideas about how to teach. Though ICT tools were used but most of the time black board or you tube video lessons are used during teaching

4.4.15 Inference

Pre-test was conducted before the treatment and it was administered on both experimental and control group. Means of pre-test result revealed that experimental group and control group were equivalent groups. It appears that there is no significant difference in the basic understanding level of both the groups as the mean of the pre-test score of both are almost similar.
Data analysis for Median for pre-test for both experimental group and control group indicated not much significant difference was observed.

The Kurtosis of Pre-Test data of Experimental and Control group is less than 0, which indicates it is light tailed dataset. Pre-Test data of Control group has much data in its tails as compare to Experimental group.
Skewness data also indicates that both the groups are similar in terms of their capability to perform and produce result.

Mean difference of pre-test and post-test for Experimental group is approximately 5.27 marks. The significant difference in the Pre and Post Test is the result of the treatment provided to the Experimental group by the investigator.

Table – 4.12 Analysis of Experimental and Control Pre-Test

Analysis of Experimental and control Group Pre-Test		
	Experimental Group	Control Group
Mean	18.838	17.486
Standard Error	0.550	0.852
Median	18.000	17.000
Mode	21.000	13.000
Standard Deviation	3.346	5.043
Sample Variance	11.195	25.434
Kurtosis	-0.314	-0.827
Skewness	0.210	0.124
Range	14.000	20.000
Minimum	12.000	8.000
Maximum	26.000	28.000
Sum	697.000	612.000
Count	37.000	35.000

Mode changed from 21 to 28, 50% of class score above 24.(60% of the total marks), platykurtic distribution, Light Tailed, Kurtosis decrease further of post test, Data is fairy Symmetrical (Skewness between -0.5 to 0.5)

Table – 4.13 Comparison of Experimental Group Pre-Test versus Post-Test

Cumulative Analysis of Experimental		
	Pre Test	Post Test
Mean	18.838	24.108
Standard Error	0.550	0.648
Median	18.000	24.000
Mode	21.000	28.000
Standard Deviation	3.346	3.943
Sample Variance	11.195	15.544
Kurtosis	-0.314	-0.698
Skewness	0.210	-0.010
Range	14.000	16.000
Minimum	12.000	16.000
Maximum	26.000	32.000
Sum	697.000	892.000
Count	37.000	37.000

There is a significant difference in the means value; 6.22 and Median value 6.0 of between Post-Test of experimental and control while the mean value difference between both the group for Pre-Test was only Mean 1.352 and median 1.0 respectively. There is a big improvement seen in the experimental group performance.

Table – 4.14 Comparison of Post-Test Experimental and Control Group

Cumulative Analysis of Post-Test Experimental & Control Group		
	Experimental	Control
Mean	24.10810811	17.88571429
Standard Error	0.648147955	0.812477722
Median	24	18
Mode	28	18
Standard Deviation	3.942530094	4.806683023
Sample Variance	15.54354354	23.10420168
Kurtosis	-0.697892253	-0.561142135
Skewness	-0.010316023	0.207685968
Range	16	19
Minimum	16	10
Maximum	32	29
Sum	892	626
Count	37	35

A paired-samples t-test was conducted to compare Post – Test marks of Experimental and Control group. There was a significant effect. The difference in the marks for Experimental (M=24.11, SD=3.9) and no caffeine (M= 17.89, SD=4.8) conditions; t (66) =5.99, p =0.00. These results suggest that investigator focused on multiple modes of teaching with central idea to enhance environment of learning has significantly improved the result of Experimental group as comparison to the control group.

A Pearson product-moment correlation coefficient was computed to assess the relationship between the Post – Test of the Control group and Post – Test of the Experimental group. There was a positive correlation between the Pre – Test and Post – Test of the Experimental group, (r = 0.214, n = 30, p = 0.256). A scatterplot above summarizes the result. Overall, there was a positive correlation between the Post – Test of the Control group and Post – Test of the Experimental group.

	Post Test	
Pearson Correlation -Post Test	*Experimental*	*Control*
Post Test Experimental Group	1	
Post Test Control Group	0.214209871	1

The chi square result shows that the experimental group is better than the control group. The significance of difference between means is found to be significant at 0.05 level. It implies that the treatment provided in the experiment was effective. (Refer Table 4.10 above)
This result shows that observed and expected frequencies in the experimental group shows Significant differences and this difference observed is true and it is shown by obtaining the Chi square value being significant at 0.05 level of confidence. It shows that the experimental group achievement result is not due to chance factors but a true representation of the Achievement as a difference for progress.

From all the above test which includes Mean, Median , Standard Deviation, t-Test , Pearson product correlation and Chi Test , all indicates that Null Hypothesis is rejected and the study conducted was successful.

Chapter 5

Major findings, Summary, Conclusion and Suggestions

Major findings, Summary conclusions and suggestions

5.0 Introduction

It is widely accepted that the function of educational research is to identify the problem that confront educational research and academic excellence of higher secondary students. It is vital and critical to all learning that appropriate skills, abilities and local competencies will determine the academic results. Today the life has become more competitive and challenging with best performance. Education has always been important but perhaps never more so in man's history than today. In the current situation of Corona pandemic, this statement does not need any testimony while the entire pharma and scientist fraternity is busy finding a solution to the current pandemic globally. Undoubtedly Importance of chemistry as a branch of science which is enabling the current research for CORONA vaccine need no explanation. Education helped the society and its constituents to upgrade and upscale living conditions, which in turn enhanced the satisfaction quotient of a human being, as a better living index is a sign which ensures prosperous living. Education is the most powerful tool for social change. Mission of education is to promote student achievement and prepare them for global competitiveness by fostering educational excellence and ensuring equal access.

Society looks upon teachers and their capability to not only keep the interest alive amongst the students to study the deep and complex fundamental of science and more so chemistry but also banking a lot on teachers to spark the interest amongst students to engage themselves constrictively to identify new solutions and technologies for the betterment of the living conditions of mankind in the ever changing and ever challenging new and complex problems. Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity, particularly in relation to the environment. Science helps in connecting knowledge across disciplinary boundaries to provide a broader framework for insightful construction of knowledge. Science is a dynamic, expanding body of knowledge, covering ever -new domains of experience. In a progressive forward -looking society, science can play a truly liberating role in helping people escape from the vicious cycle of poverty, ignorance and superstition.

Modern education emphasizes ~~on~~ learner centered approach and joyful learning which is advocated by educationists and many education commissions. According to them, children need to keep active throughout the teaching and learning process and encourage self-learning and independent learning. The present education practice also emphasizes the importance of technology usage in education. It is observed that the learner, the teacher and the learning experience are influenced by computer and information and communication technology. Enabling Platform like Skype, Microsoft Team and Zoom etc., enhances and increases the speed of learning exponentially as it provides opportunity to learners to get associated with like mined people and communities of similar interest at the comfort of location of their own choice.

Chemistry is the study of matter and energy and the interaction between them. There are many reasons to study chemistry, even if you aren't pursuing a career in science. Chemistry is an incredibly fascinating field of study, because it is so fundamental to our world, chemistry plays a role in everyone's lives and touches almost every aspect of our existence in some way. Chemical

technologies enrich our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world. Chemistry as a subject has a significant importance in students daily lives and the society in general. Everything on the earth is made of chemicals. Chemistry helps students understand how items around them are made e.g. cooking gas. In our daily life, we fall sick and consequently need drugs which are made by scientists through chemistry. Main Objectives of teaching chemistry at higher secondary level (Source Anand Krishnan K 2017) are to acquire real scientific Knowledge, develop in the students the capacity to solve problems and last but not lest to develop interest of pupil in learning chemistry.

Table 1.0 Objectives of Chemistry curriculum Primary, Secondary and Higher Secondary

Primary	Knowledge	Interest, Attitude, appreciation	Observation, Manipulative
Secondary	Knowledge Comprehension, Meta cognitive, Application	Interest, Appreciation, Habit Formation	Observation, Drawing, experimental skill
Higher Secondary	Knowledge Comprehension, Meta cognitive, Application, Analysis, Synthesis, Evaluation	Interest, Appreciation, Habit Formation, Attitude	Observation, Drawing, Problem solving

(Source Anand Krishnan K 2017)

The Fundamentals of Chemistry may include an introduction to the matter, (pure substances, mixtures), atoms and molecules, element and compounds, ions, electrons, protons, neutrons, atomic mass, molecular mass, formula unit mass, laws of chemical combination, mole concept, structure of atom, models of atom, electrons distribution in different orbits, valency atomic number, mass number, isotopes ,isobars, periodic table, flame test, symbols of elements, formulae of simple compounds and many more. Chemistry has a crucial role in finding sustainable solutions to challenges like energy crisis, environmental protection, health care, food and water safety. Green chemistry is another project which strives to work at molecular level to achieve better environment. Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances and discovery and application of new chemical technologies leading to the prevention / reduction of hazardous chemicals which

deteriorate the environment and to conserve materials and energy (EPA, March). Therefore, it is essential for secondary student to gain deep knowledge about chemistry so that they can acquire some interest in not only learning but for ensuring that knowledge of chemistry can also help them land in a rewarding career in the industry and in educational institution.

Certain conceptual hinderances in enhancing key fundamentals concepts like; Difficulties in comprehending, Difficulty in visualization in teaching/learning of chemistry, Difficulties in effective demonstration, Behavioral problems related with chemistry learning can be greatly addressed through by ensuring that design of the curriculum of chemistry should be simple, application led, not too much content laden, language should be user friendly, should develop interest in conceptual understanding, Offer experiences of graded problem-solving situations starting from the more algorithmic and moving on to the more open-ended, Involve laboratory work with very clear aims and the most important part is to ensure that assessment should be integrated into curriculum itself which will enhance better understanding of the concept and give affair idea to teacher the extent to which the subject is actually clear to students , this will ensure that teacher should only go to next level / topic once the existing topic is thoroughly understood by majority, this will avoid rote memorization.

Several pedagogies are used to make chemistry learning an experience full of understanding like; Problem Based Learning, Process Oriented Guided Inquiry Learning, Project Based Learning (PjBL), Peer Lead Team Learning, Peer Lead Guided Inquiry, Peer Instruction. There have been several technological developments like YouTube, computer simulations, Extra marks Khan Academy etc, have catalyzed the pedagogical developments which supports the student learning for reflections, critiquing and concept mapping. Some other example of technological developments is ***Turntin or kahoot*** are used for checking lab reports

Spatial ability, concept map, constructivism, collaborative learning and minimizing misconception using Johnstone's triangle have been some useful learning strategies for the development of fundamental concept of chemistry. Many researches

The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry.

The dependent variable is achievement in chemistry and the independent variables are capacity to develop concept maps, strategy and learning together cooperatively.

This chapter includes brief summary, findings of the study, implication of the study, limitations of the study, and suggestion for further research.

5.1 Rationale

In order bring a paradigm change from being a developing country to a developed nation India needs to revamp and improve radically its system of education and specially in the field of science as Science is the backbone for any innovative developments which benefits masses and brings cluster of developmental ecosystem. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry. We are living in volatile, uncertain, complex and ambiguous (VUCA) world and to remain relevant in the continuously changing expectations of the society from the fraternity of science and technology it is vital that education should remain meaningful and enjoyable. India has made tremendous progress over the last few years, but we still need an education system which is constantly reviewed for its efficacy to ensure that changes if required are done in a manner that we should be able to progress at a much higher rate to ensure we bridge the gap in science and technology vis-a vis other competing nations. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry.

The education commission report (1964-66) has dealt with science education in depth, dealing with the quality of science education.. The main purpose of teaching chemistry is to make students of chemistry understand the basic concept of chemistry which includes organic , inorganic and physical chemistry needed for the further study of modern science and technology and to understand its application. Education commission also advocates that one of the factors that impede progress in pedagogy up gradation is the failure to develop proper educational research on teaching methods..

There should be a general atmosphere of reform. Experimental efforts should be encouraged and new methods of teaching diffused among all schools and teachers. The diffusion of new methods is necessary". A change in the model of teaching is required, so that the child makes meaningful connections between his/her prior concepts with new knowledge. For achieving this in the class room the teacher and the student need to actively engage in making meaningful connections. The research in chemistry education is focusing now more on the process of understanding and improving of chemistry learning. For some students' chemistry consist of a large number of apparently unrelated, irrelevant and useless materials that they have to memorized rather than understood. In chemistry, our senses cannot help us form concepts of elements and compounds, atoms or molecules, electrons or protons- one operates in a very different intellectual area. These concepts are not tangible in the way most of other concepts are. Therefore, many students feel that they do not have to understand chemistry, but rather memorize the different concepts. Thus, they concentrate on exam marks rather than on the development of the concept.

Also, English medium students are learning chemistry through a language which is not their mother tongue. Especially, at primary and secondary level when chemistry taught through a foreign

language problem enabling the child to correctly comprehend the basic laws and concepts of chemistry is real one. Even if student understands the concepts he may find difficult in expressing his thought in his own words and to write in exams he may learn by cramming the concepts. This habit is developed in primary and secondary school education. By the time they came to the 9th standard they have a fractional understanding of the basic concepts of chemistry. Their habit of rote memorization hinder the understanding of concepts of chemistry

Investigator has selected this topic for study to understand the difficulties encountered by students in achieving level of understanding and their ability to grasp knowledge. The investigator would study the gaps between actual and expected scenario, another objective is to study reaction of students and teachers towards the treatment.

5.2The objectives of the study

1. To study the fundamental concepts of the chemistry
2. Study the opinion of chemistry Teachers on fundamental concepts.
3. To study reaction of students towards the treatment
4. Difficulties encountered by students in achieving the level of understanding

5.3 Operational definition of terms

Concept mapping or concept Diagramming: For the proposed study a concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts.

Fundamental concepts: For the proposed study Fundamental concepts in the study means the base on which the whole structure of knowledge for that field is built upon.

Micro formative assessment(MFA): For the proposed study MFA means very small/ micro assessment which include very less content ie one or two concepts. For the present study it was two sets of 10 questions each.

Misconception: For the proposed study a view or opinion that is incorrect because based on faulty thinking or understanding.

Multiple mode of presentation : For the proposed study Multiple modes of presentation refers to the various methods/strategies used for teaching of six selected concepts.

Spatial ability: For the proposed study Spatial ability or Visio-spatial ability is the capacity to understand, reason and remember the spatial relations among objects or space.

Treatment: For the proposed study Treatment means the efforts taken during the teaching of six selected concepts by investigator on experimental group.

5.4 Delimitations of the study

1. The present Study would be delimited to few fundamental concepts chosen of grade 9 Chemistry text book

2. The present study would be delimited to English medium school of New Delhi affiliated to Central Board of Secondary Education

5.5 Hypothesis of the study

There will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of teaching (including MFA) and control group with traditional methods.

5.6 Design of the study

A quasi-experimental design was implemented. The design used consisted of non-equivalent groups with pretest and a post-test because of the need to use intact classes to measure group differences. The study examined the effectiveness of treatment to understand the fundamental concepts of chemistry in ninth standard of CBSE school in Delhi.. Treatment studies the effect of multiple mode of technology integration, concept maps on achievement ,effect of micro assessments on achievement. Each of the concept was presented holistically with the central theme of making concepts clear, easy, and interesting.

5.7 Population of Study

Education in Delhi is provided/governed/regulated by the Department of Education (DoE), Govt of NCT, Delhi. For the above purpose, entire Delhi is categorised into 'Districts' and further sub-categorised into 'Zones' of education.

In Zone 18, District West-B, New Delhi there are three types of Schools. Government (Run by DoE), Government Aided (Governed by DoE) and Private Unaided (Regulated by DoE).

Approximately 10,600 students studying in Class IX in the all the Schools of 'Zone 18' constitute the population of Study. The details of total number of Schools and Students studying in Class IX covered under each type of School are mentioned below:

Table 3.0 Data on Numbers of various types of schools of Zone 18, District West- B Delhi

S.No.	Type of School	Total No. of Schools *	Approx. total No. of Students #
1	Government School	42	4200
2	Government Aided School	05	500
3	Private Unaided School	59	5900
	Total	**106**	**10600**

(Source : * Information available on official website of Department of Education, Delhi. # Assuming on an average 100 students study in each type of School)

5.8 Sampling Technique

Randomized purposive cluster sampling was used with explicit purpose of enhancing understanding of fundamental concepts in chemistry. The basic concept of purposive sampling technique is, to select the representative sample from the big population. The samples are selected on the bases of some questions like; who can represent the characteristics of population, and who can give the required information, etc Logic, common-sense and availability of required experimental condition are required here. Schools are having their tight academic schedule throughout the year, so very few schools are permitting for research work. Hence random sampling is not possible here. In random sampling it is not all time possible that randomly selected school will give permission for experiment, data collection and experimental work. The study was experimental so investigator selected two schools from the population. The investigator selected random purposive sampling technique in the selection of school. Two schools of New Delhi were purposefully selected for the present study.

5.9 Sample

As the present study was experimental one, the investigator had decided to select two schools from the population. The investigator selected randomly purposive sampling technique in the selection of school. Two schools of New Delhi were purposefully selected for the present study. The sample for the present study consisted of 89 students studying in Class IX which were randomly selected. The sample constituted of two sections, one section was control group and other section was experimental group of two different schools Both the private schools selected were co-educational English medium schools and were situated in densely populated area of District West B Zone of New Delhi, the sample ensured a fair representation of students from all the sections of the society.

5.10 Tools and techniques used for the study are described below

Academic achievement tests : This test was constructed by investigator for six concepts taken in the study. The test comprised of 40 marks having 40 MCQ for pre-test and similar test of 40 marks having 40 MCQ for post-test.
Multiple modes of presentation: Videos and information from different resources are shown in class or send through whatsapp groups.
Concept maps: Concept map was used as a tool, that enriches students' understanding of a new concept, by building relationships between abstract ideas and concepts which deepens understanding and comprehension. Students were shown many concept maps for each topic selected and then given practice for concept diagramming.
Brief information on the selected topics
Micro Formative Assessment- This test was constructed by the investigator for six concepts taken in the study. The test comprised of 20 questions with weightage of 20 marks having basic and simple test items in the form of MCQ..
Problem solving: This tool was used for concepts of mole concept and laws of chemical combination thereby helping students in better understanding and application of concepts.
Opinionnaire for students: This tool was used for taking opinions of the students to analyse content and methodology.
8.Interview schedule for teachers: This tool would be used to understand the concept clarity, difficulties encountered in teaching of abstract concepts, concept mapping and problem solving and to analyse content and methodology.

5.11 Data Collection

Data was collected from four sources academic achievement pre-test, post-test, opinionnaire for students, interview schedule for teachers.

5.11.1 The Academic achievement test was administered by the investigator to 89 students of grade 9 belonging to two different schools. The Academic achievement tests - Pre-test and Post-test were designed to ascertain the effectiveness of the treatment by measuring the learners performance on clearly defined educational tasks. Through the Academic achievement test the terminal behaviour of the learner reached after the completion of the unit of an instructional programme is assessed for ascertaining the extent to which the set objectives have been realized. Academic achievement tests were prepared by the investigator for the present study. The test was prepared for the students studying in Class IX under CBSE Syllabus. Both pre-test and post-test were equivalent tests

5.11.2 Administration of Pre-test

Administration of Pre-test: On the first day, the academic achievement pre-test developed by the investigator was administered as pre-test on one section of each school-experimental and control. Though there was no specified time limit for this test, it took a period of forty minutes duration to complete the test. This includes the time taken for giving instructions and distributing test booklets and collecting them back The students were directed to follow the given instructions.

5.11.3Administration of Post-test

Administration of Post-test: On completion of treatment of all six fundamental concepts through technology integrated, contructivist approach and using MFA to experimental group and Traditional Method for control group. Almost equivalent test was administered as post-test to both the groups The students were asked to respond to each item by putting a tick mark on the correct answer. It has been noticed that the students of both the groups took lesser time to complete the test as compared to the time taken by them to complete the test when it was administered as pre-test.
The test paper of both pre test and post test were collected and items were evaluated by investigator and scores were noted for further analysis and interpretation of data.

5.11.4 Opinionnaire of students

On the last day, the students of experimental group who were taught through the technology were given an opinionnaire to give their opinions towards the treatment. The opinionnaire consisted ten statements with necessary instructions for the students. The students were requested to put tick mark on any one of the answers which they feel apt about the programme. The students took approximately 30 minutes to complete the opinionnaire

5.11.5 Interview of teachers

The aim of the researcher to prepare this tool was to evaluate the program by getting the opinions and feedbacks from the teachers regarding implementation and implications. Also in order to judge the effectiveness of the treatment and proposed pedagogical tools, an interview of teachers. Few basic questions were discussed during the interview in order to judge the opinions of two chemistry teachers regarding implementation and effectiveness of the treatment and also the experiences of teachers.

5.12 Data Analysis and inferences

Pre-test was conducted before the treatment and it was administered on both experimental and control group. Means of pre-test result revealed that experimental group and control group were equivalent groups. It appears that there is no significant difference in the basic understanding level of both the groups as the mean of the pre-test score of both are almost similar.
Data analysis for Median for pre-test for both experimental group and control group indicated not much significant difference was observed.

The Kurtosis of Pre-Test data of Experimental and Control group is less than 0, which indicates it is light tailed dataset. Pre-Test data of Control group has much data in its tails as compare to Experimental group.

Skewness data also indicates that both the groups are similar in terms of their capability to perform and produce result.

Table – 4.12 Analysis of Experimental and Control Pre-Test

Analysis of Experimental and control Group Pre-Test		
	Experimental Group	Control Group
Mean	18.838	17.486
Standard Error	0.550	0.852
Median	18.000	17.000
Mode	21.000	13.000
Standard Deviation	3.346	5.043
Sample Variance	11.195	25.434
Kurtosis	-0.314	-0.827
Skewness	0.210	0.124
Range	14.000	20.000
Minimum	12.000	8.000
Maximum	26.000	28.000
Sum	697.000	612.000
Count	37.000	35.000

Mean difference of pre-test and post-test for Experimental group is approximately 5.27 marks. The significant difference in the Pre and Post Test is the result of the treatment provided to the Experimental group by the investigator,

Mode changed from 21 to 28, 50% of class score above 24.(60% of the total marks), platykurtic distribution, Light Tailed, Kurtosis decrease further of post test, Data is fairy Symmetrical (Skewness between -0.5 to 0.5)

Table – 4.13 Comparison of Experimental Group Pre-Test versus Post-Test

Cumulative Analysis of Experimental		
	Pre Test	Post Test
Mean	18.838	24.108
Standard Error	0.550	0.648
Median	18.000	24.000
Mode	21.000	28.000
Standard Deviation	3.346	3.943
Sample Variance	11.195	15.544
Kurtosis	-0.314	-0.698
Skewness	0.210	-0.010
Range	14.000	16.000
Minimum	12.000	16.000
Maximum	26.000	32.000
Sum	697.000	892.000
Count	37.000	37.000

There is a significant difference in the means value; 6.22 and Median value 6.0 of between Post-Test of experimental and control while the mean value difference between both the group for Pre-Test was only Mean 1.352 and median 1.0 respectively. There is a big improvement seen in the experimental group performance.

Table – 4.14 Comparison of Post-Test Experimental and Control Group

Cumulative Analysis of Post-Test Experimental & Control Group		
	Experimental	Control
Mean	24.10810811	17.88571429
Standard Error	0.648147955	0.812477722
Median	24	18
Mode	28	18
Standard Deviation	3.942530094	4.806683023
Sample Variance	15.54354354	23.10420168
Kurtosis	-0.697892253	-0.561142135
Skewness	-0.010316023	0.207685968
Range	16	19
Minimum	16	10
Maximum	32	29
Sum	892	626
Count	37	35

A paired-samples t-test was conducted to compare Post – Test marks of Experimental and Control group. There was a significant effect. The difference in the marks for Experimental (M=24.11, SD=3.9) and control (M= 17.89, SD=4.8) conditions; t (66) =5.99, p =0.00. These results suggest that investigator focused on multiple modes of teaching with central idea to enhance environment of learning has significantly improved the result of Experimental group as comparison to the control group. (Refer Table 4.7)

A Pearson product-moment correlation coefficient was computed to assess the relationship between the Post – Test of the Control group and Post – Test of the Experimental group. There was a positive correlation between the Pre – Test and Post – Test of the Experimental group, (r = 0.214, n = 30, p = 0.256). A scatterplot above summarizes the result. Overall, there was a positive correlation between the Post – Test of the Control group and Post – Test of the Experimental group. (Refer Graph 4.16)

	Post Test	
Pearson Correlation -Post Test	*Experimental*	*Control*
Post Test Experimental Group	1	
Post Test Control Group	0.214209871	1

The chi square result shows that the experimental group is better than the control group. The significance of difference between means is found to be significant at 0.05 level. It implies that the treatment provided in the experiment was effective. (Refer Table 4.10)
This result shows that observed and expected frequencies in the experimental group shows Significant differences and this difference observed is true and it is shown by obtaining the Chi square value being significant at 0.05 level of confidence. It shows that the experimental group achievement result is not due to chance factors but a true representation of the Achievement as a difference for progress.

From all the above test which includes Mean, Median , Standard Deviation, t-Test , Pearson product correlation and Chi Test , all indicates that Null Hypothesis is rejected and the study conducted was successful.

5.13 Major Findings of the study

1. Students could comprehend fundamental concepts
2. The enriched environment and treatment facilitated enhanced learning.
3. Multiple modes of presentation, peer interaction and wholesome learning enhanced learning of fundamental concepts.

5.14 Summary

Fundamental concepts of chemistry are the building blocks upon which new knowledge is constructed. If the lack of understanding of the basic concepts and difficulties in studies are identified, then a remedial course of action will help in enhancing their learning. It is a fact that sound basic fundamental concepts are not developed all of a sudden. Focus of teaching should be on joyful learning which provides intrinsic motivation to students.

In primary and middle school, students do not learn chemistry as separate subject, they learn chemistry as a part of science because there are many concepts which are common and many concepts are interrelated. So proper understanding of fundamental concepts is essential. Moreover learning at this stage should not be examination oriented but efforts should be to enhance benchmark of MLL for all students. Sound fundamental concepts not only help as scaffolding for difficult concepts but also makes students inquisitive and motivated intrinsically.

Study was quasi-experimental design where selected fundamental concepts were taught with with multiple modes of presentation (including MFA) to experimental group and control group with traditional methods.

Null hypothesis stated that there will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of teaching (including MFA) and control group with traditional methods.

A study of fundamental concepts showed that after the treatment mean difference between control group and experimental was approximately 6.22 marks approximately and mean difference between pre-test and post-test of experimental group was approximately 5.27 marks. Multiple modes of presentation was used for selected fundamental concepts. Data analysis and interpretation of data revealed through statistical measures that differences observed between experimental and control group was not by chance. Statistical measures like standard deviation, mean, t-test, chi square, product moment of correlation all reveal that null hypothesis should be rejected and treatment showed significant difference between experimental group and control group.

Qualitative analysis of concept maps revealed that many students could make concept map and could link the concepts with fundamental concepts. Students could do branching and inter-relate branches. More the branching better the concepts maps and thus better academic achievement score. A qualitative analysis of the students concept maps and students performance test showed that students who constructed more holistic and complex concept maps were able to solve problems more effectively. Though concept maps helped all students in making connections with fundamental concepts but this set of students could comprehend better and had more interactions in class with peers and teachers than their counterparts who had less developed concept maps.

5.15 Suggestions for further research

Investigator has done study using concept maps as one of the tools of study and suggests further studies on use of concept maps for all stages and subjects. Moreover concept maps were assessed qualitatively and no scoring was done. Investigator suggests the use of programmed instructed material for construction as well as for scoring of constructed concept maps.

Along with other technological intervention MFA was used as a tool for aiding construction of knowledge and for assessing MLL of fundamental concepts of chemistry by grade nine students. Investigator used micro formative assessments(MFA) only once in each period but suggests that in more planned phases it can be used twice or thrice or even four times ,which would help in recapitulating concepts and assessing terminal points very effectively.

Competency based teaching techniques is another wide area wherein lot of research in chemistry can be done at high school level, as aspiration of students are different and various levels of competency should be available to them. Competency based teaching using concept maps can be another field of study. Various technology integration in teaching as well as assessment maybe the areas where focus in present times is required.

Investigator has done the study in face to face mode but many other options of online and off line modes need attention. Though many studies recommended technological integration but less work is done on raising benchmark of MLL with Micro Formative Assessment (MFA).

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A STUDY ON FUNDAMENTAL CONCEPTS OF CHEMISTRY

A Synopsis of the Study

Guide

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A Synopsis of the Study

6.0 Introduction

It is widely accepted that the function of educational research is to identify the problem that confront educational research and academic excellence of higher secondary students. It is vital and critical to all learning that appropriate skills, abilities and local competencies will determine the academic results. Today the life has become more competitive and challenging with best performance. Education has always been important but perhaps never more so in man's history than today. In the current situation of Corona pandemic, this statement does not need any testimony while the entire pharmaceutical and scientist fraternity is busy finding a solution to the current pandemic globally. Undoubtedly Importance of chemistry as a branch of science which is enabling the current research for corona vaccine need no explanation. Education has helped the society and its constituents to upgrade and upscale living conditions, which in turn enhanced the satisfaction quotient of a human being, as a better living index is a sign which ensures prosperous living. Education is the most powerful tool for social change. Mission of education is to promote student achievement and prepare them for global competitiveness by fostering educational excellence and ensuring equal access.

Society looks upon teachers and their capability to not only keep the interest alive amongst the students to study the deep and complex fundamental of science and more so chemistry but also banking a lot on teachers to spark the interest amongst students to engage themselves constrictively to identify new solutions and technologies for the betterment of the living conditions of mankind in the ever changing and ever challenging new and complex problems. Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity, particularly in relation to the environment. Science helps in connecting knowledge across disciplinary boundaries to provide a broader framework for insightful construction of knowledge. Science is a dynamic, expanding body of knowledge, covering ever -new domains of experience. In a progressive forward -looking society, science can play a truly liberating role in helping people escape from the vicious cycle of poverty, ignorance and superstition.

Modern education emphasizes learner centered approach and joyful learning which is advocated by educationists and many education commissions. According to them, children need to keep active throughout the teaching and learning process and encourage self-learning and independent learning. The present education practice also emphasizes the importance of technology usage in education. It is observed that the learner, the teacher and the learning experience are influenced by computer and information and communication technology. Enabling Platform like Skype, Microsoft Team and Zoom etc., enhances and increases the speed of learning exponentially as it provides opportunity to learners to get associated with like mined people and communities of similar interest at the comfort of location of their own choice.

Chemistry is the study of matter and energy and the interaction between them. There are many reasons to study chemistry, even if you aren't pursuing a career in science. Chemistry is an incredibly fascinating field of study, because it is so fundamental to our world, chemistry plays a role in everyone's lives and touches almost every aspect of our existence in some way. Chemical

technologies enrich our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Thus, studying chemistry is useful in preparing us for the real world. Chemistry as a subject has a significant importance in students daily lives and the society in general. Everything on the earth is made of chemicals. Chemistry helps students understand how items around them are made e.g. cooking gas. In our daily life, we fall sick and consequently need drugs which are made by scientists through chemistry. Main Objectives of teaching chemistry at higher secondary level are to acquire real scientific Knowledge, develop in the students the capacity to solve problems and last but not least to develop interest of pupil in learning chemistry.

6.1 Rationale

In order bring a paradigm change from being a developing country to a developed nation India needs to revamp and improve radically its system of education and specially in the field of science as Science is the backbone for any innovative developments which benefits masses and brings cluster of developmental ecosystem. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry. We are living in volatile, uncertain, complex and ambiguous (VUCA) world and to remain relevant in the continuously changing expectations of the society from the fraternity of science and technology it is vital that education should remain meaningful and enjoyable. India has made tremendous progress over the last few years, but we still need an education system which is constantly reviewed for its efficacy to ensure that changes if required are done in a manner that we should be able to progress at a much higher rate to ensure we bridge the gap in science and technology vis-a vis other competing nations. The purpose of the study is to explore the factors that influence enhancement of fundamental concepts in chemistry.

The education commission report (1964-66) has dealt with science education in depth, dealing with the quality of science education. The main purpose of teaching chemistry is to make students of chemistry understand the basic concept of chemistry which includes organic, inorganic and physical chemistry needed for the further study of modern science and technology and to understand its application. Education commission also advocates that one of the factors that impede progress in pedagogy up gradation is the failure to develop proper educational research on teaching methods

There should be a general atmosphere of reform. Experimental efforts should be encouraged, and new methods of teaching diffused among all schools and teachers. The diffusion of new methods is necessary". A change in the model of teaching is required, so that the child makes meaningful connections between his/her prior concepts with new knowledge. For achieving this in the class room the teacher and the student need to actively engage in making meaningful connections. The research in chemistry education is focusing now more on the process of understanding and improving of chemistry learning. For some students' chemistry consist of a large number of apparently unrelated, irrelevant and useless materials that they have to memorized rather than understood. In chemistry, our senses cannot help us form concepts of elements and compounds,

atoms or molecules, electrons or protons- one operates in a very different intellectual area. These concepts are not tangible in the way most of other concepts are. Therefore, many students feel that they do not have to understand chemistry, but rather memorize the different concepts. Thus, they concentrate on exam marks rather than on the development of the concept.

Also, English medium students are learning chemistry through a language which is not their mother tongue. Especially, at primary and secondary level when chemistry taught through a foreign language problem enabling the child to correctly comprehend the basic laws and concepts of chemistry is real one. Even if student understands the concepts he may find difficult in expressing his thought in his own words and to write in exams he may learn by cramming the concepts. This habit is developed in primary and secondary school education. By the time they came to the 9^{th} standard they have a fractional understanding of the basic concepts of chemistry. Their habit of rote memorization hinder the understanding of concepts of chemistry

Investigator has selected this topic for study to understand the difficulties encountered by students in achieving level of understanding and their ability to grasp knowledge. The investigator would study the gaps between actual and expected scenario, another objective is to study reaction of students and teachers towards the treatment.

6.2 Review of research studies

Research is an iterative process but still enjoys a significant place in all the fields of knowledge. Research strengthens and revitalizes the field in which the research was carried out. The review revealed that every researcher conducted study with different perspectives and approach. A total of 23 studies were reviewed by investigator. From the above review, it was found that many studies are conducted in India as well as abroad in the different area of chemistry. Major area in which investigator was interested are difficulties encountered by students during understanding of fundamental concepts, concept mapping, students misconceptions, practical work in chemistry, spatial ability, assessment techniques, constructivism approach etc.

Many of the studies reviewed were experimental but few like of Griffiths and Preston, Atef Yousef, Alkhutaba, Parasurama, Shankar C were survey studies. Griffiths and Preston conducted study with semi-structured interview Griffiths and Preston (1992) investigated 12th-grade Canadian students' understanding of the concepts of atom and molecule, Haidar and Abraham (1991) compared applied and theoretical knowledge that 11th- and 12th-grade chemistry students had. Few researchers like Doran (1972) conducted the study in the area of misconceptions and curriculum development. He investigated on elementary school student’s misconception of chemistry concepts related to particulate nature of matter. Priyadarshini. E, Patel R C, studied on pedagogical approach to refute misconception in science (IUCTE 92). Merryn L conducted a mixed-method design of study while William James Loyd conducted a qualitative study on elementary school students and teachers related to collaborative learning. Review includes a study on constructivist approach on social science by Parasurama. He conducted a study on an Impact

of Technology Based Constructivist Teaching on Academic Achievement of IX Standard Students of Bengaluru City. The study aims at comparing effectiveness of Constructivist Teaching and Technology Based Constructivist Teaching on academic achievement of students. Some of the main objectives of the study were to develop Constructivist Teaching (CT) and Technology Based Constructivist Teaching (TBCT) package for selected units of IX standard Social Science subject

Investigator found few studies on concept mapping done by Nicoll G Francisco, J and Nakhleh M, Anamika, Ahmed Shukri Shawli. Ahmed Shukri Shawli conducted an exploratory, descriptive study of students' cognitive load and mental effort related to complex problem solving in high school chemistry. Nicoll G Francisco, J and Nakhleh M (2001) studied the value of using concepts maps in general chemistry. Anamika (2011) studied an experiment on concept mapping, cognitive skill and concept attainment of the 9th Grade Chemistry Students. Few studies like of John,Treesa, Anand Krishnan were on programmed instructional material .Anand Krishnan K (2017) investigated on development of multimedia courseware for teaching chemistry at higher secondary level. Atef Y M, alkhutaba (2012) studied the attitude of chemistry teachers towards using the computer in teaching eleventh grade. Prakash, B. (1990) studied the effectiveness of concrete materials to enhance learning in physical sciences.

Review also include a project study on formative assessment done by Elaina Edman Stephen G. Gilbreth Sheila Wynn on Implementation of Formative Assessment in The Classroom. The mission of this project was to identify the formative assessment literacy levels and the degree of classroom implementation of these strategies in districts and the resulting implications for leadership. The purpose of the project was to determine the use and implementation of formative assessments in classrooms in southwest Missouri.

Reviews related to spatial ability revealed following Teehee Noh (1995) conducted a study on the instructional influence of pictorial presentation of matter at the molecular level on student's conceptions and problems solving ability. Shamin Padalkar and Hegarty (2014) worked on developing representational competence in chemistry. The investigators noted spatial ability concept is not practiced in schools. Spatial reasoning has been linked to success in learning STEM subjects. Few studies examine middle school students' or in-service middle school teachers' understanding of chemistry concepts or its relation to spatial reasoning ability.

The investigator has chosen this study as none of the above reviewed studies have focused on attainment of fundamental concepts in relation to technology integration and micro-assessments in traditional teaching. This experimental study endeavors to assess the fundamental concepts of chemistry of grade 9 students.

6.3 Objectives of the study

1. To study the fundamental concepts of the chemistry
2. Study the opinion of chemistry Teachers on fundamental concepts.
3. To study reaction of students towards the treatment
4. Difficulties encountered by students in achieving the level of understanding

6.4 Statement of the Problem

A study on fundamental concepts of chemistry

6.5 Operational definition of terms

Concept mapping or concept Diagramming: For the proposed study a concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts.

Fundamental concepts: For the proposed study Fundamental concepts in the study means the base on which the whole structure of knowledge for that field is built upon.

Micro formative assessment(MFA): For the proposed study MFA means very small/ micro assessment which include very less content ie one or two concepts. For the present study it was two sets of 10 questions each.

Misconception: For the proposed study a view or opinion that is incorrect because based on faulty thinking or understanding.

Multiple mode of presentation : For the proposed study Multiple modes of presentation refers to the various methods/strategies used for teaching of six selected concepts.

Spatial ability: For the proposed study Spatial ability or Visio-spatial ability is the capacity to understand, reason and remember the spatial relations among objects or space.

Treatment: For the proposed study Treatment means the efforts taken during the teaching of six selected concepts by investigator on experimental group.

6.6.Hypotheses

There will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of teaching (including MFA) and control group with traditional methods.

6.7 Population of study

Education in Delhi is provided/governed/regulated by the Department of Education (DoE), Govt of NCT, Delhi. For the above purpose, entire Delhi is categorised into 'Districts' and further sub-categorised into 'Zones' of education.

In Zone 18, District West-B, New Delhi there are three types of Schools. Government (Run by DoE), Government Aided (Governed by DoE) and Private Unaided (Regulated by DoE).

Approximately 10,600 students studying in Class IX in the all the Schools of 'Zone 18' constitute the population of Study. The details of total number of Schools and Students studying in Class IX covered under each type of School are mentioned below:

S.No.	Type of School	Total No. of Schools *	Approx. total No. of Students #
1	Government School	42	4200
2	Government Aided School	05	500
3	Private Unaided School	59	5900
	Total	**106**	**10600**

Table 3.0 Data on Numbers of various types of schools of Zone 18, District West- B Delhi

(Source : * Information available on official website of Department of Education, Delhi. # Assuming on an average 100 students study in each type of School)

6.8 Sampling Technique

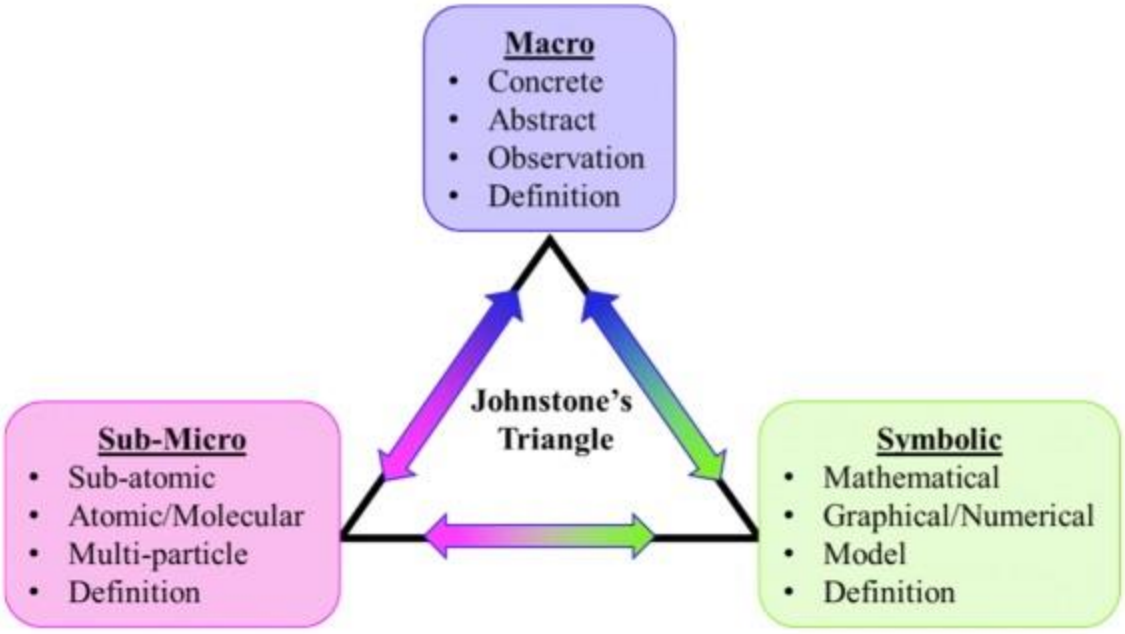
Randomized purposive cluster sampling was used with explicit purpose of enhancing understanding of fundamental concepts in chemistry. The basic concept of purposive sampling technique is, to select the representative sample from the big population. The samples are selected on the bases of some questions like; who can represent the characteristics of population, and who can give the required information, etc. Logic, common-sense and availability of required experimental condition are required here. Schools are having their tight academic schedule throughout the year, so very few schools are permitting for research work. Hence random sampling is not possible here. In random sampling it is not all time possible that randomly selected school will give permission for experiment, data collection and experimental work. The study was experimental, so investigator selected two schools from the population. The investigator selected random purposive sampling technique in the selection of school. Two schools of New Delhi were purposefully selected for the present study.

6.9 Sample

The sample for the present study consisted of 89 students studying in Class IX which were randomly selected Both the private schools selected were co-educational school. As these schools are situated in densely populated area Janak Puri , the sample ensures a fair representation of students from all the sections of the society

6.10 **Tools and Techniques of research**

It is generally accepted that chemistry is inherently a difficult subject to learn. A major problem arises because the basic concepts of chemistry can only be interpreted in submicro level and representational notations of unseen conceptual models. It is difficult for students to link chemistry at this sub-micro level with their everyday lives and thus fail to see the underlying relevance of much of the chemistry they are taught. Therefore investigator worked on to develop sound pedagogical tools for linking teaching chemistry contents with everyday life. (Johnstone's 1991)



Johnstone, A. H. 1993. The development of chemistry teaching: A changing response to changing demand. Journal of Chemical Education, 70(9), p. 701-705;

Figure -3 Johnstone's Triangle

Tools and techniques of the study were

1 Multiple modes of Technology: Videos and information from different resources are shown in class or send through whatsapp groups
2 Concept maps: Concept map was used as a tool, that enriches students' understanding of a new concept, by building relationships between abstract ideas and concepts which deepens understanding and comprehension. Students were shown many concept maps for each topic selected and then given practice for concept diagramming.
3 Brief information on the selected topics:
4 Micro Formative Assessment- This test was constructed by the investigator for six concepts taken in the study. The test comprised of 20 questions with weightage of 20 marks having basic and simple test items in the form of MCQ..
5 Problem solving: This tool was used for concepts of mole concept and laws of chemical combination thereby helping students in better understanding and application of concepts.
6 Opinionnaire for students: This tool was used for taking opinions of the students to analyse content and methodology.
7 Interview schedule for teachers: This tool would be used to understand the concept clarity, difficulties encountered in teaching of abstract concepts, concept mapping and problem solving and to analyse content and methodology.

6.11 Data collection

Data was collected from four major sources academic achievement pre-test, academic achievement post-test, opinionnaire for students, interview schedule for teachers.

Opinionnaire of students

On the last day, the students of experimental group who were taught through the technology were given an opinionnaire to give their opinions towards the treatment. The opinionnaire consisted ten statements with necessary instructions for the students. The students were requested to put tick mark on any one of the answers which they feel apt about the programme. The students took approximately 10 minutes to complete the opinionnaire

Interview of teachers

The aim of the researcher to prepare this tool was to evaluate the program by getting the opinions and feedbacks from the teachers regarding implementation and implications. Also in order to judge the effectiveness of the treatment and proposed pedagogical tools, an interview of teachers Few basic questions were discussed during the interview in order to judge the opinions of chemistry teachers regarding implementation and effectiveness of the treatment and also the experiences of teachers

6.12 Data Analysis

Data was analysed by first entering the data then followed by ordering the data. Data was analysed and interpreted using t-test and correlation of product moment using Microsoft excel sheet. Pre-test was conducted before the treatment and it was administered on both experimental and control group. Means of pre-test result revealed that experimental group and control group were equivalent groups. It appears that there is no significant difference in the basic understanding level of both the groups as the mean of the pre-test score of both are almost similar.

Data analysis for Median for pre-test for both experimental group and control group indicated not much significant difference was observed.

The Kurtosis of Pre-Test data of Experimental and Control group is less than 0, which indicates it is light tailed dataset. Pre-Test data of Control group has much data in its tails as compare to Experimental group.

Skewness data also indicates that both the groups are similar in terms of their capability to perform and produce result.

Table – 4.12 Analysis of Experimental and Control Pre-Test

Analysis of Experimental and control Group Pre-Test		
	Experimental Group	Control Group
Mean	18.838	17.486
Standard Error	0.550	0.852
Median	18.000	17.000
Mode	21.000	13.000
Standard Deviation	3.346	5.043
Sample Variance	11.195	25.434
Kurtosis	-0.314	-0.827
Skewness	0.210	0.124
Range	14.000	20.000
Minimum	12.000	8.000
Maximum	26.000	28.000
Sum	697.000	612.000
Count	37.000	35.000

Mean difference of pre-test and post-test for Experimental group is approximately 5.27 marks. The significant difference in the Pre and Post Test is the result of the treatment provided to the Experimental group by the investigator,

Mode changed from 21 to 28, 50% of class score above 24.(60% of the total marks), platykurtic distribution, Light Tailed, Kurtosis decrease further of post test, Data is fairy Symmetrical (Skewness between -0.5 to 0.5)

Table – 4.13 Comparison of Experimental Group Pre-Test versus Post-Test

Cumulative Analysis of Experimental		
	Pre Test	Post Test
Mean	18.838	24.108
Standard Error	0.550	0.648
Median	18.000	24.000
Mode	21.000	28.000
Standard Deviation	3.346	3.943
Sample Variance	11.195	15.544
Kurtosis	-0.314	-0.698
Skewness	0.210	-0.010
Range	14.000	16.000
Minimum	12.000	16.000
Maximum	26.000	32.000
Sum	697.000	892.000
Count	37.000	37.000

There is a significant difference in the means value; 6.22 and Median value 6.0 of between Post-Test of experimental and control while the mean value difference between both the group for Pre-Test was only Mean 1.352 and median 1.0 respectively. There is a big improvement seen in the experimental group performance.

Table – 4.14 Comparison of Post-Test Experimental and Control Group

Cumulative Analysis of Post-Test Experimental & Control Group		
	Experimental	Control
Mean	24.10810811	17.88571429
Standard Error	0.648147955	0.812477722
Median	24	18
Mode	28	18
Standard Deviation	3.942530094	4.806683023
Sample Variance	15.54354354	23.10420168
Kurtosis	-0.697892253	-0.561142135
Skewness	-0.010316023	0.207685968
Range	16	19
Minimum	16	10
Maximum	32	29
Sum	892	626
Count	37	35

A paired-samples t-test was conducted to compare Post – Test marks of Experimental and Control group. There was a significant effect. The difference in the marks for Experimental (M=24.11, SD=3.9) and no caffeine (M= 17.89, SD=4.8) conditions; t (66) =5.99, p =0.00. These results suggest that investigator focussed on multiple modes of teaching with central idea to enhance environment of learning has significantly improved the result of Experimental group as comparison to the control group. (Refer Table 4.7)

A Pearson product-moment correlation coefficient was computed to assess the relationship between the Post – Test of the Control group and Post – Test of the Experimental group. There was a positive correlation between the Pre – Test and Post – Test of the Experimental group, (r = 0.214, n = 30, p = 0.256). A scatterplot above summarizes the result. Overall, there was a positive correlation between the Post – Test of the Control group and Post – Test of the Experimental group. (Refer Graph 4.16)

	Post Test	
Pearson Correlation -Post Test	*Experimental*	*Control*
Post Test Experimental Group	1	
Post Test Control Group	0.214209871	1

The chi square result shows that the experimental group is better than the control group. The significance of difference between means is found to be significant at 0.05 level. It implies that the treatment provided in the experiment was effective. (Refer Table 4.10)

This result shows that observed and expected frequencies in the experimental group shows Significant differences and this difference observed is true and it is shown by obtaining the Chi square value being significant at 0.05 level of confidence. It shows that the experimental group achievement result is not due to chance factors but a true representation of the Achievement as a difference for progress.

From all the above test which includes Mean, Median , Standard Deviation, t-Test , Pearson product correlation and Chi Test , all indicates that Null Hypothesis is rejected and the study conducted was successful.

6.13 Summary

Fundamental concepts of chemistry are the building blocks upon which new knowledge is constructed. If the lack of understanding of the basic concepts and difficulties in studies are identified, then a remedial course of action will help in enhancing their learning. It is a fact that sound basic fundamental concepts are not developed all of a sudden. Focus of teaching should be on joyful learning which provides intrinsic motivation to students.

In primary and middle school, students do not learn chemistry as separate subject, they learn chemistry as a part of science because there are many concepts which are common and many concepts are interrelated. So proper understanding of fundamental concepts is essential. Moreover learning at this stage should not be examination oriented but efforts should be to enhance benchmark of MLL for all students. Sound fundamental concepts not only help as scaffolding for difficult concepts but also makes students inquisitive and motivated intrinsically.

Study was quasi-experimental design where selected fundamental concepts were taught with multiple modes of presentation (including MFA) to experimental group and control group with traditional methods.

Null hypothesis stated that there will not be any significant change on average mean scores of experimental group and control group in Pre-test and post-test of the learners where experimental group were taught fundamental concepts with multiple modes of teaching (including MFA) and control group with traditional methods.

A study of fundamental concepts showed that after the treatment mean difference between control group and experimental was approximately 6.22 marks approximately and mean difference between pre-test and post-test of experimental group was approximately 5.27 marks. Multiple modes of presentation was used for selected fundamental concepts. Data analysis and interpretation of data revealed through statistical measures that differences observed between experimental and control group was not by chance. Statistical measures like standard deviation, mean, t-test, chi square, product moment of correlation all reveal that null hypothesis should be rejected and treatment showed significant difference between experimental group and control group.

Qualitative analysis of concept maps revealed that many students could make concept map and could link the concepts with fundamental concepts. Students could do branching and inter-relate branches. More the branching better the concepts maps and thus better academic achievement score. A qualitative analysis of the students concept maps and students performance test showed that students who constructed more holistic and complex concept maps were able to solve problems more effectively. Though concept maps helped all students in making connections with fundamental concepts but this set of students could comprehend better and had more interactions in class with peers and teachers than their counterparts who had less developed concept maps.

6.14 Major Findings of the study

1 Students could comprehend fundamental concepts
2 The enriched environment and treatment facilitated enhanced learning.
3 Multiple modes of presentation, peer interaction and wholesome learning enhanced learning of fundamental concepts.

6.15 Suggestions for further study

Investigator has done study using concept maps as one of the tools of study and suggests further studies on use of concept maps for all stages and subjects. Moreover, concept maps were assessed qualitatively, and no scoring was done. Investigator suggests the use of programmed instructed material for construction as well as for scoring of constructed concept maps.

Along with other technological intervention MFA was used as a tool for aiding construction of knowledge and for assessing MLL of fundamental concepts of chemistry by grade nine students. Investigator used micro formative assessments (MFA) only once in each period but suggests that in more planned phases it can be used twice or thrice or even four times ,which would help in recapitulating concepts and assessing terminal points very effectively.

Competency based teaching techniques is another wide area wherein lot of research in chemistry can be done at high school level, as aspiration of students are different and various levels of competency should be available to them. Competency based teaching using concept maps can be another field of study. Various technology integration in teaching as well as assessment maybe the areas where focus in present times is required.

Investigator has done the study in face to face mode but many other options of online and off line modes need attention. Though many studies recommended technological integration but less work is done on raising benchmark of MLL with Micro Formative Assessment(MFA).

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APPENDIX - 1

Permission from school for conducting study as required for dissertation work

MODERN ERA CONVENT

(RECOGNISED)

B-1 Block, Janak Puri, New Delhi-110058. Ph.: 25594614

Dated : 20.01.2020

Ms. Abhilasha Malhotra,
M.Ed. Student,
The Maharaja Sayajirao University of Baroda,
Vadodara, Gujarat.

Subject – Permission for conducting study in Class IX as a part of M.Ed. course dissertation.

With reference to your letter dated 07.01.2020 and its enclosure, the permission as requested by you is granted, subject to the following conditions:

1. You shall be directly responsible for ensuring physical safety and security of students under your supervision. Further, any form of data related to their identity etc. shall not be misused in any form.

2. You shall carry out your work without any hindrance to the scheduled academic / activity calendar of the School. There shall be flexibility of periods/time allotted to you in the Class. You shall be required to come to School upon prior coordination with the Time Table Incharge.

In all cases, you shall complete your work well before commencement of Annual Examination to be held in second week of March 2020.

Principal

APPENDIX -2

Description of the Teaching points and other details regarding treatment

Sr. No	Concept Detail	Instructional Method	Activity	Technology and Techniques used	Periods taken
1	Structure of Atom (Hydrogen & helium)	Discussion, Demonstration	Note Making Modelling, Drawing	YOUTUBE, Concept mapping, School PPT MFA	2
2	Models of atom	Discussion, Demonstration	Drawing	YOUTUBE, Concept mapping, MFA	2
3	Laws of chemical combinatio n	Lecture, Problem solving	Problem solving	YOU TUBE, Concept mapping, MFA	3
4	Concept of Mole	Discussion, Problem solving	Note Making Modelling, Drawing, Concept mapping, problem solving	YOU TUBE, Concept mapping, MFA	3
5	Flame Test for metals	Experiment & Discussion	Note making	YOU TUBE, Concept mapping, MFA	2
6	Periodic Table 2006 IUPAC	Discussion and lecture	Questions	YOU TUBE, Concept mapping, MFA	2

APPENDIX-3

Description of Micro formative assessments taken during the study

Micro Formative Assessment given						
Sr.No.	Concept Detail	Sets	Number of questions in each set	Marks	Time for each MFA (in minutes)	Type of MFA
1	Structure of Atom (Hydrogen& helium)	2	10	10*2=20	5 minutes for each set	Objective
2	Models of atom	2	10	10*2=20	5 minutes for each set	Objective
3	Laws of chemical combination	2	10	10*2=20	5 minutes for each set	Objective
4	Concept of Mole	4	10	10*2=20	5 minutes for each set	Objective and subjective
5	Flame Test for metals	2	10	10*2=20	5 minutes for each set	Objective
6	Periodic Table 2006 IUPAC	2	10	10*2=20	5 minutes for each set	Objective

APPENDIX-4

ACADEMIC ACHIEVEMENT TEST --PRE TEST

Q1 .Which of the following pairs are isotopes?

a. Oxygen and ozone

b. Ice and steam

c. Nitric oxide and nitrogen dioxide

d. Hydrogen and deuterium

Q2. Which two particles each have a mass approximately equal to one atomic mass unit?

a. Proton and neutron

b. Proton and electron

c. Electron and neutron

d. None of these

Q3. Which of the following have equal number of neutrons and protons?

a. Hydrogen

b. Deuterium

c. Fluorine

d. Chlorine

Q4. The number of electrons in an element with atomic number X and atomic mass Y will be:

a. (X - Y)

b. (Y - X)

c. (X + Y)

d. X

Q5. The atomic number of an element is 11 ad its mass number is 23. The correct order representing the number of electrons, protons and neutrons respectively in this atom is:

a. 11, 11, 12

b. 11, 12, 11

c. 12, 11, 11

d. 23, 11, 23

Q6. How many molecules of water are present in 36 grams of water?

a. 12.044*1023

b. 6.022*1023

c. 18 molecules

d. 36 molecules

Q7. How many grams of carbon can be found in 1 mole of carbon dioxide?

a. 6.0233

b. 12

c. 44

d. None of these

Q8. The total number of protons in 10 g of calcium carbonate is:

a. 3.0115 × 10 24

b.1.5057 × 10 24

c. 2.0478 × 10 24

d. 4.0956 × 10 24

Q9. 3.0111022 atoms of an element weight 1.15 gm. The atomic mass of the element is:

a. 10

b. 2

c. 35.5

d. 23

Q 10 One atoms of an element x weigh 6.64310-23 g. Number of moles in 20 kg is :

a. 4

b. 40

c. 100

d. 500

Q 11. If water sample are taken from sea, rivers or lake, they will be found to contain hydrogen and oxygen in the approximate ratio of 1 : 8.This indicates the law of :

a. Multiple proportion

b. Definite proportion

c. Reciprocal proportions

d. None of these

Q 12. Which law is also known as Law of constant composition?

a. Law of multiple proportions

b. Avogadro's law

c. Law of conservation of mass

d. Law of definite proportions

Q13. Dalton incorporated the law of conservation of mass into his atomic theory by asserting that

a. Matter is composed of atoms.

b. Atoms can be destroyed in chemical reactions.

c. Atoms are indivisible.

d. None of these

Q14. According to the law of definite proportions, any two samples of KCl have

a. Slightly different molecular structures.

b. The same melting point.

c. The same ratio of elements.

d. None of these.

Q15. Which is an example of the law of multiple proportions?

a. CO and CO 2

b. CO and H 2 O

c. CO and CH 4

d. CO and C 2 H 4

Q16. Experiments with cathode rays led to the discovery of the

a. Proton.

b. Neutron.

c. Electron.

d. None of these

Q17 In Rutherford's experiments, most of the particles

a. Were absorbed by the foil.

b. Passed through the foil.

c. Combined with the foil

d. None of these

Q18 Because a few alpha particles bounced back from the foil, Rutherford concluded that they were

a. Striking electrons.

b. Repelled by densely packed regions of positive charge.

c. Magnetic.

d. None of these

Q19 According to the Bohr model of the atom, the single electron of a hydrogen atom circles the nucleus

a. In specific, allowed orbits

b. In one fixed orbit at all times.

c. At any of an infinite number of distances, depending on its energy.

d. None of these

Q20. In an alpha scattering experiment, few alpha particles rebounded because

a. Most of the space in the atom is occupied

b. Positive charge of the atoms very little space

c. The mass of the atom is concentrated in the centre

d. All the positive charge and mass of the atom is concentrated in small volume

Q21. Electronic configuration of Al+3 is

a. 2, 8, 3

b. 2, 8, 8

c. 2, 8

d. 2,8,8,3

Q22. Identify the group which is not a Dobereiner triad

a. Li, Na, K

b. Be, Mg, Cr

c. Ca, Sr, Ba

d. Cl, Br, I

Q23. Which is not true about the noble gases?

a. They are non-metallic in nature

b. They exist in atomic form

c. They are radioactive in nature

d. Xenon is the most reactive among these

Q24 Identify the wrong sequence of the elements in a group

a. Ca, Br, Ba

b. Cu, Au, Ag

c. N, P, As

d. Cl, Br, I

Q25 An element with atomic number will form a basic oxide_____

a. 7

b. 17

c. 14

d. 11

Q26. Which of the following could the flame test be used for?

a. To identify metal cations

b. To identify alkene reactions

c. To identify metal anions

d. To identify salt precipitates

Q27. Which of the following explains why different metals produce different colors during the flame test?

a. Each metal has a unique electron configuration

b. Each metal was isolated from a different place

c. Each metal has a unique salt bond

d. .Each metal has a unique number of extra electrons

Q28. A student performs a flame test on an unknown substance and observes a blue green flame. Which substance is she most likely using?

a. Copper.

b. .Lithium.

c. Calcium.

d. .Potassium

Q29. There are following zones of a flame

a. Two

b. Three

c. Four

d. No any zone

Q30. In flame testing, what element is indicated by an yellow flame?

a. Carbon

b. Sodium

c. Copper

d. Lithium

Q31. Formula of magnesium chloride:

a.MgCl

b. MgCl2

c.Mg2Cl2

d.Mg2Cl

Q32.Atomicity of ozone:

a. Triatomic

b. Diatomic

c. monoatomic

d. tetraatomic

Q33. The chemical formula of lead sulphate is

a. Pb 2 SO 4

b. Pb(SO 4) 2

c. PbSO 4

d. Pb 2 (SO 4) 3

Q34. Formula that shows the number and kind of atoms which a substance of a molecule contained, is known as

a. chemical formula

b. atomic formula

c. compound formula

d. molecular formula

Q35. Smallest particle of carbon dioxide consists of

a. two atoms

b. three atoms

c. four atoms

d. five atoms

Q36. Mass number of an atom is

a. no. of protons

b. no. of neutrons

c. A and B both

d. no. of electrons

Q37. Number of protons in nucleus constitute it's

a. atomic mass

b. atomic number

c. nucleon number

d. number of neutrons

Q38. An atom of phosphorus has an atomic number of 15 and a mass number of 31. How many neutrons does it contain?

a. 15

b. 16

c. 17

d. 31

Q39. There are how many naturally-occurring isotopes of oxygen?

a. 1

b. 2

c. 3

d. 4

Q40. The isotope deuterium of hydrogen has

a. No neutrons and one proton

b. One neutrons and two protons

c. One electron and two neutron

d. One proton and one neutron

APPENDIX - 5

ACADEMIC ACHIEVEMENT TEST –POST TEST

Q1 .Which of the following pairs are isotopes?

a. Oxygen and ozone

b. Ice and steam

c. Nitric oxide and nitrogen dioxide

d. Hydrogen and deuterium

Q2.. By whom was neutron discovered?

a. Bohr

b. Chadwick

c. Rutherford

d. Dalton

Q3. Which of the following have equal number of neutrons and protons?

a. Hydrogen

b. Deuterium

c. Fluorine

d. Chlorine

Q4.The number of molecules in 54 g of N 2 O 5

a. 3.011x10 26

b. 3.011x10 24

c. 3.011x10 23

d. 3.011x10 21

Q5. The atomic number of an element is 11 ad its mass number is 23. The correct order representing the number of electrons, protons and neutrons respectively in this atom is:

a. 11, 11, 12

b. 11, 12, 11

c. 12, 11, 11

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c. 18 molecules

d. 36 molecules

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a. 6.0233

b. 12

c. 44

d. None of these

Q8. .The maximum number of electrons that can be accommodated in third shell (n = 3) is:

a. 2

b. 8

c. 18

d. 10

Q9. Which of the following arrangements of electrons represent magnesium (Mg)?

a. 2, 8, 1

b. 2, 8, 2

c. 2, 8, 3

d. 2, 8, 4

Q 10The number of molecules in 46 g of C 2 H 5 OH

a. 6.022x10 24

b. 6.022x10 21

c. 6.022x10 23

d. 6.022x10 20

Q 11.The electrons present in the outermost shell are called

a. Valency electrons

b. Octate electrons

c. Duplet electrons

d. Valence electrons

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a. Law of multiple proportions

b. Avogadro's law

c. Law of conservation of mass

d. Law of definite proportions

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c. 2,8

d. 2,8,8,3

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c.Ca, Sr, Ba

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b. They exist in atomic form

c. They are radioactive in nature

d. Xenon is the most reactive among these

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b. 8

c. 18

d. 10

Q25An element with atomic number will form a basic oxide_____

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b. 17

c. 14

d. 11

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b. no. of neutrons

c. A and B both

d. no. of electrons

Q37. Number of protons in nucleus constitute it's

a. atomic mass

b. atomic number

c. nucleon number

d. number of neutrons

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a. 15

b. 16

c. 17

d. 31

Q39. In flame testing, what element is indicated by an yellow flame?

a. Potassium

b. Lithium

c. Sodium

d. copper

Q40. The isotope deuterium of hydrogen has

a. No neutrons and one proton

b. One neutrons and two protons

c. One electron and two neutron

d. One proton and one neutron

APPENDIX-6

MFA 1 STRUCTURE OF ATOM

Q1. In the late 1800s, experiments using cathode ray tubes led to the discovery of the

a. Electron
b. Positron
c. Proton
d. Neutron

Q2 Which subatomic particles are located in the nucleus of a carbon atom?

a. Neutrons
b. Protons
c. Electrons
d. Protons and Neutrons

Q3. Which subatomic particle is negatively charged?

a. Proton
b. Positron
c. Neutron
d. Electron

Q4. Which subatomic particle is negatively charged?

a. the mass of 1 electron plus the mass of 1 proton
b. the mass of 2 neutrons
c. the mass of 2 electrons
d. the mass of 1neutron plus mass of 1 electron

Q5. Which statement is true about a proton and and an electron?

a. They have the same masses and different charges
b. They have different masses and different charges
c. They have different masses and the same charges
d. None of these

Q6. Which statement best describes electrons?

a. They are negative subatomic particles and are found in the nucleus

b. They are negative subatomic particles and are found surrounding the nucleus

c. They are positive subatomic particles and are found surrounding the nucleus

d. They are positive subatomic particles and are found in the nucleus.

Q7. Which subatomic particle has no charge?

a. beta particle

b. neutron

c. electron

d. alpha particle

Q8. Compared to the entire atom, the nucleus of the atom is

a. larger and contains little of the atom's mass

b. smaller and contains little of the atom's mass

c. larger and contains most of the atoms mass

d. smaller and contains most of the atom's mass

Q9. The electrons present in the outermost shell are called

a. Valency electrons

b. Octate electrons

c. Duplet electrons

d. Valence electrons

Q10. Which isotope is used in the nuclear power plants to generate electricity?

a. Uranium 235

b. Iodine 131

c. Cobalt 60

d. Uranium 238

Q11. **What was the source of alpha particles in Rutherford scattering experiment?**

(a) Hydrogen nucleus
(b) Argon nucleus
(c) Helium nucleus
(d) None of these

Q12. **What property of an element determines its chemical behaviour?**

(a) Size of an element
(b) Valency of an element
(c) Molar mass of the element
(d) None of these

Q13. **Which of the following statements is incorrect about the structure of an atom?**

i. The whole mass of an atom is concentrated in the nucleus

ii. The atom is an indivisible particle

iii. The atom as a whole is neutral

iv. All the atoms are stable in their basic state

Choose the right option among the following:

(a) (i) and (iii)
(b) only (ii)
(c) (ii) and (iv)
(d) none of these

Q14. **What prevents an atom from being collapsed?**

(a) The nuclear forces
(b) Movement of electrons in discrete energy levels
(c) The electron-electron repulsions
(d) All of these

Q15. **Why do most of the elements try to participate in the chemical combinations?**

i. To gain more electrons

ii. To achieve Inert Gas configuration
iii. To complete their octet
iv. To complete their inner shells

Choose the correct option among the following

(a) Both (i) & (iii)
(b) Both (ii) & (iii)
(c) Only (ii)
(d) Both (i) & (iv)

Q16. Which f the following is not a basic particle of an element?
a. An atom
b. A molecule
c. An ion
d. None

Q17 The maximum number of electrons that can be accommodated in third shell (n = 3) is:
a. 2
b. 8
c. 18
d. 10

Q18 Which of the following arrangements of electrons represent magnesium (Mg)?

a. 2, 8, 1
b. 2, 8, 2
c. 2, 8, 3
d. 2, 8, 4

Q19 In an atom valence electron are present in:

a. Outermost orbit
b. Next to outermost orbit
c. First orbit
d. Any one of its orbit

Q20 Isobars have the same number of _____?

a. Protons

b. Electrons

c. Neutrons

d. Nucleons

APPENDIX -7
MFA 2 MODELS OF ATOM

Q1. Attraction of two ions due to opposite charge is known as

a. Ionic bonding

b. Covalent bonding

c. Metallic bonding

d. Dative bonding

Q2. If mass of protons and neutrons is 1, then mass of electron is

a. 2

b. 2-Jan

c. 4-Jan

d. 1/1890

Q3. The cathode ray experiment was done for the first time by:

a. J.J. Thomson

b. John Dalton

c. Goldstein

d. Rutherford

Q4. By whom was neutron discovered?

a. Bohr

b. Chadwick

c. Rutherford

d. Dalton

Q5. In an atom valence electron are present in:

a. Outermost orbit

b. Next to outermost orbit

c. First orbit

d. Any one of its orbit

Q6.The maximum number of electrons that can be accommodated in third shell (n = 3) is:

a. 2

b. 8

c. 18

d. 10

Q7. Which of the following arrangements of electrons represent magnesium (Mg)?

a. 2, 8, 1

b. 2, 8, 2

c. 2, 8, 3

d. 2, 8, 4

Q8. Which of the following statements is incorrect for cathode rays?

a. They move in straight line

b. Their nature depends upon the nature of gas present in the discharge tube.

c. They cost shadow of solid objects placed in their path

d. They get deflected towards positive charge.

Q9. Which of the following statements is not correct for Bohr's model of an atom?

a. The nucleus of an atom is situated at the center

b. The electrons move in circular orbits

c. Electrons jumps from one orbit to another

d. An electron neither loses nor gains energy it jumps from one orbit to another.

Q10. Which of the following has a charge of +1 and a mass of 1 amu?

a. A neutron

b. A proton

c. An electron

d. A helium nucleus

Q11.Which of the following is not a basic particle of an element?

a. An atom

b. A molecule

c. An ion

d. None

Q 12.Which would be the electrical charge on a Sulphur atom containing 18 electrons?

a. 2- c. 0

b. 1- d. 2+

Q 13. Aluminum has a valence of 3 and sulphate has valence of 2. Therefore, the correct formula for aluminum sulphate is:

a. AL2S2O4

b. AL2 (SO4)3

c. AL3 (SO4)2

d. ALSO4

Q 14.The correct representation of 3 molecules of chlorine is:

a. 6 CI

b. 3 Cl2

c. 2Cl3

d. Cl6

Q 15. While performing cathode ray experiments, it was observed that there was no passage of electric current under normal conditions. Which of the following can account for this observation?

a. Dust particles are present in air

b. Carbon dioxide is present in air

c. Air is a poor conductor of electricity under normal conditions

d. None of the above

Q 16. The fluorescence on the walls of discharge tube is due to:

a. Cathode rays

b. Anode rays

c. Canal rays

d. None of the above

Q 17. Which of the following electronic configurations is wrong?

a. Be (3) = 2, 1

b. S (16) = 2, 6, 8

c. P (15) = 2, 8, 5

Q 18.Which one of the following statement is not true?

a. Most of the space in an atom is empty

b. The total number of neutrons and protons is always equal in a neutral atom

c. The total number of electrons and protons in an atom is always equal

d. The total number of electrons in any energy level can be calculated by the formula 2n2

Q 19.17Cl35 and 17Cl37 are examples of:

a. Isobars

b. Isotopes

c. Isotones

d. None of the above

Q 20.How many electrons in a Hydrogen (H) atom:

a. One

b. Two

c. Three

d. Four

APPENDIX-8

MFA 3 LAWS OF CHEMICAL COMBINATION

Q1An unbalanced chemical reaction represents a violation of which law?

a. The law of conservation of mass
b. The law of constant proportions
c. The law of multiple proportions
d. The law of reciprocal proportions

Q2. A water sample from a lake, ocean, rain or pond must have _____ proportions of hydrogen to oxygen.

a. Identical.
b. Different
c. Similar
d. Reciprocal

Q3. Which is an example of the law of multiple proportions?

a. CO and CO_2
b. CO and H_2 O
c. CO and CH_4
d. CO and C_2 H_4

Q4.Chemical reactivities and chemical combinations depend upon

a. physical property
b. electronic configuration
c. separation of elements
d. natural property

Q5.A student heats 25g of reactant 'A' with 50g of reactant 'B'. He obtains 50g of product 'C' and recovers 25 g of unreacted 'B'. Which of the following law is confirmed in the following reaction?

a. Law of constant proportion
b. Law of conservation of mass
c. Law of conservation of mass and Law of constant proportion
d. Law of multiple proportion

Q6.Law of conservation of mass can be derived from which postulate of Dalton's atomic theory?

a. Atoms of a given element have same mass and chemical properties.
b. Matter is made of tiny particles.
c. Atom can neither be created nor destroyed.
d. The relative number and kind of atoms are constant in a given compound.

Q7. 5 grams of compound A reacts with 10 grams of compound B to produce a new compound C. What should be the mass of C according to law of conservation of mass?

a. 15 g

b. 5 g

c. 50 g

d. 10 g

Q8.According to Law of conservation of mass, mass of reactants wil be equal to the mass of:

a. Catalysts

b. Products

c. Apparatus used for reaction

d. Gases evolved

Q9.When $CaCO_3$ is heated, it forms CaO and CO_2. Which of these statements best describes the mass of the products if 100 g of $CaCO_3$ is heated?

a. The difference in the products' masses is equal to the mass of the $CaCO_3$.

b. The mass of each product is equal to the mass of the $CaCO_3$.

c. The sum of the products' masses equals the mass of the $CaCO_3$.

d. The sum of the products' masses is less than the mass of the $CaCO_3$.

Q10.Which of the following statements is true about the law of conservation of mass?

a. In a chemical reaction, efforts should be made to preserve rare elements without changing them.

b. In a chemical reaction, the final mass of the products is always greater than the starting mass of the reactants.

c. In a chemical reaction, matter is not created or destroyed, but is conserved.

d. Matter can be created and destroyed but does not change forms.

Q11.Which of the following statements is true about 'Law of conservation of mass"?

a. If two elements form more than one compound between them, then the ratios of the masses of the second element which combine with a fixed mass of the first element will be ratios of small whole numbers.

b. The elements are always present in a constant proportion in a chemical substance.

c. The rate of reaction is directly proportional to the active mass of the reactants.

d. Substances involved in a chemical reaction can change their states but the total mass of the product will be equal to that of the product.

Q12. Who gave the Law of constant proportions?

a. Cavendish
b. Proust
c. Dalton
d. Lavoisier

Q13.The balancing of chemical equation is based upon:

a. Law of conservation of mass
b. Law of multiple proportions
c. Law of definite proportion
d. Law of combining volumes

Q14. Which of the following is correct for the 'Law of Conservation of Mass'?

a. Mass can neither be created nor destroyed.
b. The rate of reaction is directly proportional to the active mass of the reactants.
c. Mass can either be created or destroyed in a chemical reaction.
d. The elements are always present in a constant proportion in a chemical substance.

Q15. 9 grams of water decompose to give:

a. 4g oxygen and 16g hydrogen
b. 2g hydrogen and 1g oxygen
c. 8g oxygen and 1g hydrogen
d. 1g hydrogen and 8g oxygen

Q16. Who stated the Law of conservation of mass?

a. Thomson
b. Lavoisier
c. Dalton
d. Cavendish

Q17. If all the reactants in a chemical reaction are completely used, which of the following statements accurately describes the relationship between the reactants and the products?

a. The reactants must contain more complex molecules than the products do.
b. The products must have different physical state than the reactants.
c. The total mass of the reactants must equal the total mass of the products.
d. The density of the reactants must equal the density of the products.

Q18. A sample of pure carbon dioxide, irrespective of its source contains 27.27% carbon and 72.73% oxygen. The data support

a. Law of multiple proportions
b. Law of reciprocal proportions
c. Law of conservation of mass
d. Law of constant composition

Q19. After a chemical reaction, the total mass of reactants and products

a. Is always increased
b. Is always decreased
c. Is not changed
d. Is always less or more

Q20. An element forms two oxides containing respectively 53.33 and 36.36 percent of oxygen. These figures illustrate the law of

a. Conservation of mass
b. Constant proportions
c. Reciprocal proportions
d. Multiple proportions

APPENDIX -9

MFA 4 MOLE CONCEPT

1. The largest no. of molecules of 28g of CO.

a. 6.022X10 23

b. 6.022X10 21

c. 12044X10 21

d. 60.22X10 20

2. How many grams of carbon can be found in 1 mole of CO 2 ?

a. 20g c. 8g

b. 12g d. 6g

3. How many molecules of H 2 O are present in 36g of H 2 O?

a. 12.044X10 22

b. 12.044X10 23

c. 12.044X10 24

d. 12.044X10 21

4. Find the total no. of protons in 10g of CaCo 3

a. 6.022X10 22

b. 6.022X10 23

c. 6.022X10 24

d. 6.022X10 21

5. Aspirin has a formula C 9 H 8 0 4 . How many atoms of Oxygen are there in a tablet weighing 360 mg?

a. 48.176X10 22

b. 48.92X10 21

c. 64.82X10 20

d. 24.088X10 20

6. How many moles of iron are present in a pure sample weighing 558.45gm?

a. 9.97 c. 9.89

b. 9.982 d. 9.70

7. Calculate no. of molecules in 54g of N 2 O5

a. 3.011X10 20

b. 3.011X10 21

c. 3.011X10 22

d. 3.011X10 23

8. Calculate no. of molecules in 46g of C 2 H 5 OH

a. 6.022X10 20

b. 60.22X10 21

c. 6.022X10 23

d. 6.022X10 22

9. No. of atoms/molecules=_____X6.022X10 23

a. Molar Mass

b. Given Mass

c. Moles

d. No. of molecules

10. No. of Moles=Mass of sample/_____.

a. Molar Mass

b. Given Mass

c. Moles

d. No. of molecules

11. Calculate no. of particles in 31g of P4.

a. 1.5055X10 23

b. 1.5055X10 21

c. 3.011X10 20

d. 3.011X10 22

12. Find no. of moles in 37g of K 2 S0 4

a. 0.282

b. 0.265

c. 2.8

d. 0.212

13. Find mass of 10 moles of Sodium sulphite.

a. 1260 g

b. 126 g

c. 12 g

d. 12.6 g

14. Find mass of moles of CO 2

a. 680 g

b. 460 g

c. 220 g

d. 440 g

15. Calculate no. of particles in 0.585g of Sodium Chloride.

a. 6.022X10 21

b. 6.022X10 22

c. 6.022X10 23

d. 60.22X10 21

16. A sample of Vitamin C contains 2.48X10 25 oxygen atom. How many moles are present in sample.

a. 41.92 c. 41.18

b. 41.28 d. 41.08

17. Which has more no. of atoms 11.5g Na or 15g of Ca.

a. 3.011X10 22

b. 3.011X10 23

c. 3.011X10 21

d. 3.011X10 24

18. Calculate no. of atoms in 4 moles of He.

a. 6.022X10 23

b. 12.044X10 23

c. 24.088X10 23

d. 3.011X10 23

19. Calculate no. of moles in 6.022X10 23 particles of an element

a. 6.022X10 23

b. 1

c. 12.044 3

d. 12.044X10 23

20. Calculate mass of 24.088X10 23 particles of oxygen gas.

a. 125 g c. 128g

b. 120 g d. 126g

APPENDIX -10

MFA 5 FLAME TEST

Question1. In flame testing, sodium metal ion exhibits which characteristic flame color

a. Blue-green
b. Yellow
c. Lilac or pale violet
d. Pink-red or magenta

Question2. Which of the following could the flame test be used for?

a. To identify metal cations
b. To identify alkene reactions
c. To identify metal anions
d. To identify salt precipitates

Question3. Which of the following explains why different metals produce different colours during the flame test?

a. Each metal has a unique electron configuration
b. Each metal was isolated from a different place
c. Each metal has a unique salt bond
d. Each metal has a unique number of extra electrons

Question4.The colour observed during the flame test results from the excitement of electrons caused by the increased temperature. The electrons jump from ground states to higher and as they return to their ground state, they emit visible light

a. The above statement is incorrect
b. The above statement is correct
c. Electrons never jump
d. None of the above

Question5. In flame testing, copper metal ion exhibits which characteristic flame colour

a. Blue-green

b. Yellow

c. Lilac or pale violet

d. Pink-red or magenta

Question6. In flame testing, potassium metal ion exhibits which characteristic flame colour

a. Blue-green

b. Yellow

c. Lilac or pale violet

d. Pink-red or magenta

Question7. To conduct a flame test

· Clean a platinum or nichrome wire with acid.

· Moisten the wire with water.

· Dip the wire into the solid you're testing, making sue that a sample sticks to the wire.

· Place the wire in the flame and observe any change in the flame color

a. The above statements are incorrect

b. The above statements are correct

c. We keep the metal on a glass dish under sun

d. None of the above

Question8. In flame testing, what element is indicated by bright green flame?

a. Potassium

b. Barium

c. Boron

d. copper

Question9. In flame testing, what element is indicated by Apple-green flame?

a. Potassium
b. Barium
c. Sodium
d. copper

Question10.The flame test is all about

a. Electrons
b. Thermal energy
c. The energy of photons
d. All of the above

Question11. In flame testing, calcium metal ion exhibits which characteristic flame colour

a. Blue-green
b. Yellow
c. Orange to orange -red
d. Pink-red or magenta

Question12. In flame testing, what element is indicated by pink-red or magenta?

e. Potassium
f. Lithium
g. Sodium
h. copper

Question13. In flame testing, barium metal ion exhibits which characteristic flame colour

a. Apple green
b. Yellow
c. Orange to orange -red
d. Lilac

Question14. In flame testing, what element is indicated by blue-green flame?

a. Potassium
b. Lithium
c. Sodium
d. copper

Question15. In flame testing, boron metal ion exhibits which characteristic flame colour

a. Bright green
b. Yellow
c. Orange to orange -red
d. Apple-green

Question16. In flame testing, lithium metal ion exhibits which characteristic flame colour

a. Yellow
b. Pink-red or magenta
c. Orange to orange -red
d. Lilac

Question17. In flame testing, what element is indicated by lilac flame?

a. Potassium
b. Lithium
c. Sodium
d. Copper

Question18. In flame testing, what element is indicated by orange to orange-red flame?

a. Potassium
b. Lithium
c. Sodium
d. Calcium

Question19. The noble metals gold, silver, platinum, palladium,

a. Blast immediately so colour cannot be produced
b. Do not produce a characteristic flame test color
c. Produce a characteristic flame test color
d. None of these

Question20. In flame testing, what element is indicated by an yellow flame?

a. Potassium
b. Lithium
c. Sodium
d. copper

APPENDIX – 11

MFA 6 PERIODIC TABLE

Q1. How many groups are there in modern periodic table?

a. 7

b. 11

c. 16

d. 18

Q2. Who is the creator of the periodic table?

a. Dimitri Mendeleev

b. Henry Moseley

Q3. The symbol Au stands for what element?

a. Gold

b. Silver

c. Copper

d. Tin

Q4. What is the atomic number for helium?

a. 1

b. 2

c. 4

d. 8

Q6. What is the symbol for tin?

a. Sn

b. Se

c. Sg

d. Sr

Q7. What is the atomic number for the element sodium?

a. 23

b. 11

c. 52

d. 73

Q8. What is the symbol for Argon?

a. A

b. An

c. Ag

d. Ar

Q9. What is the atomic number for beryllium?

a. 83

b. 4

c. 35

d. 5

Q10.The element chlorine is in which group?

a. Basic Metal

b. Non-Metal

c. Rare Earth

d. Semi-Metal

Q11. The element iron is in which group?

a. Alkaline earth

b. Basic metal

c. Alkali metal

d. Transition metal

Q12.What is the atomic number for phosphorous?

a. 20

b. 48

c. 6

d. 15

Q13. What is the symbol for bromine?

a. Br

b. Bu

c. Bh

d. Be

Q14.What is the symbol for manganese?

a. Mo

b. Mg

c. Mt

d. Mn

Q15.What is the symbol for phosphorus?

a. Po

b. P

c. Pb

d. Ph

Q16.The symbol Fe stands for which element?

a. Francium

b. Fluorine

c. Iodine

d. Iron

Q17.The element neon is from what group?

a. Halogen

b. Rare Earth

c. Noble Gas

d. Non-Metal

Q18. How many periods are there in modern periodic table?

a. 7

b. 11

c. 16

d. 8

Q19.What is the atomic mass for Nitrogen?

a. 14

b. 22

c. 7

d. 28

Q20.What is the atomic number for Nitrogen?

a. 3

b. 14

c. 7

d. 22

APPENDIX-12

Optionaire for students

S. NO	Question	Very Often	Often	Sometimes	Never	Total
1	I could ask questions in class	2	12	19	4	37
2	I used an electronic media for more clarity	0	26	11	0	37
3	I discussed assignments with peers	0	12	25	0	37
4	I received prompt feedback from instructor (written or oral)	10	16	11	0	37
5	I was reading after the class	0	8	24	5	37
6	I could synthesize and organize ideas, information, or experiences into new interpretations	0	16	16	5	37
7	I enjoy studying chemistry	0	11	21	5	37
8	Pace of interaction was slower than you expected	0	15	16	6	37
9	Work load was more than you expected	0	25	12	0	37
10	Asked questions in class or contributed in class discussion	9	15	13	0	37

APPENDIX-13

Interview questions for teacher

Q -1 Do you think NCERT is sufficient or not? How NCERT is useful in improving the quality of education?

Q-2 If NCERT is not sufficient, do you use alternate books for reference?

Q-3 Teaching of which concept you like the most and least?

Q-4 Do you think that concepts of chemistry are clearly defined in the textbook?

Q-5 Do you think Language used in the textbook of chemistry for explaining chemistry concepts are easy or difficult?

Q-6 Does your student ask you a question in case if they do not understand the concept?

Q-7 Do you encourage group discussion in the class?

Q-8 Do you motivate student to come forward and explain the concept which they have understood the best, to support peer learning?

Q-9 What are the difficulties faced in teaching of the atomic structure?

Q-10 Are number of allotted period adequate for covering the syllabus?

Q-11 What is the Teacher to student ratio in your class? should it be increased or decreased?

Q-12 How do you integrate or use ICT in teaching of chemistry?

Q-13 Do you use the concept mapping in teaching of chemistry? If Yes them name them?

Q-14 Where do you use conceptual integration between concepts related to physics, chemistry and biology?

Q-15 How do you make student understand abstract concept?

Q-16 Which teaching aid you use for fundamental concept like mole concept?

Q-17 Which method of teaching you use in teaching of Chemistry?

Q-18 Do you allow your students to take down notes?

Q-19 Do you give them notes?

Q-20 Do you use English as medium of instructions or sometime mother language?

Q-21 Do you discuss different concepts with peers?

Q-22 Which method of teaching do you use most for atomic structure?

Q-23 Which method of teaching you use for mole concept?

Q-24 Do you find difficulties in explaining or discussion due to language problem?

Q-25 Was the treatment given relevant according to students of your school?

APPENDIX - 14

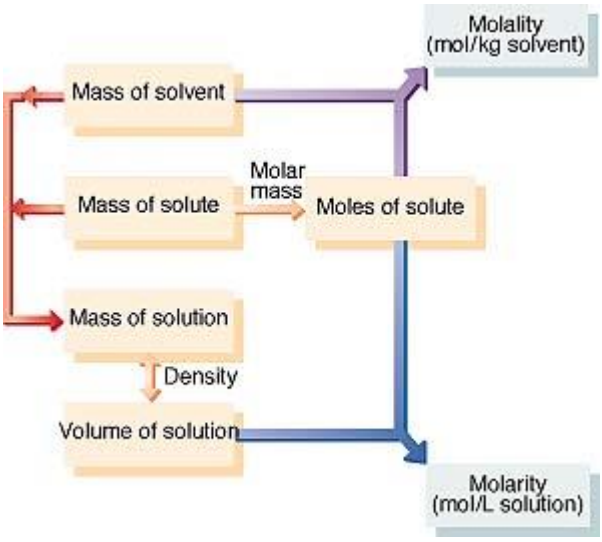
Links of video/audio used in study

1. https://youtu.be/LZg8L3NrlS4 Tricks to learn atomic mass
2. https://youtu.be/o-3I1JGW-Ck what is an atom
3. https://youtu.be/l1VXM_b2KFY Atoms and molecules
4. https://youtu.be/KuyB-445gQM measuring atomic mass
5. https://youtu.be/h98q7mqkdRU atomic mass
6. https://youtu.be/uJ-cDSpOZy8 relative atomic mass
7. https://youtu.be/qgJW1g0nCxQ isotopes and isobars
8. https://youtu.be/4DSvaHgeTfU atomic size
9. https://youtu.be/o3MMBO8WxjY calculations of molar mass
10. https://youtu.be/h8imasBKwh0 atomic mass unit
11. https://youtu.be/kJ-6Qy05u_Q Dalton atomic theory
12. https://youtu.be/bihvE-O9bNM Thompson atomic mod
13. https://youtu.be/XLaeFUKd2Y4 rutherford model of atom
14. https://youtu.be/9B3DDY27ZtE history of atomic theory
15. https://youtu.be/NSAgLvKOPLQ models of atom timeline
16. https://youtu.be/xiNf-UPpD-k Flame test
17. https://youtu.be/3Fo09_v0Zz8 Introduction to laboratory apparatus
18. https://youtu.be/Rb6MguN0Uj4 discovery of the electron: cathode ray tube experiment

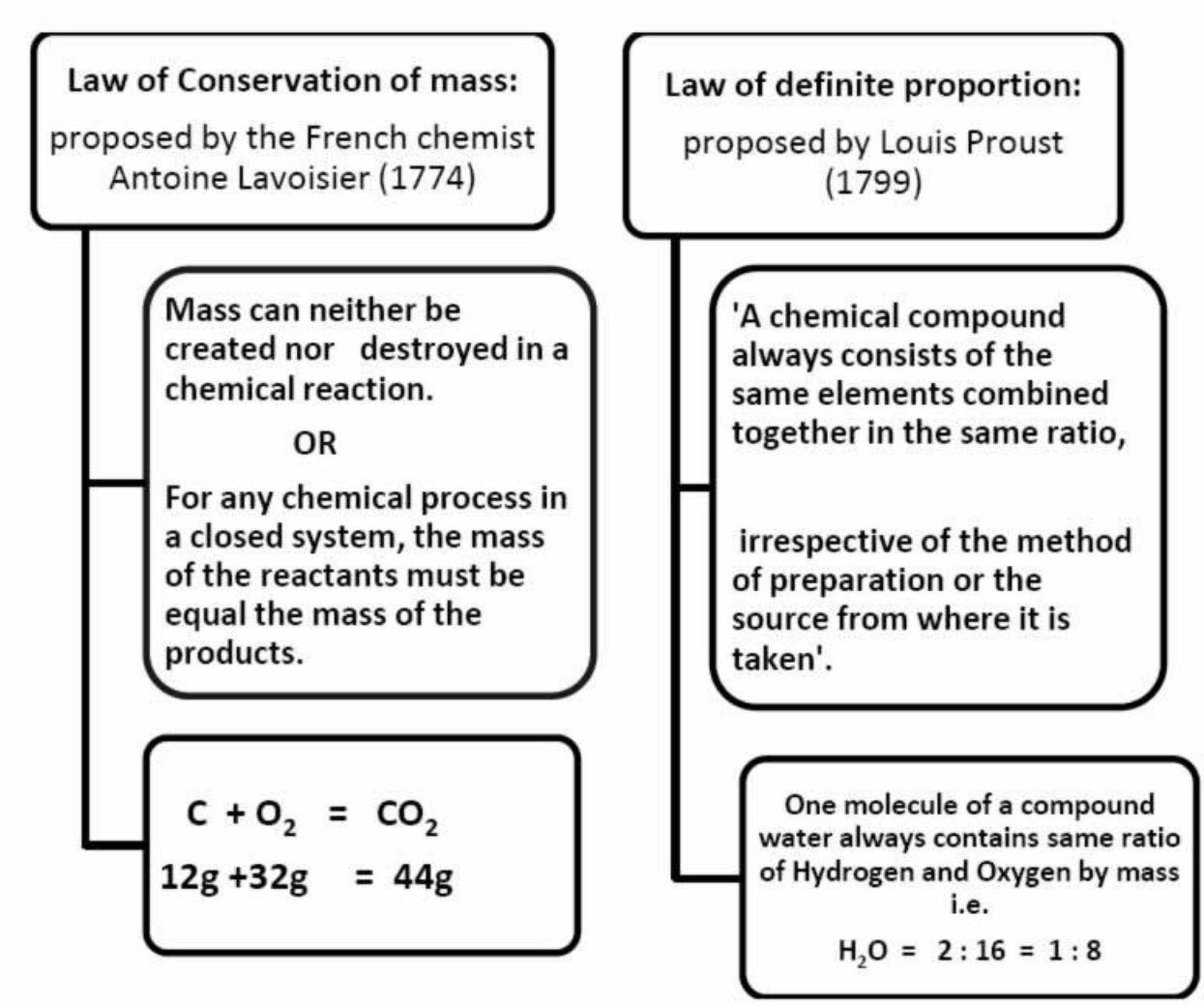
APPENDIX -15

CONCEPT MAPS

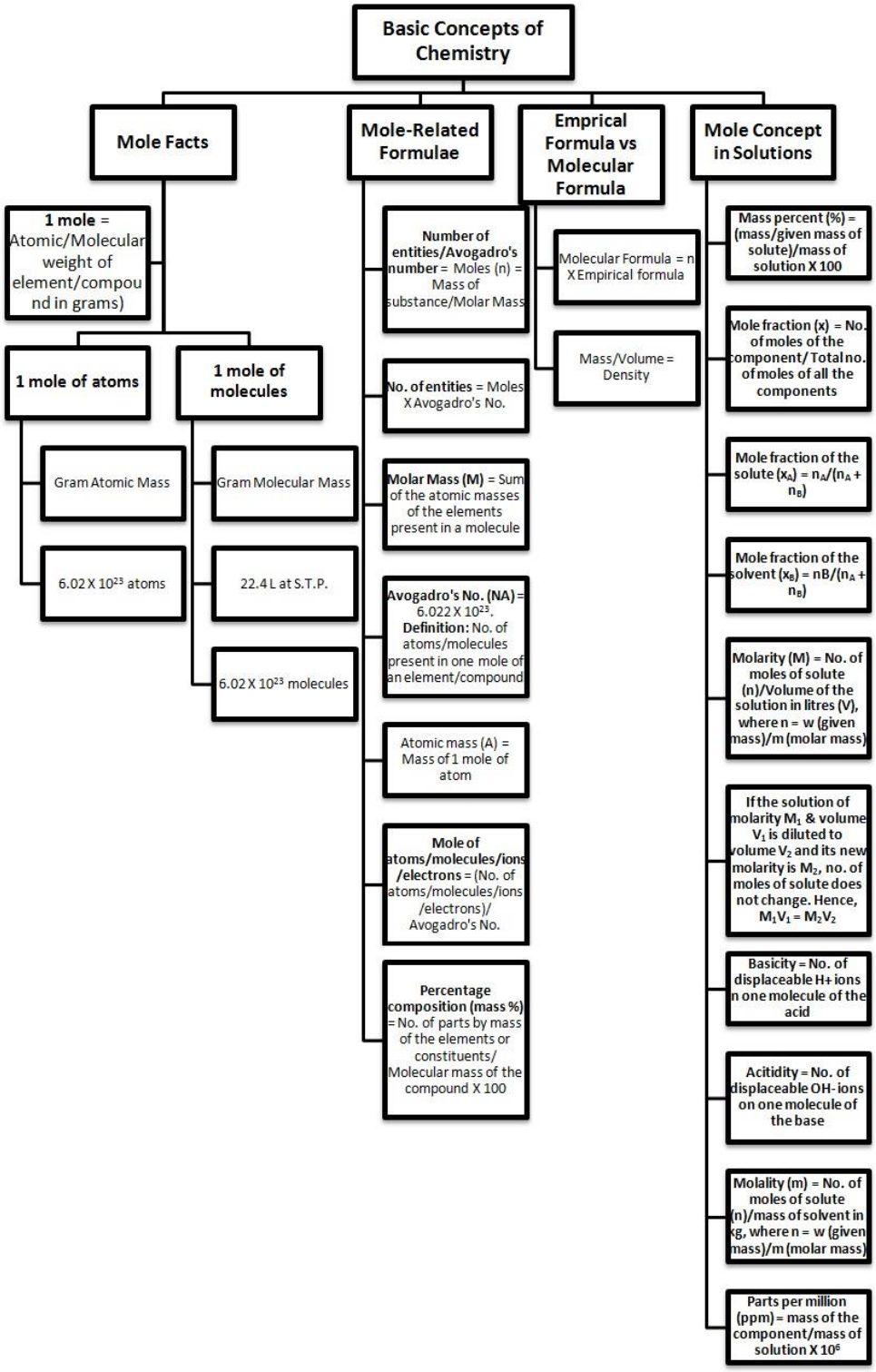
CONCEPT MAP 1



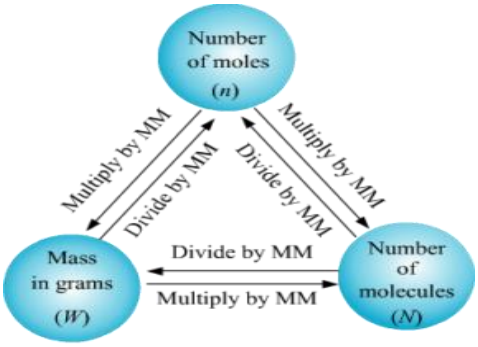
CONCEPT MAP 2



CONCEPT MAP 3

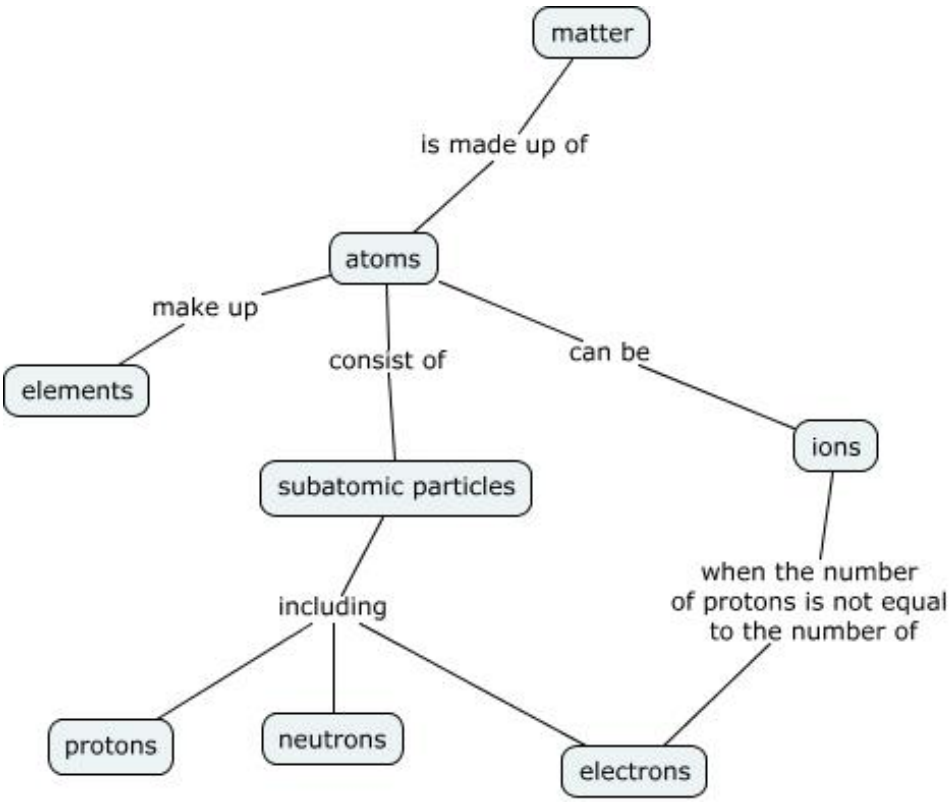


CONCEPT MAP 4

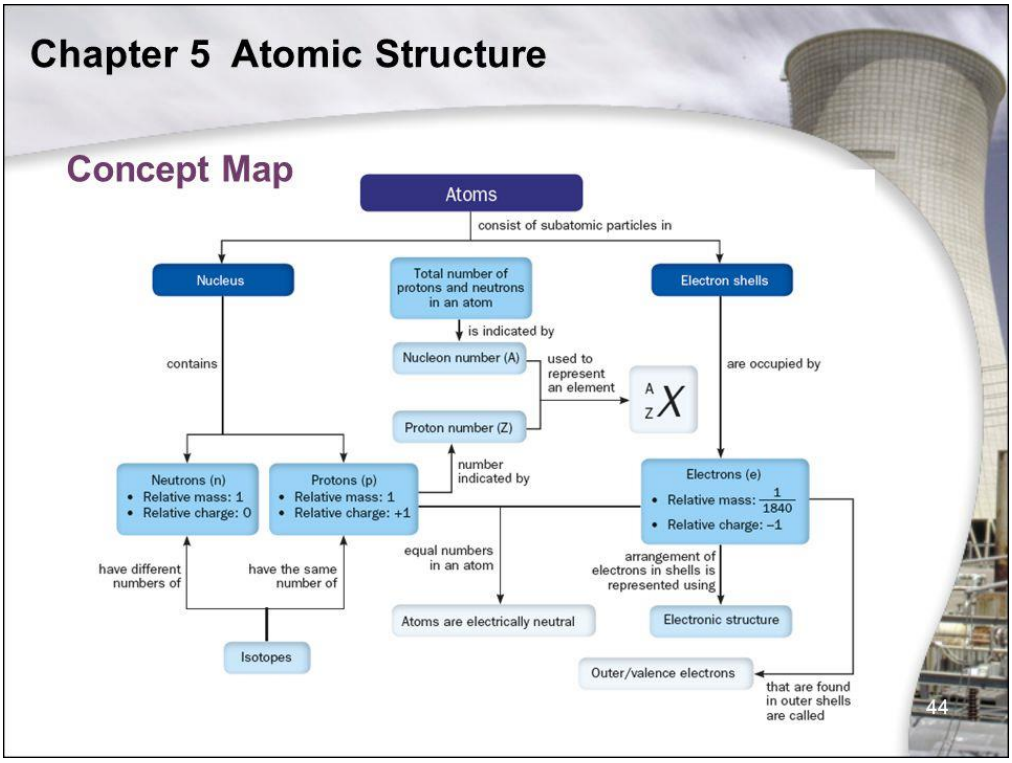


MM: Molecular mass

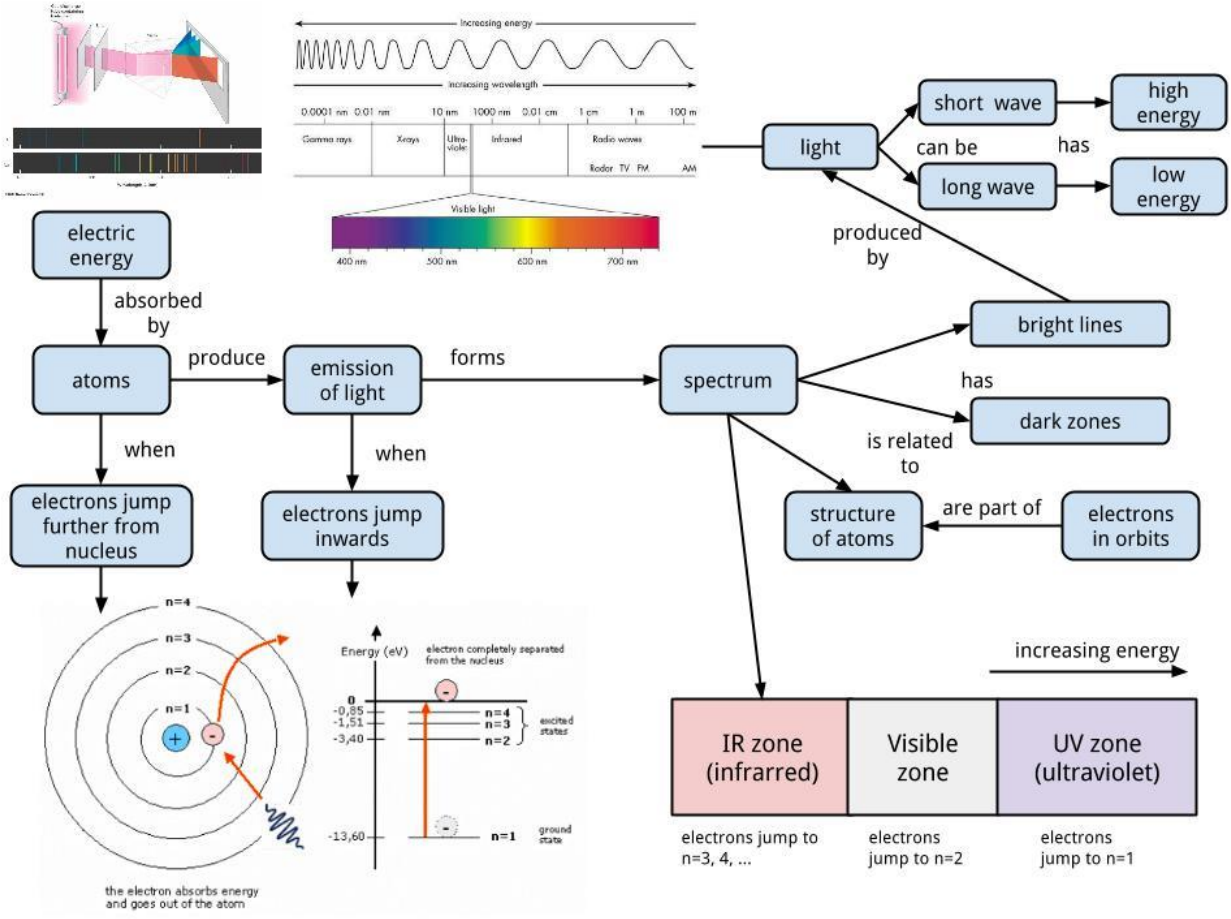
CONCEPT MAP 5



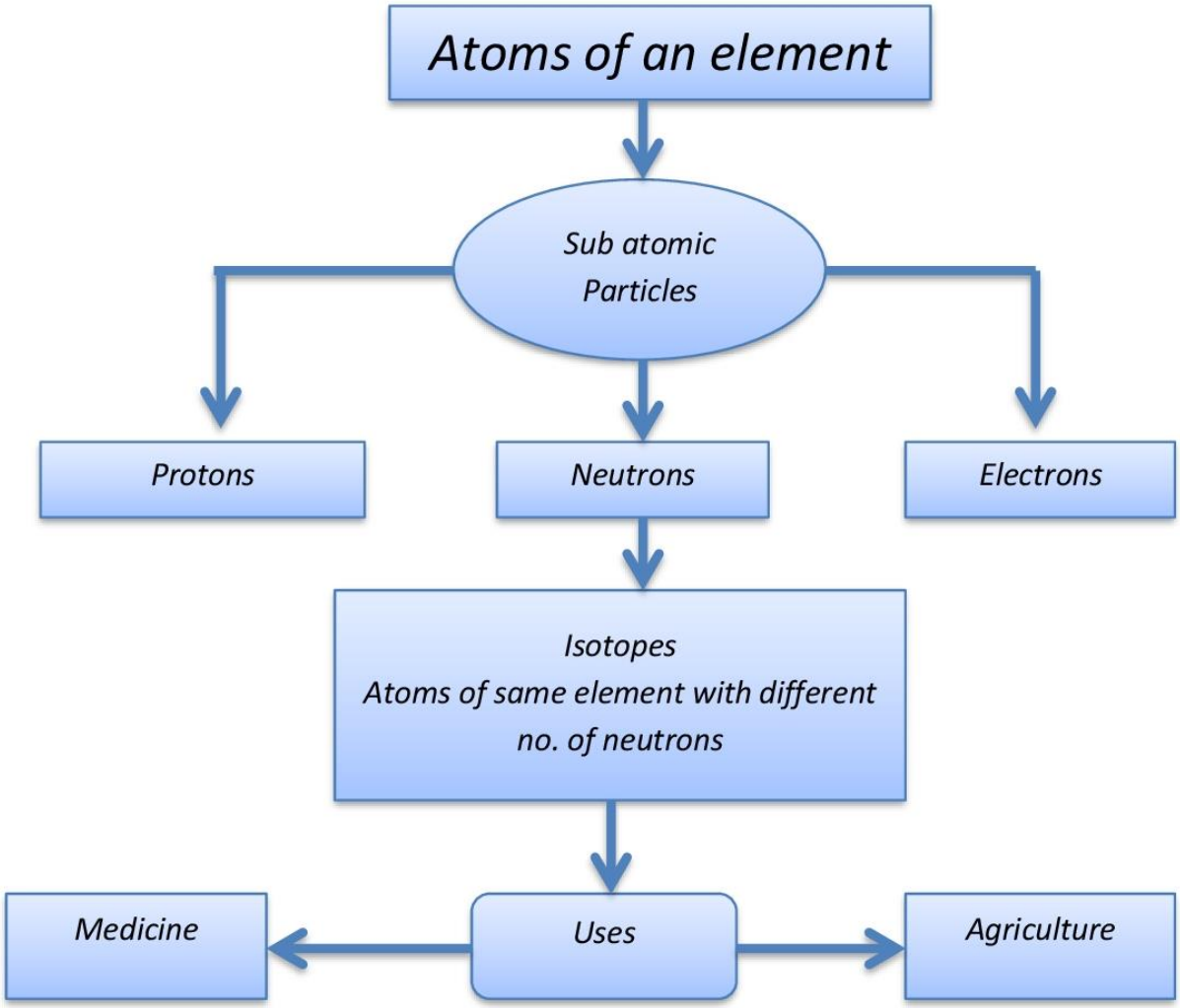
CONCEPT MAP 6



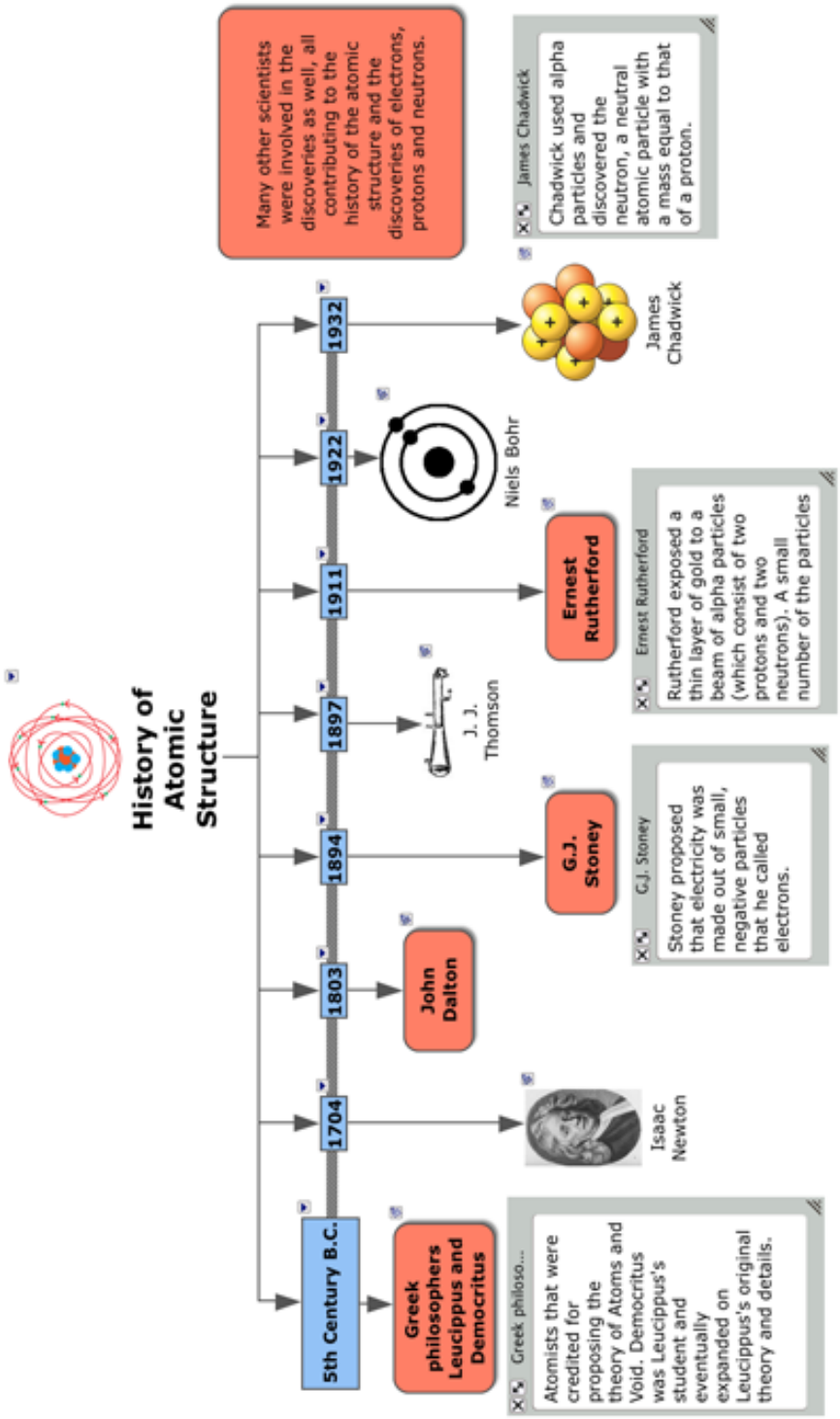
CONCEPT MAP 7



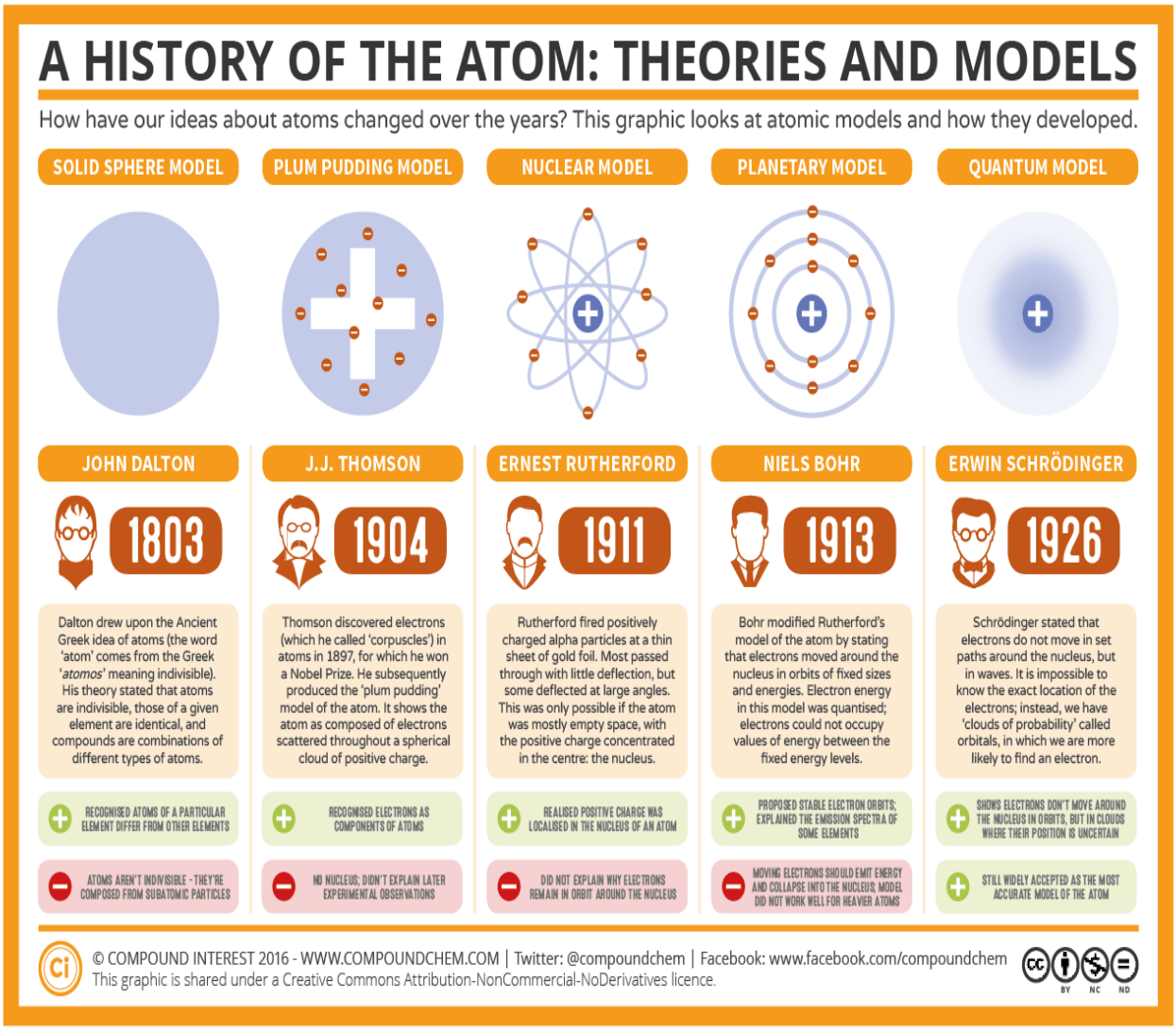
CONCEPT MAP 8



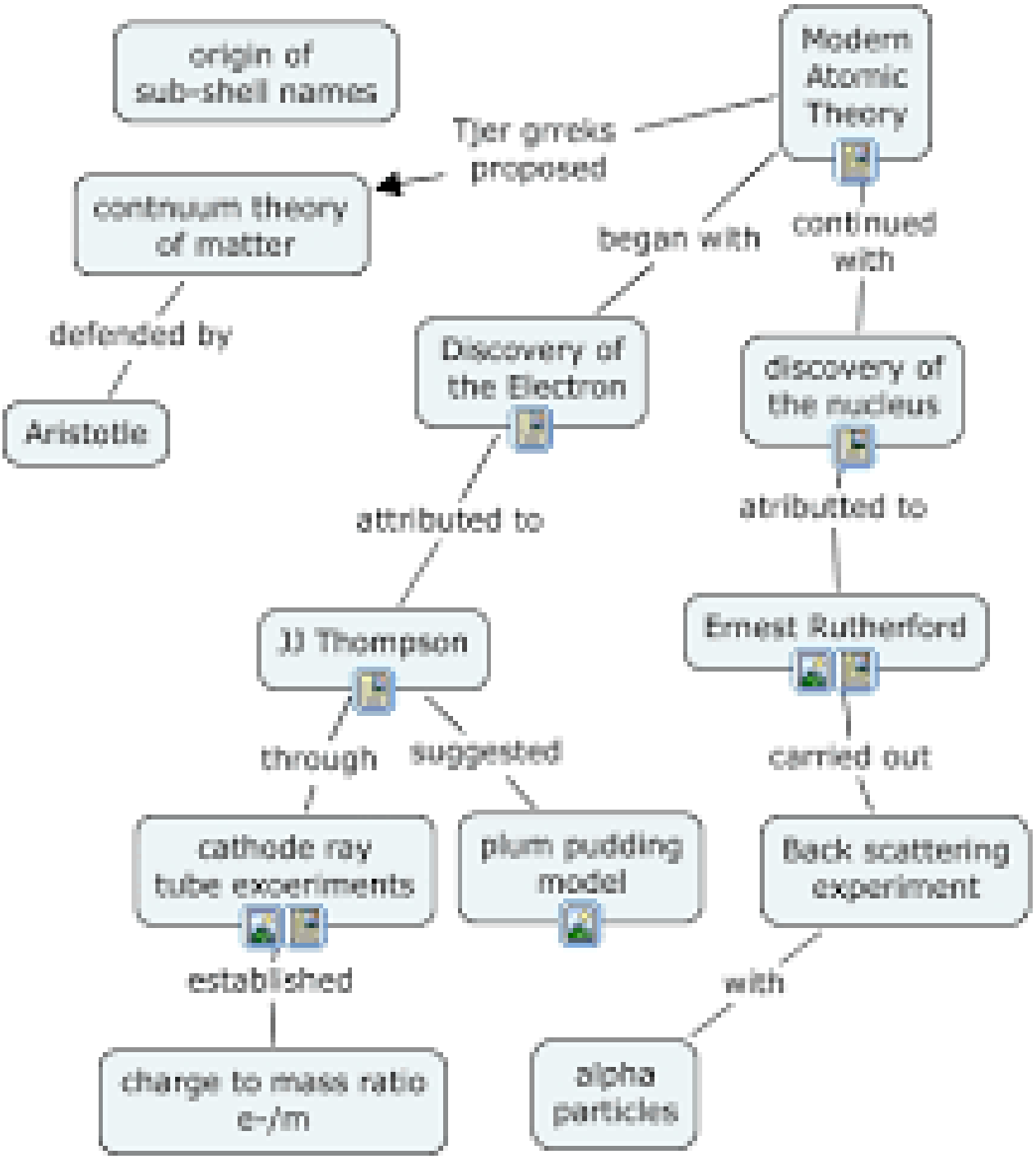
Concept Map-9



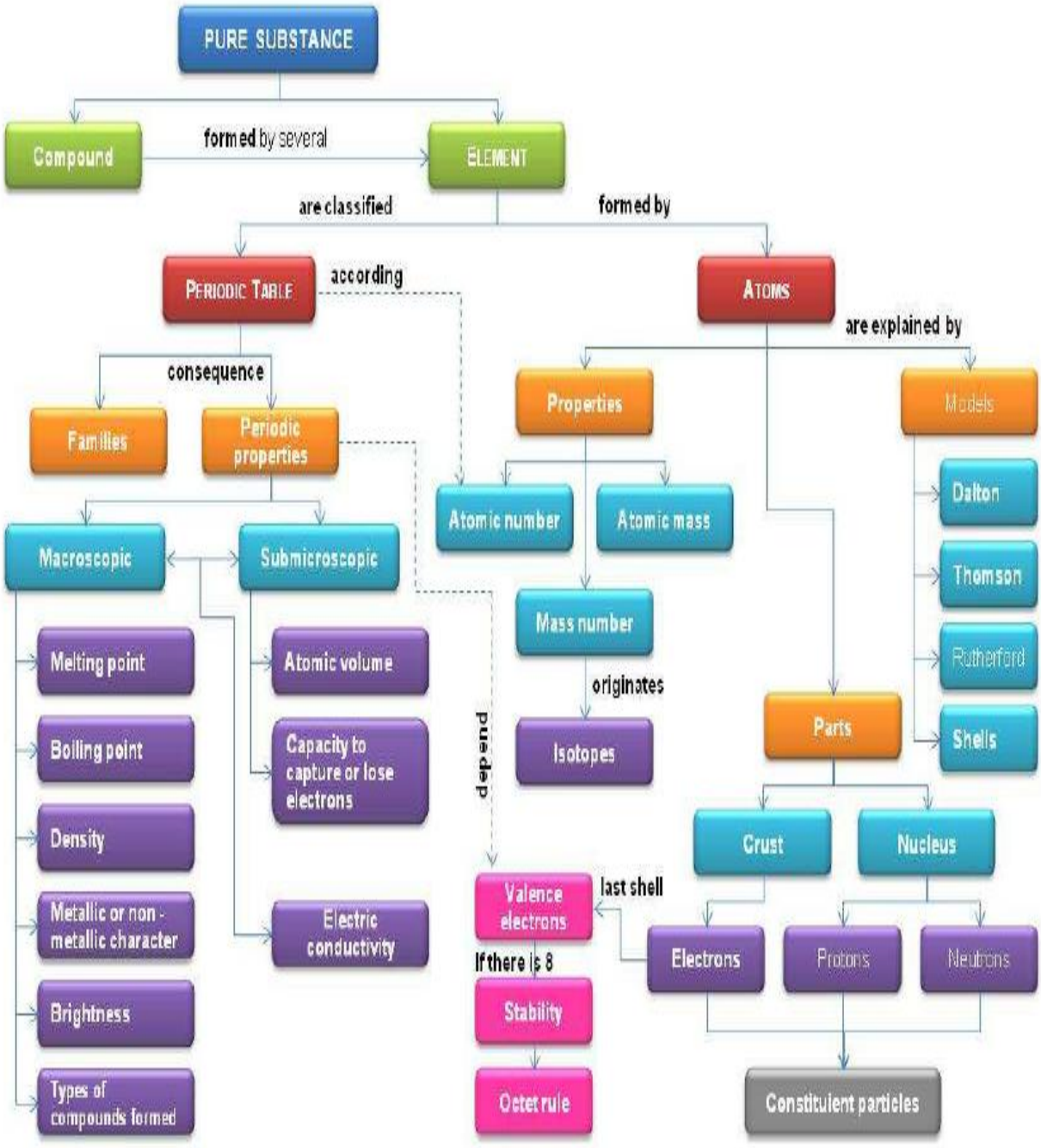
CONCEPT MAP 10



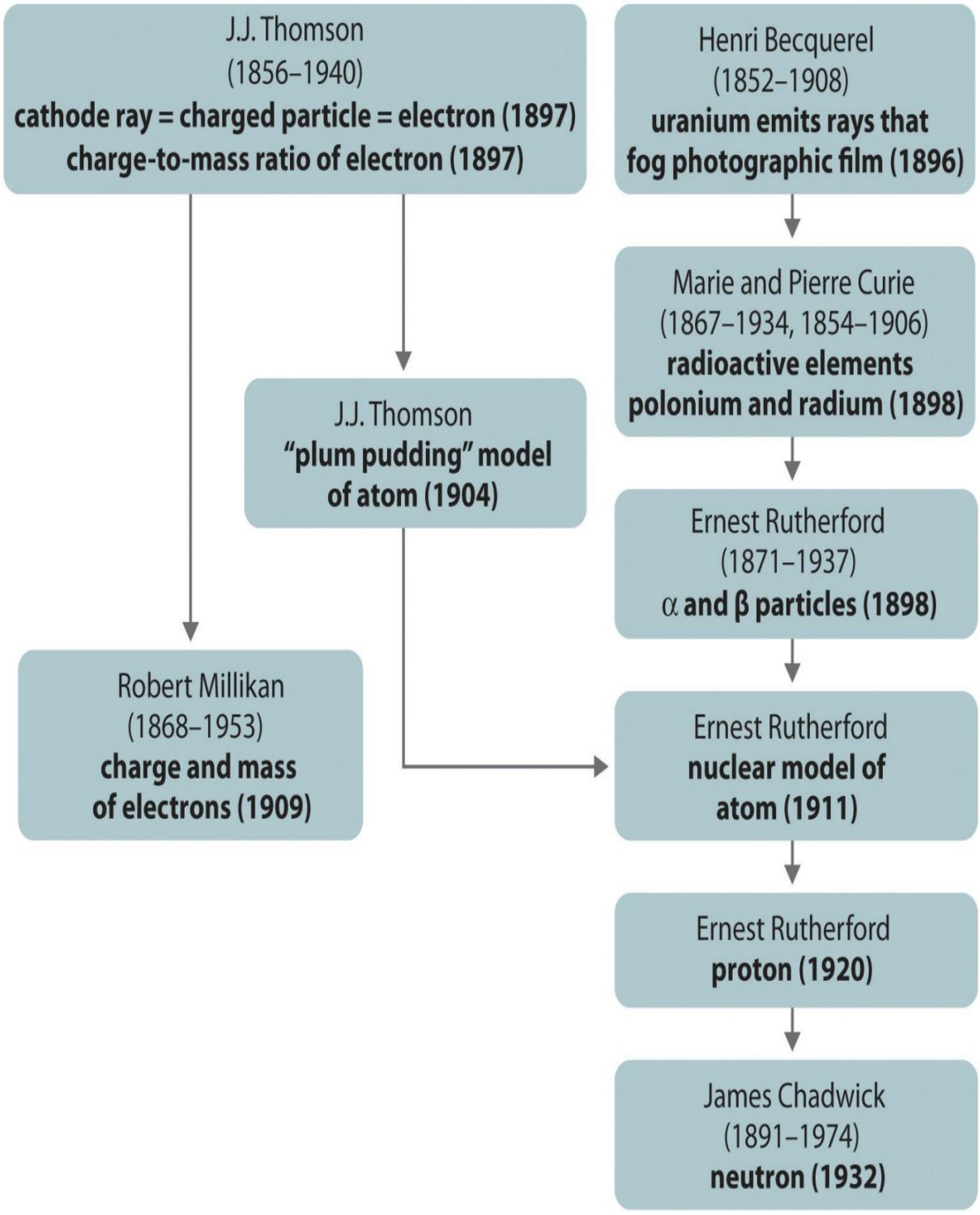
CONCEPT MAP 11



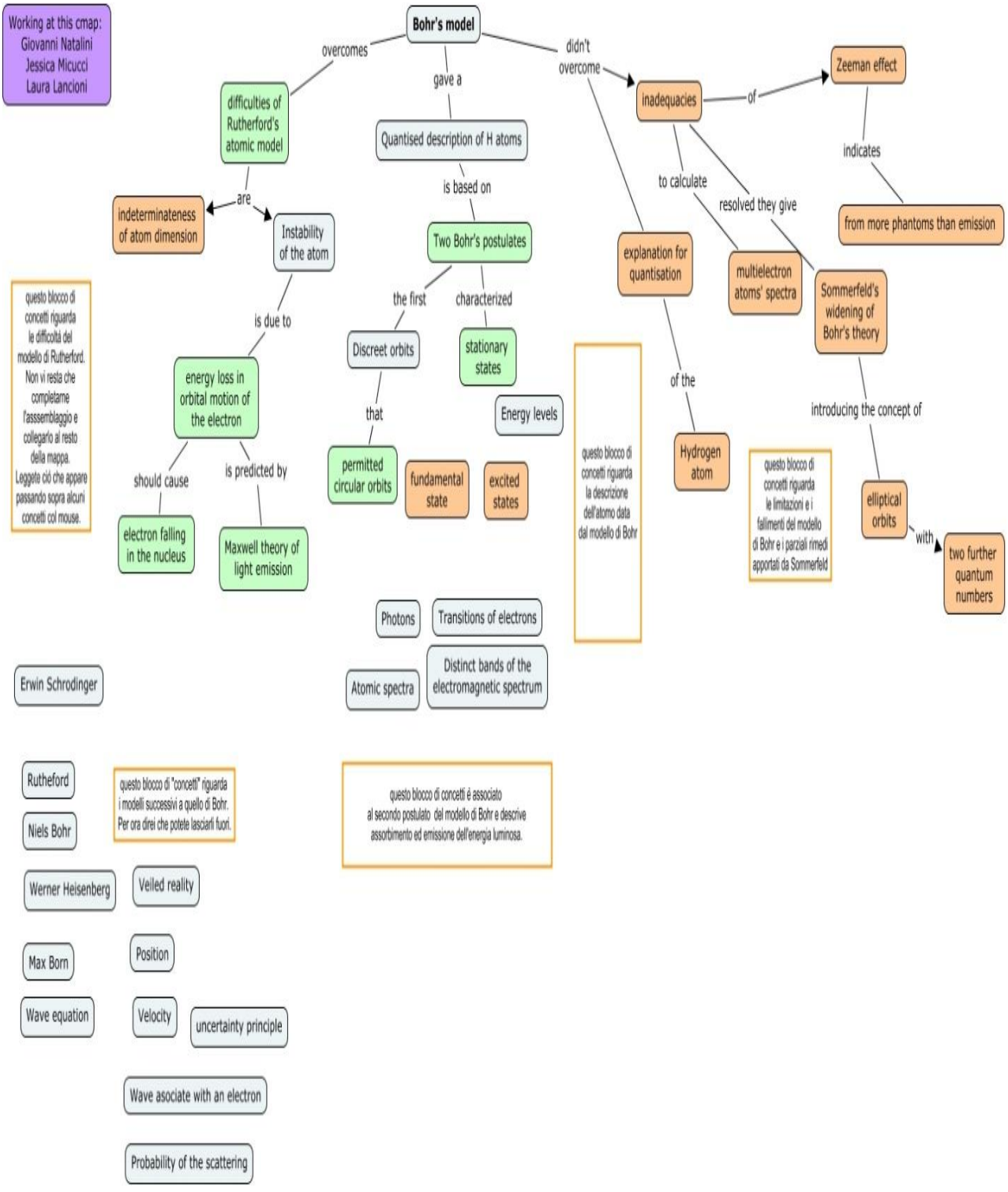
CONCEPT MAP 12



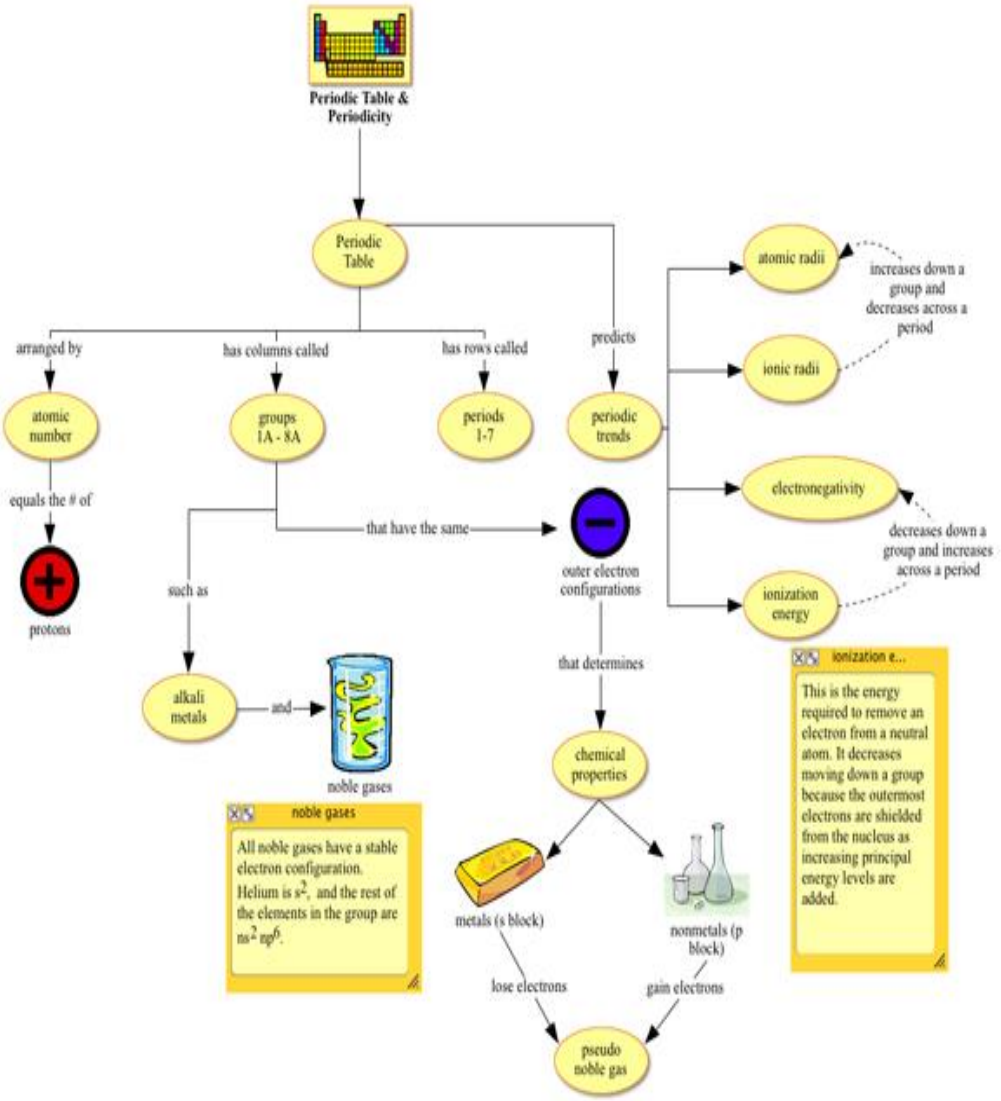
Concept 13


J.J. Thomson
(1856–1940)
cathode ray = charged particle = electron (1897)
charge-to-mass ratio of electron (1897)
Henri Becquerel
(1852–1908)
uranium emits rays that fog photographic film (1896)
Marie and Pierre Curie
(1867–1934, 1854–1906)
radioactive elements polonium and radium (1898)
J.J. Thomson
"plum pudding" model of atom (1904)
Ernest Rutherford
(1871–1937)
α and β particles (1898)
Robert Millikan
(1868–1953)
charge and mass of electrons (1909)
Ernest Rutherford
nuclear model of atom (1911)
Ernest Rutherford
proton (1920)
James Chadwick
(1891–1974)
neutron (1932)

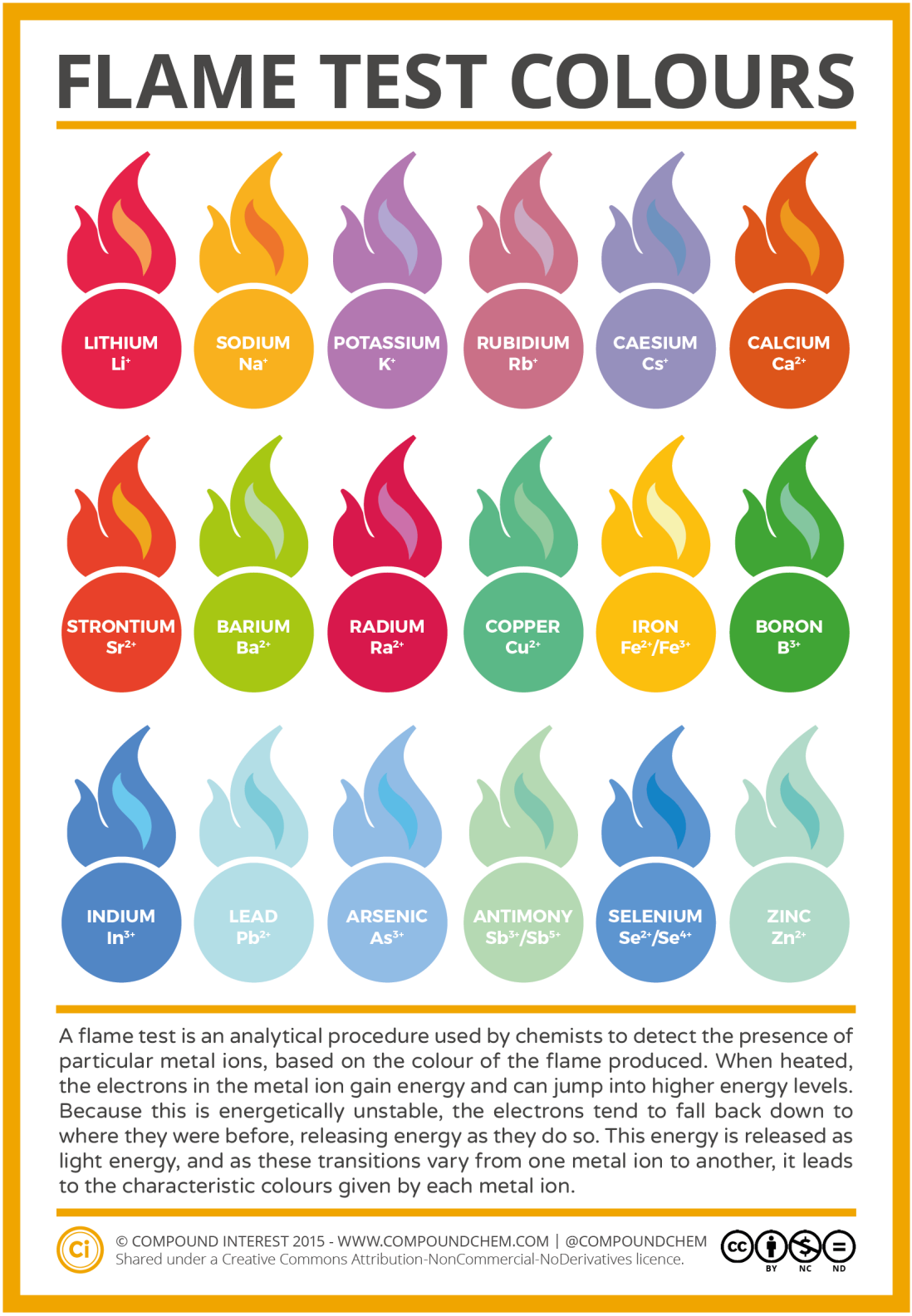
CONCEPT MAP 14



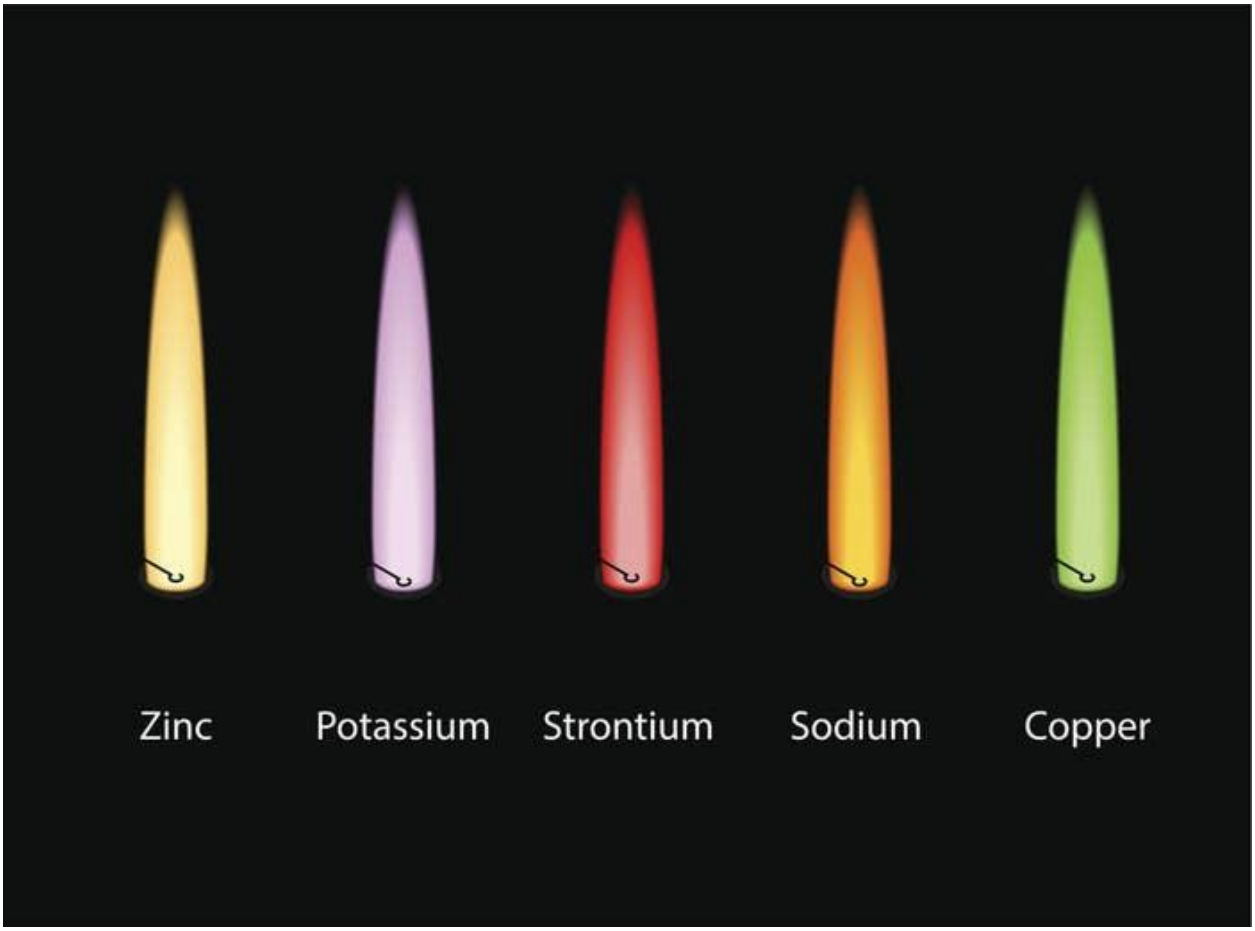
CONCEPT MAP 15



CONCEPT MAP 16



CONCEPT MAP 17



APPENDIX -16

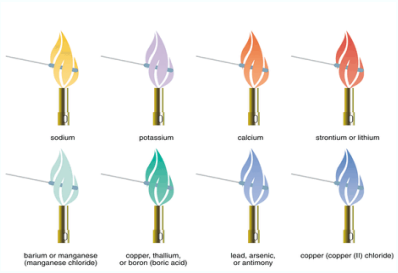
Information about flame test

Principle of Atomic Absorption /Emission Spectroscopy

ATOMIC EMISSION-THE FLAME TEST

When a small amount of a solution of a metal ion is placed in the flame of a Bunsen burner, the flame turns a color that is characteristic of the metal ion. A sodium solution gives a yellow color, a potassium solution results in a violet color, a copper solution gives a green color, etc. Such an experiment, called the flame test, has been used in conjunction with other tests in many qualitative analysis schemes for metal ions. Whatever color our eye perceives indicates what metal ion is present. When more than one metal ion is present, viewing the flame through a colored glass filter can help mask any interference. Figure 1 shows this experiment.

The phenomenon just described is an "atomic emission" phenomenon. This statement may seem inappropriate, since it is a solution of metal ions (and not atoms) that is tested. The reason for calling it atomic emission lies in the process occurring in the flame. One of the steps of the process is an atomization step. That is, the flame converts the metal ions into atoms. When a solution of sodium chloride is placed in a flame, for example, the solvent evaporates, leaving behind solid crystalline sodium chloride. This evaporation is then followed by the dissociation of the sodium chloride crystals into individual ground state atoms -a process that is termed atomization. Thus sodium atoms are actually present in the flame at this point rather than sodium ions, and the process of light emission actually involves these atoms rather than the ions .



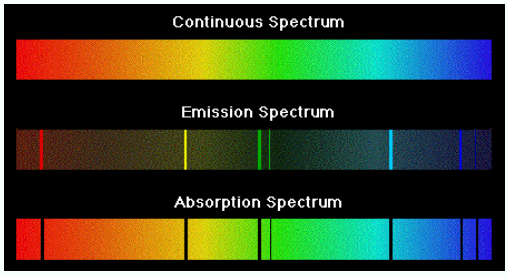


Figure 1. The flame test: observation of the flame color (a) without colored glass and (b) through prism

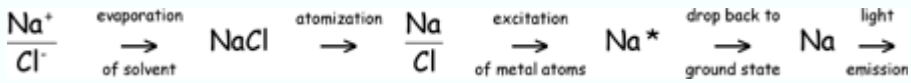
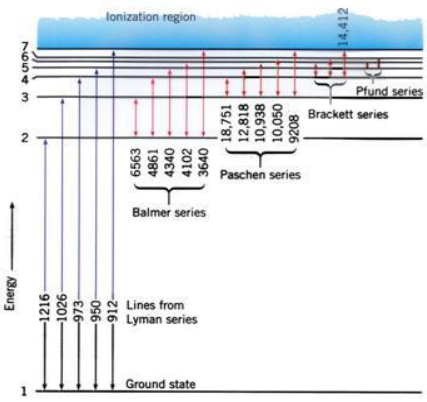


Figure 2. The sequence of events occurring in the flame test.

As with fluorescence, the atomic emission is a result of electrons dropping from an excited state to lower states. The difference is that (1) atoms are involved here, rather than molecules, and (2) light is not absorbed prior to this atomic emission. Following atomization, a small percentage of the atoms absorb sufficient energy from the flame (as opposed to a light beam) so as to be promoted to an excited state. As with molecules in fluorescence, these atoms quickly return to a lower state, and light corresponding to the energy that is lost in the process is generated. It is this light that our eye perceives. The complete sequence of events is depicted in Figures 2 and 3.

The discussion of the facts regarding atomic energy levels and molecular energy levels presented in the previous three chapters is applicable here. Since there are no vibrational levels in atoms, the energy of emission is a discrete amount of energy corresponding to the difference between two electronic levels. Also, since there are usually a number of electronic levels to which an electron in an atom can be promoted, there are a number of possible discrete energy jumps back to the lower energy states. These represent a number of distinct wavelengths of light to be emitted. What is actually emitted by the atoms in a flame is then a line emission spectrum as indicated in Figure 4. (Compare with Figures 10 and 11 in Chapter 12). Figure 5 depicts an explanation of the atomic emission phenomenon. When atoms fall back to lower energy states following the absorption of energy from a flame, a line spectrum is emitted which our eye perceives as a particular color of light. Each kind of atom is different in terms of the separation between energy levels and the line emission spectra are therefore different. Because of this, different elements are found to emit the different colors noted earlier.



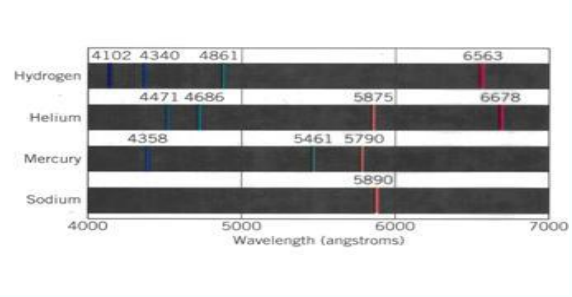
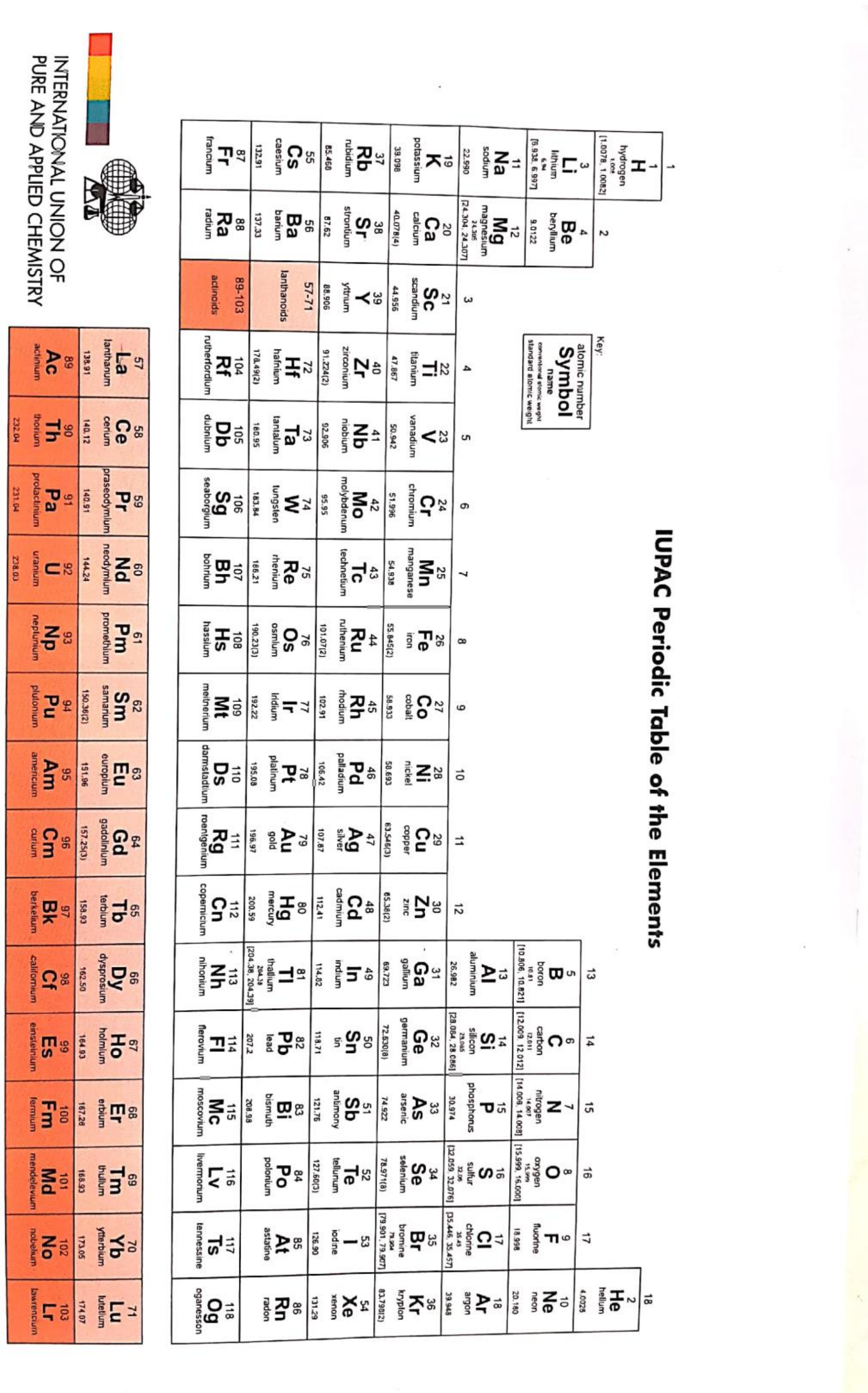


Figure 4. The atomic emission phenomenon: (a) Allowed energy jumps back to lower levels. (b) A line spectrum representing the wavelengths of the emitted light corresponds to the jumps in (a).

APPENDIX -17

Periodic Table November 2016 Version



APPENDIX -18

Periodic Table December 2018 Version

IUPAC Periodic Table of the Elements

Key: atomic number / **Symbol** / name / conventional atomic weight / standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen 1.008 [1.0078, 1.0082]																	2 **He** helium 4.0026
3 **Li** lithium 6.94 [6.938, 6.997]	4 **Be** beryllium 9.0122											5 **B** boron 10.81 [10.806, 10.821]	6 **C** carbon 12.011 [12.009, 12.012]	7 **N** nitrogen 14.007 [14.006, 14.008]	8 **O** oxygen 15.999 [15.999, 16.000]	9 **F** fluorine 18.998	10 **Ne** neon 20.180
11 **Na** sodium 22.990	12 **Mg** magnesium 24.305 [24.304, 24.307]											13 **Al** aluminium 26.982	14 **Si** silicon 28.085 [28.084, 28.086]	15 **P** phosphorus 30.974	16 **S** sulfur 32.06 [32.059, 32.076]	17 **Cl** chlorine 35.45 [35.446, 35.457]	18 **Ar** argon 39.95 [39.792, 39.963]
19 **K** potassium 39.098	20 **Ca** calcium 40.078(4)	21 **Sc** scandium 44.956	22 **Ti** titanium 47.867	23 **V** vanadium 50.942	24 **Cr** chromium 51.996	25 **Mn** manganese 54.938	26 **Fe** iron 55.845(2)	27 **Co** cobalt 58.933	28 **Ni** nickel 58.693	29 **Cu** copper 63.546(3)	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.723	32 **Ge** germanium 72.630(8)	33 **As** arsenic 74.922	34 **Se** selenium 78.971(8)	35 **Br** bromine 79.904 [79.901, 79.907]	36 **Kr** krypton 83.798(2)
37 **Rb** rubidium 85.468	38 **Sr** strontium 87.62	39 **Y** yttrium 88.906	40 **Zr** zirconium 91.224(2)	41 **Nb** niobium 92.906	42 **Mo** molybdenum 95.95	43 **Tc** technetium	44 **Ru** ruthenium 101.07(2)	45 **Rh** rhodium 102.91	46 **Pd** palladium 106.42	47 **Ag** silver 107.87	48 **Cd** cadmium 112.41	49 **In** indium 114.82	50 **Sn** tin 118.71	51 **Sb** antimony 121.76	52 **Te** tellurium 127.60(3)	53 **I** iodine 126.90	54 **Xe** xenon 131.29
55 **Cs** caesium 132.91	56 **Ba** barium 137.33	57-71 lanthanoids	72 **Hf** hafnium 178.49(2)	73 **Ta** tantalum 180.95	74 **W** tungsten 183.84	75 **Re** rhenium 186.21	76 **Os** osmium 190.23(3)	77 **Ir** iridium 192.22	78 **Pt** platinum 195.08	79 **Au** gold 196.97	80 **Hg** mercury 200.59	81 **Tl** thallium 204.38 [204.38, 204.39]	82 **Pb** lead 207.2	83 **Bi** bismuth 208.98	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium	113 **Nh** nihonium	114 **Fl** flerovium	115 **Mc** moscovium	116 **Lv** livermorium	117 **Ts** tennessine	118 **Og** oganesson

57 **La** lanthanum 138.91	58 **Ce** cerium 140.12	59 **Pr** praseodymium 140.91	60 **Nd** neodymium 144.24	61 **Pm** promethium	62 **Sm** samarium 150.36(2)	63 **Eu** europium 151.96	64 **Gd** gadolinium 157.25(3)	65 **Tb** terbium 158.93	66 **Dy** dysprosium 162.50	67 **Ho** holmium 164.93	68 **Er** erbium 167.26	69 **Tm** thulium 168.93	70 **Yb** ytterbium 173.05	71 **Lu** lutetium 174.97
89 **Ac** actinium	90 **Th** thorium 232.04	91 **Pa** protactinium 231.04	92 **U** uranium 238.03	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

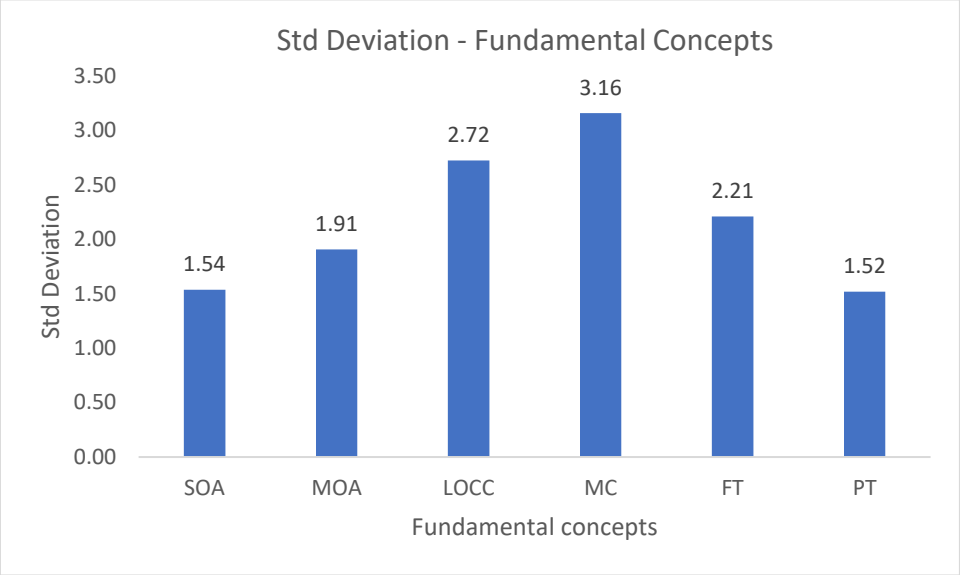
For notes and updates to this table, see www.iupac.org. This version is dated 1 December 2018.

United Nations Educational, Scientific and Cultural Organization

International Year of the Periodic Table of Chemical Elements

APPENDIX -19

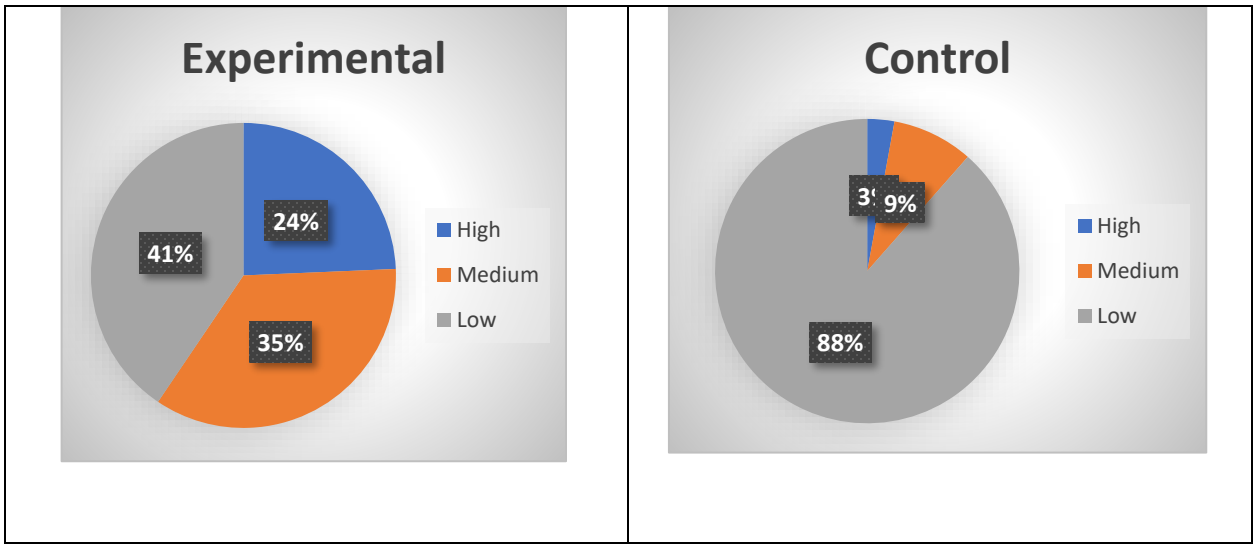
Std Deviation - Fundamental Concepts



APPENDIX-20

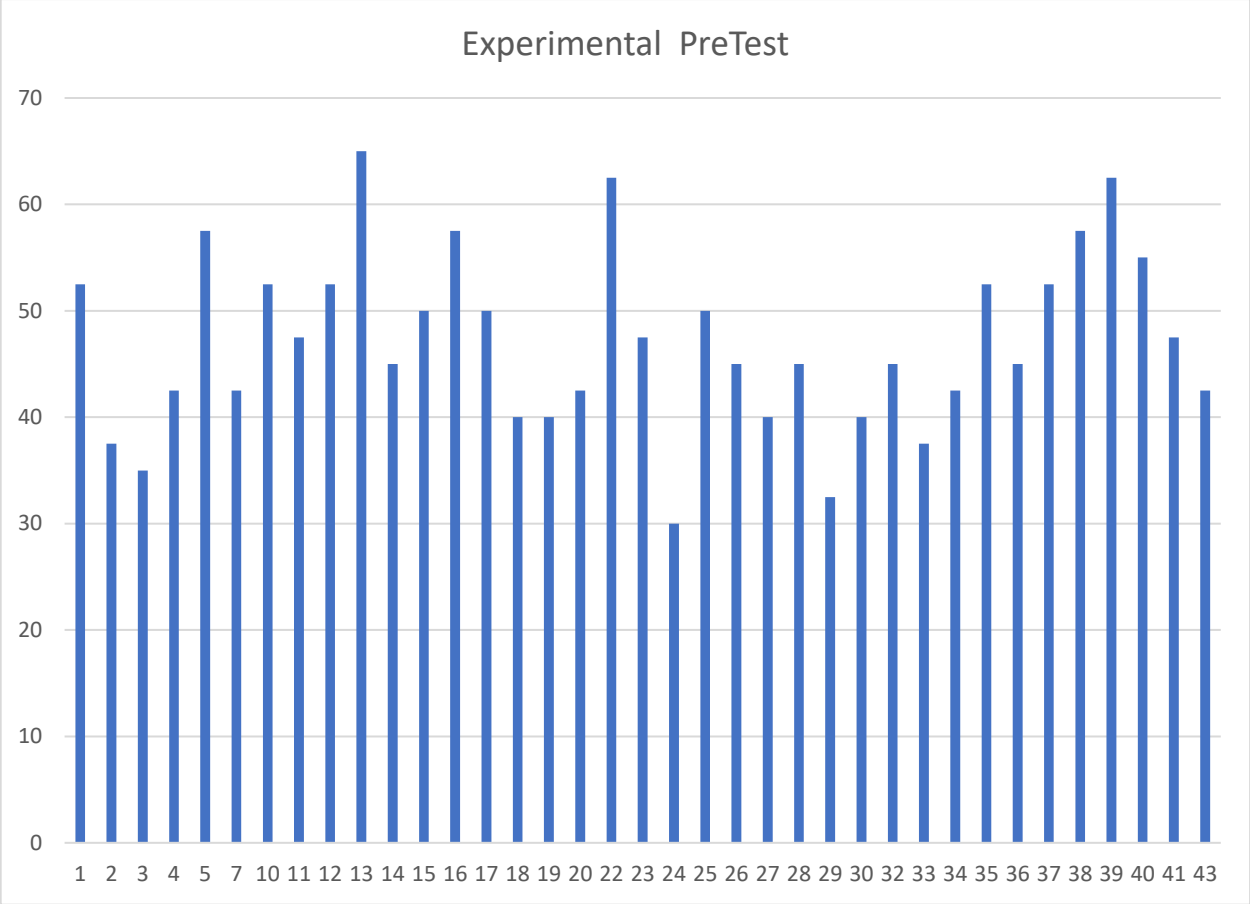
High Medium Low performers of Experimental and Control Group based on Marks obtained

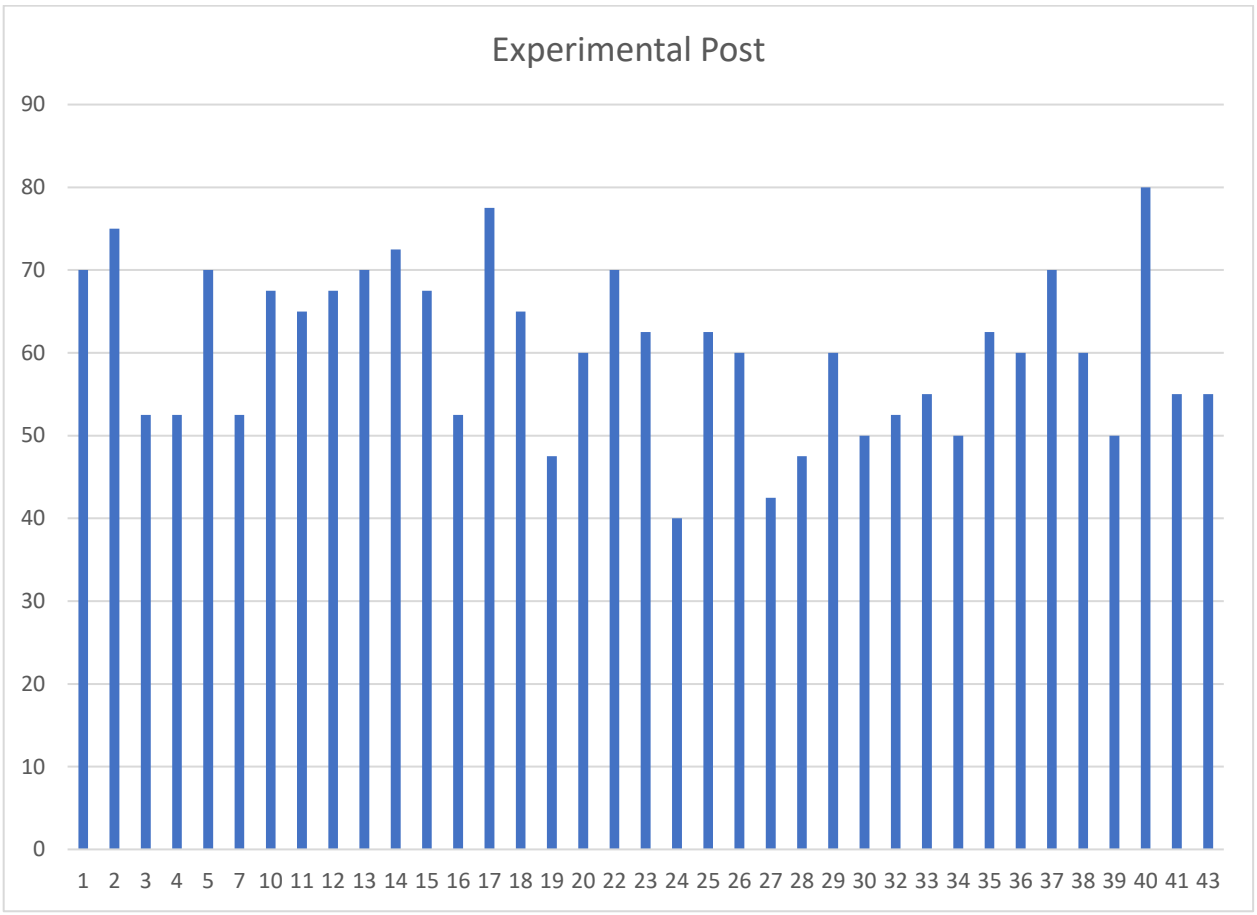
Group	High	Medium	Low
Experimental	24	35	41
Control	3	9	88



APPENDIX-21

Student Wise performance of Experimental Pre-test and Post Test




Experimental Post
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 7 10 11 12 13 14 15 16 17 18 19 20 22 23 24 25 26 27 28 29 30 32 33 34 35 36 37 38 39 40 41 43

APPENDIX – 22

Comparison of Experimental Group Pretest & Post Test

Experimental Group Analysis			
	Pre Test	Post Test	Remarks
Mean	18.838	24.108	Mean score improved by 5.27
Standard Error	0.550	0.648	
Median	18.000	24.000	50% of class score above 24.(60% of the total marks)
Mode	21.000	28.000	Mode changed from 21 to 28
Standard Deviation	3.346	3.943	
Sample Variance	11.195	15.544	
Kurtosis	-0.314	-0.698	platykurtic distribution, Light Tailed, Kurtosis decrease further of post test
Skewness	0.210	-0.010	Data is fairy Symmetrical (Skewness between -0.5 to 0.5)
Range	14.000	16.000	
Minimum	12.000	16.000	
Maximum	26.000	32.000	
Sum	697.000	892.000	
Count	37.000	37.000	

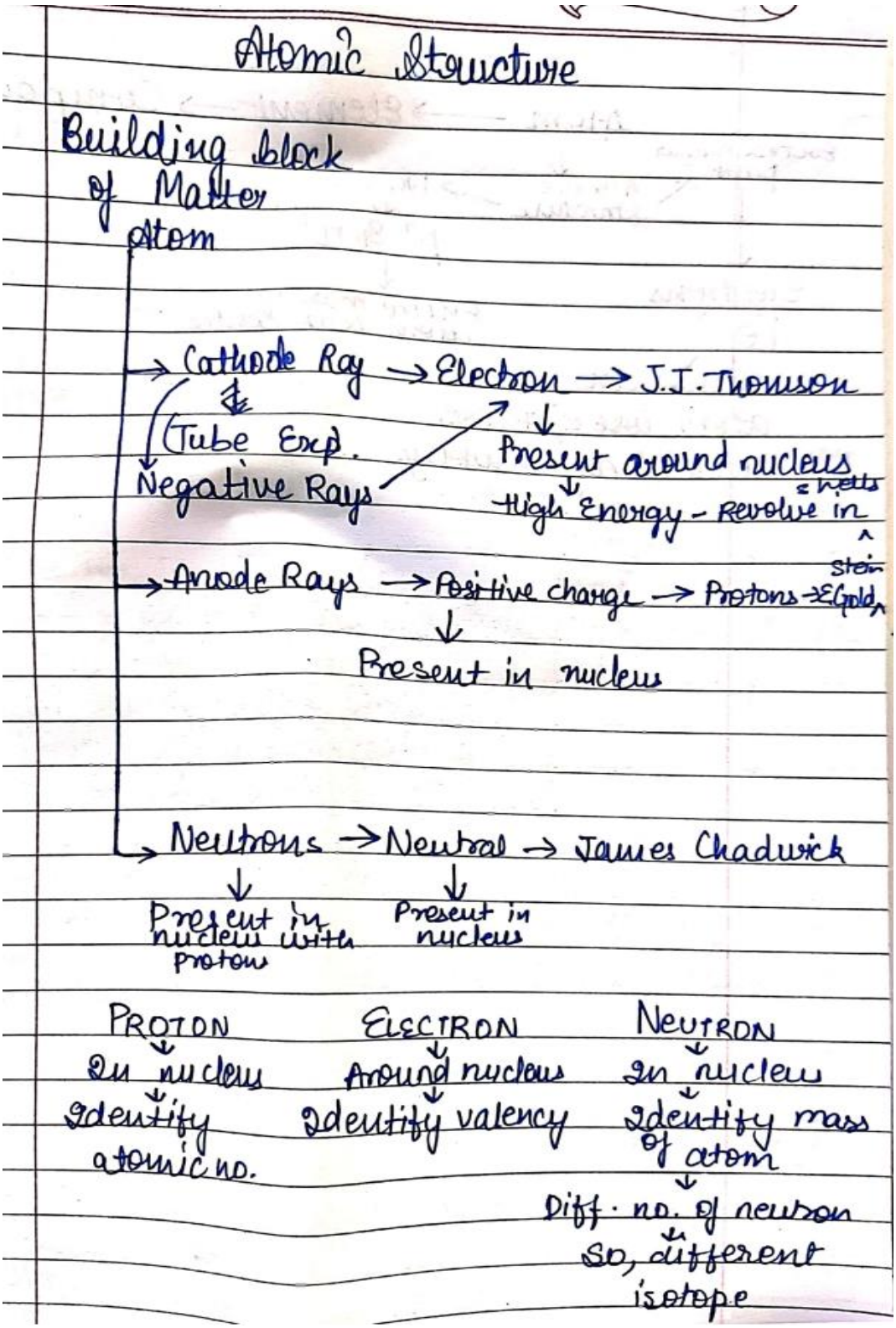
APPENDIX -23

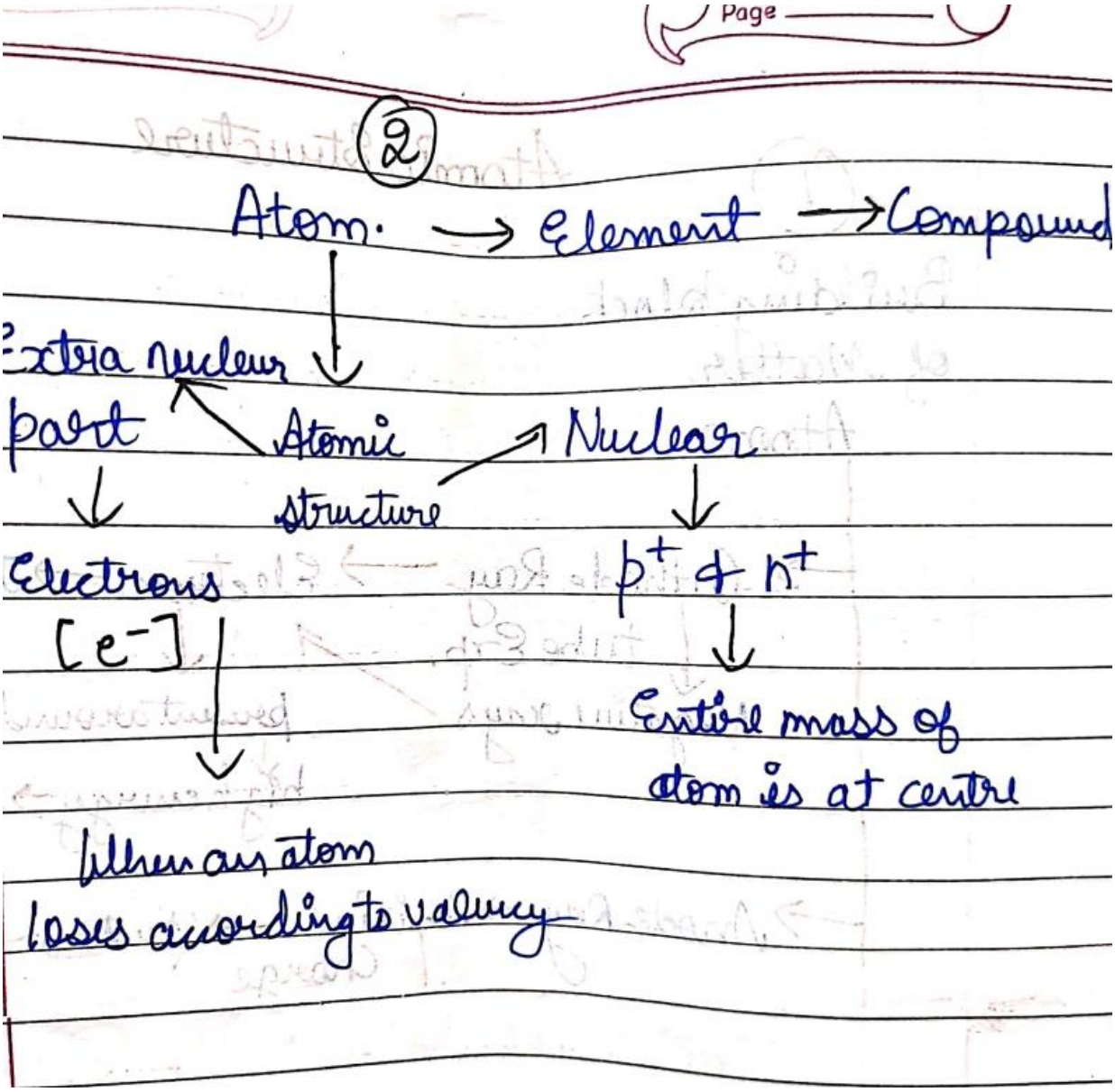
CUMULATIVE STASTICAL MEASURES of Pre test for experimental and control

Metrices	Pre-Test	
	Experimental	Control
Median	18.0	17.0
Mean	18.8	17.5
Mode	21.0	13.0
Kurt	-0.3	-0.8
Skewness	0.2	0.1
Standard Deviation	3.3	5.0

Appendix -24

Concept Map constructed by students




Page
(2)
Atom. → Element → Compound
Extra nuclear part
Atomic structure
Nuclear
Electrons [e⁻]
p⁺ & n⁺
Entire mass of atom is at centre
When an atom loses according to valency

Date
Page

FLAME TEST

↓

Elements jumps to higher level

↓

release electrons

↓

prominent colours released

↓

Add HCl

↓

Paste

Dip glass Road → bit paste → brought on flame

imparts colours ——— Electron jump on higher level

→ Electrons filled as per formula ($2n^2$)

→ K, L, M, N shells.

Limitations :-

Thomson	Rutherford
– stability explained but could not explain result of other model.	– Electrons revolved & accelerate & radiate energy. – may fall in nucleus. – unstable.

④ Model of Atom.

Thomson

– No. of protons is equal to no. of electron → Atom stable

Model → Neil Bohr

- Atoms have fixed shells
- K, L, M, N shells
- descrete shells
- Fixed energies of each shell called energy shell

Rutherford

discovered

- protons at centre
- Electrons revolves around nucleus
- Discovered nucleus too hard & large.
- very small volume.

→ Electrons filled as per formula ($2n^2$)

→ K, L, M, N shells.

Limitations :-

Thomson	Rutherford
- Stability explained but could not explain result of other model.	- Electrons revolved & accelerate & radiate energy. - may fall in nucleus. - unstable.

④ Model of Atom.

Thomson

- No. of protons is equal to no. of electron
- Atom stable

Neil Bohr

- Atoms have fixed shells
- K, L, M, N shells.
- discrete shells
- Fixed energies of each shell called energy shell

Rutherford (discovered)

- protons at centre
- Electrons revolve around nucleus
- Discovered nucleus has hard charge.
- very small volume.

Law of Chemical Combination :

Law of conservation of mass

Mass can neither be created nor destroyed

- Mass remains same forever
- Mass of LHS = Mass of RHS
- $C + O_2 \rightarrow CO_2$

$12 + 2 \times 16 = 12 + 2 \times 16$

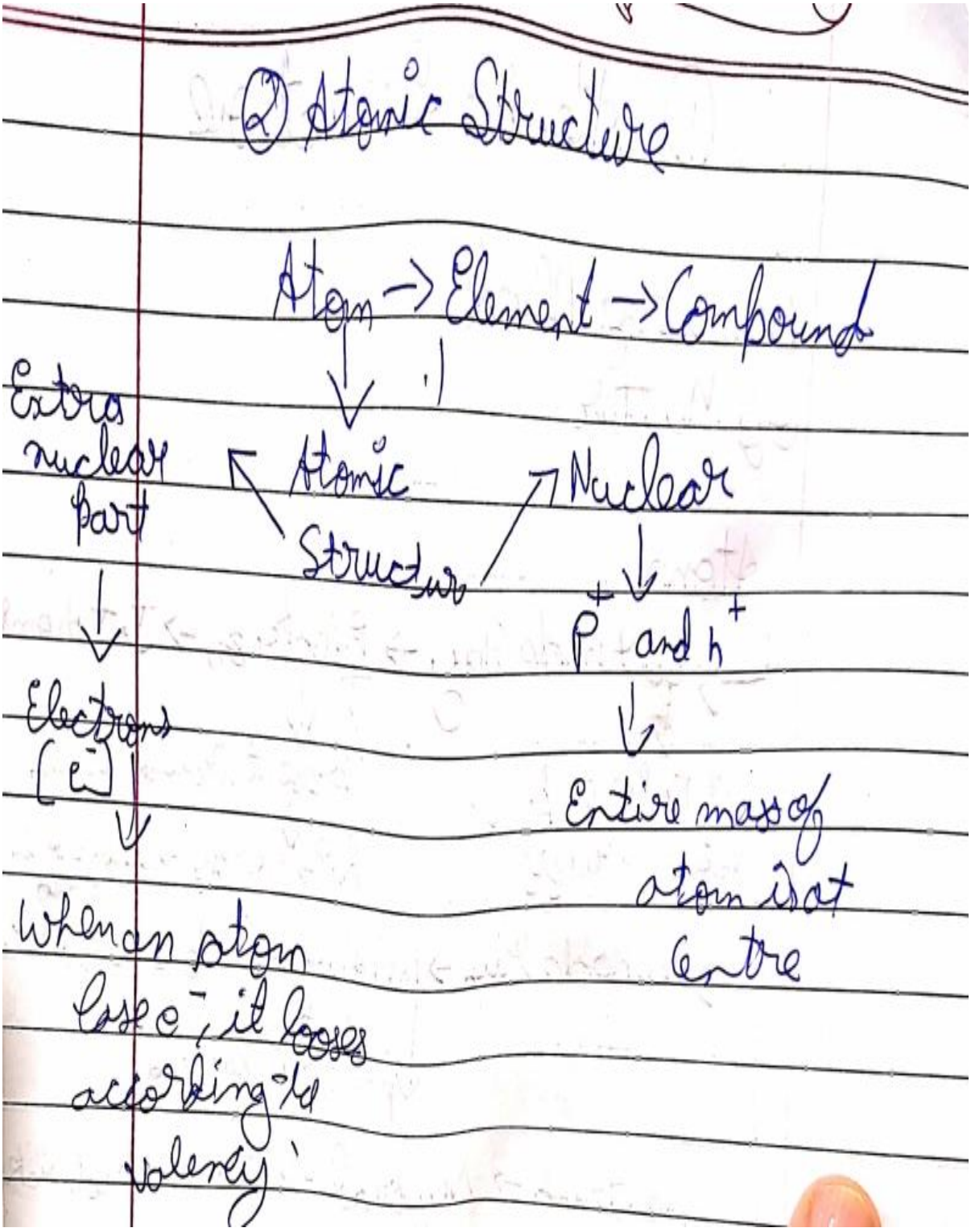
$44u = 44u$

Law of Multiple proportion

- Elements present in fixed proportion by mass
- Chemical compound has fixed ratio
- H_2O

$2:16 = 1:8$

Law of Constant proportion


② Atomic Structure
Atom → Element → Compound
Atomic Structure
Extra nuclear part
Electrons [e⁻]
When an atom loses e⁻, it loses according to valency.
Nuclear
P⁺ and n⁺
Entire mass of atom is at centre

Atomic Structure

①

Building blocks of matter

Atom

→ Cathode Ray → Electron → J J Thomson
↓ Tube exp.
Negative rays → present around nucleus
↓
high energy → revolve in shells

→ Anode rays → Positive → Protons → E. Goldstein
↓ charge
present in nucleus

→ Neutrons → Neutral - James Chadwick
↓
Present in nucleus
Present in nucleus with protons

Proton	Electron	Neutron
↓	↓	↓
On nucleus	Around nucleus	On nucleus
↓	↓	↓
Identify Atomic No.	Identify valency	Identify mass of atom
		↓
		diff no. of neutron
		↓
		So, diff.