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MODELS OF TEACHING CHEMISTRY

Chemistry

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ABSTRACT

This is a theoretical paper in chemistry describing the various models of teaching chemistry and their characteristics. The author has tried to present the initiatives of the IUPAC and UNESCO and the Green chemistry Network Centre (GCNC), Delhi University, Delhi, India. Wilkinson says that the chemistry is a innovative area of work with more theoretical and practical correlations to arrive at the structure of substances and their properties. The model of the substances and their properties remains as understanding and discussion to the effect of laboratory experimentation or industrial application. The Chemistry models are growing in number with more explanations and solutions to the problems of nature and man. The concept maps have helped the teacher and student in acquiring the concepts, understanding, analyzing the data, understanding methodologies for more close examination and better generalization. With the availability of network and enormous information from research institutions, it may be possible to arrive at newer models and methodologies for the known problems of nature.

KEYWORDS

Concept Map, Mental Models, Teaching Models, Network Information, Iupac And Unesco Activities

A model is a representation of an object, event or idea. The model may be an outline of a structure or a set of links and codes that network for conceptualization of the representation. Models introduce science and facilitate in understanding the process, link the ideas and provide a fair basis for the theory. It also facilitates numerical representation and programming of events and objects under transformation.

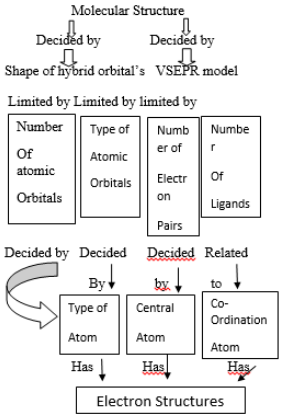


Fig.1 Concept Map of Molecular Structure

Models are represented in different types.

1. Mental models: It facilitates visualization of the event, process or transformation in two or more dimensions.
2. Expressed Model: The mental model is expressed in another form that facilitates building units or systems.
3. Consensus model: It is expressed mental model that has wider acceptance within the scientific community.
4. Historical model: A consensus model which has been superseded at the 'cutting edge' of science for example 'plum pudding 'model of an atom is an historical model superseded by 'orbiting electrons' model.
5. Teaching model: Specifically designed for instructional purposes considering learning objectives, strategies and evaluation.

R.E. Mayer specifies the following criteria for a good model:

1. Structurally complete: The periodic table of elements is the representation of the known elements. There are spaces and relations that may be predicted with new research. However, the periodic table is considered in a holistic representation of elements. For example, the long form of periodic table is has become rather obsolete and the new IUPAC 2018 periodic table (IYPT2019 UNESCO) is used in the education of young.
2. Coherent and appropriate in its level of detail;
3. Uses appropriate vocabulary and form of presentation (according to IUPAC).
4. Concrete in its representation: The modeling electronic structure through ball and stick model shows concrete representation. However, representing bond angle and appropriate orientation is a rather difficult task.
5. Model provides clear conceptual explanation. The associated ideas also may be related and used in solving problems. It also shows limitations in the system.
6. It highlights the correct comparatives between the model and the target idea the scope and limitations of the model are enlisted for consideration.

The above points are considered for evaluating effectiveness of the model.

How models are used effectively in Chemistry teaching? The common experience is that the chemistry teacher introduces the topic and starts presenting logically the equations, contexts, conditions, the various processes and products in given time for effective conceptualization for example, Haber's process of preparation of Ammonia.

The related questions are how to increase the volume of ammonia production? How systems efficiency could be improved in order to facilitate chemical transformation. There are laboratory models, proto type models and industrial models. The other related questions are: How long Ammonia (NH_3) could be used as a coolant in a system? How ammonium salts are better fertilizers? Why salts could be controlled in its solid than liquid or gaseous forms? A Nano form of the substance is also solid structure in terms of its properties.

Determine the amount of heat (in KJ) given off when $1.26x10^4$g of ammonia is produced as observed in the equation:

$$N_2(g)+3H_2 \longrightarrow 2NH_3(g)$$

$$\Delta H^\circ_{rxn} = -92.6 KJ/mol$$

Assume that the reaction takes place under standard state conditions at 25◦C (Chang,R 2008).

Molecular structure theory is a model to understand the molecular structure of substances.It is shown in the Figure No. 2.

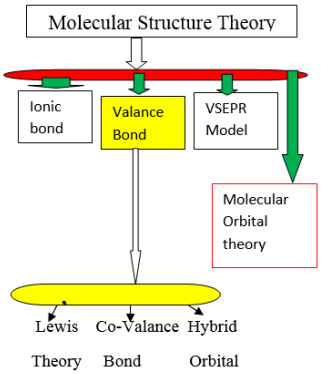
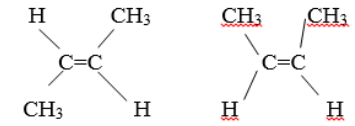


Figure No.2 Hierarchical diagram of theory of molecular structure

1. Mental Models: Mental models are the visual representation of the chemical transformation, structure of substance in its properties for example, in stereo isomers the substance has dextrose rotation or levos is equally a mental representation as much as physical phenomenon. The position of the functional group on one side and rotating 180◦ to the other position is the optical phenomena. It is represented in the following example, Cis-Trans isomers.

Cis-Trans isomers:



Trans-but2ene Cis-but2-ene

2. Expressed Models: The expressed models have definite dimensions, specific shape and functional properties that exhibit transformations.

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

$$\Delta H = -904 KJmol$$

Acid –Base reactions:

$$OH^- + H_3O^+ \longrightarrow 2H_2O$$

$$NH^+_4 + NH^-_2 \longrightarrow 2NH_3$$

Identify the Bronsted acid and base in each case.
Test the household compounds to identify the chemical substance in it:
Table salt Na Cl
Vinegar (Contains Acetic acid)
Table sugar (Sucrose)
Baking soda $NaHCO_3$
Washing soda $Na_2CO_3 10H_2O$
Boric acid H_3BO_3
Milk of Magnesia $Mg(OH)_2$
Calcium Carbonate $CaCO_3$
Epsom salt $MgSO_4\ 7H_2O$
Sodium hydroxide (Used in drain openers)
Hydrogen halide (HF, HBr, and HCl, HI) are highly reactive in laboratory as well as industry and finds many uses for various applications.
Friedel Crafts reaction
Decomposition reaction

$$NH_4Cl(s) \longrightarrow NH_3(g) + HCl(g)$$

$$2H_2O \longrightarrow 2H_2 + O_2$$

Identifying the metal complexes as MX_1MX_2..... reactions.

Consensus Model:This is the model accepted byIUPAC and scientists as the correct representation of the chemical phenomenon.

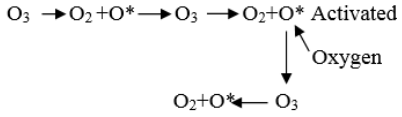


Figure No. 3 Showing process of Ozone depletion (natural)

The Peroxide effect(Kharasch 1933) The presence of oxygen or per oxides that are formed when the alkenes stands exposed to the air, or added per oxides such as benzoyl per oxide causes the addition of hydrogen bromide to take place in the direction opposite to that predicted by Markownikoff's rule. This is due to the per oxide effect. The Hydrogen chloride, Hydrogen iodide and Hydrogen fluoride do not show such reaction. It has been found that the addition of hydrogen bromide is 'abnormally' effected photo chemically as well as by per oxide catalysts. The mechanism of the per oxide effect is a free-radical chain reaction, the per oxide generating the free radical R^1.

$$(R^1CO_2)_2 \rightarrow 2R^1CO_2 \rightarrow 2R^1 + 2CO_2$$

$$R^1 + HBr \longrightarrow R^1H + Br^{\cdot}$$

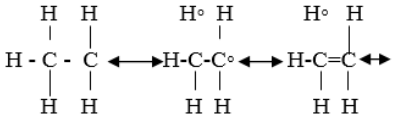
$$R^2CH{=}CH_2 + Br^{\cdot} \longrightarrow R^2CHCH_2Br \xrightarrow{HBr}$$

$$R^2CH_2CH_2Br + Br^{\cdot} \text{ etc.}$$

In the photochemical reaction (addition), the bromine atom is produced by absorption of a quantum of light.

$$HBr \xrightarrow{h\nu} H^{\circ} + Br^{\cdot}$$

A favored theory is that the order of stability of free radicals is the same as that for Carbonium ions i.e., tertiary (t)>secondary(s)>primary. One explanation for the order is no bond resonance. Hence, the primary free radical $R^2CHBr\ CH_2$ being much less favored energetically than the secondary R^2CHCH_2Br



Among other factors,the energy of activation in a given reaction is lower the greater the strength of the new bond formed.The bond broken is the Π bond and the energy change will not affect the activation energy whichever way the free radical addition occurs. The strength of a C-H bond is in the order p>s> t(Finar,I.L 2009). This could be considered as the consensus model.

4. Historical model: The level of energy of atom and electrons are explained by VSPER model. The present investigation shows that the spins are opposite and exists in higher and lower in the frontier orbital that actually participates in the chemical reaction. The energy(heat Δ) involved in the interaction helps in understanding the level of chemical interaction. The later explanation is clearly provided by Hoffman.

5. Teaching Model of Chemistry: This model is specifically designed for instructional purposes considering learning objectives, strategies and processes and outcomes and evaluation.The current thinking gives equal or more importance to the visual learning and visualization of structures, chemical reactions, transformations and products. The preferred designs of instruction being the hybrid designs such as flipped classroom, web based instruction (for example, Tata classrooms), mobile learning, Use of 'U'tube, interactive activity based lessons.

One of the example of a activity based inquiry classroom is represented by curriculum alignment project(CAP) developed by Pinkarton to cover the entire semester of activities with multiple approach and design and construction projects that provide students with a concrete task to accomplish, rather than an abstract theme to appreciate. Jones has discussed introductory chemistry learning environments that promote the use of design activities which can provide students with opportunities to develop authentic scientific inquiry skills. Many of the activities students complete in their course work are school activities, activities conducted only in classroom settings (Ray, B 2013).

Problem Based learning is another approach that provides insight in the classroom activities as well as the activities in the field for example, project on testing of river water (Ganga for example).

Concept mapping as a metacognitive strategy facilitates better active understanding of the concept (Mani, R.S.2018). The activities, idea, links and the strategy to solve problems becomes a group activity that involves co-operative learning and common rising of standards.

TED project 2003: Bill Gates introduced Teaching Effectiveness project in the year 2003 for the teachers of United States of America. It has the target of around 3000 teachers to be involved in video recording of their teaching, organizing their students into groups for active interaction and feedback. The teacher after developing the video live has the opportunity to view it for self analysis and improvement. The teachers have showed initially good improvement in conceptualization, strategy, teaching, diagnosing problems and evaluation. This seems to be a promising project for teaching science (Chemistry) also after the Classroom 2000+ project.

Marzano and Kendall (1996) contend that both content and performance standards need to be used. Further, they suggest that content standards are articulated at a general level but with specific sub components at developmental levels or 'bench marks' by Blyth (2002). 'bench marks are essential in describing the developmental components of the general domain identified by a standard. Rosenholtz(1991) and Swanson and Stevenson(2002) assert that

standards provide a common focus,clarity, understanding, accelerate,communication,

And promote persistence and collective purpose.

Schmoker and Marzano (1999) contend that educators have to be very disciplined about writing clear standards and that the standards must be limited in number. Moore (2000) notes that the standards must be carefully linked to assessment. It is also necessary to state the minimum acceptable levels of performance or criterion of success (amount of time taken (speed) for the transformation, accuracy or quality. The PISA tests in science and mathematics have focused on these aspects.

Roger Schank (2011) defined 'learning as improvement in one's cognitive proceses.He listed 12 cognitive processes underlying learning and they are classified under three categories namely (i) Conceptual processes, (ii) Analytic processes and (iii) Social processes.

(i) Conceptual processes involve prediction, modeling, experimentation and evaluation.
(ii) Analytic processes: Diagnosis, planning, causation and judgment.
(iii) Social processes: It involves social influence, team work, negotiation and describing.

Tolman, E.C. described 'behavior as goal directed, purposive and guided by the goal determined by the cognitive structure of the organism. He developed the concept of 'Concept map'. He refers to acquisitions, representation and the use of spatial information to perform tasks. According to Tolman'learning is of sign gestalt, formation, refinement, selection and invention'.

Tiwari, M (2005) studied the influence of preparation in organic chemistry and its effect on achievement at the California State University San Marcos (CSUSM). The factors influencing achievement considered in the study were: gender, class standing, age , preparation in Basic chemistry.

The preparation in Basic chemistry showed ^{2}=9.57, df=3,p=0.023) and in success and grade le^{2} =23.24,

Df=2,P< 0.001). There was a significant correlation of passing rate with response for SEM1 (^{2}=15.92, df=3, P=0.001).

The hypothesis that a student who scores 'A' grade in coursework, tend to work hard and try to achieve with higher realistic expectations.It indicates that the students' necessary level of work and commitment for success is consistent with the preparation for organic chemistry. These results are consistent with a previous study of high school physics students that indicated students expectations are correlated with course performance. The 'study habits' seems to be one of the variable correlated with success as much as the 'participation in study groups'. Assignments may be a help for studies to refer and review to fill ideas and gaps of connections in the understanding.

General Chemistry preparation CSUSM Chemistry Faculty to be the minimum content for entering organic chemistry students. The first semester general chemistry courses consisted of the following topics: Atomic theory, Chemical bonding, Moles and Stoichiometry, Qualitative ideas of acids and bases, basic chemical reactions (acid-base, precipitation, and oxidation-reduction). Qualitative aspects of energy changes, Qualitative ideas of chemical equilibrium.

The quantitative ideas presented in the course are those related to basic stoichiometry, limiting reagents, percentage yield, and molarity. Although, the idea of chemical equilibrium and the equilibrium constant are introduced, problem solving requiring algebra is not learnt by students. There is a small component of co-operative learning in some semesters(< 20% of class time).

In the CSUSM lower division curriculum, the two semester organic chemistry sequence is followed in the fourth semester by the more quatitative ideas of acid-base and oxidation-reduction chemistry as well as thermodynamics and kinetics. Postponing the quantitative aspects of introductory chemistry until the fourth semester gives students time for remediation of deficiencies, in maths skills. For this purpose there is a Calculus I co requisite for the fourth semester quantitative chemistry course.

Global efforts in increasing the standard in teaching of chemistry: Science achievement and Gross national product per capita of TIMSS 1999 countries. One of the indicators of the level of success in science education in a country is the results of the Third International Mathematics and Science Study (TIMMS) in 1995 and its sequel TIMMS-Repeat in 1998 .Thirty eight countries participated in the sequel, of which Turkey was 31st in Maths and 33rd in science.

Joint Initiatives of IUPAC and UNESCO: (i) the DIDAC teaching resources were originally created in Belgium, and were quite expensive to acquire in their original form. They comprise a series of nearly 300 colorful transparencies (language free), supported by text for the chemistry teacher. Following endorsement of the material by IUPAC's committees on chemical industry and on teaching of chemistry attempts were made to achieve wider dissemination in co-operation with UNESCO.Books and CDs have been prepared and posters have been printed from some of the transparencies. The teacher texts are available in six languages.(ii) the micro chemistry concept has been promoted by IUPACand UNESCO through workshops in more than 70 countries and workshops and practical work.Pilot projects are completed in many countries and workbooks are available in several languages. It is available as worksheets in the UNESCO website. UNESCO associated centres are established to provide continuing support in different regions. Some 15 countries have acquired micro chemistry kits and chemicals. As Beasley and Chant observed in Australia nearly ten years ago 'the trend from macro is now established'.IUPAC's commission on Toxicology and committee on teaching of chemistry prepared a resource titled'EssentialToxicology and a C.D is prepared that has PowerPoint presentations on the subject for secondary school and tertiary level teachers. The aim is to sensitive and inform chemistry teachers who have usually not received any initial or subsequent training thereon.C.D. was facilitated by UNESCO.(iii) The chemistry clearing house was initiated in Russia with the support of IUPAC. This has been established in Mascow to adapt and disseminate recommended materials and methodologies that have been originated in IUPAC and other reputable sources to the Russian speaking community of chemistry educators.(iv) A News letter of the Committee on teaching chemistry was initiated. A glossary of chemical concepts are proposed to IUPAC for the future.(v) International conference on chemical education (biannual)(ICCE) a unique biennial event in the international calendar that facilitates helping chemistry educators around the world to fulfill their role.

Green Energy Centre was established in Penang, National University of Malaysia,in order to train, develop and disseminate the green ideas among the teachers and teacher educators and students with reference to the energy efficacy and effectiveness. Teachers, teacher educators, and students participated equally well and developed the consciousness of energy efficacy and effectiveness for the national development.

GREEN INITIATIVES IN INDIA:

IUPAC committee visited the Department of Physical Chemistry , Pune University, Pune and made a historic declaration that the Chlorofluoro Carbon will be gradually discontinued to use in industries. The green experiments will be carried out in the chemistry department.

The green chemistry network centre(GCNC) was established in Chemistry department of the Delhi University under the recommendations of a panel of world leaders headed by Prof. Paul Anastas, Director, American Chemical Society's Green Chemistry Institute. It has the following aims:

- Build a network for exchange of expertise, discussion and knowledge between industrialists and academicians and between chemists and engineers with interests and expertise relevant to Green chemistry. GCNC will act as the nodal center to initiate and sustain such co-ordinated activities.
- Prepare and disseminate the teaching materials on green chemistry for school, college and university levels, with the simultaneous design of laboratory experiments for these levels as well.
- Design training to make them aware, gain concepts, principles and methodologies of green chemistry and empower them to initiate changes in their institutions and industries. The structure of the training will be designed to provide them with the knowledge and basic tools they need to begin planting seeds of green chemistry within their own educational structure.
- Translate existing green chemistry materials for broader

distribution through the network allover India.

ACHIEVEMENT:

The Green chemistry network centre received the prestigious ChemRAWN XIV-GCI Developing and Emerging Nations Grant Award for the year 2005,2006 and 2007 from American Chemical Society's Green Chemistry Institute for these activities.

The Centre for Environmental Education, Thaltej Tekra, Ahmedabad,Gujarat,India has prepared the environmental training material for teachers and students., organized workshops,conferences, and publishes the articles, papers and researches in a journal namely Biodiversity.It has also developed telefilms on green concepts for students and broadcast for the purpose with the American collaboration.

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