Effect of Concept Mapping Strategy on Concept Retention and Concept Attrition in Organic Chemistry

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Abstract

This paper reports on a quasi-experimental study which was conducted to compare the effect of Concept mapping strategy and Conventional teaching method on concept retention and concept attrition among Class XII science students in Organic Chemistry. For this reason the achievement test scores in Organic Chemistry of the Class XII science students from an English Medium school at Varanasi (U.P.), affiliated to CBSE who were taught "Ketone" in Chemistry course either using Conventional teaching method (Control Group or Group A) or Concept mapping strategy (Experimental Group or Group B), were analysed. The results of the present study indicates that Concept mapping strategy is significantly more effective than the Conventional method in the improvement of achievement in Organic Chemistry, concept retention in Organic chemistry and for preventing concept attrition (retention loss) in Organic Chemistry.

Organic Chemistry is one of the major branches of chemistry which is being studied by those who desire to join professional courses such as Medical, Engineering, Agriculture, Pharmacy, Environmental Sciences, Earth Sciences and Home Science.

Generally like any other science, at all the stages of education viz., primary, secondary and tertiary, Organic Chemistry is also being taught mainly through conventional methods. However, students of the 21st century find it very difficult to engage themselves in the learning of Organic Chemistry through traditional methods of teaching in view of changing learning needs have changed in this digital age (NCREL, 2003). Hence a reform in the teaching and learning of Science, in general, and Organic Chemistry, in particular, is needed which can help students to learn more effectively.

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In schools, Chemistry classes at 10+2 level are conducted to achieve mastery of the textbook content, including exercises of the end of chapter in a textbook, textbook assignments and examinations. Many students who are considered successful in conventional classes are not successful when it comes to solving problems in newer contexts. At times, students who have mastered solving end of chapter problems have a weak grasp of basic concepts and are unable to apply what they know to new situations.

The common problem in Chemistry is that even if students do well in examinations they still may fail in solving basic textbook problems, which is a sign of rote learning (Pendley *et al.,* 1994). Owing to its nature, Chemistry is often full of abstract concepts. It may lead to extensive misconceptions among students. If there is lack of hands-on-experience and intense interaction, one area of focus for improving scientific literacy is changing the way science is taught in the classroom. Chemistry is considered as a difficult subject among the natural science. It has been observed that learners tend to depend on memorisation of concepts and mechanisms of Chemistry instead of applying their rationale and reasoning. Such learning is rarely consolidated and easily forgotten. There is a need to bring improvement in teaching Chemistry which provide easy explanations of principles so that students become interested in Chemistry and do not develop "Chemo phobia" when later faced with systemised and scientific explanation of phenomena.

One way to fulfil this is to use Concept Mapping as a teaching strategy. Concept mapping is a method to visualise the structure of knowledge. Since the knowledge expressed in the map is mostly semantic, concept maps are sometimes called semantic networks. Often it is claimed that concept mapping bears a similarity to the structure of long-term memory. Instead of describing all concepts and their relations in text, one may choose to draw a map indicating concepts and relations in graph or network. Visual representation has several advantages. Visual symbols are quickly and easily recognised and this can be demonstrated by considering the large amount of logos, maps, arrows, road signs, and icons that most of us recall with little effort. Visual representations also allows the development of a holistic understanding that words alone cannot convey, because the graphical form allows representations of parts and whole in a way that is available in sequential structure of text (Lawson, 1994).

Concept mapping which is based on Ausubel's theory of meaningful verbal learning is currently a favourite subject of research in the western world. Concept maps are diagrammatic representations which show meaningful relationships between concepts in the form of propositions which are linked together by words, circles, and cross links. Concepts are arranged hierarchically with the super ordinate concepts at the top of the map, and subordinate at the bottom which are less inclusive than higher ones. "Cross links" are used to connect different

segments of the concepts hierarchy which indicate syntheses of related concepts, a new interpretation of old ideas, and some degree of creative thinking.

In Chemistry, the use of Concept maps has been widely investigated. According to several studies (e.g., Cardellini, 2004; Francisco *et al.,* 2002; Markow and Lonning, 1998; Nicoll *et al.,* 2001; Osman Nafiz, 2008; Pendley *et al.,* 1994; Regis *et al.,* 1996; Stensvold and Wilson, 1992), concept maps help Chemistry learning both in classrooms and in laboratories. According to Francisco *et al.,* (2002) and Nicoll *et al.* (2001), Concept maps are a useful learning tool in Chemistry. Concept maps can improve understanding of chemical concepts and help build connections among abstract concepts. Concept maps can also be used as misconception-correction tool. Concept maps bind concepts with linking words that help students see connections among them and organises the knowledge hierarchically, based on scientific knowledge (Francisco et al., 2002; Nicoll *et al.,* 2001).

There is however, an apparent dearth of studies in Organic Chemistry on it. According to Lopez *et al.,* (2011), "Concept Maps carry the potential to illuminate misconceptions and enhance instruction and learning, this need is especially pronounced in difficult yet widely required courses such as Organic Chemistry".

Since the subject of Organic Chemistry occupies an important place in the school curriculum, there is a need to probe the effectiveness of Concept mapping strategy. Hence, the investigator has selected Concept mapping strategy to find out its relative effect on student's achievement, concept retention and concept attrition in Organic Chemistry.

Objectives

1. To study the effectiveness of Concept mapping strategy in comparison to the Conventional method in terms of achievement in Organic Chemistry.
2. To study the concept retention in Organic Chemistry of students being taught through Concept mapping strategy and by Conventional method over a period of time after the termination of treatment.
3. To study the concept attrition in Organic Chemistry of students being taught through Concept mapping strategy and through Conventional method over a period of time after the termination of treatment.

Hypotheses

$H_0$1: There is no significant difference between the achievement in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance.
$H_0$2: There is no significant difference between concept retention in Organic Chemistry of students taught through Concept mapping Strategy and students taught through Conventional method at the 0.01 level of significance.
$H_0$3: There is no significant difference between concept attrition in Organic

Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance.

Design and Sample of the Study

The study was quasi-experimental in nature where Pre-test and Post-test Non-Equivalent Groups Design was used. The sample of the present study comprised of 60 science students studying in two intact sections that is 'A' and 'B' of Class XII of an English Medium school at Varanasi. Out of these two sections, section 'A' was randomly assigned as the experimental group (n_1=30) and other section 'B' as the control group (n_2=30) for the study. To eliminate the initial variability of intelligence in both the groups, the students were measured on general mental ability test employing, a Mixed Group Test of Intelligence by Dr P.N. Mehrotra. t-test was applied to find out the difference between intelligence test scores of both the groups. Results have been given in Table 1.

Table 1
Mean, S.D. and 't' values obtained on Intelligence test by Experimental Group and Control Group

Group	*N*	*Mean*	*S.D.*	*df*	*'t'*	*p*
Experimental Group	30	52.23	5.24	58	1.60	> 0.05
Control Group	30	54.65	6.35			

Table 1 reveals that "t" value of 1.60 for intelligence scores was not significant at the 0.05 level of significance. It meant that significant difference does not exist between the intelligence of both the groups.

Tools Used

9 Concept maps of one concept from selected one unit of Organic Chemistry syllabus prescribed by the C.B.S.E. Board.

Mixed Group Test of Intelligence (Hindi Version) by Dr P.N. Mehrotra, Verbal and Non-verbal Test was used for equating both the groups i.e., experimental and control groups on the basis of their intelligence scores.

An Achievement test consisting of 25 multiple-choice questions based on one concept from selected one unit of Organic Chemistry syllabus prescribed by the C.B.S.E. Board for Class XII science students was developed by the investigator to measure the students' achievement, concept retention and concept attrition in Organic Chemistry. In this test each question carries one mark. The achievement test served as both Pre-test and Post-test (Post-test I and Post-test II).

Classroom Experiment

The experiment was conducted in the four steps given below:

Step 1: Administration of the Pre-tests

Firstly, intelligence test and achievement test were administered

to the students of both groups i.e., experimental group and control group.

Step 2: Experimental Treatment

Both the groups' viz., experimental group and control group were taught by the investigator herself so as to avoid teacher variable—the experimental group was taught through Concept mapping strategy, while the control group was taught through Conventional method. Same concepts were taught to both the groups.

Teaching of Experimental Group

The group was exposed through Concept mapping strategy. The investigator introduced one concept of selected one unit namely Ketone through 9 concept maps regarding various aspects such as preparation, properties, reactions and interconversions, which were developed with the help of students by the investigator on the blackboard.

Figure 1 to 9 at a glance present, how concept namely Ketone was introduced to the experimental group through concept maps in an effective manner.

Step 4: **Delayed Post-testing**

After a gap of six weeks from the treatment achievement test was administered again as Post-test II to students of experimental group and control group for measuring their concept retention and concept attrition.

Analysis and Interpretation of the Data

Effect of Concept Mapping Strategy on Achievement in Organic Chemistry

$H_0$1: There is no significant difference between the achievement in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance.

It is evident from Table 2 that mean gain achievement scores of experimental group is significantly higher than that of the control group and 't' value is significant at the 0.01 level of significance. Therefore the null hypothesis $H_0$1 stating that "there is no significant difference between the achievement in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance" is rejected. Meaning thereby that there is a

Table 2

$Mean_{Gain}$, S.D. and 't' values obtained on Pre-test and Post-test-I in Organic Chemistry by Experimental Group and Control Group

Group	*N*	*Mean Gain (Post-test I – Pre-test)*	*S.D.*	*df*	*'t'*	*p*
Experimental Group	30	6.10	2.02	58	3.18	< 0.01
Control Group	30	4.43	2.03			

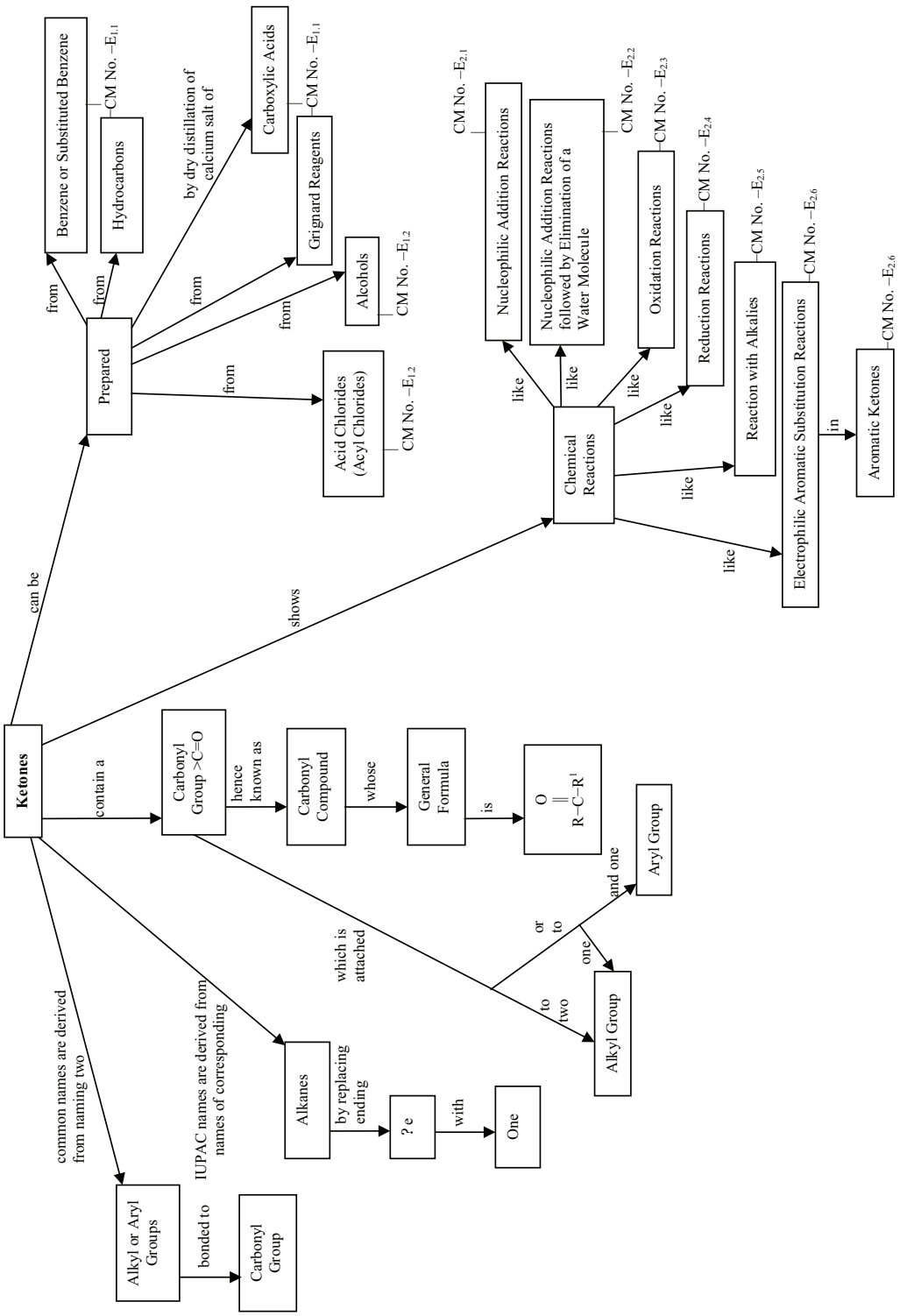
Ketones
can be
Prepared
from
Benzene or Substituted Benzene
CM No. –E1.1
from
Hydrocarbons
CM No. –E1.1
from
by dry distillation of calcium salt of
Carboxylic Acids
CM No. –E1.1
from
Grignard Reagents
from
Alcohols
CM No. –E1.2
from
Acid Chlorides (Acyl Chlorides)
CM No. –E1.2
shows
Chemical Reactions
like
Nucleophilic Addition Reactions
CM No. –E2.1
like
Nucleophilic Addition Reactions followed by Elimination of a Water Molecule
CM No. –E2.1
like
Oxidation Reactions
CM No. –E2.2
like
Reduction Reactions
CM No. –E2.3
like
Reaction with Alkalies
CM No. –E2.4
like
Electrophilic Aromatic Substitution Reactions
CM No. –E2.5
in
Aromatic Ketones
CM No. –E2.6
contain a
Carbonyl Group >C=O
hence known as
Carbonyl Compound
whose
General Formula
is
O
R–C–R1
common names are derived from naming two
Alkyl or Aryl Groups
bonded to
Carbonyl Group
IUPAC names are derived from names of corresponding
Alkanes
by replacing ending
? e
with
One
which is attached
to two
Alkyl Group
or to one
and one
Aryl Group

Fig. 1

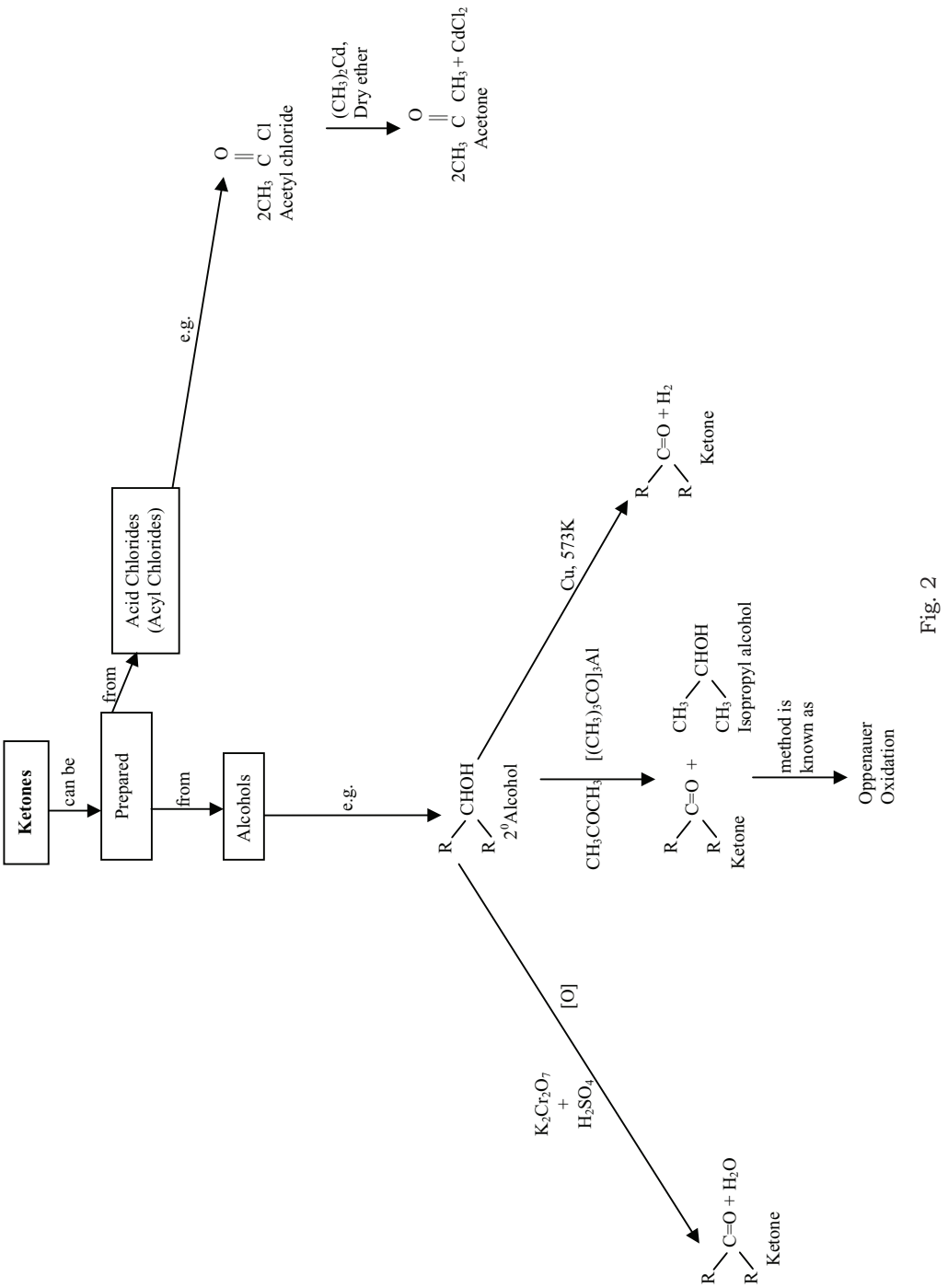
Ketones
can be
Prepared
from
Acid Chlorides
(Acyl Chlorides)
e.g.
O
2CH3 C Cl
Acetyl chloride
(CH3)2Cd,
Dry ether
O
2CH3 C CH3 + CdCl2
Acetone
from
Alcohols
e.g.
R
CHOH
R
2⁰Alcohol
Cu, 573K
R
C=O + H2
R
Ketone
CH3COCH3
[(CH3)2CO]3Al
R
C=O +
R
Ketone
CH3
CHOH
CH3
Isopropyl alcohol
method is
known as
Oppenauer
Oxidation
K2Cr2O7
+
H2SO4
[O]
R
C=O + H2O
R
Ketone

Fig. 2

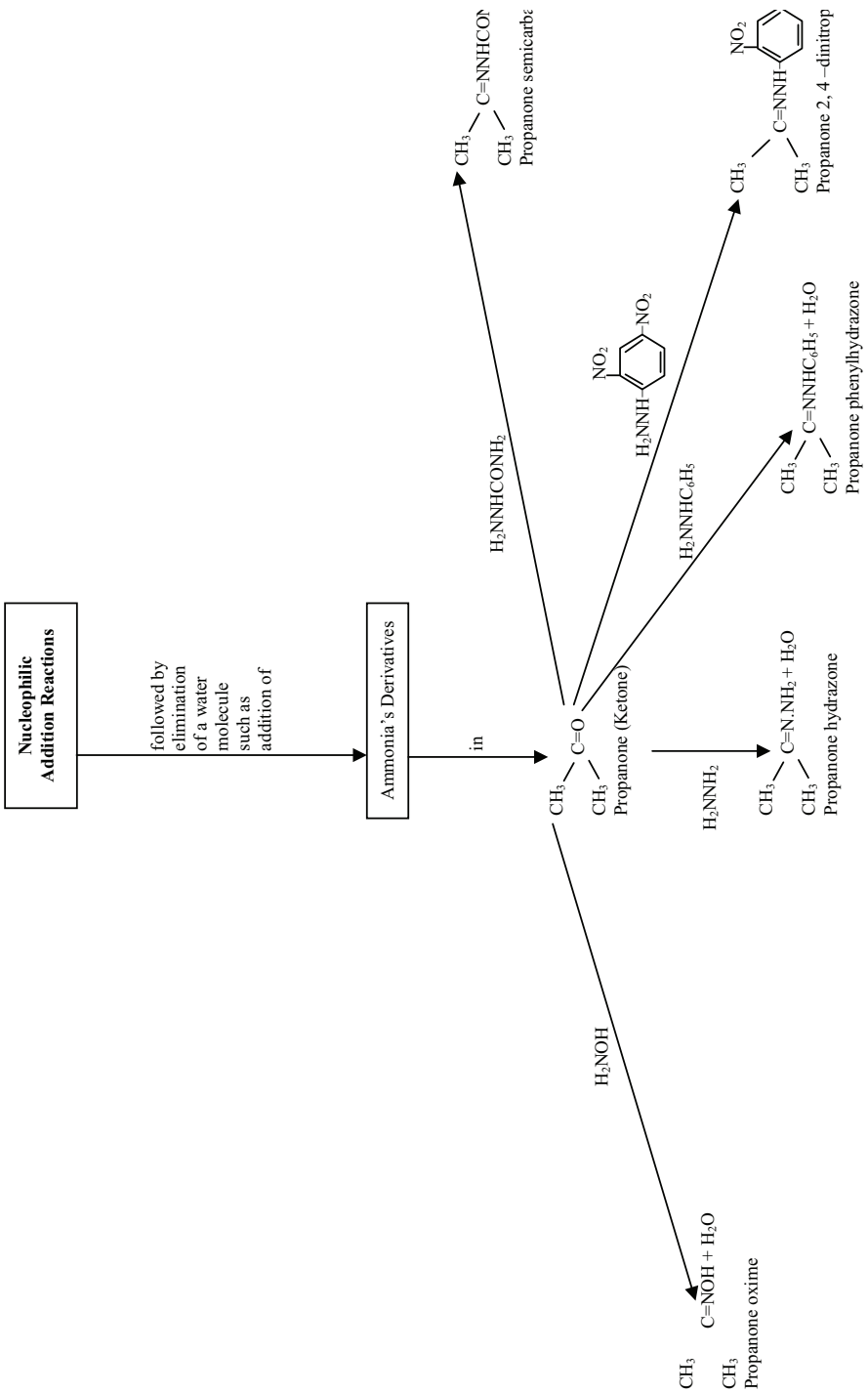
Nucleophilic Addition Reactions
followed by elimination of a water molecule such as addition of
Ammonia's Derivatives
in
C=O
Propanone (Ketone)
H2NNH2
C=N.NH2 + H2O
Propanone hydrazone
H2NOH
C=NOH + H2O
Propanone oxime
H2NNHCONH2
C=NNHCONH2
Propanone semicarbazone
H2NNHC6H5
C=NNHC6H5 + H2O
Propanone phenylhydrazone
H2NNH
NO2
NO2
C=NNH
Propanone 2, 4 –dinitrophenylhydrazone

Fig. 3

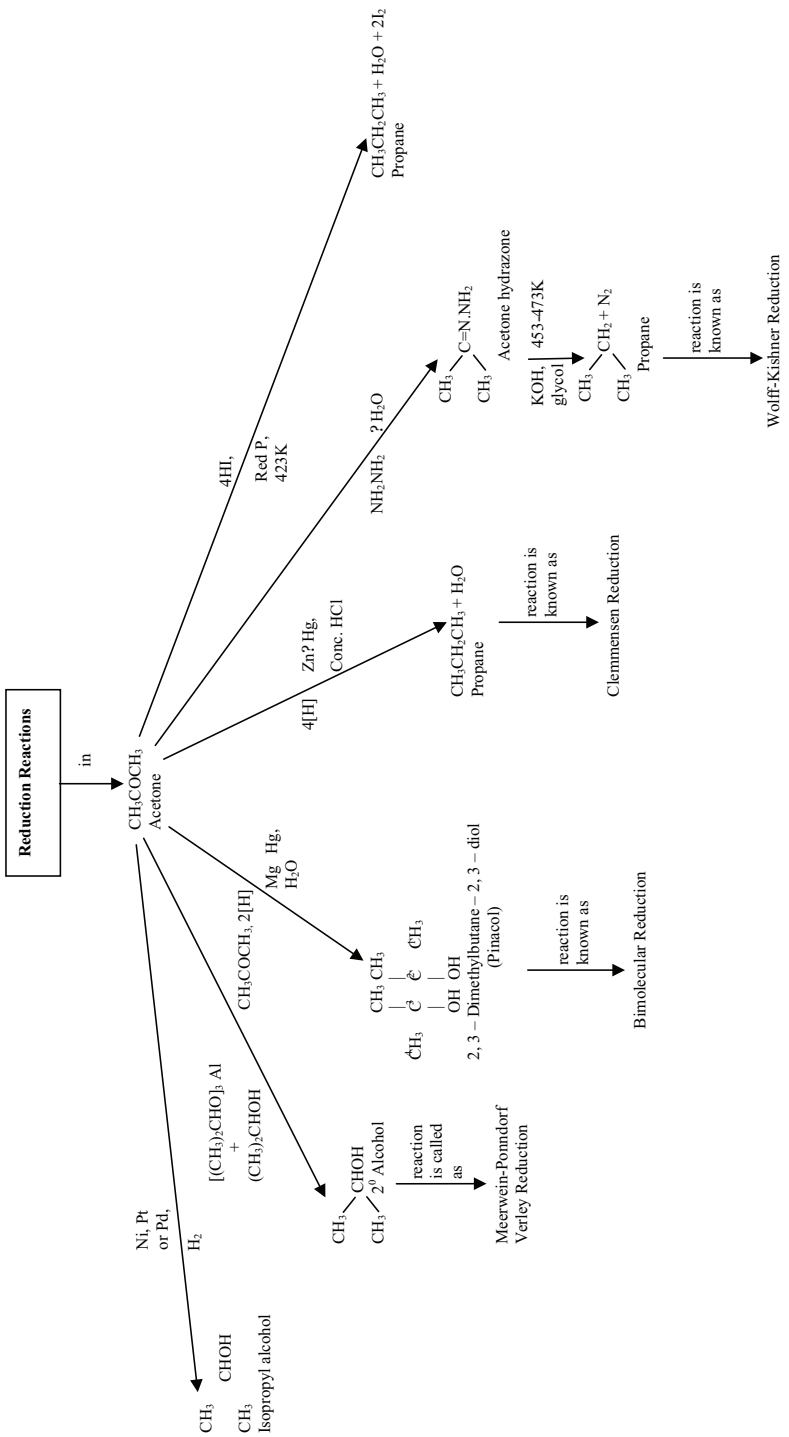
Reduction Reactions
in
CH3COCH3
Acetone
Ni, Pt
or Pd,
H2
CH3 CHOH
CH3
Isopropyl alcohol
[(CH3)2CHO]3 Al
+
(CH3)2CHOH
CH3COCH3, 2[H]
CH3 CHOH
CH3 2⁰ Alcohol
reaction
is called
as
Meerwein-Ponndorf
Verley Reduction
Mg Hg,
H2O
CH3 CH3
C C
CH3 CH3
OH OH
2, 3 – Dimethylbutane – 2, 3 – diol
(Pinacol)
reaction is
known as
Bimolecular Reduction
4[H]
Zn? Hg,
Conc. HCl
CH3CH2CH3 + H2O
Propane
reaction is
known as
Clemmensen Reduction
4HI,
Red P,
423K
CH3CH2CH3 + H2O + 2I2
Propane
NH2NH2 ?H2O
CH3 C=N.NH2
CH3
Acetone hydrazone
KOH, 453-473K
glycol
CH3 CH2 + N2
CH3
Propane
reaction is
known as
Wolff-Kishner Reduction

Fig. 4

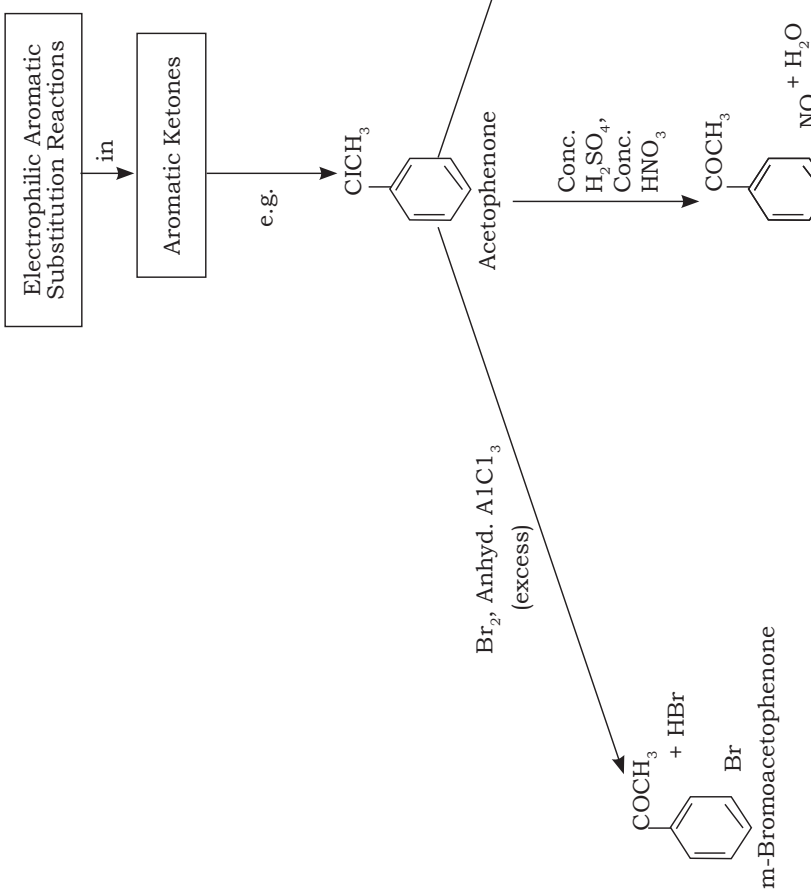
Electrophilic Aromatic Substitution Reactions
in
Aromatic Ketones
e.g.
COCH3
Acetophenone
Cone. H2SO4
COCH3
SO3H
+ H2O
m-Acetophenonesulphonic acid
Conc. H2SO4, Conc. HNO3
COCH3
NO2
+ H2O
m-Nitroacetophenone
Br2, Anhyd. A1C13 (excess)
COCH3
Br
+ HBr
m-Bromoacetophenone

Fig. 5

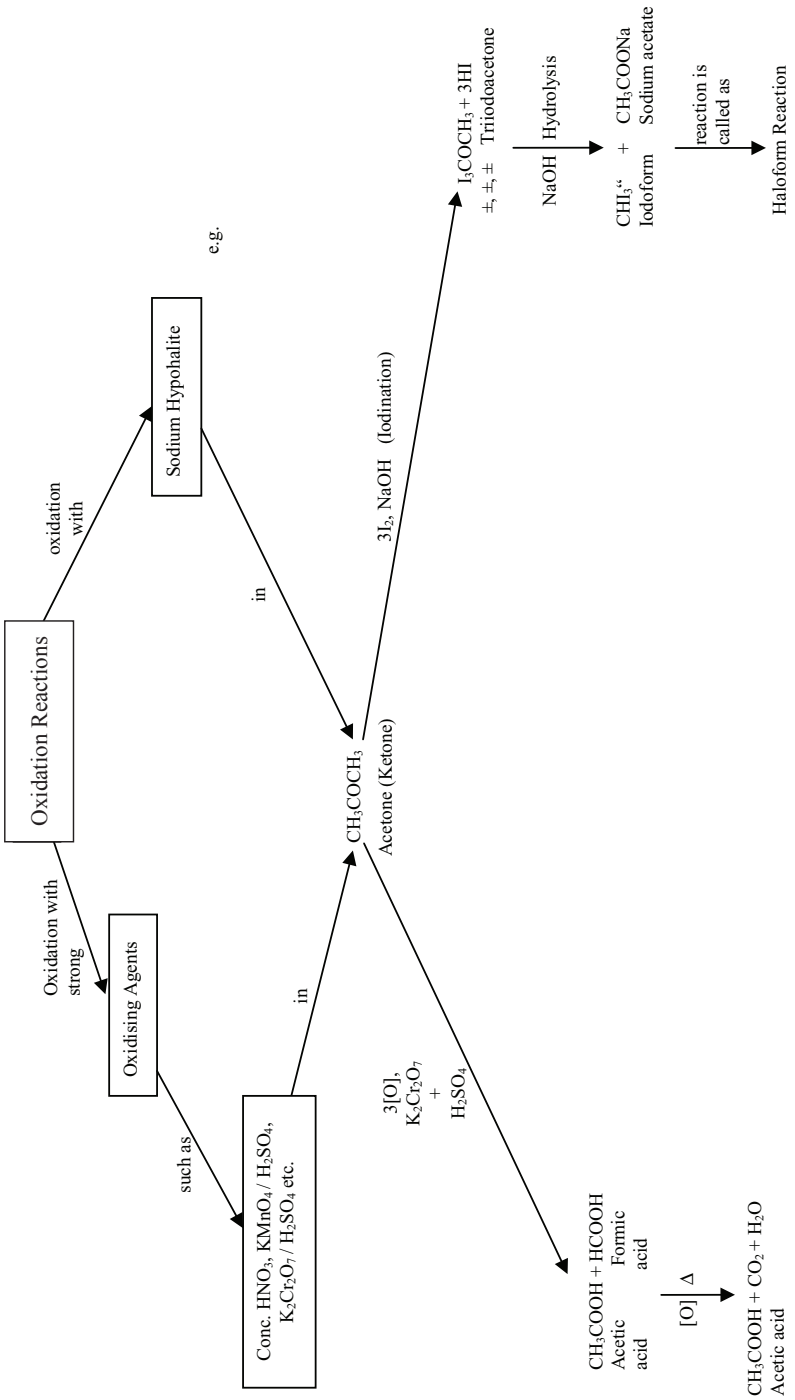
Oxidation Reactions
oxidation with
Sodium Hypohalite
e.g.
in
Oxidation with strong
Oxidising Agents
such as
Conc. HNO_3, $KMnO_4$ / H_2SO_4, $K_2Cr_2O_7$ / H_2SO_4 etc.
in
CH_3COCH_3
Acetone (Ketone)
$3I_2$, NaOH (Iodination)
$I_3COCH_3 + 3HI$
Triiodoacetone
NaOH | Hydrolysis
CHI_3 " + CH_3COONa
Iodoform Sodium acetate
reaction is called as
Haloform Reaction
3[O], $K_2Cr_2O_7$ + H_2SO_4
$CH_3COOH + HCOOH$
Acetic acid Formic acid
[O] | Δ
$CH_3COOH + CO_2 + H_2O$
Acetic acid

Fig. 6

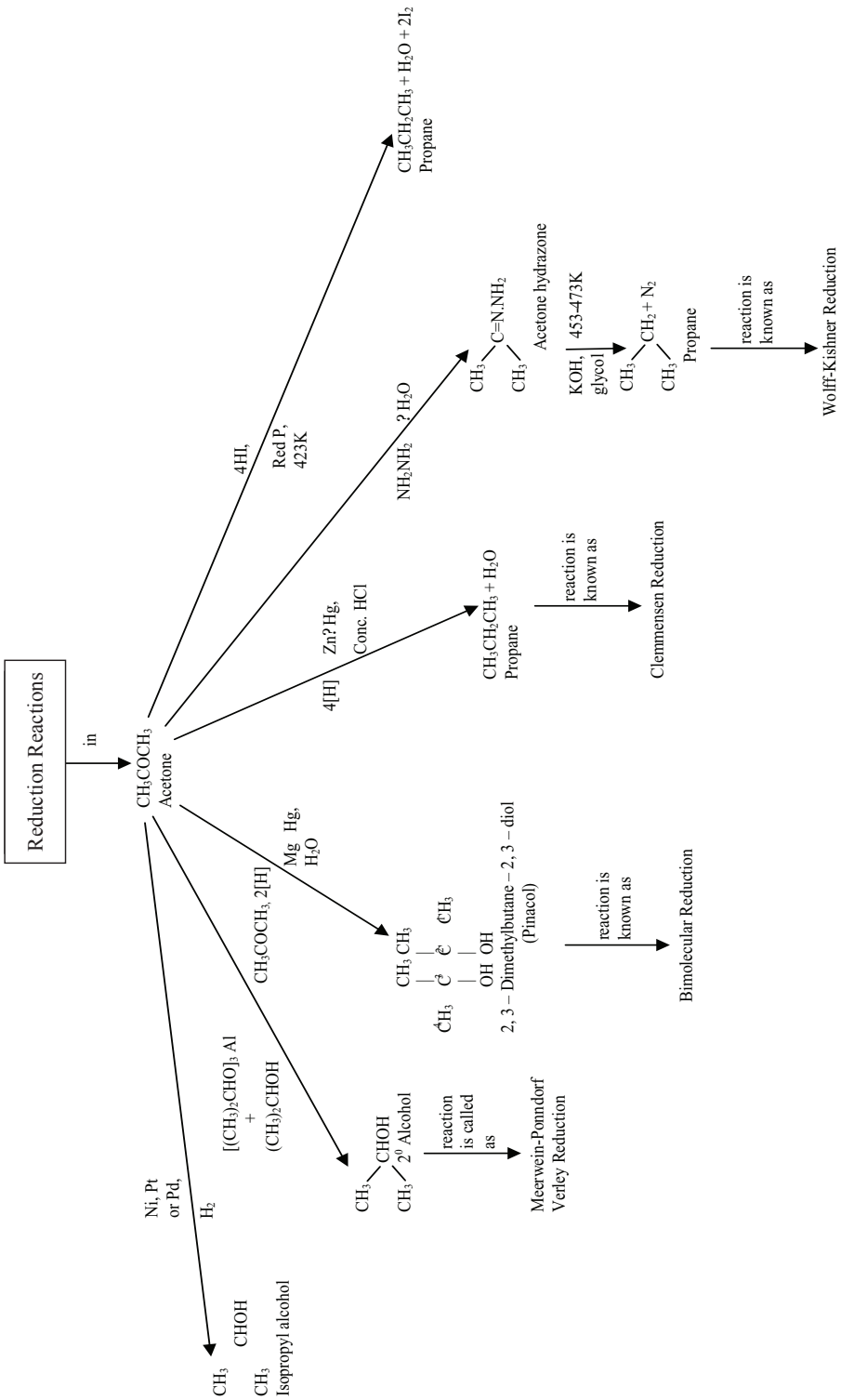
Reduction Reactions
in
CH3COCH3
Acetone
Ni, Pt or Pd, H2
CH3 CHOH CH3
Isopropyl alcohol
[(CH3)2CHO]3 Al + (CH3)2CHOH
CH3COCH3, 2[H]
Mg Hg, H2O
CH3 CHOH CH3
2⁰ Alcohol
reaction is called as
Meerwein-Ponndorf Verley Reduction
CH3 CH3
OH OH
2, 3 – Dimethylbutane – 2, 3 – diol (Pinacol)
reaction is known as
Bimolecular Reduction
4[H] Zn? Hg, Conc. HCl
CH3CH2CH3 + H2O
Propane
reaction is known as
Clemmensen Reduction
4HI, Red P, 423K
CH3CH2CH3 + H2O + 2I2
Propane
NH2NH2 ? H2O
CH3 C=N.NH2 CH3
Acetone hydrazone
KOH, glycol 453-473K
CH3 CH2 + N2 CH3
Propane
reaction is known as
Wolff-Kishner Reduction

Fig. 7

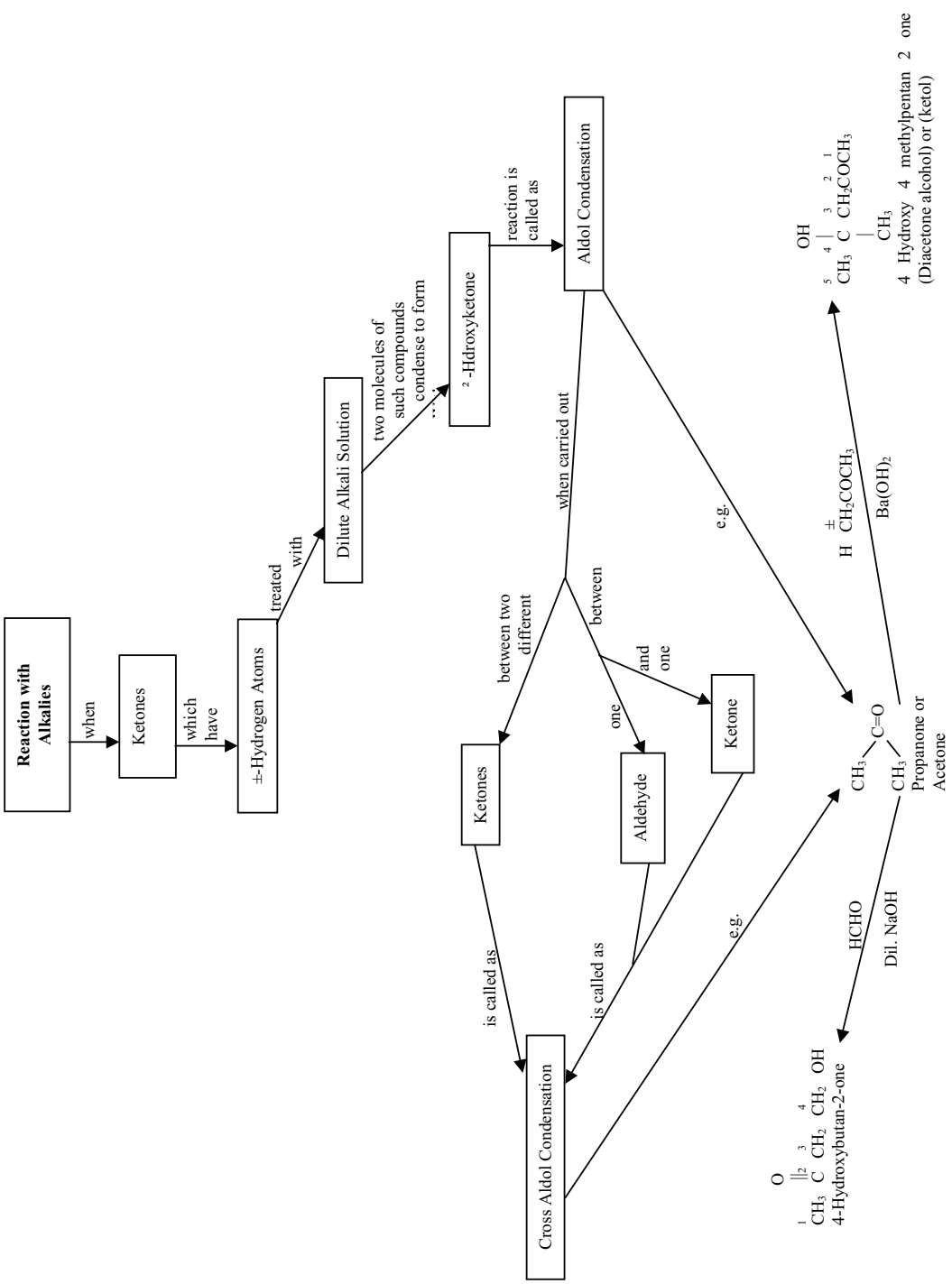
Reaction with Alkalies
when
Ketones
which have
±-Hydrogen Atoms
treated with
Dilute Alkali Solution
two molecules of such compounds condense to form
²-Hdroxyketone
reaction is called as
Aldol Condensation
when carried out
between two different
between one and one
e.g.
Ketones
Aldehyde
Ketone
is called as
is called as
e.g.
Cross Aldol Condensation
HCHO
Dil. NaOH
Propanone or Acetone
Ba(OH)2
4-Hydroxybutan-2-one
4 Hydroxy 4 methylpentan 2 one
(Diacetone alcohol) or (ketol)

Fig. 8

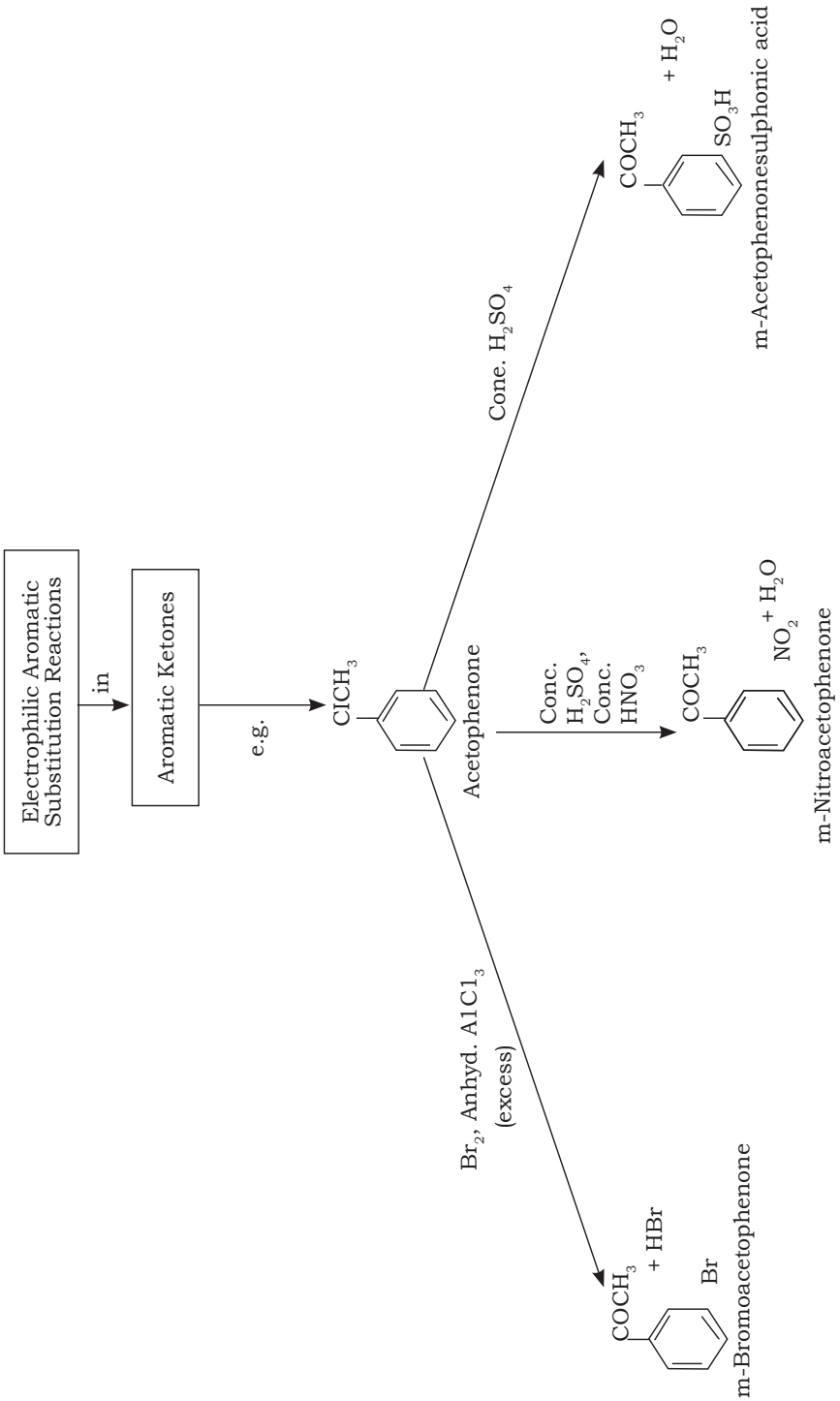
Electrophilic Aromatic Substitution Reactions
in
Aromatic Ketones
e.g.
COCH3
Acetophenone
Cone. H2SO4
COCH3
SO3H
+ H2O
m-Acetophenonesulphonic acid
Conc. H2SO4, Conc. HNO3
COCH3
NO2
+ H2O
m-Nitroacetophenone
Br2, Anhyd. AlCl3 (excess)
COCH3
Br
+ HBr
m-Bromoacetophenone

Fig. 9

significant difference in the mean gain achievement scores of students taught through Concept Mapping strategy as compared to those taught through Conventional method. On the basis of this result we can say that Concept Mapping strategy is significantly more effective than the Conventional method for improving achievement in Organic Chemistry.

Effect of Concept Mapping Strategy on Concept Retention in Organic Chemistry

$H_0$2: There is no significant difference between concept retention in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance.

It is clear from Table 3 that mean concept retention gain scores of experimental group is significantly higher than that of the control group and the 't' value is significant at the 0.01 level of significance. Therefore the null hypothesis $H_0$2 stating that "there is no significant difference between concept retention in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance" is rejected. Meaning thereby that there is a significant difference in the mean concept retention gain scores of students taught through Concept mapping strategy as compared to those taught through Conventional method. On the basis of this result we can say that Concept mapping strategy is significantly more effective than the Conventional method for concept retention in Organic Chemistry.

Effect of Concept Mapping Strategy on Concept Attrition in Organic Chemistry

$H_0$3: There is no significant difference between concept attrition in Organic Chemistry of students taught through Concept mapping strategy and

Table 3

$Mean_{Gain}$ (Retention), S.D. and 't' values obtained on Pre-test and Post-test-II (Delayed Post-test) in Organic Chemistry by Experimental Group and Control Group

Group	*N*	*Mean Gain (Retention) (Post-test II – Pre-test)*	*S.D.*	*df*	*'t'*	*p*
Experimental Group	30	4.76	2.10	58	8.20	< 0.01
Control Group	30	1.2	1.10			

Table 4

$Mean_{Attrition}$, S.D. and 't' values obtained on Post-test-I and Post-test-II (Delayed Post-test) in Organic Chemistry by Experimental Group and Control Group

Group	*N*	*Mean Attrition (Post-test I – Post-test II)*	*S.D.*	*df*	*'t'*	*p*
Experimental Group	30	1.36	0.98	58	5.73	< 0.01
Control Group	30	3.50	1.78			

students taught through Conventional method at the 0.01 level of significance.

It is apparent from the result in Table 4 that mean attrition values (retention loss) of control group is significantly higher than that of experimental group and the 't' value is significant at the 0.01 level of significance. Therefore the null hypothesis $H_0$3 stating that "there is no significant difference between concept attrition in Organic Chemistry of students taught through Concept mapping strategy and students taught through Conventional method at the 0.01 level of significance" is rejected. Meaning thereby that there is a significant difference in the mean attrition values (retention loss) of students taught through Concept Mapping strategy as compared to those taught through Conventional method. On the basis of this result we can say that Concept Mapping strategy is significantly more effective than the Conventional method for preventing concept attrition (retention loss) in Organic Chemistry.

Discussion of Results

The study by Lagowski (1990) asserted that retention of concepts was related to the kind of activity involved during teaching. He reported that students usually retained 10% of what they read, 26% of what they heard, 30% of what they saw, 50% of what they saw and heard, 70% of what they said and 90% of what they said while doing a task. This indirectly implies that the extent of attrition of concepts (retention loss) is also dependent on the kind of activity performed during the task of teaching.

The results of the present study indicates that Concept mapping strategy is significantly more effective than the Conventional method in the improvement of achievement in Organic Chemistry, concept retention in Organic Chemistry and for preventing concept attrition (retention loss) in Organic Chemistry.

The above results are in tune with the findings of Okebukola (1990), Rao (2004), Ahuja (2006), Gupta (1999), Yekta Z. and Nasrabadi A. (2004), Ling and Boo (2007), Wisher, Curnow and Seidel (2001) and Semb and Ellis (1994). The results of the present study stand reinforced and validated on the basis of findings of other researches cited above. Whereas Jay (1995) did not find significant difference between experimental and control group mean scores on an achievement exam and has reported results inconsistent with the results of the present study. Bantanur (2007), Chiou (2008) and Aparna (2002) have also found this strategy to be superior to Conventional method.

Conclusion

Taking the result into consideration, it may be concluded that the Concept mapping strategy has a positive effect on the achievement and concept retention in Organic Chemistry of students belonging to experimental group. This strategy is also significantly more effective for preventing concept attrition in Organic Chemistry of Class XII science students when compared to the Conventional method. From a student's view, concept mapping strategy encourages them to think

independently, produces more self-confidence and provides an increased awareness of findings connections between different topics. Teachers reported that Concept mapping assisted students to become active learners and organised theoretical knowledge in an integrative manner or conceptual framework (Boxtel *et al.*, 2002; Harpaz *et al.*, 2004). Hence there is a need to include Concept mapping strategy with the constructivist basis as one of the major approaches to teach Organic Chemistry in our schools. Use of Concept Mapping strategy as a main route of teaching or as a complementary strategy for traditional teaching method may improve the students' achievement in Organic Chemistry and knowledge retention capability.

Implications of the Study

Implications for Students

Concept mapping strategy as an instructional method would be helpful to raise the achievement levels of students. Besides adding to the clarity of concepts, concept maps will lead to the formation of strong linkages with related concepts. Thus Concept Mapping strategy would be helpful to the students for enhancing retention of concepts in their cognitive structure. It would also be helpful to the students for preventing concept attrition (retention loss). During the preparation of Board exams and other competitive exams Concept maps can also be used by the students as revision tools.

Implications for Teachers

Concept maps would also be helpful for the subject teachers to identify the causes of under-achievement among students and to remedy them. It would also be helpful for the teachers to organise their curriculum systematically and present it effectively. Teacher can also use concept maps as misconception correction tools. From students' constructed concept maps teachers can diagnose students' understanding of concepts and can identify the existing misconceptions. Once misconception in students' cognitive structure are diagnosed, remedial teaching in this direction can also be done by using Concept maps.

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