CONCEPT MAPS IN ORGANIC CHEMISTRY TEACHING

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The importance of chemistry is now recognised by all educationists. Owing to its complex nature, chemistry is often full of abstract concepts. It may lead to extensive misconceptions among students.

Researchers indicate (Pendley et al., 1994) that, instead of understanding the science concepts, students learn science concepts by rote learning. In our country various methods are being used to teach organic chemistry but the current methods of teaching organic chemistry are often didactic and do not involve pupil's prior knowledge actively. Therefore, there is a need to introduce a new method of teaching organic chemistry which gives easy explanations of principles so that students become interested in chemistry and do not develop chemophobia when later faced with systemised and scientific explanation of phenomena. Use of concept maps as a teaching method is one of them.

This article describes what are concept maps, why use concept maps, how to construct concept maps. It mainly describes how to construct and use concept maps. Example of phenol has been chosen to describe construction and use of concept map in teaching organic chemistry. It also emphasises on the advantages of using concept maps in teaching-learning process of organic chemistry as they can make learning an active process, can reinforce students' understanding and learning, can improve students' achievement in organic chemistry, can clarify misconceptions, and can be used as a tool to assess student's understanding, etc., which can be helpful for meaningful learning in organic chemistry.

The importance of chemistry is now recognised by all educationists. Chemistry has gained a secure position in the curricula of schools, technical colleges and universities, both as an essential part of general education for life and as a separate branch of science.

Planning the chemistry education of young people is all about selection of content to be included, selection of processes and skills to be practiced, and selection of appropriate activities to familiarise the students. This selection is normally carried out at the syllabus formulation stage or course production level. However, at the classroom level, it is rarely so. Keeping in mind the immense course content of the chemistry curriculum, some new teaching methods must be adopted by the teacher. It has been observed that the 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. The interest in the subject is also not substantiated and wavers more often. Chemistry is considered as a difficult subject among the natural sciences. The fundamentals behind the phenomena, the world of atoms and molecules, are not simple to perceive by our sensory organs.

The common problem in learning 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).

One way to avoid rote learning is to use concept map as a teaching strategy. The use of concept map as a teaching strategy was first developed by J.D. Novak in the early 1980's, derived from Ausubel's learning theory which places central emphasis on the influence of student's prior knowledge on subsequent meaningful learning.

Edmonson (1989) identified students as rote learners, meaningful learners, and those midrange between the two learning approaches. In a study that involved observations and videotaped stimulated recall interviews of college biology students in the laboratory, Robertson (1984) concluded that some students tended to use rote strategies in learning and others tended to formulate relationships, or learn meaningfully. Donn (1989) used a Likert-type instrument, adapted from the work of Entwistle and Ramsden (1983), to identify meaningful and rote learners and subsequently found a clear distinction in their approach to learn new concepts. Meaningful learners responded to novel problems by self-questioning and by relating and elaborating ideas. In contrast, rote learners responded by stating definitions and could not extrapolate their ideas (Donn, 1989).

According to Ausubel (1963, 1968), three things are most important for a meaningful learning to take place : (a) the concepts presented to the learner must be potentially meaningful and hence must provide opportunity for the learner to form non-arbitrary relationships with existing conceptual frameworks (meaningful learning tasks), (b) the learner must have a conceptual framework to which the new concepts can be linked (relevant prior knowledge), and (c) the learner must manifest the meaningful learning set. To fulfil this last criterion, the learner must actively attempt to relate what is known to substantive aspects of new concepts (Ausubel, 1963, 1968; Novak, 1988).

So to make our students meaningful learners and not the rote learners, teachers should use some new teaching strategies in the classrooms and concept map is one such strategy. According to several studies (e.g. Cardellini, 2004, Francisco *et. al.*, 2002, Markow and Lonning, 1998, Nicoll *et. al.*, 2001, Osman Nafiz, 2008, Pandley, *et. al.*, 1994, Regis, *et al.*, 1996, Stensvold and Wilson 1992), concept maps help chemistry learning both in classroom and laboratories. According to Francisco *et. al.*, 2002 and Nicoll *et. al.*, 2001, concept maps are a useful learning tool in chemistry. These can improve understanding of chemical concepts and help build connections among abstract concepts. These can also be used as a tool to correct misconception. Concept maps help make links between concepts. Linking words help students see connections among concepts and organisation of scientific knowledge hierarchically.

What are Concept Maps?

Concept map is a way of representing relations between ideas, images or words, in the same way as a diagram represents the grammar of a sentence, a roadmap represents the location of highways and towns and a circuit diagram represents the working of an electrical appliance. Concept maps are tools for organising and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions (indicating by a connecting line and linking word) between two concepts.

A concept map is a structural representation consisting of nodes and labelled lines. The nodes correspond to important terms (standing for concepts) in the domain. The lines denote a relation between a pair of concepts (nodes), and the label on the line tells how the two concepts are related. The combination of two nodes and a labelled line is called proposition. A proposition is the basic unit of meaning in a concept map and the smallest unit that can be used to judge the validity of the relation (line) drawn between two concepts.

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. In concept map, we hierarchically arranged the super ordinate concepts at the top of the map, and subordinate at the bottom which are less inclusive than higher ones. The various concepts are linked through lines and these linkages are well defined using words or phrases that highlights the relationships between concepts.

Why Use Concept Maps?

As a pedagogical tool, concept maps help to see the effects in teaching on learning, and to negotiate the concept meaning with the learner, as assessment tool, concept maps serve as a formative or summative assesment tool, as a knowledge organisation tool. The concept maps help as a research tool in investigating the students' understanding, their knowledge structure and capability for sharing the ideas. Concept maps have been useful tool as diagnostic, pedagogical, assessment, data collection, knowledge organisation tool. Concept maps have been effective in eliciting knowledge, depicting misconceptions, tracing conceptual changes in students' understanding of a domain.

A teacher can use concept maps to:

- clarify thinking and reinforcing understanding;
- stimulate creative thinking;
- integrate new knowledge;
- identify misconceptions;
- correct misconceptions;
- solve complex problems;
- solve rote learning problems.

How to Construct Concept Maps?

The process of preparing a concept map comprises five major steps:

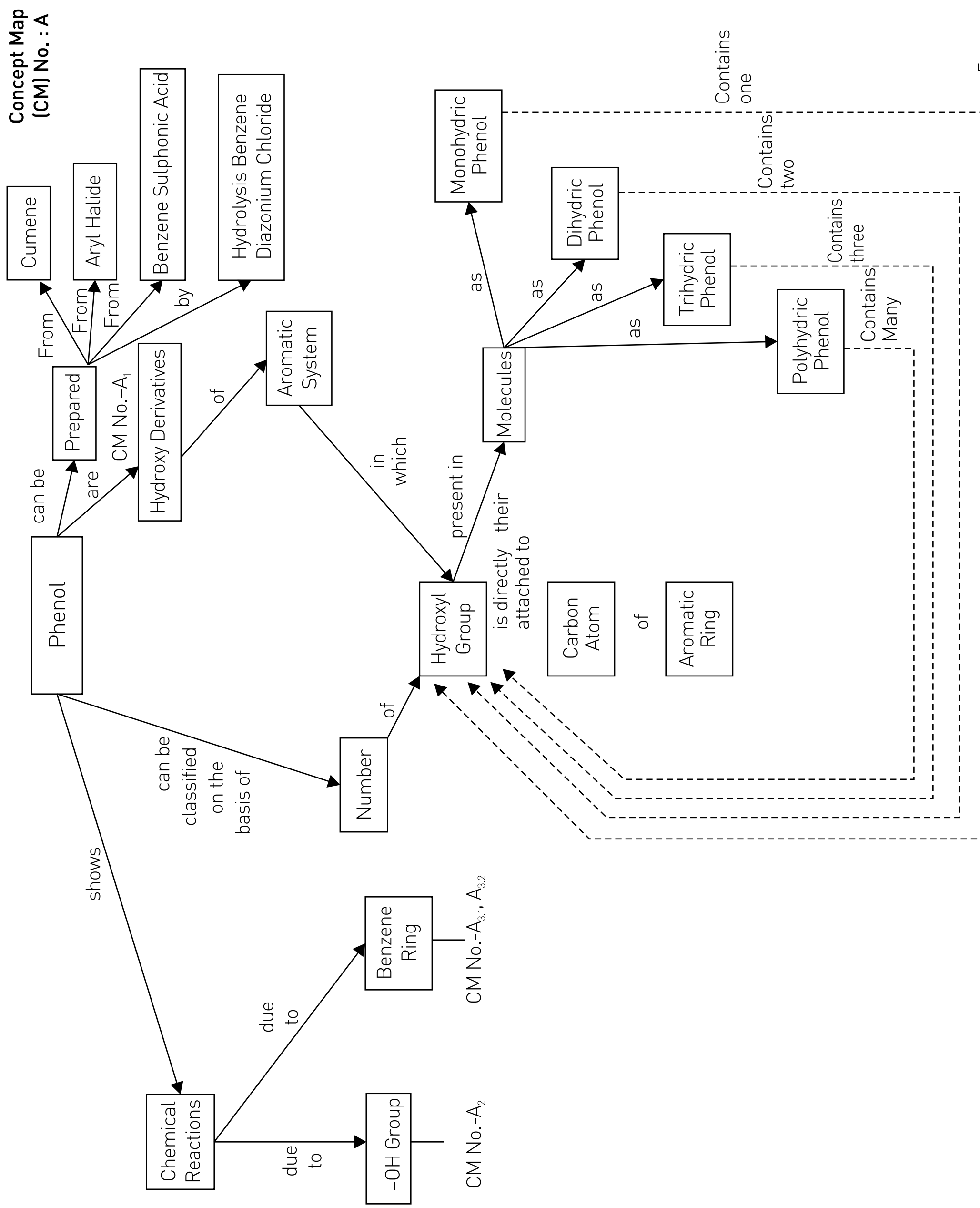
1. Identify the key concept, intermediate concepts and specific concepts.
2. Arrange the most important concepts. Place the most important concept on the top of the map. Add the lesser important concepts on a layer below the top concept.
3. Connect the concepts with arrows or links.
4. Add verbs to the links.
5. Add more links and concepts, if required, to complete the map.

The concept maps can be drawn using paper and pencil, blackboard and computer software. The concept maps are user-friendly and easy to draw. To begin with, the mapper select a topic of interest and reads the topic, for example Phenol (Fig. 1). While reading, around 10–15 major concepts are identified, for instance, Hydroxy derivatives, Chemical reactions, Benzene, Hydroxyl group, etc. The concepts are enclosed within an elipse outline. These concepts are arranged from general to specific levels, by placing the most important concept (Subordinate concept) on the top of the map and lesser important concepts (Subordinate concept) on a layer below the top concept. This is followed by labelling links by drawing lines to these concepts. These links provide meaning to the concepts and few such linking words are : on the basis of, are, can be, in which, due to, etc., which are written on the lines connecting the concepts.

Concept Maps in Organic Chemistry Teaching

In the teaching-learning process of organic chemistry, use of concept maps as a teaching strategy will be most useful for the students and teachers both. Figs. 1 to 5 at a glance, present how organic chemistry (Phenol) can be taught through concept maps in an effective manner.

Teaching organic chemistry through concept maps may lead to the development of the concept. In organic chemistry as a teaching strategy, concept maps can be used to help students to solve rote learning problems and to clarify their misconceptions so that the students' achievement in organic chemistry will be higher. The misconception , if identified after teaching, can be greatly reduced when the sources of these misconceptions were specifically addressed during teaching process. Using concept maps can reinforce students' understanding and learning. Concept maps can also be useful for teachers in evaluating the process of teaching. They can assess the students' achievement by identifying misconceptions and missing concepts. They can also help teachers plan lesson, teaching units, and course of study. One big advantage of using concept maps in organic chemistry teaching is that it provides a visual image of the concepts under study in a tangible form, which can be focused very easily. They can be readily revised any time when necessary. During the formulation process, it consolidated a concrete and precise understanding of the meanings and inter-relations of concepts. Thus it makes learning an active process, not a passive one.


Concept Map (CM) No. : A
Phenol
can be
Prepared
From
Cumene
From
Aryl Halide
From
Benzene Sulphonic Acid
by
Hydrolysis Benzene Diazonium Chloride
are
Hydroxy Derivatives
CM No.-A_1
of
Aromatic System
in which
Hydroxyl Group
is directly attached to
Carbon Atom
of
Aromatic Ring
present in
their
Molecules
as
Monohydric Phenol
as
Dihydric Phenol
as
Trihydric Phenol
as
Polyhydric Phenol
Contains one
Contains two
Contains three
Contains Many
can be classified on the basis of
Number
of
shows
Chemical Reactions
due to
Benzene Ring
CM No.-$A_{3.1}$, $A_{3.2}$
due to
–OH Group
CM No.-A_2

5

Fig. 1

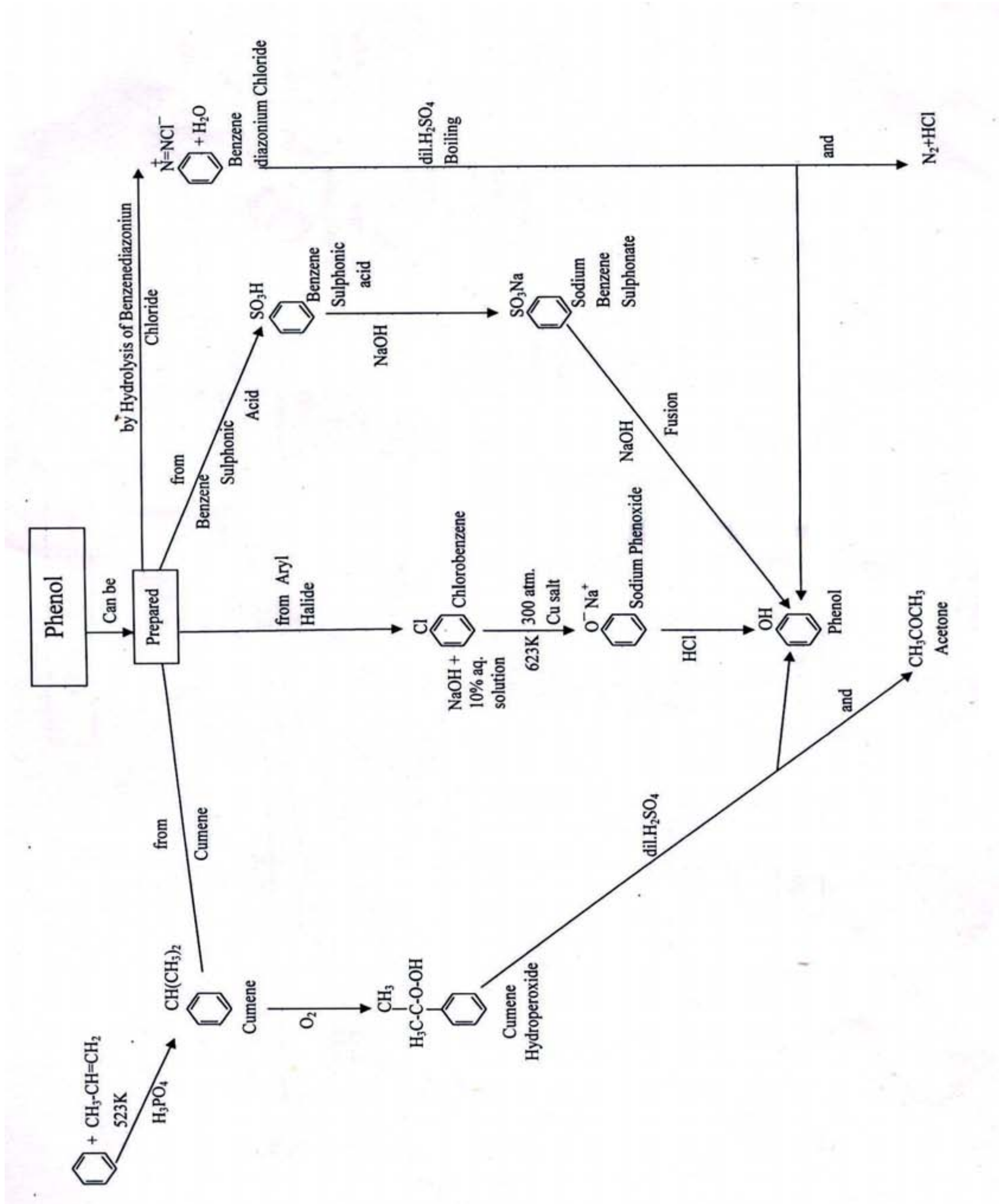
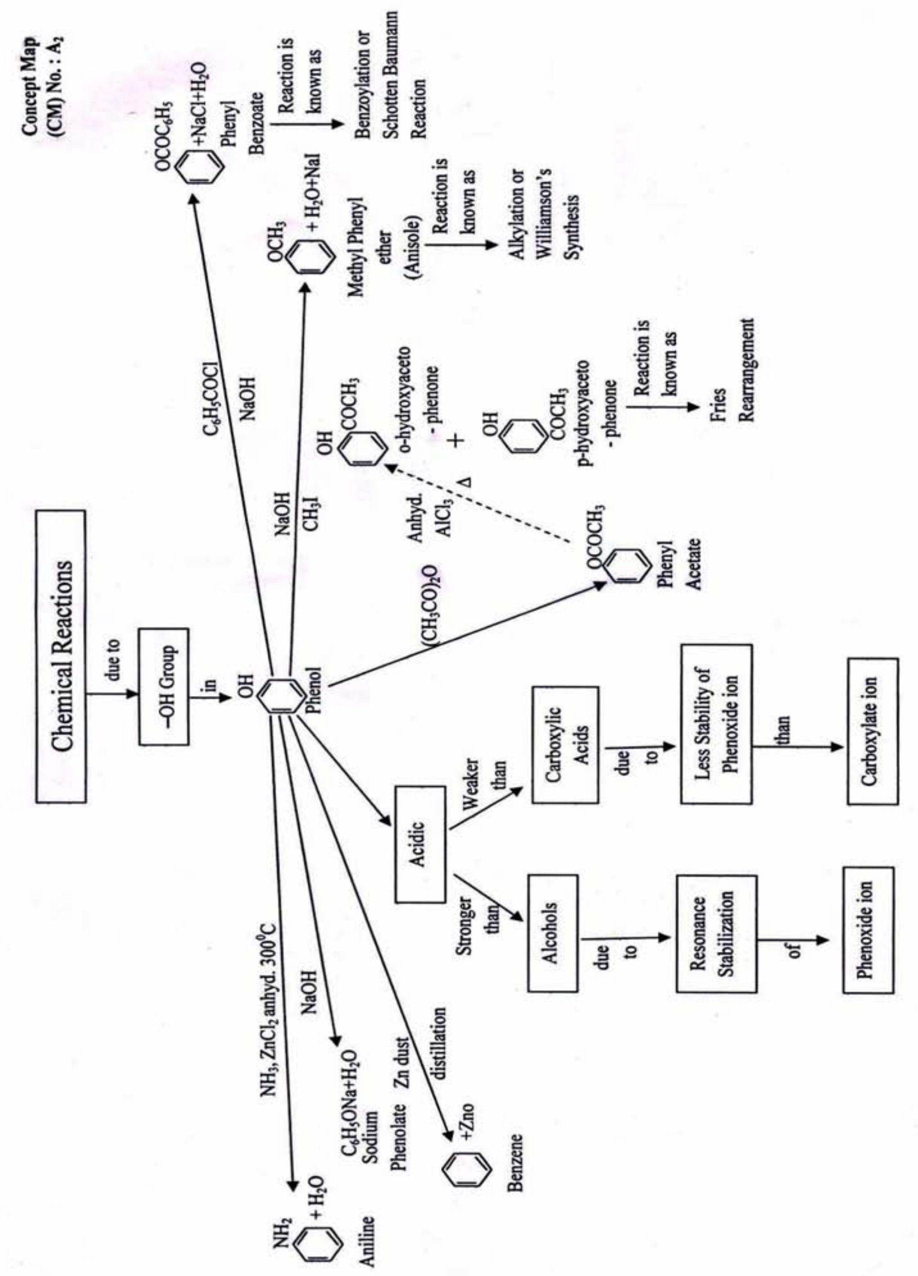
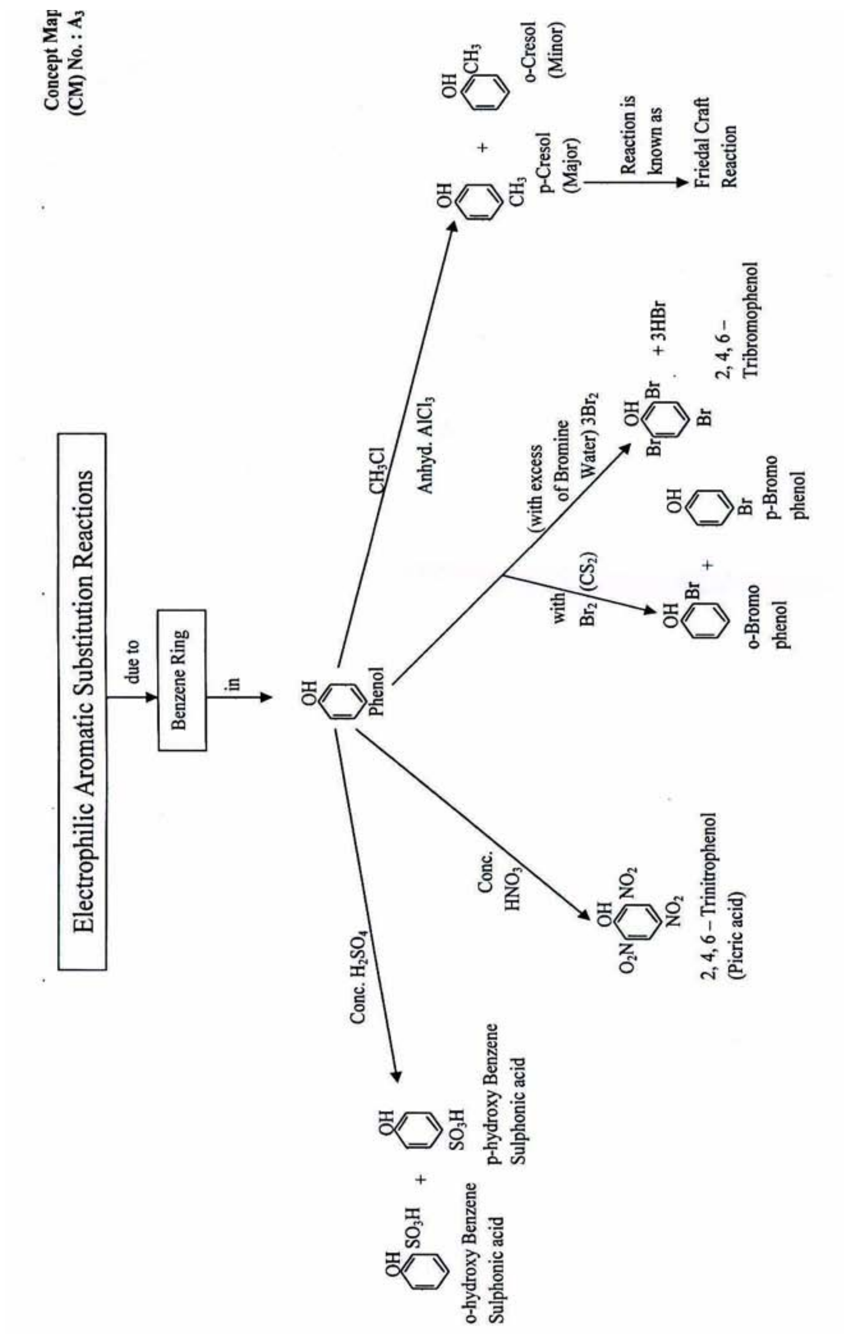

Phenol
Can be
Prepared
by Hydrolysis of Benzenediazonium Chloride
+ H2O
Benzene diazonium Chloride
dil.H2SO4 Boiling
and
N2+HCl
from Benzene Sulphonic Acid
SO3H
Benzene Sulphonic acid
NaOH
SO3Na
Sodium Benzene Sulphonate
NaOH Fusion
from Aryl Halide
Cl
Chlorobenzene
NaOH + 10% aq. solution
300 atm. Cu salt 623K
O⁻Na⁺
Sodium Phenoxide
HCl
OH
Phenol
from Cumene
+ CH3-CH=CH2
523K
H3PO4
CH(CH3)2
Cumene
O2
CH3
H3C-C-O-OH
Cumene Hydroperoxide
dil.H2SO4
and
CH3COCH3
Acetone

Fig. 2



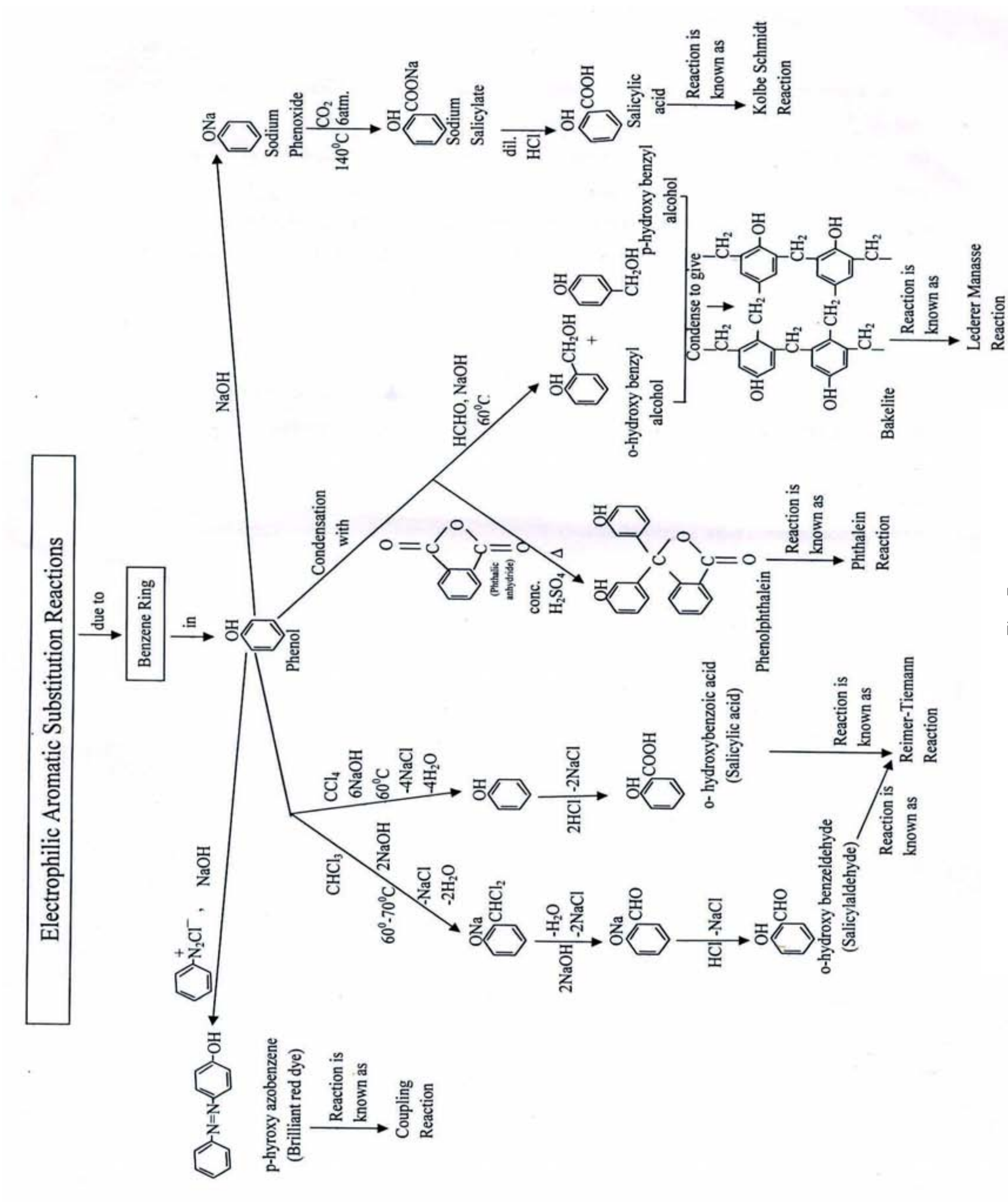
Concept Map (CM) No. : A2
Chemical Reactions
due to
–OH Group
in
OH
Phenol
NH3, ZnCl2 anhyd. 300°C
NH2 + H2O
Aniline
NaOH
C6H5ONa+H2O
Sodium Phenolate
Zn dust distillation
+Zno
Benzene
Acidic
Stronger than
Alcohols
due to
Resonance Stabilization
of
Phenoxide ion
Weaker than
Carboxylic Acids
due to
Less Stability of Phenoxide ion
than
Carboxylate ion
(CH3CO)2O
OCOCH3
Phenyl Acetate
Anhyd. AlCl3
Δ
OH COCH3
o-hydroxyaceto - phenone
+
OH COCH3
p-hydroxyaceto - phenone
Reaction is known as
Fries Rearrangement
NaOH CH3I
OCH3 + H2O+NaI
Methyl Phenyl ether (Anisole)
Reaction is known as
Alkylation or Williamson's Synthesis
C6H5COCl NaOH
OCOC6H5 +NaCl+H2O
Phenyl Benzoate
Reaction is known as
Benzoylation or Schotten Baumann Reaction

Fig. 3



Concept Map
(CM) No. : A_3
Electrophilic Aromatic Substitution Reactions
due to
Benzene Ring
in
OH
Phenol
CH_3Cl
Anhyd. $AlCl_3$
OH
CH_3
p-Cresol
(Major)
+
OH
CH_3
o-Cresol
(Minor)
Reaction is
known as
Friedal Craft
Reaction
(with excess
of Bromine
Water) $3Br_2$
OH
Br
Br
Br
+ 3HBr
2, 4, 6 –
Tribromophenol
with
Br_2 (CS_2)
OH
Br
o-Bromo
phenol
+
OH
Br
p-Bromo
phenol
Conc.
HNO_3
OH
O_2N
NO_2
NO_2
2, 4, 6 – Trinitrophenol
(Picric acid)
Conc. H_2SO_4
OH
SO_3H
o-hydroxy Benzene
Sulphonic acid
+
OH
SO_3H
p-hydroxy Benzene
Sulphonic acid

Fig. 4



Electrophilic Aromatic Substitution Reactions
due to
Benzene Ring
in
OH
Phenol
NaOH
ONa
Sodium Phenoxide
CO2 6atm.
140°C
OH COONa
Sodium Salicylate
dil. HCl
OH COOH
Salicylic acid
Reaction is known as
Kolbe Schmidt Reaction
Condensation with
HCHO, NaOH 60°C
o-hydroxy benzyl alcohol
p-hydroxy benzyl alcohol
CH2OH
Condense to give
CH2
Bakelite
Reaction is known as
Lederer Manasse Reaction
(Phthalic anhydride)
conc. H2SO4
Δ
Phenolphthalein
Reaction is known as
Phthalein Reaction
CCl4 6NaOH 60°C -4NaCl -4H2O
2HCl -2NaCl
o- hydroxybenzoic acid (Salicylic acid)
Reaction is known as
Reimer-Tiemann Reaction
CHCl3 2NaOH 60°-70°C -NaCl -2H2O
ONa CHCl2
2NaOH -H2O -2NaCl
ONa CHO
HCl -NaCl
OH CHO
o-hydroxy benzeldehyde (Salicylaldehyde)
Reaction is known as
N2Cl⁻ , NaOH
N=N OH
p-hyroxy azobenzene (Brilliant red dye)
Reaction is known as
Coupling Reaction

Fig. 5

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